Grant agreement for: Collaborative project*

Annex I - "Description of Work"

Project acronym: COMBO

Project full title: " COnvergence of fixed and Mobile BrOadband access/aggregation networks "

Grant agreement no: 317762

Version date: 2012-09-07

Table of Contents

Part A

Workplan Tables

A1:
Project summary

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per project

General information			
Project title [3]	COnvergence of fixed and Mobile BrOadband access/aggregation networks		
Starting date [4]	01/01/2013		
Duration in months [5]	36		
Call (part) identifier [6]	FP7-ICT-2011-8		
Activity code(s) most relevant to your topic [7]	:		
Free keywords [8]	Network of the future, Optical communication, PON, Optical fiber access, Next generation networks.		

Abstract [9]

Tremendous changes in fixed and mobile networks are required to enable the Gigabit society, leading to enormous investments in network infrastructures (billions of €). In the past, fixed and mobile networks have been optimized and evolved independently. Today, standardization work and bodies dealing with fixed and mobile networks are still separated, and Fixed Mobile Convergence (FMC) is mainly implemented at service level with introduction of all IP services and IMS, allowing a converged service control layer. In contrast, COMBO will allow the convergence of fixed and mobile networks themselves, combining both an optimal and seamless quality of experience for the end user together with an optimized network infrastructure ensuring increased performance, reduced cost and reduced energy consumption.
To achieve this target, COMBO will propose and investigate new integrated approaches for Fixed / Mobile Converged (FMC) broadband access / aggregation networks for different scenarios (dense urban, urban, rural). COMBO architectures will be based on joint optimisation of fixed and mobile access / aggregation networks around the innovative concept of Next Generation Point of Presence (NG-POP). This will lead to a better distribution of all essential functions, equipment and infrastructures of convergent networks.
The key objectives of COMBO will be to:
• Define optimised FMC network architectures, which will be quantitatively assessed and compared with respect to Key Performance Indicators such as cost, energy consumption, bitrate, delay, QoS;
• Assess multi-operator FMC scenarios to ensure openness and flexibility for network operators and service providers;
• Demonstrate experimentally FMC network features in lab and field tests to show the feasibility of proposed architectures;
• Drive standardization bodies with respect to FMC architectures to boost COMBO concepts in coming standards and to foster large scale implementation of FMC networks.

A2:
List of Beneficiaries

Project Number [1]	317762	Project Acronym [2]	COMBO

List of Beneficiaries

No	Name	Short name	Country	Project entry month[10]	Project exit month
1	JCP-CONSULT SAS	JCP	France	1	36
2	DEUTSCHE TELEKOM AG	DTAG	Germany	1	36
3	TELEFONICA INVESTIGACION Y DESARROLLO SA	TID	Spain	1	36
4	FRANCE TELECOM SA	FT	France	1	36
5	ALCATEL-LUCENT ITALIA S.P.A.	ALU-I	Italy	1	36
6	Institut Mines-Telecom	IT-TB	France	1	36
7	ERICSSON AB	EAB	Sweden	1	36
8	ADVA OPTICAL NETWORKING LIMITED	ADVA-UK	United Kingdom	1	36
9	LUNDS UNIVERSITET	ULUND	Sweden	1	36
10	CENTRE TECNOLOGIC DE TELECOMUNICACIONS DE CATALUNYA	CTTC	Spain	1	36
11	DOCOMO COMMUNICATIONS LABORATORIES EUROPE GMBH	DOCOMO	Germany	1	36
12	POLITECNICO DI MILANO	POLIMI	Italy	1	36
13	BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM	BME	Hungary	1	36
14	AITIA INTERNATIONAL INFORMATIKAI ZARTKORUEN MUKODO RT	AITIA	Hungary	1	36
15	TELNET REDES INTELIGENTES SA	TELNET	Spain	1	36
16	ADVA AG OPTICAL NETWORKING	ADVA-DE	Germany	1	36
17	FON Wireless Ltd	FON	United Kingdom	1	36

A3:
Budget Breakdown

Project Number [1]	317762	Project Acronym [2]	COMBO

One Form per Project

Participant number in this project [11]	Participant short name	Fund. % [12]	Ind. costs [13]	Estimated eligible costs (whole duration of the project)					Requested EU contribution
				RTD / Innovation (A)	Demonstration (B)	Management (C)	Other (D)	Total A+B+C+D	
1	JCP	75.0	T	289,440.00	0.00	368,900.00	162,453.00	820,793.00	748,433.00
2	DTAG	50.0	A	865,513.00	179,072.00	109,628.00	245,144.00	1,399,357.00	877,064.00
3	TID	50.0	A	611,278.00	169,397.00	51,655.00	40,656.00	872,986.00	482,648.00
4	FT	50.0	A	712,863.00	247,702.00	43,043.00	136,392.00	1,140,000.00	659,717.00
5	ALU-I	50.0	A	196,098.00	110,838.00	21,903.00	40,104.00	368,943.00	215,475.00
6	IT-TB	75.0	T	481,734.00	0.00	13,934.00	69,203.00	564,871.00	444,437.00
7	EAB	50.0	A	713,999.00	601,999.00	39,000.00	79,000.00	1,433,998.00	775,998.00
8	ADVA-UK	50.0	A	171,150.00	223,970.00	5,705.00	45,640.00	446,465.00	248,905.00
9	ULUND	75.0	T	634,400.00	0.00	50,200.00	52,800.00	737,400.00	578,800.00
10	CTTC	75.0	A	399,767.00	81,585.00	24,579.00	13,159.00	519,090.00	378,355.00
11	DOCOMO	50.0	A	227,910.00	0.00	34,597.00	29,194.00	291,701.00	177,746.00
12	POLIMI	75.0	A	601,190.00	0.00	19,943.00	32,660.00	653,793.00	503,495.00
13	BME	75.0	T	379,200.00	0.00	33,900.00	34,600.00	447,700.00	352,900.00
14	AITIA	75.0	T	256,000.00	32,000.00	22,400.00	41,600.00	352,000.00	272,000.00
15	TELNET	75.0	T	48,000.00	276,800.00	16,480.00	11,520.00	352,800.00	202,080.00
16	ADVA-DE	50.0	A	86,170.00	73,860.00	6,155.00	43,085.00	209,270.00	129,255.00
17	FON	75.0	T	350,336.00	141,952.00	24,252.00	43,712.00	560,252.00	401,692.00
Total				7,025,048.00	2,139,175.00	886,274.00	1,120,922.00	11,171,419.00	7,449,000.00

Note that the budget mentioned in this table is the total budget requested by the Beneficiary and associated Third Parties.

*** The following funding schemes are distinguished**

Collaborative Project (if a distinction is made in the call please state which type of Collaborative project is referred to: (i) Small of medium-scale focused research project, (ii) Large-scale integrating project, (iii) Project targeted to special groups such as SMEs and other smaller actors), Network of Excellence, Coordination Action, Support Action.

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project, and it cannot be changed. The project number **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

2. Project acronym

Use the project acronym as indicated in the submitted proposal. It cannot be changed, unless agreed during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry info force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a detailed justification on a separate note.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Activity code

Select the activity code from the drop-down menu.

8. Free keywords

Use the free keywords from your original proposal; changes and additions are possible.

9. Abstract

10. The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

11. The number allocated by the Consortium to the participant for this project.

12. Include the funding % for RTD/Innovation – either 50% or 75%

13. Indirect cost model

A: Actual Costs
S: Actual Costs Simplified Method
T: Transitional Flat rate
F :Flat Rate

Workplan Tables

Project number

317762

Project title

COMBO—COnvergence of fixed and Mobile BrOadband access/aggregation networks

Call (part) identifier

FP7-ICT-2011-8

Funding scheme

Collaborative project

WT1
List of work packages

Project Number [1]	317762	Project Acronym [2]	COMBO

LIST OF WORK PACKAGES (WP)

WP Number [53]	WP Title	Type of activity [54]	Lead beneficiary number [55]	Person-months [56]	Start month [57]	End month [58]
WP 1	Project Management and Coordination	MGT	1	45.50	1	36
WP 2	Framework Definition, Architecture and Evolution	RTD	3	98.00	1	35
WP 3	Fixed Mobile Convergent Architectures	RTD	4	233.20	1	35
WP 4	Traffic and Performance Management	RTD	7	162.30	1	36
WP 5	Techno-Economic Assessment	RTD	13	144.00	1	36
WP 6	Functional Development & Experimental Research Activities	DEM	8	190.50	1	36
WP 7	Dissemination and Standardization	OTHER	2	73.50	1	36
			Total	947.00		

WT2:
List of Deliverables

Project Number [1]	317762	Project Acronym [2]	COMBO

List of Deliverables - to be submitted for review to EC

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1	Project Web Site	1	1	12.50	O	PU	2
D1.2	Project Reference Manual	1	1	11.00	O	RE	3
D1.3	Project Quality Insurance Manual	1	1	11.00	O	RE	3
D1.4	Knowledge Management Guide and IPR	1	1	11.00	O	RE	6
D2.1	Framework reference for fixed and mobile convergence	2	3	24.00	R	PU	9
D2.2	Roadmaps for independent fixed and mobile network evolution	2	3	24.00	R	PU	8
D2.3	Traffic modelling in FMC network scenarios	2	3	25.00	R	PU	11
D2.4	Requirements for converged fixed and mobile networks	2	3	25.00	R	PU	12
D3.1	Analysis of key functions, equipment and infrastructures of FMC networks	3	4	58.00	R	PU	10
D3.2	Assessment of network scenarios based on functional convergence	3	4	58.00	R	PU	22
D3.3	Assessment of network scenarios based on structural convergence	3	4	58.00	R	PU	22
D3.4	Final architectural recommendations	3	4	59.20	R	PU	35

WT2:
List of Deliverables

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	for FMC networks						
D4.1	Monitoring parameters relation to QoS/QoE and KPIs	4	7	33.00	R	PU	12
D4.2	Performance monitoring for FMC networks	4	7	33.00	R	PU	18
D4.3	Performance optimization concepts based on multi-operator, multi-vendor scenarios	4	7	33.00	R	PU	24
D4.4	Performance optimization concepts	4	7	33.00	R	PU	30
D4.5	Evaluation of performance management concepts	4	7	30.30	R	PU	36
D5.1	Assessment framework and evaluation of state-of-the-art architectures	5	13	47.00	R	PU	11
D5.2	Intermediate techno-economic analysis of candidate FMC scenarios	5	13	48.00	R	PU	22
D5.3	Techno-economic assessment and business analysis of the proposed FMC architectures	5	13	49.00	R	PU	35
D6.1	Summary of planned experimental activities and gap analysis	6	8	63.00	R	PU	6

WT2:
List of Deliverables

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D6.2	Report on testing status relative to each lab based experiment	6	8	63.00	R	PU	24
D6.3	Report describing results of field based testing, capturing lessons learned and recommendations	6	8	64.50	R	PU	34
D7.1	Project presentation, communication plan and dissemination plan	7	2	18.50	R	PU	2
D7.2	Dissemination material and publication policy	7	2	18.50	R	PU	36
D7.3	Report on standardization and dissemination activities I	7	2	18.50	R	PU	18
D7.4	Report on standardization and dissemination activities II	7	2	18.00	R	PU	36
			Total	947.00			

WT3:
Work package description

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per Work Package

Work package number [53]	WP1	Type of activity [54]	MGT
Work package title	Project Management and Coordination		
Start month	1		
End month	36		
Lead beneficiary number [55]	1		

Objectives

Effective Project Management requires effective decision-making, clear external communication, operational internal communication, and effective administrative and technical control. On this basis, the project will maintain a set of management structures with clear responsibilities. Policies and procedures will be defined assuring that the consortium members will act in a coordinated way and that the necessary quality levels will be met.

In the administrative domain, the work package will:
• Set the basis for coordination of the technical activities of WP2-7 and the interaction of partners;
• Establish and maintain links between project partners and the EU, as well as the ICT community.

The management will be responsible for monitoring the progress of the technical outcomes of the project and the potential risks, with emphasis given to project milestones and deliverables.

In more detail the objectives of the management work package are:
• To establish appropriate relationships and communication channels with the funding actors as well as between consortium partners
• To administer the project resources and monitor the overall project performance
• The coordination and operational management
• Quality management
• Risk management
• Reporting to the EU
This work package is led by JCP.

Description of work and role of partners

The management and coordination of the project is divided into several specific tasks. The success of each task will be measurable based on milestones and deliverables.

During consortium meetings participants from all partners will be involved and future actions, reporting, and timing of the work and creation of output will be discussed. The set up and maintenance of adequate intra-project information channels such as website (collaborative tool), an FTP site and discussion forum, depending on the emerging needs of the consortium. 'External interactions' will be coordinated and monitored in order to promote multi-disciplinary objectives of the project. This means that the WP will safeguard the fact that the work of all involved disciplines will be communicated to the outside as a real combined effort, not as fragmented pieces of work, thereby ensuring integration of the effort spent in a pro-active way.

The WP will also manage the overall legal, contractual, ethical, financial and administrative aspects of the consortium. It will take care of the interaction with the INFSO and the EU commission in general, of the coordination of the submission of the contractual documents, the preparation, updating and management of the consortium agreement between the participants and of the generation and updating of the information-exchange platforms (www, newsletter).

Task 1.1: Project Organisation and Management [M1 – M36]
(Leader: JCP, Contributors: ALL)

This task is dedicated to the daily management and control of the project, as well as the liaison with the Commission and external organizations
• Ensure the daily management of the project, monitor the overall progress of the work, the production of the deliverables and milestones and their delivery at the agreed deadlines
• To ensure the communications between the project and the Commission (representation at the regular Concertation meetings, participation to events organised by other projects, participation as requested to events organised by the Commission, etc.) and to external organisations;
• Set up and continuous update of a project collaborative platform that will assist in the co-ordination of activities, sharing of technical documents, dissemination and organisational tasks
• Resource management and mobilisation in order to optimise the project efficiency. The project may be slightly modified or re-focus if necessary taking into account project evolution and risks.
• Reporting to the European Commission: This includes the Quarterly management reports (QMR), yearly Periodic review reports (APRR), cost claims, and a final report.

Task 1.2: Project Quality Management [M1 – M36]
(Leader: JCP, Contributors: ALL)
This task is devoted to the assessment of the quality of the work and the deliverables produced in the project. A quality Manager will be appointed by the Steering Committee: he/she will be asked periodically to review technical progress such that the project remains in line with the Description of Work and expected quality of results.

The objectives of this task are to ensure adequate quality of the outcomes of the project:
• Quality of the produced deliverables,
• Quality of the internal deliveries and processes.

Task 1.3: Project Risk Management [M1 – M36]
(Leader: JCP, Contributors: ALL)
Keeping in mind that some risks may have an impact on the project schedule and project objectives and finally may lead to contractual issues, this management process shall identify and monitor internal and external risks for the project and take appropriate measures.

Internal risks can originate from:
• The technical nature of the R&D: unexpected technical difficulty or key technologies not available,
• Problems with an underperforming partner or a key partner leaving the project,
• Project execution risks: key milestones or critical deliverable delayed,
• The lack of professionalism of some partners (incomplete system specification and architecture study, poor quality or insufficient documentation, incomplete unit testing of software/hardware components, insufficient integration testing/verification/validation, planning errors, over specification without resource counterpart, …),
• Poor communication and cooperation between the partners,
• Too ambitious objectives (in terms of budget) or feasibility,
• IPR.

External risks are essentially coming from the existence of other industrial solutions as well as from worldwide competing R&D.

Mitigation is undertaken at the appropriate level in the project organisation: work-packages, Project Management Committee, Steering Committee or General Assembly in accordance with the rules defined in the Consortium Agreement.

Partners' individual contributions
JCP-Consult will lead WP1 and have the overall administrative coordination responsibility of the project: it will set-up and maintain an internal website for project coordination purposes and prepare the reporting documents. All other partners will contribute.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JCP	30.00

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
2	DTAG	3.00
3	TID	3.00
4	FT	3.00
5	ALU-I	0.50
6	IT-TB	0.50
7	EAB	0.50
8	ADVA-UK	0.50
9	ULUND	0.50
10	CTTC	0.50
11	DOCOMO	0.50
12	POLIMI	0.50
13	BME	0.50
14	AITIA	0.50
15	TELNET	0.50
16	ADVA-DE	0.50
17	FON	0.50
	Total	45.50

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1	Project Web Site	1	12.50	O	PU	2
D1.2	Project Reference Manual	1	11.00	O	RE	3
D1.3	Project Quality Insurance Manual	1	11.00	O	RE	3
D1.4	Knowledge Management Guide and IPR	1	11.00	O	RE	6
		Total	45.50			

Description of deliverables

D1.1) Project Web Site: The project's website will be set up. [month 2]

D1.2) Project Reference Manual: Project Reference Manual will be finished. [month 3]

D1.3) Project Quality Insurance Manual: Project Quality Insurance Manual will be finished. [month 3]

D1.4) Knowledge Management Guide and IPR: Knowledge Management Guide will be finished. IPR issues will be dealt with. [month 6]

WT3:
Work package description

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS1	Project consortium agreement	1	1	Project consortium agreement signed.
MS2	Quarterly management report	1	3	
MS3	Quarterly management report	1	6	
MS4	Quarterly management report	1	9	
MS5	Quarterly management report	1	15	
MS6	Quarterly management report	1	18	
MS7	Quarterly management report	1	21	
MS8	Quarterly management report	1	27	
MS9	Quarterly management report	1	30	
MS10	Quarterly management report	1	33	

WT3:
Work package description

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per Work Package

Work package number [53]	WP2	Type of activity [54]	RTD
Work package title	Framework Definition, Architecture and Evolution		
Start month	1		
End month	35		
Lead beneficiary number [55]	3		

Objectives

WP2 will provide the general framework for fixed and mobile networks and assess current evolution trends. In more detail, WP2 will:
• Define the general framework for fixed and mobile networks by common area descriptions as a basis for the development of future FMC network architecture and propose FMC network use cases.
• Define the reference scenario as a starting point covering today´s network status. This scenario will be further developed to address the network evolution without an FMC approach so that it can serve as basis for comparison with the FMC scenarios developed in WP3.
• Investigate the fixed and mobile evolution paths over time starting from the current trends.
• Define and model future converged fixed and mobile traffic scenarios based on the reference framework and network evolution.
• Identify the requirements and KPI for COMBO project that will have to be considered during the FMC network architectures design.
This work package is led by TID.

Description of work and role of partners

Task 2.1: Reference framework [M1-M9]
The first task of this WP will provide a general description of the considered FMC network framework by common area descriptions as a basis for the development of future FMC network architectures. It will take into consideration the current metro-access fixed and mobile networks to define common reference areas e.g. typical number of households, mobile users, number and location of sites, etc., in which both networks can converge. Furthermore, current market descriptions and projections towards 2020 will be analysed. In a later stage, based on the results of Task 2.2, this activity will propose high level FMC network use cases, e.g. NG Central Office as result of centralised fixed and mobile network approach, as input for WP3.
The reference framework will be defined by network operators with the support of other partners: DTAG will provide inputs regarding typical network data needed for dimensioning, FT, TID will participate in the definition of the common reference areas, ADVA-G will contribute with the definition of front-haul/back-haul concepts, ALU-I will provide market aspects and FON will contribute in the framework definition and the picturing of AS-IS situation in the market. FMC networks use cases will be defined at the end of this task with the joint work of all partners and their respective point of view: DTAG, FT, TID, ALU-I, EAB, DOCOMO (handover and CoMP) and FON.
Fed by:WP2 (T2.2 for network use cases)
Feeds: WP2 (T2.2, T2.3, T2.4), WP3-WP7 (All Tasks)
Task leader: DTAG
Contributing partners: DTAG, TID, FT, ALU-I, EAB, DOCOMO and FON.

Task 2.2 Fixed and mobile network evolution [M1-M8]
This task will study the basis of FMC networks, defining a network reference scenario covering today's network status and analyzing the future evolution paths over time with a 2020 time horizon without an FMC approach, so that it can serve as basis for comparison with the FMC scenarios in WP3 such as node consolidation, NGPON2 and beyond, Wi-Fi cooperation and off-loading, C-RAN and intelligence to the mast approaches, etc. A qualitative assessment will be performed to analyse the "Pros and Cons" of each concept based on aspects like e.g. performance, interface requirements and application (for which application and area is this

concept relevant). The most likely concepts (time dependence, maturity, etc.), will be identified in a joint effort in order to establish one roadmap for fixed and one roadmap for mobile networks. Public available results from other European and national funded projects like OASE, ACCORDANCE, etc. will be integrated with respect to potential network evolution.
This task will be developed by all partners involved in this WP: DTAG will contribute to the network evolution and in the assessment of the evolution trends to create a roadmap, considering also the OASE results, FT will participate in the evolution trends regarding migration issues, central office consolidation and NGPON2, indoor coverage, offloading alternatives, network cooperation and control plane, TID will analyse NGPON2 architecture evolution, offloading alternatives, wireless solutions for FBB replacement, cloud RAN, new technologies for improved performance and multi-RAT heterogeneous networks, ALU-I will participate in radio back-hauling evolution towards optical solutions, central office, node consolidation issues and C-RAN evolution, EAB will participate in NGPON2, CRAN and heterogeneous dense urban area broadband solutions, ADVA-UK will contribute with the analysis of evolving fixed and mobile packet layers and synchronization issues, ADVA-DE will explore WDM-PON approaches and the evolution path of front-haul/back-haul, POLIMI will contribute with the possible strategies for node consolidation in the fixed segment, CTTC will study the evolution of wireless and access aggregation segments, traffic offloading technique, and the mobile backhaul in the context of fixed packet and optical network integration, ULUND will study the evolution towards hybrid fibre-copper solutions and DOCOMO will explore WDM-PON technologies for mobile backhaul.
Fed by: WP2 (T2.1)
Feeds: WP2 (T2.1, T2.3, T2.4), WP3-WP7 (All Tasks)
Task leader: TID
Contributing partners: DTAG, TID, FT, ALU-I, EAB, ADVA-UK, ADVA-DE, POLIMI, CTTC, ULUND and DOCOMO.

Task 2.3 FMC traffic modelling [M1-M11]
This task will analyze traffic scenarios for FMC networks from the current status with a 2020 time horizon, starting from the current traffic demands and forecast, analyzing which are the key drivers of traffic growth (such as user terminals and applications) and its impact. This task will study fixed and mobile traffic models and will analyze how traffic and its related parameters (volume, service mix and distribution, etc.) will evolve considering current real traffic in different FMC network scenarios.
DTAG and FT will contribute to the definition of traffic scenarios providing inputs in the 2020 time horizon based on traffic data coming from their own networks (both fixed and mobile); the analysis of these data and their past evolutions and forecast will allow to identify key trends in terms of service and usage evolution and correlation between fixed and mobile applications, and thus to define related offloading and convergence scenarios. CTTC will contribute in traffic modelling for FMC networks implementing offloading scenarios by means of WLAN or small cells; the main objective of this contribution is to study the impact that offloading techniques might have on the converged network, with a focus on modelling data and signalling traffic that arrives to the FMC network after applying offloading. This work includes estimations regarding performance limits of the network resources (including energy) consumption, which can be used when dimensioning the FMC network, and also assessing the benefits of offloading by comparing the required resources before and after deploying offloading for providing a given quality of services. POLIMI will focus on traffic models for FMC scenarios and their application to real traffic data sets provided by other partners. First, they survey the recent literature with the aim of identifying traffic models coupling simplicity, for ease of analysis and simulation, with good adherence to the empirical characteristics. Once real measurement data sets will be made available by partners (AITIA and others) involved in this task, the traffic models so identified will be applied to empirical data. Mathematical tools for traffic data analysis will include (not exclusively) the well-known Modified Allan Variance, for the estimation of network traffic long-range dependence and multi-scaling behaviour. Its unprecedented fineness and sensitivity, well appreciated since the '80s for frequency stability measurement, should allow an accurate verification of the actual fitting of traffic theoretical models to empirical data. Based on service delivery requirements and traffic models ULUND will study the growth and the demands on the network, with a 2020 perspective. With an increased usage of demanding services there will follow more demands on the network structures that the management system should cope with. These increasing demands need to be identified and modelled in terms of scenarios. DOCOMO will contribute to the traffic modelling for FMC networks based on the study of the mobile network evolution toward 2020; the main objective of this contribution is to study the impact of advanced mobile network features such as inter-site Coordinated Multipoint transmission and reception (CoMP) techniques on signalling and data traffic in the mobile backhaul network which composes the FMC network. AITIA will provide data on current traffic characteristics (especially its application mixture and distribution between endpoint-pairs) based on monitoring results at fixed and mobile core networks. The measurement points will be core and

backhaul connections with corresponding mobile and fixed traffic, hence allowing FMC-related analysis. The analysis results will include basic traffic statistics, and correlated statistics as well, in order to reveal trends of used applications and mobile platforms (equipment type, OS used), mobility during data transfer, and other features reflecting user-behaviour. Furthermore, suggestions for modelling schemes will be proposed in order to estimate probable traffic mix distributions.
Fed by: WP2 (T2.1, T2.2)
Feeds: WP2 (T2.4), WP3-WP7 (All Tasks)
Task leader: AITIA
Contributing partners: DTAG, FT, POLIMI, ULUND, CTTC, DOCOMO and AITIA.

Task 2.4 Requirements[M4-M35]
Task 2.4 will identify the requirements derived from the framework definition and FMC use cases identified in Task 2.1, the defined roadmaps in Task 2.2 and the traffic forecast in Task 2.3. The study will consider multi-layer requirements such as protection needs, availability, flexibility, synchronization, interfacing, backhaul, multi operator environment, etc. This task will also define the key performance indicators (KPI) to perform the technical assessment and comparison among FMC architectures and traffic monitoring alternatives; KPI such as bit rate, bandwidth, delay, delay variation, reach, QoS, etc will be considered.
An initial set of requirements and KPI will be provided (M7) as input for the other WPs. These requirements and KPI can be reviewed during the assessment and might be adapted in order to address latest developments and to ensure the most cost efficient design with regards to technical or economic reasons, for this reason a revision will be done during the second (M12) and third project year (M35).
The partners' expertise will support the identification of the requirements and KPI: DTAG (technical and economic assessment), FT (requirements definition including multi-operator environment and mobile back-hauling), TID (mobile synchronization, HetNet and CoMP issues), ALU-I (physical layer design and enabling technologies, radio back-hauling interface protocols and multi operator SLA for aggregation segments issues), EAB (KPI for handling different types of backhauling, e.g. CPRI, and their impact on advanced radio features, e.g. CoMP, for mobile broadband), ADVA-UK (KPI for synchronization and packet delay variation), ULUND (access-aggregation network issues including multi-operator environment), DOCOMO (mobile network aspects), AITIA (access-metro related KPI) and FON (KPI for mobile data offloading: delay, QoS, etc.).
Fed by: WP2 (T2.1, T2.2)
Feeds: WP3-WP7 (All Tasks)
Task leader: TID
Contributing partners: DTAG, TID, FT, ALU-I, EAB, ADVA-UK, ULUND, DOCOMO, AITIA, FON.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
2	DTAG	11.00
3	TID	14.00
4	FT	10.00
5	ALU-I	10.00
7	EAB	7.00
8	ADVA-UK	3.00
9	ULUND	6.00
10	CTTC	7.00
11	DOCOMO	7.00
12	POLIMI	9.00
14	AITIA	8.00
16	ADVA-DE	1.00
17	FON	5.00

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
	Total	98.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D2.1	Framework reference for fixed and mobile convergence	3	24.00	R	PU	9
D2.2	Roadmaps for independent fixed and mobile network evolution	3	24.00	R	PU	8
D2.3	Traffic modelling in FMC network scenarios	3	25.00	R	PU	11
D2.4	Requirements for converged fixed and mobile networks	3	25.00	R	PU	12
		Total	98.00			

Description of deliverables

D2.1) Framework reference for fixed and mobile convergence: Report on the framework reference, common reference areas and network user cases for FMC. [month 9]

D2.2) Roadmaps for independent fixed and mobile network evolution: Report on the evolution paths and trends of fixed and mobile networks and their roadmaps. [month 8]

D2.3) Traffic modelling in FMC network scenarios: Report on the expected network traffic evolution of FMC network scenarios. [month 11]

D2.4) Requirements for converged fixed and mobile networks: Review on (M24) and (M35). Requirements analysis regarding FMC networks and KPI definition for network assessment. [month 12]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS11	Initial report on FMC networks requirements	3	7	Initial report on FMC requirements according to the reference framework definition.
MS12	Final report on FMC networks requirements	3	12	Detailed report on FMC requirements based on the results of all WP2 previous tasks.

WT3:
Work package description

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per Work Package

Work package number [53]	WP3	Type of activity [54]	RTD
Work package title	Fixed Mobile Convergent Architectures		
Start month	1		
End month	35		
Lead beneficiary number [55]	4		

Objectives

This work package will propose, define and technically assess candidate architectures for future Fixed-Mobile Convergent (FMC) networks, both in terms of data plane and control plane.
WP3 will answer key questions on convergent networks: Which are the appropriate levels of convergence? Which network functions and equipment should be centralized or distributed? How will convergence impact handover mechanisms? How will convergence impact data plane, control plane or both? WP3 will take into account emerging needs such as network virtualization and programmability, increased openness of network interfaces. WP3 will technically assess each candidate architecture and translate it into an innovative but realistic network scenario, in function of requirements and KPIs defined in WP2. Based on these requirements and KPIs, WP3 will also compare (pros/cons analysis) the candidate architectures with each other and with the reference framework defined in WP2. This comparison will take into account different kinds of functions, equipment and infrastructures deployed in different parts of the network. In each case, the required amount of equipment will be dimensioned (i.e. minimized) for the considered traffic scenarios. This will lead to a qualitative and technical comparison between the different solutions in terms of complexity, scalability, compatibility with relevant network migration strategies…, but not to the determination of an absolute optimum. In other words, WP3 will propose the most appropriate architectures from an engineering and technical viewpoint, and this work will be the basis for quantitative cost and energy assessment performed in WP5.
More specifically, WP3 will be in strong relation with the other technical work packages: the network scenarios provided and technically assessed by WP3 will be also assessed in terms of traffic and performance management by WP4 and in terms of cost, energy and business models by WP5. Technical proposals from WP3 will also contribute to the choice of architectures to be demonstrated in WP6, and to the project proposals to be pushed in standardization bodies in WP7.
This work package is led by FT.

Description of work and role of partners

Task 3.1: Overall analysis and recommendations [M1-M35]

The first task of WP3 will prepare the overall work of the work package through a preliminary identification and analysis of network functions, equipment and infrastructures to be implemented in fixed/mobile convergence scenarios. Examples of network functions are: aggregation, routing, authentication and mobility management, access interface selection, synchronization distribution, multicast support (routing/proxying), content addressing/caching, service continuity, access to specific services. Examples of equipment and infrastructures are: cable plants, cabinets, central offices, points of presence, and all related transmission and networking equipment. This preliminary analysis will thus include all essential functionalities, equipment and infrastructures of fixed/mobile networks independently from their localization in current networks (e.g. mobility functions which are currently implemented in the Evolved Packet Core). This task will feed definition of convergence scenarios in tasks 3.2 (functional convergence) and 3.3 (structural convergence) as depicted in the overall COMBO concept (cf. 1.1.3). Task 3.1 will also technically assess and compare (with each other and with the reference framework of WP2) the architecture and network scenarios defined in T3.2 and T3.3. This pros/cons technical assessment of network scenarios according to WP2 requirements and KPIs will focus on architectural issues of FMC networks, e.g. cooperation issues between various access techniques (fixed wireline, WiFi, mobile macro, mobile femto) and more generally handover issues according to 3 dimensions (horizontal handover between cells, vertical handover between access techniques and transversal handover between different operators

and virtual operators). The ultimate objective is to technically assess the most appropriate degree of functional convergence and/or structural convergence enabling lowest complexityand costs compared to independent fixed / mobile network evolutions, thus targeting and defining the concept of Next Generation Point of Presence (NG-POP) as explained in 1.1.3. T3.1 will contribute to the choice of representative scenarios to be advertised and/or demonstrated in WP6, and will also contribute to the project proposals to be pushed in standardization bodies in WP7.

DTAG, TID, FT, EAB, ULUND and AITIA will contribute to the preliminary analysis of FMC network functions, equipment and infrastructures and to the technical assessment and comparison of FMC scenarios according to identified requirements and KPIs. ALU-I will analyse functions and equipment for node configurations and consolidation. IT-TB will analyse functions of both the non-converged and converged access/metro networks and identify benchmark scenarios and their application to WP2 use cases. DOCOMO will contribute to the preliminary analysis from mobile network perspective. BME will analyse architectural, strategic, business and protocol requirements for the proposed 3D handover.

Fed by:WP2, WP3 (T3.2, T3.3), WP6
Feeds: WP3 (T3.2, T3.3), WP6-WP7
Task leader: DTAG
Contributing partners: DTAG, TID, FT, ALU-I, IT-TB, EAB, ULUND, DOCOMO, BME, AITIA.

Task 3.2: Convergence of fixed / mobile network functions (functional convergence) [M7-M27]

This task will propose and define candidate architectures and scenarios for future networks allowing functional convergence, defined as the convergence of fixed and mobile network functions(at or below layer 3 (IP)). The task will in particular identify the network functions (including layer 3) to be provided if the convergence is provided below layer 3. Functional convergence will primarily impact the control plane of future networks through harmonized or even unified control mechanisms of fixed and mobile networks, but will also impact their data plane through an improvement of protocol stack and a better distribution of data flows in the converged network. Both data plane and control plane architectures will thus be addressed, with the specific target of unified control mechanisms for these fixed / mobile architectures and a better and possibly dynamic distribution of control functions. The related network scenarios will take into account emerging needs such as network virtualization and programmability and increased openness of network interfaces (e.g. through concepts such as OpenFlow that can allow a common simplified control and management of packet and circuit flows and allow network APIs for future NaaS solutions). The proposed network architectures will be technically analysed so as to assess the most appropriate degree of functional convergence enabling lowest complexity and costs compared to independent fixed / mobile network evolutions. This will include identification of the best distribution of network functions, one extreme being centralization in a national POP (point-of-presence), another being distribution in access nodes at local POP level. Special attention will be brought to the issues related to separation of control plane and data plane in future convergent networks, and to the issues related to control of heterogeneous networks and technologies (e.g. in multi-operator environment) by service providers. Proposed architectures will also target convergence and homogenization at functional level of authentication, subscriber management, and content functionalities.

JCP will analyze CDN performances and evolution to CCN concepts in the framework of hybrid fibre wireless, and analyze multi-operator / multi ISP/ASP context and the related impact on layer 2 and control plane.
DTAG, TID and FT will work on functional distribution and analyse which functions can be merged in which architectures, and assess the corresponding architectures according to KPIs. FT will also work on a unified approach to service-specific control functionalities, based on logical networks. ALU-I will provide inputs related to inter operator service level agreements (SLA) and related impacts on control plane and service / business plane, and identify possible network scenarios with virtualisation of aggregation segment. IT-TB will study encapsulation and control plane issues, including MAC definition and handling of service level features (e.g. mobility). It will also optimise the mechanisms ensuring vertical and horizontal handovers. ADVA-UK will develop functional convergence in Ethernet, MPLS and IP layers as appropriate, and address related SLA and service monitoring issues. CTTC will focus on the definition of a unified control plane (GMPLS/PCE architectures) for the integration of packet and optical technologies in meshed, dynamic and flexible FMC networks. AITIA will perform complex load tests towards SGSN and GGSN with various kinds of traffic mix and inspect the conflicting control mechanisms of Ethernet, GMPLS, IP and higher layers and their combined effect in network efficiency.FON will propose and define different types of integrations at different protocol layers between mobile and fixed networks

and operators, based on previous experiences with heterogeneous players (mobile only, fixed only, combined mobile and fixed...).

Fed by: WP2, WP3 (T3.1), WP4-WP5
Feeds: WP3 (T3.1), WP4-WP5, WP7
Task leader: IT-TB
Contributing partners: JCP, DTAG, TID, FT, ALU-I, IT-TB, ADVA-UK, CTTC, AITIA, FON.

Task 3.3: Convergence of fixed / mobile equipment and infrastructures (structural convergence) [M7-M27]

This task will propose and define candidate architectures and scenarios for future networks allowing structural convergence, defined as the mutualization and integration of fixed and mobile equipment and infrastructures (e.g. cable plants, cabinets, central offices, points of presence and all related equipment). This task will in particular include central office consolidation scenarios mixed with BBU hotelling techniques as an intermediate step, and will ultimately target joint fixed/mobile equipment and infrastructures for access and aggregation networks. The work will be related to the evolutions, on the one hand, of the network technologies supported within the various network segments (e.g. fixed access, metropolitan/regional, wireless access, mobile backhaul, mobile backbone) and, on the other hand, of functional blocks implementation within the various equipment in the network segments. Structural convergence will drastically decrease complexity, cost and energy consumption, thus improving the return on investment of access/aggregation infrastructures and fostering large scale deployments of very high fixed and mobile broadband in Europe. The proposed network engineering scenarios will also be technically analysed so as to assess the most appropriate degree of structural convergence enabling lowest complexity, costs and energy consumption compared to separate fixed and mobile infrastructures and equipment. Attention will be paid to identifying equipment and infrastructure issues related to heterogeneous networking (e.g. multi-operator environment) within the access / aggregation framework, and assessing the impact of these issues on the proposed architectures.

DTAG and FT will analyse the potentialities and limitations (technical, regulation, etc.) of convergent architectures based on infrastructure and equipment integration and node consolidation, with application case to BBU hotelling with resource pooling. A proposal of BBU hotelling application over a convergent NG-PON2 system will be made. TID will analyse access and metro consolidation scenarios and will study the benefits and issues associated with a distributed control multi RAT network that supports different mobile standards and Wi-Fi. ALU-I and EAB will propose network scenarios for node consolidation and centralized BBU hotelling. EAB will also study convergence level and common usage and optimization of resources. IT-TB will study aggregation architectures benefitting from optical transparency (e.g. optical packet/burst switching of flexible WDM), encapsulation and control plane issues of equipment mutualization, and assess the impact of the selected architecture on the traffic flows within the access/metro network. ADVA-UK will propose system-level architecture covering mobile and fixed line, and explore the provision of synchronisation and content services at the central office. ULUND will contribute and analyse architectural solutions for node consolidation and centralized solutions. This will include optimization of resources for backhauling and access scenarios on data plane. CTTC will study within the aggregation segment optimised network infrastructures leveraging the advantages of integrating both packet (e.g., MPLS and MPLS-TP) and optical (i.e., WSON) transport technologies. POLIMI will evaluate how separate access/aggregation infrastructures can evolve in the envisioned FMC architecture enabling resource sharing of deployed equipment and supporting all service types. TELNET will analyse the technical and cost viability of infrastructures and equipment and participate in the decision of FMC architectures. ADVA-DE will propose metro and access optical network architecture including architectural concepts for remote BBU/RFU.

Fed by: WP2, WP3 (T3.1), WP4-WP5
Feeds: WP3 (T3.1), WP4-WP5, WP7
Task leader: EAB
Contributing partners: DTAG, TID, FT, ALU-I, IT-TB, EAB, ADVA-UK, ULUND, CTTC, POLIMI, TELNET, ADVA-DE.

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JCP	12.00
2	DTAG	32.00
3	TID	16.00
4	FT	46.00
5	ALU-I	13.00
6	IT-TB	19.20
7	EAB	27.00
8	ADVA-UK	6.00
9	ULUND	5.00
10	CTTC	11.00
11	DOCOMO	8.00
12	POLIMI	4.00
13	BME	3.00
14	AITIA	9.00
15	TELNET	10.00
16	ADVA-DE	3.00
17	FON	9.00
	Total	233.20

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D3.1	Analysis of key functions, equipment and infrastructures of FMC networks	4	58.00	R	PU	10
D3.2	Assessment of network scenarios based on functional convergence	4	58.00	R	PU	22
D3.3	Assessment of network scenarios based on structural convergence	4	58.00	R	PU	22
D3.4	Final architectural recommendations for FMC networks	4	59.20	R	PU	35
		Total	233.20			

Description of deliverables

D3.1) Analysis of key functions, equipment and infrastructures of FMC networks: Report on detailed analysis of key functions, equipment and infrastructures to be implemented in fixed / mobile convergence scenarios. [month 10]

D3.2) Assessment of network scenarios based on functional convergence: Report on technical assessment of FMC scenarios based on functional convergence, i.e. convergence of fixed and mobile network functions. [month 22]

D3.3) Assessment of network scenarios based on structural convergence: Report on technical assessment of FMC scenarios based on structural convergence, i.e. mutualization and integration of equipment and infrastructures. [month 22]

D3.4) Final architectural recommendations for FMC networks: Final report on technical assessment and comparison of FMC scenarios with each other and with the reference framework of WP2. [month 35]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS13	Identification of key functions, equipment and infrastructures of FMC networks	4	6	Identification of key functions, equipment and infrastructures to be implemented in fixed / mobile network convergence scenarios.
MS14	Definition of candidate architectures for functional convergence	4	12	Definition of candidate architectures and scenarios for future networks allowing fixed/mobile functional convergence, i.e. convergence of fixed and mobile network functions.
MS15	Definition of candidate architectures for structural convergence	4	12	Definition of candidate architectures and scenarios for future networks allowing fixed / mobile structural convergence, i.e. mutualization and integration of equipment and infrastructures.
MS16	Intermediate analysis of FMC scenarios	4	27	Intermediate technical assessment and comparison of FMC scenarios with each other and with the reference framework of WP2.

WT3:
Work package description

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per Work Package

Work package number [53]	WP4	Type of activity [54]	RTD
Work package title	Traffic and Performance Management		
Start month	1		
End month	36		
Lead beneficiary number [55]	7		

Objectives

The FMC network should be very flexible and able to cope with demands from services of various kinds. The network management therefore has to be able to optimise the traffic according to a number of criteria. In some cases it can be that the network should be optimised for capacity and coverage, while other traffic streams should be optimised for quality parameters. Simultaneously, there will be demands on achieving low energy consumption, which might lead to tradeoffs with other optimization criteria. In addition the network will function in a traffic situation with performance requirements from both customers and service providers where specific services might put specific requirements on the traffic streams. To manage such a network it must be better understood how different measureable QoS parameters reflect the optimization criteria, like capacity, quality and/or energy consumption. The objective of this work package is to gather this information and develop a system for optimization on a selected subset of parameters and tools.
Key components of this work package include the performance monitoring tools that are needed in order to underpin service delivery prior to live deployment and once operational for monitoring against a Service Level Agreement (SLA), and traffic/performance management tools that allow the service to be tuned based on the results of initial performance monitoring.
This WP is led by EAB.

Description of work and role of partners

Task 4.1 Performance monitoring [M1-M18]

The purpose of task 4.1 is to define parameters and technologies for performance monitoring of mobile backhaul and fixed access networks. This includes physical layer monitoring (fibre, copper and microwave) as well as layer 2 and 3 monitoring. The task will be divided into two surveys where one will describe parameters and methods for passive monitoring while the other will describe tools for active monitoring techniques. The usability of all tools and parameters in different network topologies should also be discussed, as well as issues with multi-vendor, multi-operator and multi-service providers should be considered. All pros and cons of the methods should be discussed as well as scalability issues and performance/cost trade-offs. Also, service delivery is a growing market that in a near future will put service assurance requirements on the networks. To be able to meet those requirements it is important to understand what requirements the QoE from different applications mean on lower layers, in terms of QoS and KPI parameters.
The considered performance monitoring techniques should be significant for:

- Capacity estimation
- QoS (including delay and jitter (delay variations))
- Energy consumption
- Synchronization

Therefore, the performance monitoring developed in this task should include all KPIs described in T2.4 and it should also consider the implications for the different use cases defined in T2.1. The task should also describe how the passive and active monitoring techniques could be used for fault detection and fault localization.

The target of task 4.1 is to provide a report describing a performance monitoring solution to secure QoS and minimize the OPEX costs of converged fixed mobile networks. To define an efficient performance monitoring system it is important to have tools and monitoring points on different network layers, including layer one of each

access technology, and understand how these relates to each other. The output of this task is a description of monitoring points and tools and their relation to KPIs and QoS. The tasks starts with a survey of existing techniques since some can be reused, but new tools for e.g. fault localization will also be defined and included in the report. The output of WP4 is specified in more detail in the bullet list below:

• Survey of existing passive probing techniques (parameters and monitoring points)
• Survey of existing active probing techniques
• Study of the relationship between tools and parameters (both new and existing), KPIs and QoS (also crosslayer)
• Conclude all relevant techniques in one proposed monitoring solution to secure QoS and minimized OPEX of converged fixed mobile networks. The solutions should among other things consider:
o Scalability issues
o Synchronization monitoring
o Energy consumption monitoring
• Development of missing performance monitoring techniques, including fault localization, that is needed to fulfill the overall COMBO requirements

TID will study optical level performance monitoring. TID will also focus on fibre network monitoring issues on higher level layers and study existing alternatives to network monitoring, pros & cons, requirements, system architectures, performance vs. cost and new solutions to reduce OPEX in fixed networks. ADVA-UK will study monitoring concepts and tools and look into the impact on scalability and complexity as customer numbers scale. They will also contribute to the development of synchronization SLA monitoring concepts. DTAG will study monitoring concepts for converged fixed mobile networks with particular emphasize on required information from mobile networks and information exchange between mobile and fixed networks for performance improvement. EAB and ULUND will study passive and active techniques for performance monitoring of heterogeneous backhaul networks including the physical layer of the link technologies (fibre and copper). EAB will also develop fault localization methods. The study of QoE parameters and their connection to QoS and KPI parameters will be performed by ADVA-UK, ULUND and AITIA. ULUND will also study energy consumption monitoring for the considered equipment.

Fed by: WP2 (T.2.1, T2.3, T2.4), WP3 (T.3.2, T3.3)
Feeds: WP4 (T4.2, T4.3)
Task leader: ADVA-UK
Contributing partners: TID, EAB, ADVA-UK, ULUND, AITIA, DTAG

Task 4.2 Performance management [M7-M30]

In task 4.2 network management and traffic optimization techniques should be developed. The optimization should be based on different criteria such as capacity, QoS, service availability, service assurance, energy consumption and network sharing (fairness between operators and services). Examples of these are load adaptive energy aware traffic routing and efficient resilience (protection and restoration) schemes. Furthermore the requirements for different types of services should be incorporated in the optimization procedures. Both the behaviour of prioritized services such as IPTV and services delivered over best-effort channels, such as Over-The-Top (OTT) services needs to be considered. This is especially important since voice transport over LTE is currently not supported, instead OTT services like Skype are required, or a method of falling back to 3G services which requires two types of networks. It is also crucial to understand which network management tools can be used to secure that these requirements are met. The management tools should also consider handling different classes of users (according to their services and demands of QoS) and multiclass bandwidth sharing models will be investigated and developed to handle this.

On a physical level the management solutions should work with FMC networks. This includes managing transparency of transportation media, e.g. fibre, copper or radio. On higher levels the traffic load and characterisation is of high importance. To fully exploit FMC performance management the solutions should utilize RAN – transport network interaction. Task 4.2 should therefore develop use cases that describe where this is relevant and then based on these use cases develop concepts for enhancing QoE, transmission and network management for various link layers from part of the “RBS features” ecosystem.

The solutions for the management system should be able to optimise on one single criterion as well as to handle scenarios where several different criteria are considered simultaneously. Additionally the methods should

consider multi-vendor and multi-operator capabilities. An example of this is the knowledge plane concept that is a method to exploit information gathered from both the edges and the core, and make optimal decisions even in a multi-operator environment.
The techniques developed in task 4.2 should utilize the performance monitoring features in T4.1 and should also be able to cope with the service requirements in T4.3.

The documentationof this task is split in four parts, partially relying on each other:
• M4.2 Use cases for RAN-transport interaction will contain descriptions of a set of use cases where RAN-transport interaction is an attractive technology for the management system.
• M4.3 Overview of performance optimization for FMC networks. A first survey of the optimization criteria and techniques suitable for an FMC network. A specification of the tools and simulation packages used in the evaluation is also given.
• D4.3 Performance optimization concepts based on multi-operator, multi-vendor scenarios. A report on the criteria and optimization methods suitable for use cases involving multi-operators and/or multi vendors.
• D4.4 Performance optimization concepts. The final report from the task. It will include a complete survey of the relevant use cases and optimization methods. Also cases where one or several criteriaare considered at the optimization will be included.

In this task the use cases, criteria and optimization methods for the FMC network will be developed and reported. The process will contain tools for simulations and testing, containing the chain from monitoring of the considered parameters from T4.1, and include thespecified use cases. This will include optimization for specific criterion as well as combinations of criteria. The work process will then continue in the subsequent task, T4.3, where the main testing and evaluation will be performed.The developed tools and simulation packages will be specified in milestone M4.3.A subset of these methods and tools will be tested and implemented in task T4.3, and further on in the test-bed developed in WP6.

Different management techniques, like traffic and path optimization, capacity planning, hand over management and self-organizing scenarios, will be studied by EAB, ADVA-UK, IT-TB, CTTC, FON and ULUND. Topics related to RAN-transport interaction, covering for example load balancing in RAN, will be covered by EAB, CTTC and BME. Furthermore, problems related to network resilience will be treated by ADVA-UK, DTAG and BME. How multi-operator capabilities and the impact of fairness can be treated in FMC networks will be covered by POLIMI, BME and ADVA-UK. Topics related to energy efficient resource managements, like load adaptive energy aware routing, is studied by POLIMI, ULUND, ADVA-UK, IT-TB and BME. IT-TB will contribute by checking which management tools are efficient for different SLAs and BME will develop multiclass bandwidth sharing models to be used in the tools. ADVA-UK will investigate operator drivers and tools to enable monetization of OTT services. AITIA will investigate the application possibilities for the knowledge plane concept for FMC and suggest a possible framework for integration.

Fed by: WP2 (T2.1, T2.3, T2.4), WP3(T3.2, T3.3), WP4 (T4.1, T4.3)
Feeds: WP4 (T4.1, T4.3), WP5(T5.1, T5.2, T5.4), WP6(T6.2)
Task leader: ULUND
Contributing partners: EAB, ADVA-UK, POLIMI, IT-TB, CTTC, ULUND, BME, AITIA, FON

Task 4.3 Use case evaluation [M19-M36]

The Performance management solutions from T4.1 and T4.2 should be evaluated against the use cases from WP2. The evaluation should also consider the architectures developed in WP3.
The evaluation will be based on a direct evaluation of the considered algorithms as well as simulations. When considering simultaneous optimization of several criterions, simulations will be useful. Parts of the evaluations should also be performed in the test-bed developed in WP 6. Since both the performance management tools and the use cases and architectures they will be evaluated against will be developed during the project this task will be specified more in detail when there is a clear view of how these solutions will evolve.

IT-TB, and ULUND will participate in evaluating the performance management solutions against WP2 use cases and WP3 architectures. CTTC will specifically evaluate the traffic offloading, the RRM enablers and the meshed backhaul deployment. They will also make an experimental evaluation to assess the dynamic fixed packet and optical transport infrastructures for mobile backhaul. BME will apply selected methods for 3D handover proposed in Task 4.2 to selected cases defined in WP2, and will also carry out availability analysis of the proposed FMC architectures on the chosen case studies (reference areas). POLIMI will evaluate the traffic optimization

strategies in FMC architectures with an optical backend supporting a wireless front-end. AITIA will look at power management and study power measurements and optimization concepts.

Fed by: WP2 (T.2.1, T2.3, T2.4), WP3(T3.2, T3.3), WP4 (T4.1, T.4.2, T.4.3), WP6 (T6.2, T6.3)
Feeds: WP6(T6.2, T6.3)
Task leader: CTTC
Contributing partners: POLIMI, IT-TB, CTTC, ULUND, BME, AITIA

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
2	DTAG	4.00
3	TID	4.00
6	IT-TB	23.30
7	EAB	17.00
8	ADVA-UK	6.00
9	ULUND	35.00
10	CTTC	24.00
12	POLIMI	11.00
13	BME	9.00
14	AITIA	23.00
17	FON	6.00
	Total	162.30

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D4.1	Monitoring parameters relation to QoS/QoE and KPIs	7	33.00	R	PU	12
D4.2	Performance monitoring for FMC networks	7	33.00	R	PU	18
D4.3	Performance optimization concepts based on multi-operator, multi-vendor scenarios	7	33.00	R	PU	24
D4.4	Performance optimization concepts	7	33.00	R	PU	30
D4.5	Evaluation of performance management concepts	7	30.30	R	PU	36
		Total	162.30			

Description of deliverables

D4.1) Monitoring parameters relation to QoS/QoE and KPIs: Report describing the relations between monitoring parameters, QoS/QoE and KPIs. [month 12]

D4.2) Performance monitoring for FMC networks: Report describing performance monitoring solutions for FMC networks. [month 18]

D4.3) Performance optimization concepts based on multi-operator, multi-vendor scenarios: Report on performance optimization for multi-operator, multi-vendor scenarios. [month 24]

D4.4) Performance optimization concepts: Final report on performance optimization concepts for FMC networks. [month 30]

D4.5) Evaluation of performance management concepts: Report describing the evaluation of the performance management concepts. [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS17	Survey of monitoring parameters and methods	7	6	Report on passive and active monitoring parameters and methods on different network levels.
MS18	Use cases for RAN-transport interaction	7	12	Report describing use cases for when RAN-transport interaction can be used for performance management.
MS19	Overview of performance optimization for FMC networks	7	18	Initial report on performance optimization for FMC networks.
MS20	Structures for evaluations of monitoring and managements concepts	7	24	Report describing how the monitoring and management concepts will be evaluated.

WT3:
Work package description

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per Work Package

Work package number [53]	WP5	Type of activity [54]	RTD
Work package title	Techno-Economic Assessment		
Start month	1		
End month	36		
Lead beneficiary number [55]	13		

Objectives

The convergence of fixed and mobile networks is expected to reduce costs, and improve service quality due to sharing and joint optimization of network resources and architectures. Techno-economic assessment, including cost estimation, energy efficiency analysis and optimization of the proposed FMC architectures has therefore key importance in determining the optimal level of convergence, i.e. the fundamental question of the project.
This work package complements WP3 and WP4 by evaluating and validating the proposed FMC architectures, considering cost and energy efficiency, and also other aspects formulated by other work packages as evaluation criteria.
Assessment of proposed, future network architectures is not straightforward: the best practices for network rollout are still unexplored and statistical data for expenses does not exist. Therefore an assessment framework has to be defined. The optimal layout of the new, converged network is necessary for accurate techno-economic calculations; therefore FMC network design and planning methods will be developed and integrated in the assessment framework. The assessment shall clarify the impact of different convergence levels, highlight the differences between various FMC architectures, and identify the best suitable architecture for the selected scenarios. Therefore a thorough economic evaluation will be carried out on selected, representative real-world reference areas, considering their geographic, social and economic characteristics, providing insights and feedbacks on the proposed architectures and network scenarios.
Additionally the WP will analyze the current business situation and examine the evolution of business models linked with FMC, taking into account the results of WP2, WP3, and cost analysis work of WP5, more particularly the evolving roles of existing actors, apparition of new actors, and value network building, defining relations between the stakeholders.
Energy consumption adds another important aspect of evaluation: sustainable FMC architectures require shared resources and joint optimization of fixed and mobile infrastructures, which is in itself an important driving force towards FMC architectures.
This work package is led by BME.

Description of work and role of partners

Task 5.1 Assessment Framework [M1-M36]
The framework for assessment and optimization of FMC architectures will be defined within Task 5.1, considering cost and energy efficiency, including network planning processes for various network scenarios, and the ways and interfaces for collecting data describing the reference areas. In task 5.1 novel cost- and energy efficiency assessment tools will be developed, specifically targeted for techno-economic analysis and also optimization for deployment of FMC architectures.
The objective of the tools reflects the specific expertise within the consortium: i) a map-based detailed deployment tool which takes into account the actual geographic characteristics of the reference area (e.g., buildings and roads patterns in a real urban context). The network planning & analysis framework will allow operators to perform a reality check on the feasibility in terms of capital expenditures (cost of equipment, metro offices, cable digging) and operational expenditures (maintenance cost, energy consumption) of an FMC architecture in case of an actual deployment in an urban context.; ii) a more flexible assessment tool with wider range of applicability and less geographical: the objective in this case is to provide operators and vendors with an agile tool that on generic scenarios (generically identified by number of users, capacity per users, extension of the areas to be covered) can be used to contrast different technological options: e.g., different

optical transmission technologies for FMC traffic backhauling (colored, colorless or tunable transceivers), different topologies (ring vs. tree), or different branching equipment (AWG vs. splitters), etc.
The level of detail in the description of network equipment will be very different and the questions to be addressed are different (the first simulator will answer the question: “how costly and feasible is a specific architecture on a specific geographical urban area?”, the second simulator will answer the question “which transmission technology/topology better fits an FMC architecture targeted to comply certain generic requirements in terms of coverage, capacity and number of users?”).
As a final note, the activities of tool development, as performed by the various partners are not independent and uncorrelated, but they can benefit, and sometimes require, a continuous dialogue and fine-tuning of the assumptions and models used in the different tools in order to have a consensus on an uniform approach. These tools will be then used throughout the project for techno-economic assessment, reliability and technical analyses, i.e. overall analysis of FMC architectures (T3.1), use case evaluation (T4.3), economic and energy efficiency analysis (T5.2 & T5.4) , and business modeling (T5.3)

The academic partners are heavily involved in the development of the above described tools. Activity of POLIMI will be mostly devoted to the tool modeling and conceptual preparation (how to build it, which structures to use, etc..),the acquisition of the requirements coming from WP3, the identification of optimization procedures for traffic aggregation/distribution, and the coding itself. BME is working on the development of the map-based deployment optimization and assessment tool, which requires various problems to be solved, e.g. processing geospatial information and digital maps, integration of various data sources describing the reference areas, optimization and network planning methods for various fixed and mobile networks, and also analysis and reporting capabilities that support the validation and evaluation activity.
DTAG, TID and FT will contribute to network and the architecture modeling though their operators’ and business perspective, in particular their experience in fixed and mobile network planning and related deployment scenarios. They are participating in this task to assure that the tools developed during this task contain all the operator concepts, aspects and possible parameters and that the design of the application is according to what is expected for an operator point of view, so the final cost analysis can be as real and useful as possible focusing in the benefits of FMC architectures.

Fed by: WP2 (T2.1, T2.3, T2.4), WP3 (T3.1, T3.2, T3.3), WP4 (T4.2)
Feeds: WP3 (T3.1), WP4 (T4.3), WP5 (T5.2, T5.3, T5.4)
Task leader: BME
Contributors: DTAG, TID, FT, POLIMI, BME

Task 5.2 Cost analysis [M7-M36]
A thorough cost analysis of the proposed FMC architectures will be carried out, using the reference areas defined within WP2 (Task 2.1), and the assessment tools developed in Task 5.1. The cost models are derived from the proposed FMC architectures. Cost evaluation of various case studies supports a comparative analysis of FMC architecture proposals, in order to find the optimal level of convergence regarding cost (including CAPEX, OPEX and Business Case Calculations). Publicly available geographic and demographic data of the selected reference areas will be used (e.g. OpenStreetMap), coupled with statistical cost and marketing data from network operator partners, in order to achieve reliable and accurate results.
The economic assessment provides feedback for WP3 and WP4, validates the proposed FMC architectures demonstrating the cost reduction possibilities, and also helps architecture development work by providing insights of the main cost factors. WP3 does no cost analysis. WP5 will provide feedback to WP3 regarding cost points in order to find the lowest cost option.
The inter-relation between tasks 3.2, and especially 3.3 with 5.2 reflects the objectives and scopes of the corresponding workpackages 3 and 5. While task 3.2 and 3.3 are devoted to the definition, technical analysis and qualitative assessment of the functions and structures of the FMC architecture, tasks 5.2 will perform a quantitative cost analysis, using the tools developed in task 5.1 and receiving as input the FMC solutions devised in Tasks 3.2 and 3.3. We expect this relation to be iterative and interactive: tasks 3.2and 3.3 may in fact devise initial solutions which will be extremely performing at a technological level, which might then result highly expensive after a proper cost analysis.

Network operator partners (DTAG, FT, TID and FON) are involved in the cost analysis activity, due to their experience with existing network architectures. They will be involved into the cost assessment, the comparative analysis and benefits identification, so we expect to provide a clear view regarding FMC benefits based on real qualitative and quantitative results. FON already has experience on building complete cost models and related

business case calculations for real mobile offloading scenarios. This experience can contribute on building the cost models required for the different proposed FMC architectures.
POLIMI will input the possible architectures coming from WP3, testing different possible technologies and topologies as enabled by the assessment tool developed in Task 5.1. Feedbacks from vendors (ALU-I, ADVA) will be used when technologies to be modeled are not on-the-shelf options and educated guesses and estimations will be needed. A library of components and systems identified in WP3 will be modeled and introduced in the tool.
BME focuses on the map-based cost analysis of the selected reference areas and network architectures, which requires extensive preparation of the scenarios: geospatial data has to be processed, cost models and the actual cost values to be filled, and also the network design rules have to be defined. On all these key aspects, the vendor and network operator partners will have a very important contribution. The validation and evaluation process have to be iterated with WP3, considering their aspects and criteria.

Fed by: WP2 (T2.1), WP3 (T3.2, T3.3), WP4 (T4.2), WP5 (T5.1)
Feeds: WP3 (T3.1, T3.2, T3.3), WP4 (T4.2), WP5 (T5.3)
Task leader: POLIMI
Contributors: DTAG, TID, FT, POLIMI, BME, FON

Task 5.3 Impact of convergence on business ecosystems [M7-M12, M25-M34]
This task will focus on the impact of convergence, principally by answering the questions: “is there any significant difference between business ecosystems for FMC networks and separate fixed/mobile networks?”, “how to improve the existing business model by leveraging the changes in the eco¬system?”, and “which could be the different paths in order to implement the changes?”

Phase 1 [M7-M12]
The existing business models for both types of access networks (converged and separate fixed-mobile networks) will be analyzed separately, in order to determine their current elements and components and the way they correlate to each other; once the business model is identified, the current ecosystems shall be analyzed as well, with the objective of identifying the existing stakeholders, their roles and value stream flows between them. Tools and methods to use and follow for phases 1 and 2 will be selected, with in mind to use existing available tools, either coming from other R&D projects or available on a commercial basis, without significant adaptation (CMAP, Stategylet, Mactor-tool). About the methods, MACTOR/MASAM and Strategic Service Vision are foreseen as possible methods and could be used concurrently.
In this first phase, T5.3 will interact with task 2.1 and task 2.4 and receive information from M2.1 on requirements.

Methodology:
• CAPEX/OPEX cost drivers used to build the business models: quantitative analysis of the figures obtained from the CAPEX/OPEX data will be used to construct the current business models.
• Case studies for access networks: information using surveys and interviews.
• Comparison between separate and converged fixed-mobile networks: assessed through workshops organized with specific partners at each of the phases.
• Ecosystem scenarios interpreted from the case studies provided: identification of actors, roles and value networks will be performed upon the data provided by the network operators.

Phase 2 [M25-M34]
During this phase, the evolved ecosystems based on the information obtained from phase 1, WP3/4 results, and T5.1 and T5.2 information, shall be built, and new entrants like FVNOs, MVNOs, community operators, municipality operators, OTT, cloud providers, social networks will be incorporated and segmented into relevant categories like infrastructure providers, network operators, ISP, IaaS, PaaS, SaaS providers, ...). The possible business models of the converged fixed-mobile networks will be designed in order to leverage the existing business models through the changes provided by the projected evolution of the ecosystem and the business model.

Methodology:
• Interpretation of the future architectures in order to obtain the potential actors and their roles: candidate architectures determined by WP3/WP5 will be used to identify potential actors and roles.

• Market analysis in order to project the evolution of the business model: the identification of market demands and revenue scenarios will be made based on the market studies developed by the Operators internally (i.e. by the entities incorporated within their group) and the market description obtained from task 2.1.
• User scenarios in order to map the evolution of the ecosystem obtained from the information produced in WP2 and WP3: new possible entrants, equipment vendors, end users and value networks will be defined.
• Interviews and case studies: operators shall take advantage of the regular meetings held with its partners to obtain the relevant information.
• Relation within the possible business model and the new technology ecosystem: the relationships between the possible business models and the new technology ecosystem arising from the interpretation of the data will be mapped and described using the tools and methods selected in phase 1.

JCP will be the leading executing partner, with participation of FON, TID, and DTAG. Main sources of information about CAPEX/OPEX, market studies and business models/value networks feedback will come from operators of the COMBO consortium (DTAG, TID, FON, FT) and their partners / subsidiaries. The details on each partner's involvement is provided below:
TID will be involved with the business models analysis considering those countries in which it has both FTTx and 2G/3G mobile subscribers, specifically Spain and Brazil or Chile. TID will compare and assess how the evolved FMC business models can fit in the evolution of Telefónica business units; this means taking the adequate provisions in order to be able to eventually take decisions to implement such business models.

Fon will get the information from its business partners (i.e. fixed and mobile operators which Fon holds a business relation with) and current business propositions. Currently, Fon has several business models applied across the different partners: for instance, Fon acting as an offloading network for pure mobile operators; Fon providing and operating a community WiFi on top of integrated operators (i.e. fixed and mobile operator) providing offloading capabilities and value added services for end customers, etc. These different propositions show different business models which are currently in place. FON will take advantage of current and future partners' relationship in Europe, Asia and America to collect feedback about the current business models and the potential ones on future architectures. Among the bundle of partners, Fon will choose those that have the different and significant business models and propositions.

CAPEX/OPEX cost drivers provided by DTAG will focus on the German access and aggregation network, fixed and partly mobile lines. DTAG will gather information onand CAPEX / OPEX costs and market studies from their internal business units and subsidiaries in a series of workshops and interviews. DTAG will provide feedback on the business models as well.

JCP-Consult (with FON and TID) will define the actors and the roles played by each one of them (i.e. network owner, network operator, service provider) within the business environment in the FMC networks based mainly on the information and data gathered by the operators.

Afterwards possible technological and business ecosystems for candidate architectures will be built based on the data provided by the Operators and their partners; JCP-Consult will take advantage of its experience within the telecom field to be able to interpret and project potential business structures and scenarios that could take place in converged networks.
The overall study will be oriented to current approaches that aim at converging fixed and mobile networks in the near future.

Fed by: WP2 (T2.1, T2.4), WP3, WP5 (T5.1, T5.2)
Feeds: WP3
Task leader: JCP
Contributors: JCP, DTAG, TID, FON

Task 5.4 Analysis of energy consumption [M7-M36]

Task 5.4 features two main focuses: (1) the quantitative study/assessment of the energy consumption of the architectures defined in WP3, which complements the cost analysis in task 5.2; and (2) the investigation of possible mechanisms (from a functional point of view) and strategies (from a network design point of view) to decrease the energy consumption in FMC network with the specific aim to verify if the specificity of a FMC architecture can bring to the table new options for energy minimization (multi-operator cooperation, efficiency of CRAN architectures and 3-D handover, etc.). The analysis results will support recommendations for improved energy-awareness of FMC networks.

Task 5.4 is intended to do more than just the analysis of “energy savings”, i.e. provide and develop the tools that can enable understanding how the architectural and functional choices for the convergent FMC network map onto energy consumption figures. At a high level we can envision at least three main novel dimensions in terms of energy efficiency which are specific of a fixed-mobile convergent scenario:

• 3D handover: where the active end users can be handed over not only between cells of the same operator using a single networking technology, but also between different fixed and mobile technologies, as well as between different operators.
• BBU Hotelling/remotization: COMBO will analyze the effects of moving intelligence / functionality from base stations into the gateway node or Next Generation POP, at the same time as a massive increase in small cells takes place and coordination between small cells and macrocells is coming online; adding to that WiFi offloading, it results a mix of convergence going on in parallel – all of which are factors in energy consumption.
• Distribution of content replicas in metro/core area: An efficient support of video traffic based on optimizing the location and operation of video servers, closer to end-users in a distributed manner.
These three scenarios will require different evaluation approaches: e.g., the optimization of a multioperator scenario with competitive collaboration can be effectively tackled with using the mathematical approaches of the game theory, while more classical optimization approaches (integer linear programming and/or heuristics) might be used for the BBU hotelling scenario. The assessment tools developed in Task 5.1 will also be extended to cover energy consumption analysis and optimization issues.

Different partners, by bringing in their specific network expertise, will look at diverse mechanisms that can enable energy efficiency. Moreover, as for the cost analysis, energy consumption analysis will require collection of detailed data or estimations of the energy consumption of the basic elements of future FMC architectures. As for the cost models, the actual energy consumption values have to be filled, which is far not straightforward as we are addressing novel network architectures, not off the shelf technologies; and also the impacts of energy-saving mechanisms on network design rules have to be quantitatively assessed.

In summary, the main outcome of these activities is a comprehensive set of guidelines for energy efficient design and operation of FMC networks, i.e. an in-depth understanding of the power-consumption drivers and mechanisms to increase energy efficiency in the context of next-generation access and mobile backhaul / aggregation networks.

POLIMI and BME are the leading partners within this task, considering the analysis, assessment and optimization activity. ADVA and CTTC is adding industrial aspects from a technology point of view, while the DTAG, FT and FON bring the operator perspective in the task.

POLIMI in addition of its task leader role, will i) assess how much energy can be saved through cooperation in a multioperator environment considering both the case of operator offering the same access (e.g., LTE) or different access (e.g., LTE and Wi-Fi); ii) investigate the energy optimization due to BBU resource pooling and decreased number of metro offices/equipment; iii) explore energy efficiency of different transmission technologies for fixed-mobile traffic backhauling in a metro access area. POLIMI will develop new approaches or upgrade/adapt the tools of Task 5.1 to perform energy analysis of possible scenarios identified in WP3 and WP4. Other activities might arise following the results coming from the WP3 and WP4.

BME will not only propose methods for enhancing energy efficiency but these will also evaluated by an algorithmic-simulation tool also developed within the framework of COMBO. The result will be the FMC network architectures as well as the methods how to operate the network in most cost efficient way for different scenarios along with the amount of saving compared to the case when these strategies were not applied.

ADVA contributes to the in-depth understanding of the power-consumption drivers and mechanisms to increase energy efficiency in the context of next-generation access and mobile backhaul / aggregation networks, since it ensures compliance with the increasing energy-efficiency requirements from all, standardization (e.g., ITU-T, IEEE), legislation (e.g., EU Broadband Code of Conduct), and also large network operators. Therefore ADVA will collect the relevant power-consumption figures for relevant functions and their implementation and, since not all of them are available today, estimate to the best possible extent. As already known from other projects, this requires substantial effort, especially for components which do not exist today (e.g., various PICs, transceivers, 20-nm CMOS components, etc.).

FT will collect and provide specific data inputs on energy consumption related to fixed and mobile networks and contribute to the analysis of energy-saving mechanisms and energy-optimized network scenarios in the context

of FMC architectures defined in WP3. CTTC will assess the energy saving benefits obtained by applying the new approach to set up RRM enablers in RAN (defined in WP4-T4.2). DTAG supports the energy optimization discussion and provides input data for access and aggregation network. FON will add the approach of mobile offloading, and contribute on designing and defining energy-optimizing and energy-savings strategies. FON will model and quantify (measure) existing mobile to fixed offloading scenarios from an energy consumption perspective, both at end user and offloading network level, assess the impact of the proposed FMC architectures on end user devices and targeted offloading networks (e.g. WiFi), and model energy consumption of the proposed FMC architectures under offloading scenarios.

Task leader: POLIMI
Contributors: DTAG, FT, CTTC, POLIMI, BME, ADVA-DE, FON
Fed by: WP2 (T2.1), WP3 (T3.2, T3.3), WP4 (T4.1, T4.2), WP5 (T5.1), WP6
Feeds: WP3 (T3.1, T3.2, T3.3), WP4 (T4.2)

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JCP	15.00
2	DTAG	11.00
3	TID	10.00
4	FT	4.00
10	CTTC	7.00
12	POLIMI	36.00
13	BME	44.00
16	ADVA-DE	3.00
17	FON	14.00
	Total	144.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D5.1	Assessment framework and evaluation of state-of-the-art architectures	13	47.00	R	PU	11
D5.2	Intermediate techno-economic analysis of candidate FMC scenarios	13	48.00	R	PU	22
D5.3	Techno-economic assessment and business analysis of the proposed FMC architectures	13	49.00	R	PU	35
		Total	144.00			

Description of deliverables

D5.1) Assessment framework and evaluation of state-of-the-art architectures: Proper assessment methodology and tool(s) will be selected and ready-to-use, reference scenarios will be prepared for assessment studies

in T5.2, T5.4. State-of-the-art, separate fixed and mobile architectures will be assessed, and the business ecosystems of separate architectures will be analysed, in order to provide results for later comparison with FMC architectures. [month 11]

D5.2) Intermediate techno-economic analysis of candidate FMC scenarios: The candidate FMC architectures will be assessed regarding economic and energy efficiency, in order to provide feedback and insights for WP3 about further development directions for the proposed final FMC architectures. [month 22]

D5.3) Techno-economic assessment and business analysis of the proposed FMC architectures: A comprehensive analysis of the FMC architectures will be carried out on the selected case studies, including comparison with separate fixed and mobile architectures. It supports validation of the proposed level of convergence with respect to economic and energy efficiency, considering also business ecosystems for converged architectures and a multi-operator environment. [month 35]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS21	Initial results on candidate architectures	13	19	The assessment methodology for candidate converged architectures will be outlined, and the first results presented for WP3 and WP4, in order to provide feedback, and supporting their activity.
MS22	Initial results on proposed architectures	13	30	The assessment methodology and the improved network planning techniques for FMC scenarios will be presented. It will be used for an intermediate evaluation of the proposed FMC scenarios will be carrie

WT3:
Work package description

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per Work Package

Work package number [53]	WP6	Type of activity [54]	DEM
Work package title	Functional Development & Experimental Research Activities		
Start month	1		
End month	36		
Lead beneficiary number [55]	8		

Objectives

This work package is the vehicle for COMBO to mobilise the transfer of knowledge or findings from the project into real world activities. It will bring vendors and operators together to demonstrate varying levels of convergence identified within the project in addition to development of functions beyond state of the art in the field of Fixed Mobile Convergence on an as needed basis.

In more detail, WP6 will:
• Using architectures discussed in WP3 and KPIs identified within WP2 to set the boundary conditions, experimentally explore areas such as those established in WP4 and potential candidates such as:
o Converged network solutions for fixed & mobile access/backhaul
o Novel physical and protocol layer approaches
o Solutions for traffic engineering and Quality of Experience (QoE) monitoring
o Opportunities and challenges of remote BBU/RFU concepts
o Synchronization architectures and best practice for LTE Advanced and beyond
o Concepts for content awareness and content caching
o Open access and wholesale approaches across multiple technologies
• Perform a gap analysis of functionality and where needed develop additional functionality
• Explore practical opportunities which simulate or pose realistic 'real-world' traffic and network conditions
• Capture best practice, lessons learned and hurdles that need further consideration in order to achieve FMC
• Generate practical results underpinning the dissemination of theoretical concepts developed in COMBO.
This work package is led by ADVA-UK.

Description of work and role of partners

WP6 is split into three main tasks, consisting of a coordination task, a lab based task allowing each system vendor to tune functions in existing products or develop functionality beyond state of the art based on a gap analysis, and a final operator based experimental task involving operators and vendors in a multiple operator/multiple vendor scenario and multiple use case scenario covering fixed and mobile backhaul. It will thus demonstrate real convergence aligned with the overall project objective, with operators providing/describing a close to real-world environment or use-model, and academic and other partners adding capability to the system vendors to explore new areas perhaps not yet present in their portfolio. WP6 will be used to underpin the dissemination activities from the COMBO project.

Task 6.1: Coordination Task [M1-M36]
This task will allow the coordination of activities within the WP, enable communication/discussion between the various partners and tasks within the WP and enable a controlled communication of requirements from other work packages to flow into WP6. It will also allow a controlled release of results from WP6 into other work packages. The coordination task will be a review forum for experimental results to be published.
Specific objectives of the task are to :
• Compile a list of inputs from other WPs
• Perform a gap analysis in conjunction with Task 6.2 and identify new functions to be developed
• Provide opportunity to review mutual test results (to be published)
• Enable discussion forum on results identified within the WP
• Manage repository of results, findings etc to be used for dissemination activities

Fed by: WP2 (T2.x, T2.y), WP3-WP7 (All Tasks)
Feeds: WP6 (All tasks), WP7 (All Tasks)
Task leader: ADVA-UK
Contributing partners: DTAG, TID, FT, ADVA-UK, EAB, TELNET, FON

Individual contributions of partners:
• ADVA-UK will maintain a list of inputs from other WPs. ADVA will coordinate regular update sessions to enable the exchange of information, status, and provide the forum for discussion on findings and results. ADVA will ensure that a repository/or index of all published material relating to results is available throughout the project.
• DTAG, TID and FT will coordinate with the other operators and vendors about test activities and will support test cases definition (test bed scenarios design and test plan preparation) for the work of task 6.2 and 6.3. TID will participate in the gap analysis, in test bed scenarios design and in the test plan selection and preparation, collaborating with the rest of the partners.
• TELNET and EAB will contribute in the collection of results from other WPs and its analysis. They will also contribute in the design of testbeds for proposed architectures with their available devices, and of course, new eventual developments of equipment will be also studied and assessed.
• FON will verify requirements and evaluate these for test bed activities

Task 6.2 Lab based Practical Work & Development [M4-M24]
Lab based practical work will be associated with the functions identified in other WPs, especially WP3 and WP4. Vendors will develop practical, lab-experimental and/or modelling facilities relating to solutions and concepts proposed within the COMBO project. Early in the project it is expected that Work Package 6 partners will perform a gap analysis to identify missing functions and plan any development of functions beyond state of the art. Once existing and new functionality is in place and assembled, practical laboratory work will include experiments relating to KPIs identified within the project, as well as capacity and performance measurements and will be based around a test plans prepared by vendors. The use of mixed vendor interoperability exercises will be used where multiple vendors are working on similar functions or complimentary solutions. Results will be captured for analysis and comparison between the KPIs identified and requirements/constraints that will be seen in future applications and networks. Closing the task will include discussion on the preparation activities for Task 6.3 which brings operators and vendors together in field related activities.

The concepts proposed within the architectural and requirement Work Packages of COMBO will to some extent shape the laboratory and operator practical work, however initial examples of the topics that could be in scope includes the following:
• Synchronization aspects - Backhaul and fronthaul, Packet and Optical considerations
• OAM requirements for FMC networks including SLA verification tools enabling COMBO proposals and in view of possible functional convergence
• QoS/QoE Management for different applications and services, traffic engineering, content awareness
• WDM-PON technologies and physical/protocol layer functions for back-haul and fronthaul
o Centralized BBU solutions with long distance main-remote connections;
o Ability to handle multi-vendor main-remote scenarios where the different RRU/MU could have its own CPRI flavor;
o Capacity planning and impact of very high demands on link technologies
o Possibility for integration of digital RoF concepts into a WDM-PON framework
• Identification of specific functions required for multi-operator/wholesale support
• Impact of new concepts such as Open BS, antenna clusters, BBU hotels on fronthaul/backhaul
• Automatic configuration/self-organization functions to facilitate network setup
• Application demonstration and Evaluation activities
o Support demanding services for mobile and residential users (e.g. 3D HD TV, HD video conferencing)
o Evaluate synchronization, delay and delay variation for CPRI and CoMP connections
• WiFi offloading and management of services as they are handled by different access media
o Hand-off of services between access medium and implications on the QoE
This task is in close connection to WP2, WP3 and WP4 results, hence its timing is related to the availability of the results. After the initial building of the lab for FMC-specific tests, the development of the prototypes and verification methods will mostly be done in the second year.

The table below provides a summary of the functional areas where vendors plan at the project outset to focus.
Function ALU-I ADVA-UK & AG EAB AITIA TELNET FON CTTC

FronthauldRoF Y Y Y N
Sync distribution Y Y
L1 Issues Y Y Y
L2 Issues Y Y Y
WiFi Offloading N Y
Energy Analysis Y Y N
Control Plane Y Y Y

Fed by: WP6 (T6.1), WP2-5
Feeds: WP6 (T6.3), WP4, WP7
Task leader: ADVA-UK
Contributing partners: ALU-I, CTTC, EAB, ADVA-UK, ADVA-DE, AITIA, TELNET, FON

Individual contributions of partners:
• ADVA-UK & ADVA-DE will explore practical aspects of fixed mobile convergence with focus on two principal areas, although the range of functions involved fit into many areas. Wherever it is appropriate the intention is to build interoperability aspects into the practical work so that multi-vendor, multi-operator end-to-end solutions can be the eventual goal
o ADVAs experience in the Ethernet Access Device and Demarcation market will be utilised, pulling together three strands, including need for demarcation services and OAM in fixed/mobile converged network, use of MPLS as a convergence layer, and how well this supports the combined needs of mobile and fixed line network, and synchronization distribution and monitoring. Progress beyond state of the art is associated with the step towards realizing proof of concept synchronization distribution over a convergence layer like MPLS with on-path support, boundary clock and transparent clock architectures in a FMC network. No standards yet exist that cater for 1588 over MPLS in this way, the COMBO project could positively impact standards bodies such as the ITU-T and IETF as well as wider industry if proof of concept is achieved
o Augmenting ADVAs WDM-PON studies, within COMBO ADVA will focus on fronthaul applicability of WDM-PON. Focus on Energy reduction and scalability for front haul architectures, effects of fronthaul environment on WDM-PON wavelength control, and protocol aspects associated with fronthaul such as extensions to CPRI or open platforms as appropriate. Progress beyond state of the art relates to integration of digitised RF over fibre for NG-POP locations with LTE-Advanced MIMO antenna clusters in mind
• EAB work will focus on converged transport solutions that utilize the capabilities provided by WDM based access and aggregation networks, resulting WDM-PON and DWDM network technology enablers. The experimental research activities will initially address radio access related WDM-PON solutions in their most challenging forms from a transport perspective, i.e. through Main-Remote (Remote Radio Head) solutions. For radio access and in particular in dense urban HetNet scenarios, wireless backhauling will also be addressed as a complement for fixed access to small cells.
In the first year, operators will be invited to visit the Ericsson Research's Laboratory in Stockholm in the first months of the project, when a C-RAN testbed will be exhibited by Ericsson. This testbed will consist of existing Ericsson radio products and state-of-the art architecture solutions. In particular, Microwave links and WDM-PON centralized solutions for Main-Remote deployments and node consolidation will be demonstrated. The Ericsson's testbed for C-RAN and centralized Baseband concepts assumes:
• Topology making use of both fibre and microwave link technologies
• CPRI transport between BBU and each RRUs
• WDM-PON connections offering a colorless, bit-rate flexible and tunable solution
• Microwave link supporting a CPRI
• WDM-PON Supervision, considering identification and location of fibre faults.
Among the innovative aspects to be discussed during EAB's Lab trials, potential ideas for open issues such as wireless and fixed topologies, resource sharing and load balancing of BBUs and RRUs are expected, especially as input to WP3.
The next phase covers areas beyond pure access, by looking at aggregation/metro parts in support of large deployments of small cell site solutions. This entails both packet based and Main-Remote based backhauling, although the major capacity and other stringent network characteristics will of course be driven by the latter. Here, EAB intends to perform practical experimental research to demonstrate the feasibility of WDM based access and aggregation without the involvement of packet switching in this part of the network, whilst still supporting fundamental requirements of large deployments such as resilience, auto-configuration and control & management.
By means of lab-trials, EAB intends to tackle open issues like
• Centralized BBU solutions with long distance main-remote connections;

• Ability to handle multi-vendor main-remote scenarios where the different RRU/MU could have its own CPRI flavor;
• Impact of very high demands on link technologies.
• ALU-I will be working on the backhaul of next generation base stations utilising Lightradio technology
• CTTC work will concentrate on experimentally validating selected functions of specific parts of the FMC architecture. Specifically, the CTTC infrastructure covers the following FMC network segments: emulated RAN (based on LTE), optical aggregation network (based on integrated MPLS-TP WSON) and limited EPC. This provides the following potential functions and tests:
o Emulation of eNB and UE
o Evaluation of different LTE RAN aspects (e.g., RRM, QoS-aware packet scheduling, etc.)
o Accurate RLC modeling
o Evaluation of the statistical multiplexing and flexibility provided by MPLS-TP and the deterministic multiplexing and coarse capacity provided by WSON,
o Full or limited emulation of different interfaces (e.g., S1-U, S1-MME, Gi)
The developed emulation toolsets and equipment will be used by other vendors to integrate control and data aspects into the other vendor's practical work aiming at conducting multi-partner validation tests
• AITIA will focus on traffic- and performance management issues. The subtasks will include
o building a lab environment for testing and verification,
o developing the actual FMC-specific algorithms for SLA verification based on passive monitoring,
o creating verification methods for the possible impact of future traffic scenarios,
o developing a prototype for the Monitor Plane that fits the need of a possible Knowledge Plane in a multi-vendor, multi-operator FMC architecture, and
o supporting QoS/QoE management efforts by providing a prototype for application identification and traffic matrix calculation through passive traffic monitoring.
• TELNET will explore the new architectures, technologies and solutions for FMC architectures, and test and validate pre-existing solutions within frame of a converged network. Wherever it is required, TELNET would be able to incorporate new developments or modifications that could arise from the architecture evolution. Following work areas are defined
o WDM-PON based access network. Telnet will validate several concepts around WDM-PON technology, such as physical transmission, QoS measurements, OAM features, synchronisation with IEEE1588, etc. New ideas, such as RoF transmission, CPRI transmission and microwave radiolinks integration will be also studied. Progress beyond the state-of-art is expected for WDM-PON architectures based on future optical technologies.
o Backhaul connectivity. Different solutions for the integration of WDM-PON OLT nodes in aggregation or core networks will be investigated. Probably new developments based on ROADM and EDFA equipment will be considered. One of the main goals in this point will be the interoperability issue.
o Control plane. TELNET will offer its hardware and expertise to other partners in order to build a testbed where control plane architecture could be tested with actual equipment.
• FON intend to explore WiFI offloading aspects as part of new behaviour in a converged network. In this context FON will investigate the impact on user experience in terms of QoS and QoE as services are offloaded from a 3G network to a WiFi network as the coverage changes during the life of the service or application i.e. voice call, video stream or web application

Task 6.3: Operator Based Experimental Task [M24-M35]
This task is the forum to bring multiple operators and multiple vendors together in an operator based experiment, with the intention of taking lab based functions into more realistic environments. With regards to the focus areas of each vendor, a field based experiment or operator controlled lab test will be pulled together offering real word environment and demonstrating the interoperability of the partners with in the project. The outcome of the task will be to capture lessons learned, propose best practice and dissemination activities in coordination with WP7 and providing feedback into WP4 and WP5.

To demonstrate in the field the concepts and technical solutions developed by the industrials to perform FMC, France Telecom will place dedicated tools at the disposal of other project partners, around field infrastructures located in Lannion in Brittany. These infrastructures are composed of a metropolitan ring of 12 fibres of 18km each (2 fibres will be made available for COMBO activities) and PON infrastructures connected to some of the ring nodes, together with extended measurement equipment to perform physical tests, performance tests, residential services support tests, business services support tests, CPRI backhauling tests, mobile services support tests, power consumption measurements and system management tests. These field and measurement resources to be committed will allow to show, for example:

- the coexistence and management of mobile and fixed customers by the same node equipment, including offloading;
- WDM PON functionalities including CPRI over PON fixed / mobile equipment integration;
- NG-POP functionalities, including automatic configuration/self-organization functions to facilitate network setup and specific functions required for multi-operator/wholesale support;
- video services implementation (High Definition TV with streams up to 30Mbit/s, HD VoD, HD video-conferencing) on several interface types (Femto cell, WiFi, LTE, fixed access) by involving a limited number of service platforms;
- a high data bit rate access to Internet (up to 1Gbit/s);
- synchronisation control, QoS/QoE functionalities and OAM, including performance monitoring and management in integrated scenarios.

The detailed and refined planning of these third year field activities will be elaborated on by tasks 6.1 and 6.2 during the first two years of the project.

Topology of the proposed field infrastructure for operator-based experimental activities.
The metropolitan ring is composed of 12 fibres
and tree access infrastructures are connected to some of the ring nodes.
Fed by: WP6 (T6.1, T6.2), WP3-WP7 (All Tasks)
Feeds: WP6 (T6.1), WP7 (All Tasks)
Task leader: FT
Contributing partners: CTTC, DTAG, FT, TID, ADVA-UK, ADVA-DE, ALU-I, EAB, TELNET, FON

Individual contributions of partners:
• ADVA-UK & ADVA-DE would like to work with all operators to perform experiments on realistic infrastructure test environments. Progress beyond state of the art explored in the lab phase will be offered as proof of concept solutions so that evaluation can be made over a typical network or link. Where functions are part of a distributed end-to-end service like OAM or QoS/QoE and Synchronization, ADVA will endeavour to provide inter-op support between vendors so that multi-vendor solutions can be realized within COMBO
o ADVA will offer to attend and participate in measurements and evaluation activities to aid in operator test phases.
• ALU-I will bring test bed activities with FT to bear in COMBO operator based testing
• TELNET will collaborate with vendors and operators in order to carry out common experiments in real environments. Existing devices and developments and studies from task 6.2 will be tested in this task, with two main purposes, test of the proposed solutions and the interoperability validation.
• EAB will demonstrate converged WDM solutions across both access and aggregation networks with support for fully automated connectivity management over the all-optical user data plane. In the last year, the work shall converge into a lab-trial/field-trial at an operator premises to demonstrate the most promising COMBO solutions developed in the project, supporting both mobile and fixed broadband transport services. The resulting network will automatically adapt to support any service (packet or CPRI mobile backhaul, fixed residential and business access). Therefore, EAB aims at:
o Demonstrate demanding services for mobile and residential users (e.g. 3D HD TV, HD video conferencing);
o Evaluate capacity and QoS issues according to defined KPIs;
o Evaluate Performance management, e.g., SON aspects;
o Evaluate synchronization, delay and delay variation for CPRI and CoMP connections.
• CTTC will use the work done with vendors in T6.2 and lift integrated functionality for re-use in T6.3 to check and compare results from the lab with more realistic use environment
• DTAG will focus their efforts on demonstrating the FMC key points arising from WP3 – such as:
o NG-POP functions (convergence functional level)
o Offloading (send data to end user via WiFi instead of LTE if WiFi has better performance, control for this is in the network)
o Fixed mobile integration
☐ CPRI over PON
☐ Equipment convergence (Mobile site with integrated PON, or vice versa
☐ (non-intrusive) Performance monitoring in integrated scenarios
☐ Synchronization
• FT will participate to the integration work on the field premises and contribute to the test campaigns with the other partners according to a detailed planning worked out in coordination task 6.1. FT will also ensure active support to these test campaigns by providing the field infrastructure and premises and some of the required

measurement and test equipment. Some key issues addressed will be fibre radio network integration, energy and resource optimization by FMC, converged control functions.
• TID will collaborate with all partners to demonstrate FMC concepts, focussing in NG-POP, CPRI transport, WDM-PON, resource optimization and resilience related scenarios. TID will participate during the test plan definition, the execution and the validation with the collaboration of the rest of the partners.
• FON will work with other partners to contribute to deploy a successful scenario based on experience of high density projects and combining the new aspects investigated during T6.2 with the operator scenarios in focus

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
2	DTAG	12.00
3	TID	12.50
4	FT	21.00
5	ALU-I	13.00
7	EAB	43.00
8	ADVA-UK	17.00
10	CTTC	10.00
14	AITIA	5.00
15	TELNET	38.00
16	ADVA-DE	6.00
17	FON	13.00
	Total	190.50

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D6.1	Summary of planned experimental activities and gap analysis	8	63.00	R	PU	6
D6.2	Report on testing status relative to each lab based experiment	8	63.00	R	PU	24
D6.3	Report describing results of field based testing, capturing lessons learned and recommendations	8	64.50	R	PU	34
		Total	190.50			

Description of deliverables

D6.1) Summary of planned experimental activities and gap analysis: To identify new areas of functional development within COMBO [month 6]

D6.2) Report on testing status relative to each lab based experiment: [month 24]

D6.3) Report describing results of field based testing, capturing lessons learned and recommendations: [month 34]

WT3:
Work package description

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS23	Functional lab based experiments operational	8	18	Report on the status of lab based demonstration facilities
MS24	Lab based experimental results and lessons learned available	8	24	
MS25	Field based experiments operational	8	30	Report status of operator/vendor field based experiments and proposals for final tests
MS26	Field based experimental test reports issued	8	34	

WT3:
Work package description

Project Number [1]	317762	Project Acronym [2]	COMBO

One form per Work Package

Work package number [53]	WP7	Type of activity [54]	OTHER
Work package title	Dissemination and Standardization		
Start month	1		
End month	36		
Lead beneficiary number [55]	2		

Objectives

The main goal of this Work Package is to coordinate and perform project results dissemination, giving broad visibility of COMBO project results to the relevant European, national and international fora. This will lead to maximized chances for achieving the required impact level of the project. Particular focus will be on dissemination of the results and proposed FMC concepts towards different standardization and discussion fora to foster the dialogue between the different bodies.
In more detail the objectives of the work package are:
• Promote the technical results of COMBO to the European and global research community (e. g. setting up a project web site, dissemination event).
• Coordination of dissemination activities (e. g. participation in conferences, contribution to scientific journals, organisation of workshops and events, etc).
• Coordination of activities relevant to standardization carried out by the project, provide contributions to related standardization bodies and fora and stimulate the discussion in these fora.
• Exchange with other projects active in neighbouring fields with similar focus (within and possibly outside FP7).
This work package is led by DTAG.

Description of work and role of partners

T7.1 – Dissemination material & publication policy [M1 – M36]
The main results of this project will be disseminated through ICT coordination meetings and workshops, external publications, exhibitions, and national and international conferences. In order to structure and streamline dissemination, WP7 will produce a project communication and dissemination plan in month 2 of the project which will describe the publication policy and will serve as a living document that will be continuously updated based on new dissemination opportunities.

The dissemination of the project concept and results will be based upon a number of different activities:
• A detailed calendar of events will be created and updated regularly in the project communication and dissemination plan, containing all relevant international and national conferences, exhibitions and events. Based on this, contributions will be submitted for publication as soon as some initial results are ready. At least 10 publications per year are targeted.
• Project presentation material like a leaflet, a poster and an overview presentation as well as a project web site will be designed to disseminate project concepts and objectives. These will be distributed at project workshops and to the conferences, where project members will participate. The project web page will include information about concepts, vision, objectives and expected outcomes as well as public documents, derived from the project work. It will be updated regularly, offering links to other relevant sites and links to partners' web sites.
• The list of intended publications in scientific journals and international conferences by all partners and covering all project topics will be produced and maintained in the project communication and dissemination plan.
• External activities are foreseen in order to present the COMBO project results to the research community as well as to the relevant industry:
o Articles and papers in scientific journals (e. g. IEEE periodicals as Communication Magazine, Transactions on Communications, Transactions on Networking, Transactions on Wireless Communications, Wireless Communications Magazine, Communication Letters, Journal of Lightwave Technology, Journal on Selected Areas in Telecommunications, EURASIP Journal on Wireless Communications and Networking, Springer Annals on Telecommunications)

o Articles and papers on national and international conferences (e.g. GlobeCom, OECC, IEEE ICC, IEEE VTC, IEEE Wireless Communications and Networking Conference, FIA Mobile Summit, ICT and Horizons conferences, WWRF, ECOC, OFC, ACM MobiCom, PIMRC)
o Organize workshops on FMC at major conferences, e.g. at the IEEE ICC, OFC, ECOC, MobiCom
o Submit a tutorial to a special issue of a major Journal or Magazine.

Fed by: WP2, WP3, WP4, WP5 and WP6
Task leader: JCP
Contributing partners: All

T7.2 – Collaborations [M1 – M36]
Since COMBO aims at establishing a sustainable long term path towards fixed mobile converged networks a well-organized information exchange with other European projects, network operators and vendors is necessary.

In order to realize this information exchange, the following activities are planned:
• Concertation meetings/workshops with European projects and industry fora:
a) STREP ACCORDANCE:
Input from ACCORDANCE on the suitability of OFDM-PON for LR PON and backhauling will be a starting point for the architecture work in WP3.
Coordination: The collaboration with ACCORDANCE can be easily implemented with minimum administration, since COMBO partners DTAG and JCP are involved in ACCORDANCE.
b) STREP ERMES:
ERMES investigates a new optical technology for the support of large-bandwidth end-users in next-generation access network. A knowledge transfer of the capabilities of this new solution could be helpful in the identification of the feasible new solutions for the fixed segment to be considered in the FMC objective of COMBO.
Coordination: Partners POLIMI, FT and ALU-I are members of ERMES and therefore the interactions between projects will be easy.
c) IP OASE:
OASE studies different access technologies and architectures for their suitability to allow a restructuring of the fixed line access and aggregation network. It also investigates co-operation models for multi-operator and service provider open access scenarios. Since almost all OASE deliverables are public the findings from OASE will serve as a starting point for WP2 fixed line roadmap and also for WP3 and the cost and multi-operator assessment in WP5.
Coordination: Since DTAG has the technical lead in the project OASE a thorough knowledge transfer can be assured.
d) NoE TREND:
TREND covers aspects of energy efficiency in different parts of the network. Inputs from TREND public results about promising wired/wireless technologies in the access network segment can be useful to COMBO.
Coordination: Partners FT, TID and POLIMI are also active in TREND and therefore the interaction between the two projects will be established.
• COMBO will also make use of publicly available results of the more recently completed European projects by the time COMBO will likely to start, in particular from projects IP ALPHA, IP FUTON IP ARTIST4G, IP EARTH and NoE BONE, about the new architectural and transmission solutions for the wired/wireless access segment.
• Fruitful interactions will be established also with other FP7 projects submitted (and funded) under the same FP7 call as COMBO.
• Exchange with other FP7 projects not cited before but with neighbouring work and research fields (e. g. MEVICO) with similar focus will be performed.

Time frame:
• A discussion about requirements with these EU projects will be initiated after the first phase of WP2, Task2.1, as soon as the internal list of requirements is completed for distribution. Earliest starting date is M4.
• Participation to EC Future Networks Concertation meetings (Plenary and CaON cluster) from the start of the project (twice a year).
• Follow-up concertation meetings will be performed as needed, but at least once a year.

For certain topics which are not in the focus of the aforementioned projects, COMBO will hold interactions with industry fora or European Technology Platforms (ETP) such as:
• ETNO (European Telecommunication Network Operator Association) for discussion of COMBO results with respect to converged network architectures and potential infrastructure enhancements.

• FTTH Council Europe, member organisation with a mission to accelerate FTTH deployments in Europe, and with Ericsson as one of the members.
• GreenTouch for all topics related to energy efficiency of networks.
• Net!Works ETP for topics related to network architectures, in particular mobile networks.
• Photonics21 ETP for topics related to very high fixed broadband access.

Fed by: WP2, WP3, WP4, WP5, and WP6
Task leader: POLIMI
Contributing partners: All

T7.3 – Standardization [M13 – M36]
Contribution to standards will be a key priority of COMBO project, since the dramatic network evolutions and revolutions required by fixed/mobile convergence will be made possible only when standardised. One of COMBO goals will thus be to strongly push in several standardization bodies a uniform and detailed vision of fixed/mobile convergence, so as to foster a consistent approach in key standards related to fixed and mobile network architectures.

The role of this task will thus be to coordinate the standardization activities and contributions to the relevant bodies. A preliminary list of targeted bodies and fora are IEEE 802, ITU-T, OIF, MEF, FSAN, 3GPP, NGMN Alliance, Open Mobile Alliance (OMA), Broadband Forum (BBF), Future Internet Assembly (FIA), Wi-Fi Alliance and Wireless Broadband Alliance (WBA).

During the start phase of the project this list of the targeted standardization bodies, forums and associated planned contributions will be further assembled, continuously updated and added to the project communication and dissemination plan.

The following partners are currently active in the following standardization bodies:
• Deutsche Telekom is actively participating in IEEE, ITU-T, OIF, MEF, FSAN, 3GPP, NGMN Alliance, OMA, BBF, and Wi-Fi Alliance.
• France Telecom has several delegates actively involved in BBF, 3GPP, IETF, FSAN and ITU-T on issues of fixed and mobile network architectures.
• TID will contribute with its involvement in FSAN, BBF and 3GPP.
• Ericsson AB is actively participating in IEEE, ITU-T, OIF, MEF, FSAN and BBF.
• ADVA is actively participating in IEEE, MEF, IETF, FSAN,ITU-T and Broadband Forum (BBF).
• ALU-I is contributing to FIA pre-standardization actions and to ITU-T.
• FON is actively participating in the Wi-Fi Alliance and the Wireless Broadband Alliance (WBA).
• JCP is active in 3GPP and ETSI.

Given that each standardization body has its own logic and vision which might be difficult to change quickly, a gradual approach will be adopted to build COMBO contribution to standards, so as to make the various logics/visions converge ultimately. In particular, COMBO will analyse whether the gains from FMC architectures are worth the transformation, and if yes how to smoothen it. The corresponding migration scenarios will be pushed in standards so as to guarantee actual implementations. The strategy of contribution to standards will thus be three-fold:
• Network operators of the consortium, together with vendors, will form a taskforce to jointly and strongly advertise COMBO solutions in the scientific and industrial community;
• For each of the promising architectures proposed by COMBO, migration scenarios will be worked out to seek intermediate architectures which could be pushed successfully in some targeted fora. As an example, contributions on mobile architectures related to WiFi or femto offloading will be pushed in 3GPP / SA2 in coherence with BBF;
• As an ultimate goal, push in several standardization bodies a uniform and detailed vision of fixed/mobile convergence, so as to foster a consistent approach in key standards related to fixed and mobile network architectures.

Fed by: WP2, WP3, WP4, WP5, and WP6
Feeds: all tasks with respect to feedback from standardization bodies
Task leader: FT
Contributing partners: DTAG, FT, TID, EAB, ADVA-UK, ADVA-DE, FON, JCP

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JCP	10.00
2	DTAG	10.00
3	TID	3.00
4	FT	11.00
5	ALU-I	4.00
6	IT-TB	3.00
7	EAB	5.00
8	ADVA-UK	4.00
9	ULUND	3.00
10	CTTC	1.00
11	DOCOMO	1.00
12	POLIMI	3.00
13	BME	3.00
14	AITIA	5.00
15	TELNET	1.00
16	ADVA-DE	3.50
17	FON	3.00
	Total	73.50

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D7.1	Project presentation, communication plan and dissemination plan	2	18.50	R	PU	2
D7.2	Dissemination material and publication policy	2	18.50	R	PU	36
D7.3	Report on standardization and dissemination activities I	2	18.50	R	PU	18
D7.4	Report on standardization and dissemination activities II	2	18.00	R	PU	36
		Total	73.50			

Description of deliverables

D7.1) Project presentation, communication plan and dissemination plan: [month 2]

D7.2) Dissemination material and publication policy: [month 36]

D7.3) Report on standardization and dissemination activities I: [month 18]

D7.4) Report on standardization and dissemination activities II: [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS27	Updated communication and dissemination plan	2	18	
MS28	Overview collaboration activity	2	12	
MS29	Update on standardization and collaboration activity	2	24	

WT4:
List of Milestones

Project Number [1]	317762	Project Acronym [2]	COMBO

List and Schedule of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS1	Project consortium agreement	WP1	1	1	Project consortium agreement signed.
MS2	Quarterly management report	WP1	1	3	
MS3	Quarterly management report	WP1	1	6	
MS4	Quarterly management report	WP1	1	9	
MS5	Quarterly management report	WP1	1	15	
MS6	Quarterly management report	WP1	1	18	
MS7	Quarterly management report	WP1	1	21	
MS8	Quarterly management report	WP1	1	27	
MS9	Quarterly management report	WP1	1	30	
MS10	Quarterly management report	WP1	1	33	
MS11	Initial report on FMC networks requirements	WP2	3	7	Initial report on FMC requirements according to the reference framework definition.
MS12	Final report on FMC networks requirements	WP2	3	12	Detailed report on FMC requirements based on the results of all WP2 previous tasks.
MS13	Identification of key functions, equipment and infrastructures of FMC networks	WP3	4	6	Identification of key functions, equipment and infrastructures to be implemented in fixed / mobile network convergence scenarios.
MS14	Definition of candidate architectures for functional convergence	WP3	4	12	Definition of candidate architectures and scenarios for future networks allowing fixed/mobile functional convergence, i.e. convergence of fixed and mobile network functions.

WT4:
List of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS15	Definition of candidate architectures for structural convergence	WP3	4	12	Definition of candidate architectures and scenarios for future networks allowing fixed / mobile structural convergence, i.e. mutualization and integration of equipment and infrastructures.
MS16	Intermediate analysis of FMC scenarios	WP3	4	27	Intermediate technical assessment and comparison of FMC scenarios with each other and with the reference framework of WP2.
MS17	Survey of monitoring parameters and methods	WP4	7	6	Report on passive and active monitoring parameters and methods on different network levels.
MS18	Use cases for RAN-transport interaction	WP4	7	12	Report describing use cases for when RAN-transport interaction can be used for performance management.
MS19	Overview of performance optimization for FMC networks	WP4	7	18	Initial report on performance optimization for FMC networks.
MS20	Structures for evaluations of monitoring and managements concepts	WP4	7	24	Report describing how the monitoring and management concepts will be evaluated.
MS21	Initial results on candidate architectures	WP5	13	19	The assessment methodology for candidate converged architectures will be outlined, and the first results presented for WP3 and WP4, in order to provide feedback, and supporting their activity.
MS22	Initial results on proposed architectures	WP5	13	30	The assessment methodology and the improved network planning techniques for FMC scenarios will be presented. It will be used for an intermediate evaluation of the proposed

WT4:
List of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
					FMC scenarios will be carrie
MS23	Functional lab based experiments operational	WP6	8	18	Report on the status of lab based demonstration facilities
MS24	Lab based experimental results and lessons learned available	WP6	8	24	
MS25	Field based experiments operational	WP6	8	30	Report status of operator/vendor field based experiments and proposals for final tests
MS26	Field based experimental test reports issued	WP6	8	34	
MS27	Updated communication and dissemination plan	WP7	2	18	
MS28	Overview collaboration activity	WP7	2	12	
MS29	Update on standardization and collaboration activity	WP7	2	24	

WT5:
Tentative schedule of Project Reviews

Project Number [1]	317762	Project Acronym [2]	COMBO

Tentative schedule of Project Reviews

Review number [65]	Tentative timing	Planned venue of review	Comments, if any
RV 1	15	Brussels (or other)	Another location might be chosen.
RV 2	27	Brussels (or other)	Another location might be chosen.
RV 3	38	Brussels (or other)	Another location might be chosen.

WT6:
Project Effort by Beneficiary and Work Package

Project Number [1]	317762	Project Acronym [2]	COMBO

Indicative efforts (man-months) per Beneficiary per Work Package

Beneficiary number and short-name	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	WP 7	Total per Beneficiary
1 - JCP	30.00	0.00	12.00	0.00	15.00	0.00	10.00	67.00
2 - DTAG	3.00	11.00	32.00	4.00	11.00	12.00	10.00	83.00
3 - TID	3.00	14.00	16.00	4.00	10.00	12.50	3.00	62.50
4 - FT	3.00	10.00	46.00	0.00	4.00	21.00	11.00	95.00
5 - ALU-I	0.50	10.00	13.00	0.00	0.00	13.00	4.00	40.50
6 - IT-TB	0.50	0.00	19.20	23.30	0.00	0.00	3.00	46.00
7 - EAB	0.50	7.00	27.00	17.00	0.00	43.00	5.00	99.50
8 - ADVA-UK	0.50	3.00	6.00	6.00	0.00	17.00	4.00	36.50
9 - ULUND	0.50	6.00	5.00	35.00	0.00	0.00	3.00	49.50
10 - CTTC	0.50	7.00	11.00	24.00	7.00	10.00	1.00	60.50
11 - DOCOMO	0.50	7.00	8.00	0.00	0.00	0.00	1.00	16.50
12 - POLIMI	0.50	9.00	4.00	11.00	36.00	0.00	3.00	63.50
13 - BME	0.50	0.00	3.00	9.00	44.00	0.00	3.00	59.50
14 - AITIA	0.50	8.00	9.00	23.00	0.00	5.00	5.00	50.50
15 - TELNET	0.50	0.00	10.00	0.00	0.00	38.00	1.00	49.50
16 - ADVA-DE	0.50	1.00	3.00	0.00	3.00	6.00	3.50	17.00
17 - FON	0.50	5.00	9.00	6.00	14.00	13.00	3.00	50.50
Total	45.50	98.00	233.20	162.30	144.00	190.50	73.50	947.00

WT7:
Project Effort by Activity type per Beneficiary

Project Number [1]	317762	Project Acronym [2]	COMBO

Indicative efforts per Activity Type per Beneficiary

Activity type	Part. 1 JCP	Part. 2 DTAG	Part. 3 TID	Part. 4 FT	Part. 5 ALU-I	Part. 6 IT-TB	Part. 7 EAB	Part. 8 ADVA-UK	Part. 9 ULUND	Part. 10 CTTC	Part. 11 DOCOMO	Part. 12 POLIMI	Part. 13 BME	Part. 14 AITIA
1. RTD/Innovation activities														
WP 2	0.00	11.00	14.00	10.00	10.00	0.00	7.00	3.00	6.00	7.00	7.00	9.00	0.00	8.00
WP 3	12.00	32.00	16.00	46.00	13.00	19.20	27.00	6.00	5.00	11.00	8.00	4.00	3.00	9.00
WP 4	0.00	4.00	4.00	0.00	0.00	23.30	17.00	6.00	35.00	24.00	0.00	11.00	9.00	23.00
WP 5	15.00	11.00	10.00	4.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	36.00	44.00	0.00
Total Research	27.00	58.00	44.00	60.00	23.00	42.50	51.00	15.00	46.00	49.00	15.00	60.00	56.00	40.00
2. Demonstration activities														
WP 6	0.00	12.00	12.50	21.00	13.00	0.00	43.00	17.00	0.00	10.00	0.00	0.00	0.00	5.00
Total Demo	0.00	12.00	12.50	21.00	13.00	0.00	43.00	17.00	0.00	10.00	0.00	0.00	0.00	5.00
3. Consortium Management activities														
WP 1	30.00	3.00	3.00	3.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total Management	30.00	3.00	3.00	3.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
4. Other activities														
WP 7	10.00	10.00	3.00	11.00	4.00	3.00	5.00	4.00	3.00	1.00	1.00	3.00	3.00	5.00
Total other	10.00	10.00	3.00	11.00	4.00	3.00	5.00	4.00	3.00	1.00	1.00	3.00	3.00	5.00
Total	67.00	83.00	62.50	95.00	40.50	46.00	99.50	36.50	49.50	60.50	16.50	63.50	59.50	50.50

WT7:
Project Effort by Activity type per Beneficiary

Activity type	Part. 15 TELNET	Part. 16 ADVA-DE	Part. 17 FON	Total
1. RTD/Innovation activities				
WP 2	0.00	1.00	5.00	98.00
WP 3	10.00	3.00	9.00	233.20
WP 4	0.00	0.00	6.00	162.30
WP 5	0.00	3.00	14.00	144.00
Total Research	10.00	7.00	34.00	637.50
2. Demonstration activities				
WP 6	38.00	6.00	13.00	190.50
Total Demo	38.00	6.00	13.00	190.50
3. Consortium Management activities				
WP 1	0.50	0.50	0.50	45.50
Total Management	0.50	0.50	0.50	45.50
4. Other activities				
WP 7	1.00	3.50	3.00	73.50
Total other	1.00	3.50	3.00	73.50
Total	49.50	17.00	50.50	947.00

WT8:
Project Effort and costs

Project Number [1]	317762	Project Acronym [2]	COMBO

Project efforts and costs

Benefi-ciary number	Beneficiary short name	Estimated eligible costs (whole duration of the project)						Requested EU contribution (€)
		Effort (PM)	Personnel costs (€)	Subcontracting (€)	Other Direct costs (€)	Indirect costs OR lump sum, flat-rate or scale-of-unit (€)	Total costs	
1	JCP	67.00	448,900.00	17,753.00	53,000.00	301,140.00	820,793.00	748,433.00
2	DTAG	83.00	757,541.00	6,000.00	94,665.00	541,151.00	1,399,357.00	877,064.00
3	TID	62.50	427,686.00	7,500.00	18,500.00	419,300.00	872,986.00	482,648.00
4	FT	95.00	705,257.00	3,800.00	36,000.00	394,943.00	1,140,000.00	659,717.00
5	ALU-I	40.50	234,900.00	0.00	18,000.00	116,043.00	368,943.00	215,475.00
6	IT-TB	46.00	298,045.00	0.00	55,000.00	211,826.00	564,871.00	444,437.00
7	EAB	99.50	884,555.00	5,000.00	36,000.00	508,443.00	1,433,998.00	775,998.00
8	ADVA-UK	36.50	321,200.00	0.00	30,000.00	95,265.00	446,465.00	248,905.00
9	ULUND	49.50	396,000.00	3,000.00	63,000.00	275,400.00	737,400.00	578,800.00
10	CTTC	60.50	282,051.00	2,500.00	23,000.00	211,539.00	519,090.00	378,355.00
11	DOCOMO	16.50	117,150.00	0.00	41,000.00	133,551.00	291,701.00	177,746.00
12	POLIMI	63.50	412,750.00	3,000.00	23,000.00	215,043.00	653,793.00	503,495.00
13	BME	59.50	230,563.00	2,000.00	48,000.00	167,137.00	447,700.00	352,900.00
14	AITIA	50.50	202,000.00	0.00	18,000.00	132,000.00	352,000.00	272,000.00
15	TELNET	49.50	148,500.00	0.00	72,000.00	132,300.00	352,800.00	202,080.00
16	ADVA-DE	17.00	164,900.00	0.00	0.00	44,370.00	209,270.00	129,255.00
17	FON	50.50	325,220.00	1,500.00	24,000.00	209,532.00	560,252.00	401,692.00
	Total	947.00	6,357,218.00	52,053.00	653,165.00	4,108,983.00	11,171,419.00	7,449,000.00

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It cannot be changed unless agreed so during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

53. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

54. Type of activity

For all FP7 projects each work package must relate to one (and only one) of the following possible types of activity (only if applicable for the chosen funding scheme – must correspond to the GPF Form Ax.v):

• **RTD/INNO =** Research and technological development including scientific coordination - applicable for Collaborative Projects and Networks of Excellence

• **DEM =** Demonstration - applicable for collaborative projects and Research for the Benefit of Specific Groups

• **MGT =** Management of the consortium - applicable for all funding schemes

• **OTHER =** Other specific activities, applicable for all funding schemes

• **COORD =** Coordination activities – applicable only for CAs

• **SUPP =** Support activities – applicable only for SAs

55. Lead beneficiary number

Number of the beneficiary leading the work in this work package.

56. Person-months per work package

The total number of person-months allocated to each work package.

57. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

58. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

59. Milestone number

Milestone number:MS1, MS2, …, MSn

60. Delivery date for Milestone

Month in which the milestone will be achieved. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

61. Deliverable number

Deliverable numbers in order of delivery dates: D1 – Dn

62. Nature

Please indicate the nature of the deliverable using one of the following codes

R = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

63. Dissemination level

Please indicate the dissemination level using one of the following codes:

• **PU =** Public

• **PP =** Restricted to other programme participants (including the Commission Services)

• **RE =** Restricted to a group specified by the consortium (including the Commission Services)

• **CO =** Confidential, only for members of the consortium (including the Commission Services)

• **Restreint UE =** Classified with the classification level "Restreint UE" according to Commission Decision 2001/844 and amendments

• **Confidentiel UE =** Classified with the mention of the classification level "Confidentiel UE" according to Commission Decision 2001/844 and amendments

• **Secret UE =** Classified with the mention of the classification level "Secret UE" according to Commission Decision 2001/844 and amendments

64. Delivery date for Deliverable

Month in which the deliverables will be available. Month 1 marking the start date of the project, and all delivery dates being relative to this start date

65. Review number

Review number: RV1, RV2, ..., RVn

66. Tentative timing of reviews

Month after which the review will take place. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

67. Person-months per Deliverable

The total number of person-month allocated to each deliverable.

PART B

COLLABORATIVE PROJECT

Table of Contents

B1. CONCEPT AND OBJECTIVES, PROGRESS BEYOND STATE-OF-THE-ART, S/T METHODOLOGY AND WORK PLAN

B1.1 Concept and Project Objectives

1.1.1. Introduction

In the next decade, an exponential growth of data traffic in fixed and mobile networks is expected. The major drivers for these developments are:

- Increasing number of internet-based services, such as community services and various kinds of interactive information and entertainment services - including bandwidth-hungry service such as HD or 3D video services (streaming, conferencing, …);
- Rapidly growing variety of devices, in particular mobile or portable devices such as smart phones, tablets or laptops;
- Intensified usage of any kind of online services, in particular by younger generations, independently of user's locations ("always online").

Today, customers can access services via fixed line networks or via mobile networks. Fixed broadband networks in Europe are currently dominated by different flavours of ADSL technologies which provide up to 16 Mbit/s. FTTCurb with VDSL are state of the art with access speeds up to 50 Mbit/s. Fibre to the home networks (FTTH) are the next step and first deployment have been started. These networks enabling data rate capacities of several hundred Mbit/s. In the mobile area, 2G and 3G networks are widely available and in some countries the deployment of LTE technology with data rates up to 100Mbit/s has been started. The next step is LTE advanced with data rates up to 1Gbit/s. Since in the mobile area a technology evolution from one generation to a next one takes about 10 years some early "5G" oriented research has been initiated, or will start soon.

Up to now, fixed and mobile access networks have been optimised and evolved independently, with partly contradicting trends (e.g. centralization of fixed networks, decentralization of mobile networks). Currently, there is a complete functional and physical separation of fixed line access/aggregation networks and mobile networks. As example, up to now the availability of locations for mobile base station sites and for fixed network central offices are not re-considered by each other for new deployments.

Today, Fixed Mobile Convergence (FMC) is mainly based on the service level with introduction of all IP services and IMS, and operators have started to build a converged service control layer. In contrast, this project focuses on the convergence of fixed and mobile access / aggregation networks themselves and their related functions as depicted in Figure 1.

A key aspect is scalability to cope in the most efficient way with the increasing number of customers, devices and traffic: this might lead to new distribution of functions in the converged network. For this reason, COMBO will also analyse, compare and merge the functionalities of the fixed and mobile core components. Target is to get a converged network architecture with a minimised number and optimised locations of network elements. The vision of the future would be one single network which can provide all functions in a simple way. Furthermore, this project will also consider aspects of service control, mobile core as well as the service creation points as far as it is necessary for the design of a converged and scalable network. Additionally, COMBO needs to understand, assess and merge the different evolutions in fixed and mobile networks to develop a future proof and optimised converged network. There is lot of uncertainty with respect to technological evolution due to many technical options in fixed and mobile networks.

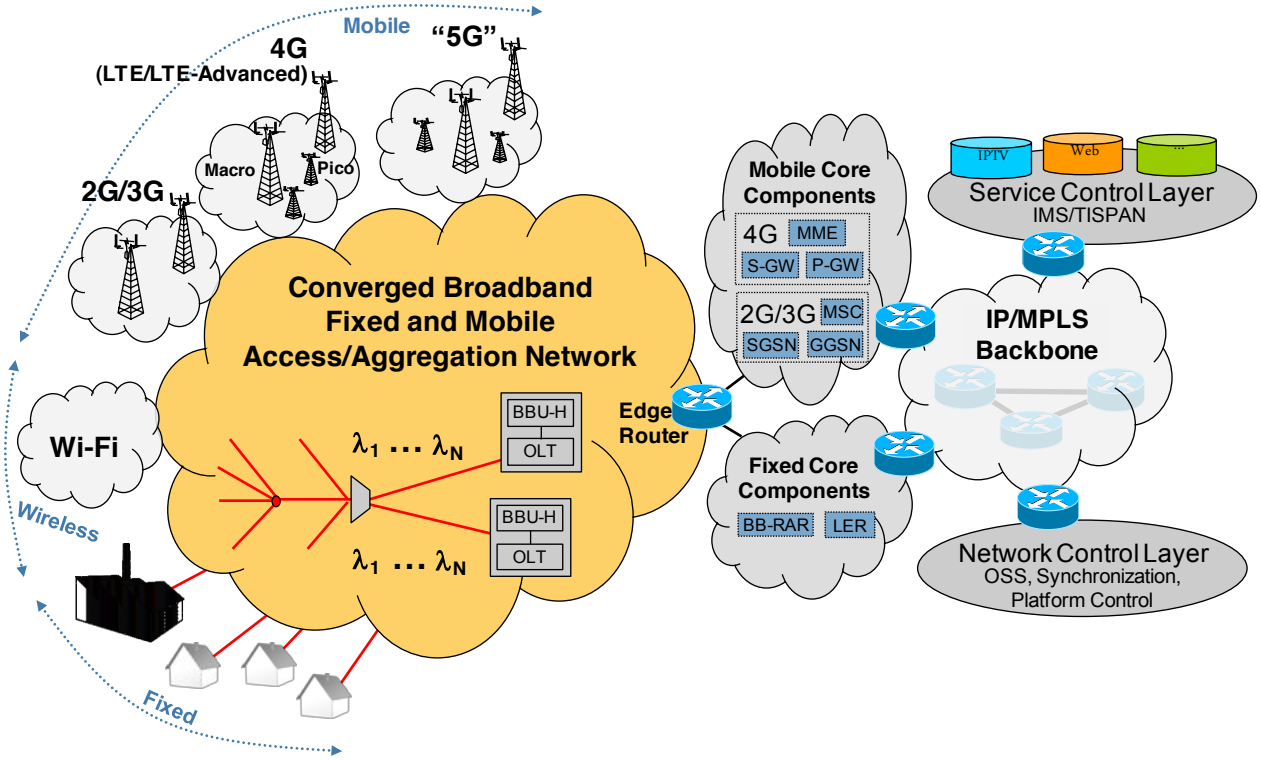

Figure 1: Scope of the COMBO project

1.1.2. Motivation

In the future, the telecommunications industry has to answer the following key questions:

- How to provide the user with a convincing experience of being always best connected and best served and to cope with the upcoming capacity demands, tremendous improvements in fixed and mobile access networks are required.
- How to cope with high cost pressure and stagnating revenues, future infrastructure solutions need to be much more cost efficient (which includes also energy efficiency) than current solutions.
- How to reduce the carbon footprint of the communication network even with strongly increasing traffic demands

It is further very important to understand that investments in access infrastructure are long term investments and more than 50% of total infrastructure investments. Therefore, a sustainable mid- and long-term network evolution strategy is required.

The COMBO project will answer the key questions by addressing the following challenges:

Challenge 1- Save Costs: The overriding challenge associated with any type of network or traffic evolution is to save cost both in the network for operators, including CapEx and more importantly long term OpEx, eventually for end users, while maintaining adequate quality of service and experience.

Challenge 2 – Deal with increasing traffic and changing applications: Traffic volume increase and end user application is a key challenge to understand within COMBO. It is well documented that traffic utilisation is in continuous growth both in terms of fixed line and mobile backhaul. The Cisco Visual Networking Index provides a view as to how this traffic is changing as well as other sources such as the

traffic flowing through Internet exchange points[1]. An average growth rate in European cities of more than 50% is recorded.

Coupled with traffic growth, the end-user applications are also going through transition. Traffic growth is nearly all coming from social networking and video on demand from over the top services such as YouTube, Skype etc. Data from Cisco's VNI shows the expected growth by application between 2010 and 2015 and video is by far the largest growth area[2]. Future FMC networks have to be flexible and scalable enough to deal with traffic increase and uncertainty.

Challenge 3 – Adapt Network structure: Whereas fixed line network evolution may warrant node consolidation (as analysed in projects such as OASE), future mobile network requirements may imply a required increase in the number of nodes. The subject of node consolidation at the same time as supporting more antenna sites needs to be a key consideration within COMBO.

Challenge 4 – Where to place Intelligence in the network: COMBO will address the question of where to place intelligence to support functionality such as distribution of content, handover mechanisms for nomadic use of cells within the network, handover between technology domains such as LTE, 3G and WiFi to support end-user services and other more network support oriented functionality such as OAM, synchronization distribution and multicast support.

Challenge 5 – Enable multi-operator/multi-vendor environment: Evolution in terms of network ownership and operator relationships is another challenge to consider in Fixed Mobile Convergence. Increasingly mobile operators are joining forces in many geographical areas to share costs and enhance the business model. Therefore the functions performed by a converged network need to be open and support multiple operators as well as multi-vendor interoperability.

Challenge 6 – Seamless performance monitoring and management in shared networks: In conjunction with the converged network, sharing of network resources requires common approaches to performance monitoring and performance management as well as defined network to network interfaces.

Challenge 7 – Reduce Energy: The efficient implementation of all functions described above under the constraints of a 20% reduction of energy consumption is a hard target but an important target given the ever increasing demands on energy in order to meet the increase in user traffic within the network.

An important approach to meet these challenges - followed by the COMBO project - is a joint optimization of fixed and mobile access and aggregation networks. It is expected, that significant synergy potentials, can be exploited by a converged network and significant benefits in terms of cost, network performance & quality and energy consumption will be achieved.

1.1.3. COMBO Concept

COMBO will target a unified access and aggregation network architecture allowing fixed and mobile networks to converge (Fixed / Mobile Convergence, FMC). This convergence of fixed and mobile networks will be driven by the requirement to combine an optimal and seamless quality of experience for the end user

[1] Source: Euro IXP Annual report 2010: https://www.euro-ix.net/documents/380-euro-ix-report-2010-pdf?download=yes

[2] http://newsroom.cisco.com/press-release-content?type=webcontent&articleId=324003

together with an optimised network infrastructure ensuring both reduced cost and reduced energy consumption.

"Convergence" is a trendy word, notably because it is seen as synonym for cost gains and also because it corresponds to the behaviour of end users, who care for the service whatever the technical means (3GPP, WiFi, DSL, fibre…). Beyond the trend, convergence of fixed and mobile networks is a very complex task, because convergence supposes trade-offs to make different things find interest to get closer. When several network domains taken separately are locally optimised (on their own scope), it does not imply that the situation is globally optimised. It is certainly worth accepting only partial optimization of some domains, if this leads to a global optimum for the entire scope. This is precisely COMBO strategy: globally optimising the fixed and mobile networks as a whole, even if this leads to sub-optimal architectures for the fixed network and the mobile network taken separately. Note that COMBO will not develop new physical interfaces, neither wireline nor wireless, but will concentrate on network design and architectures so as to jointly optimise fixed and mobile networks.

1.1.3.1. Overall Architecture

Today's fixed and mobile networks are separate:

- The fixed network is basically composed of 3 segments, the access network, the metropolitan/regional aggregation network, and the core network. The central office (CO) is the traditional boundary between access and aggregation networks, and this boundary tends to move towards the core network (optical node concentration, also called central office consolidation);
- The mobile network is composed of 2 segments, which are different from the fixed network segments: the radio access network (RAN, composed itself of the wireless access network and the mobile backhaul network) and the mobile backbone network. The traditional boundary between the RAN and mobile backbone network is the MTSO (Mobile Telephone Switching Office), also known as MSC (Mobile Switching Center) for circuit applications and SGSN (Serving GPRS Support Node) for packet applications. Note that LTE plans to merge the mobile backhaul network and mobile backbone network into a single converged backhaul and backbone network.

To achieve a global optimization of fixed and mobile networks, the COMBO project proposes a new access / aggregation network architecture organised around the innovative concept of Next Generation Point of Presence (NG-POP).**By NG-POP we designate the disruptive evolution of the first aggregation node**, also called Central Office (CO), or Local POP by opposition to more centralized POPs. This first aggregation node plays a key role in telco networks because it is the mediation between downstream segments which are connecting customers (access networks) and upstream segments characterized by converged flows (core networks). Hence this aggregation level has to deal with several constraints: a wide variety of services and technologies, scalability issue, regulation duties, operational constraints, to mention a few.

The NG-POPs will be higher in the network than the traditional central offices, thanks to optical node concentration, and will be able to host advanced functions of the mobile network such as Serving Gateways (S-GW) or Packet data network Gateways (P-GW). More generally, through this NG-POP concept, the COMBO strategy is to find a **better distribution of all essential functions, equipment and infrastructures of convergent networks**. This will drastically reduce ICT infrastructure costs and energy consumption, whereas guaranteeing an optimal and seamless quality of experience for the end user. The overall COMBO concept is illustrated in the figure below. The arrows of the drawing indicate either shifts of some network functions to the NG-POP (e.g. content distribution, S/P-GWs), or even structural changes such as optical node concentration or BBU hotelling. Such movements of functions or equipment are explained in more details below (1.1.3.2,1.1.3.3).

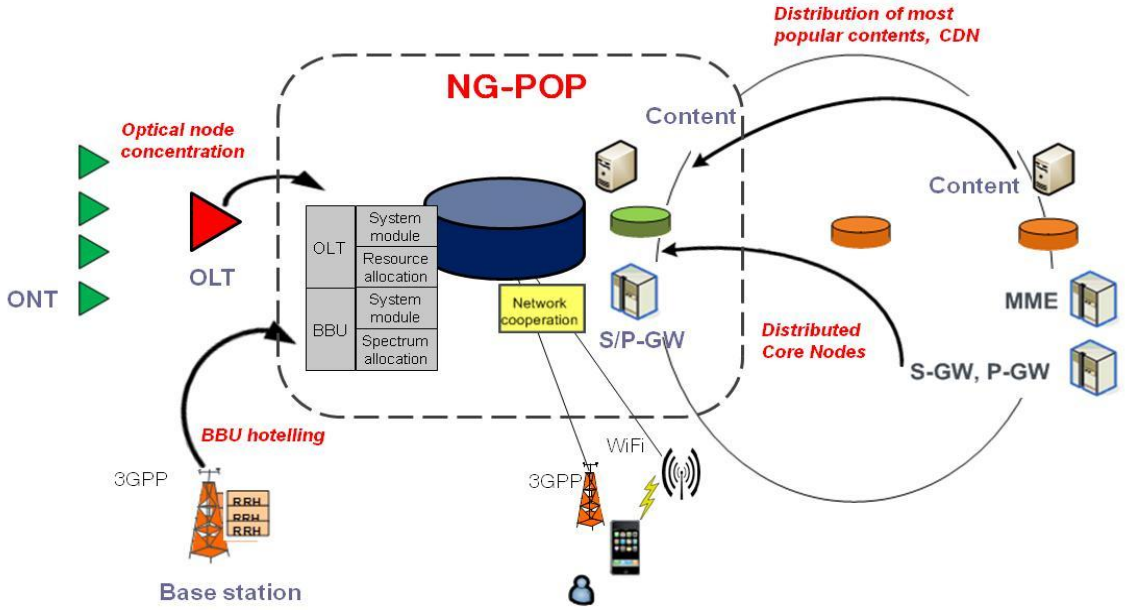

Figure 2: COMBO overall concept towards a Next Generation Point of Presence

From research concept to real field application, the NG-POP may very well take various forms and timeframes: e.g. progressive deployment or different services, depending on countries' contexts. Besides, as any disruptive evolution, this concept will generate operational transition challenges; some of COMBO stakes will thus be to analyse whether the expected gains are worth the transformation, and if yes how to smoothen it.

The ultimate NG-POP-based COMBO architectures will combine basically two important aspects of fixed / mobile network convergence:

- The convergence of fixed and mobile network functions, which we call **functional convergence**,
- The convergence of infrastructures and equipment, which we call **structural convergence.**

1.1.3.2. Convergence of Fixed / Mobile Network Functions (Functional Convergence)

The **convergence of fixed and mobile network functions** will allow key functionalities of fixed and mobile networks to be implemented uniquely at or below layer 3 (IP), ensuring **increased openness of network interfaces**, **collaborations between various access technologies**, a **unified control plane**, and also increased network efficiency through a **better distribution/localization of essential network functionalities**. This aspect of fixed / mobile convergence, which we call **functional convergence**, is schematically depicted on Figure 3. It will primarily impact the control plane of future networks through unified control mechanisms of fixed and mobile networks, but will also impact their data plane through an optimization of protocol stack and a better distribution of data flows in the converged network. Functional convergence will improve QoS, QoE and flexibility for the end user (e.g. coverage/accessibility and speed/comfort), it will also improve the service attractiveness and the openness of infrastructures, thus fostering collaboration between service providers and network operators. As an example, functional convergence would allow a WiFi community service provider to implement fast handover for its customers between its WiFi platform and the 3GPP network of another operator, thanks to unified control of heterogeneous networks and technologies as well as homogenization at functional level of authentication and subscriber management.

As the wireless segment of FMC networks can be composed of base stations using different access technologies (WiFi, WiMAX and LTE/LTE-A) and different cell sizes (macrocells, microcells, picocells, femtocells), functional convergence will be needed to provide interconnection of all the components of these heterogeneous networks and technologies. It will allow optimised localisation and integration of functionalities (e.g. (centralized) mobile base band processing) to enable efficient network level load balancing schemes by means of dynamic routing (BS as a router). Energy aspects will be also taken into account in such kind of meshed BSs deployment to enable network sleeping tools when possible. Moreover, effective traffic offloading strategies by means of IP flow mobility in multi-access environment will be studied in COMBO to solve network capacity problems and to avoid congestion in the network. COMBO will in particular target a better distribution and localisation of EPC advanced functions such as P-GW to decrease the load of EPC, as depicted on Figure 4. The outcome of all these advanced functional mechanisms that are expected to be developed within the COMBO project is the enhanced mobile segment of FMC network architecture that is able to support enormous traffic growth generated by thousands of current and future services and applications.

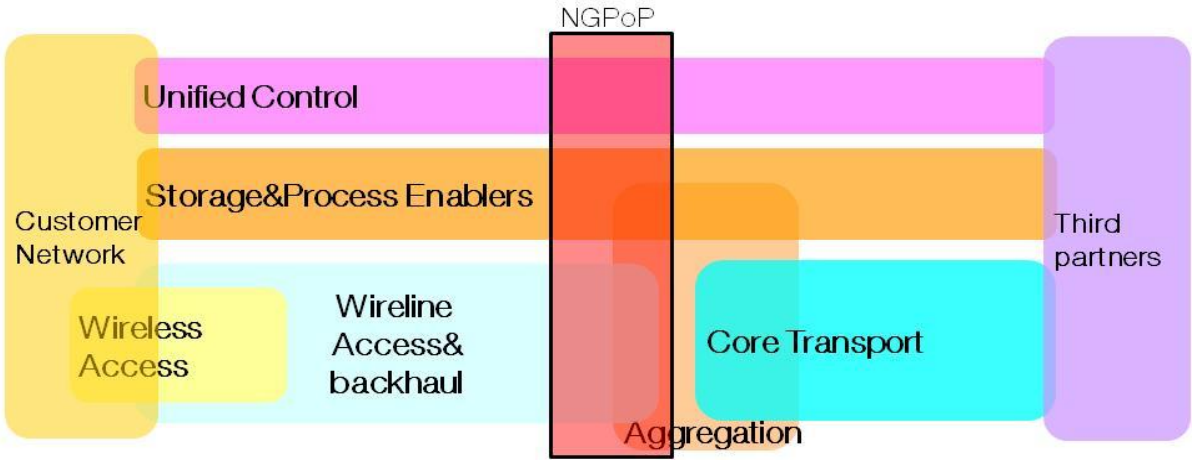

Figure 3: Convergence of fixed / mobile functions towards NG-POP

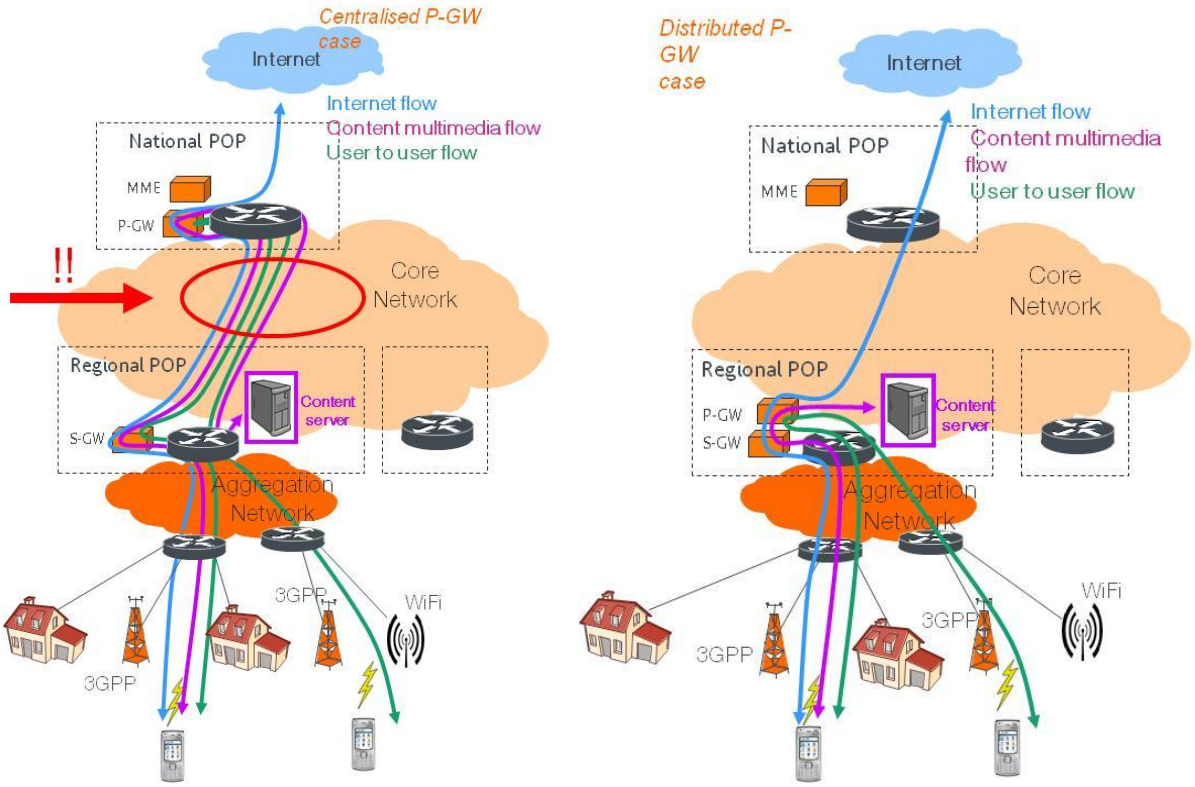

Figure 4: Example of functional convergence: distribution of P-GW functionalities at regional level

From a business perspective, functional convergence is getting more familiar to the Telco market and it is one of the most important targets because there is much work to do. Large companies which combine fixed and mobile networks are seeking functional convergence, because it will provide them differentiated products and services to offer to the users, who will be able to get wider QoS and QoE, paying only one subscription. MVNO´s operators are also interested by functional convergence so as to cut costs generated by traffic data paid to its wholesalers. For all these reasons, functional convergence is strongly expected in the incoming business models inside the Telco world.

1.1.3.3. Convergence of Fixed / Mobile Equipment and Infrastructures (Structural Convergence)

Structural convergence is defined as the **mutualization** of fixed and mobile access / aggregation network **infrastructures and hardware (e.g. cable plants, cabinets, sites, equipment, buildings)**. To reach this requires a deep understanding of both worlds and common network design targeting an overall optimum is required. This convergence of fixed and mobile equipment and infrastructures is depicted schematically on Figure 5. It will be fostered by central office consolidation and BBU hotelling techniques, and aims at defining **joint fixed/mobile equipment and infrastructures for access and aggregation networks**. It will optimise the use of the most costly part of the network, and thereby drastically decrease cost and energy consumption, thus improving the return on investment of access/aggregation infrastructures and fostering large scale deployments of very high fixed and mobile broadband in Europe.

Structural convergence is an important target of COMBO. More specifically, COMBO will propose new mobile backhaul architectures that allow to move the mobile-traffic processing equipment (which takes place in the so called Base Band Unit, or BBU) in a separated and possibly distant location at NG-POP, that can be far from the antenna location (reduced to a Remote Radio Header or RRH). Furthermore, structural convergence will also allow central office consolidation of fixed networks to be performed in strong synergy with the development of mobile access infrastructures: COMBO will thus target convergence of traditional

PON access and dedicated wavelengths for mobile traffic backhauling on a single fibre infrastructure, or even on a single equipment, as illustrated on Figure 5.

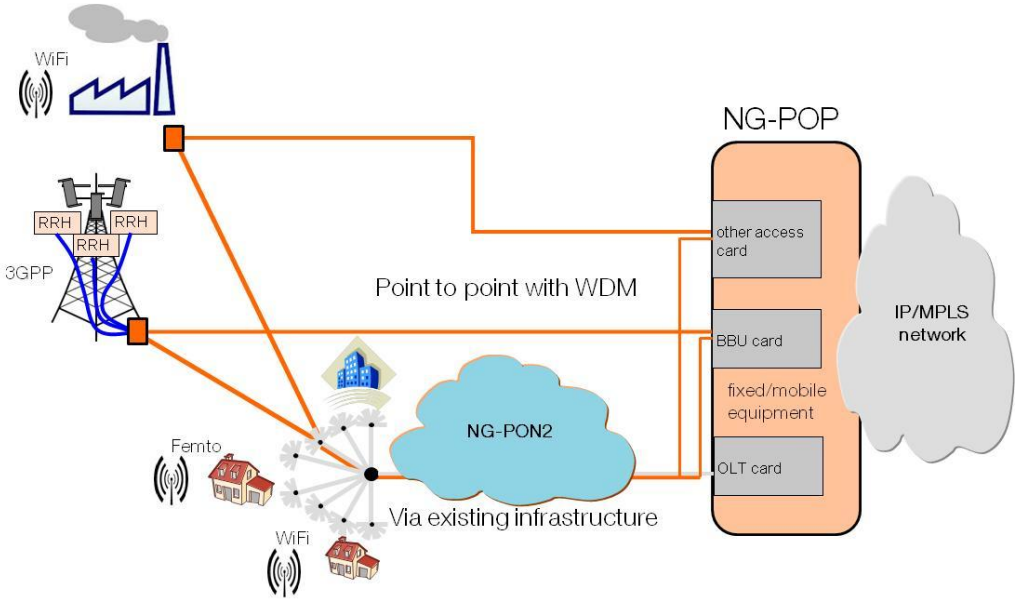

Figure 5

1.1.4. Scientific and Technological Objectives

The end goal of the COMBO project will be to demonstrate concepts of potential convergence and mutualization of fixed and mobile access / aggregation networks that allow for a significant reduction of cost per bit and energy consumption, to prove their feasibility and benefits, to propose specific solutions for their implementation and to validate them experimentally. This end goal can split into a set of four key objectives, which we call **targets**, to be achieved during the three years of the project:

- **Target 1: Definition of optimised FMC architectures;**
- **Target 2: Assess multi-operator FMC scenarios;**
- **Target 3: Experimental demonstration of FMC in lab tests and field trials;**
- **Target 4: Drive standardization bodies with respect to FMC architectures.**

To ensure a clear mapping of these four targets with the work plan, they are refined into a number of more specific and measurable objectives. The four COMBO targets and related specific objectives are described below, together with the means of verification of the specific objectives (refer to the work plan in section 1.3 for details on the milestones and deliverables).

Target 1: Definition of optimised FMC architectures

The realization of this target will be performed through:

- the definition of a framework for techno-economic assessment of FMC architectures (including the definition of reference areas and FMC network scenarios);
- the establishment of requirements and KPIs for the assessment of FMC networks;
- the architecture definition, taking into account how fixed and mobile networks will evolve in the medium term and which will be the traffic evolution;
- the techno-economic and energy efficiency assessment of state-of-the-art broadband access architectures, for comparison with the proposed FMC architectures;
- the investigation of scalability and fault localization potential in the different architectures;
- the development and use of models and methods for optimization of the architecture, topology, configuration and performance.

The assessment of final FMC architecture propositions will allow identifying the most suitable architectures for the various reference areas and use cases, thanks to a comprehensive economic and energy efficiency analysis of these architectures. The specific objectives related to target 1 are described in the following table:

Description of specific objectives	Work packages addressing the objective	Year of completion of the objective	Means of verifications (milestones & deliverables)
SO1.1: Establish requirements and KPIs for the assessment of FMC networks	WP2	Y1	M2.1, M2.2, D2.1, D2.2, D2.3, D2.4
SO1.2: Make a survey of passive and active monitoring parameters and tools and study their relationships to QoS, QoE and KPIs	WP4	Y1	M4.1, D4.1
SO1.3: Prepare the techno-economic assessment framework and reference scenarios of FMC architectures	WP5	Y1	D5.1
SO1.4: Develop FMC architectures and appropriate performance monitoring solutions	WP3, WP4, WP5	Y2	M3.2, M3.3, M4.2, M5.1, D3.2, D3.3, D4.2, D5.2
SO1.5: Determine optimised FMC architectures	WP5, WP3	Y3	M3.4, M5.2, D3.4, D5.3

Target 2: Assess multi-operator FMC scenarios

The realization of this target includes the development and assessment of multi-operator scenarios based on:

- emerging needs, such as network virtualization and programmability, increased openness of network interfaces and fair access to network resources;
- advanced functions, such as authentication and mobility management, service continuity, access to specific services;
- transversal handover between different operators and virtual operators, as a key feature of future FMC networks;
- the implementation of Software Defined Networking concepts, such as Open Flow or FORCES in FMC networks, allowing a common simplified control and management of packet and circuit flows and network APIs for future NaaS solutions.

The proposed multi-operator FMC network architectures will be assessed in terms of openness and flexibility for network operators and service providers, and also in terms of cost and energy efficiency. The impact of these architectures on business ecosystems will be thoroughly analysed. The specific objectives related to target 2 are described in the following table:

Description of specific objectives	Work packages addressing the objective	Year of completion of the objective	Means of verifications (milestones & deliverables)
SO2.1: Develop multi-operator FMC scenarios	WP3, WP4	Y2	M4.3, D3.2, D4.3
SO2.2: Assess multi-operator FMC scenarios	WP3, WP4, WP5	Y3	M3.4, M5.2, D3.4, D4.4, D4.5, D5.3

Target 3: Experimental demonstration of FMC in lab tests and field trials

The realization of this target will be performed though:

- the formulation of a test plan for each function type and a gap analysis, performed by vendors, in order to plan the equipment needed or beyond state of the art functionalities required;

- a survey of passive and active monitoring parameters and tools and of their relationships to QoS, QoE and KPIs;
- implementation and validation of new functions in lab based experiments;
- the deployment of FMC functionality in close to real-world environments, while focussing on multi-operator and multi-vendor operation;
- the practical evaluation of FMC performance management concepts in these field trials.

Results and lessons learned associated with this target will be used to underpin dissemination activities with real-world data. The specific objectives related to target 3 are described in the following table:

Description of specific objectives	**Work packages addressing the objective**	**Year of completion of the objective**	**Means of verifications (milestones & deliverables)**
SO3.1: Develop test cases, test lab requirements, and set-up of test-labs infrastructure suitable for research on FMC aspects	WP6	Y1	D6.1
SO3.2: Move experimental work into lab based experiment and plan field trials	WP6	Y2	M6.1, M6.2, D6.2
SO3.3: Move experimental work from lab phase into field trial phase with operators	WP6	Y3	M6.3, M6.4, D6.3

Target 4: Drive standardization bodies with respect to FMC architectures

This target will be achieved by:

- pushing initial COMBO ideas towards specific standardization bodies, which are key to fixed and mobile network evolution and where COMBO partners are already particularly active: FSAN, ITU-T SG15 Q2 & Q6, IEE 802.3, WDM PON forum, Open Lambda Initiative, eth-wdm-phy group, 3GPP, NGMN Alliance, BBF, IETF, Wi-Fi Alliance;
- simulating interactions between these different bodies on FMC issues;
- proposing COMBO contributions to the relevant standardization bodies, which are key to fixed and mobile network evolution.

Note that each standardization body has its own logic and vision which might be difficult to change quickly. A gradual approach will thus be adopted to build COMBO contribution to standards, so as to make the various logics/visions converge ultimately. In particular, COMBO will analyse whether the gains from FMC architectures are worth the transformation, and if yes how to smoothen it: the corresponding migration scenarios themselves will be pushed into standards so as to guarantee actual implementations.

The specific objectives related to target 4 are described in the following table:

Description of specific objectives	**Work packages addressing the objective**	**Year of completion of the objective**	**Means of verifications (milestones & deliverables)**
SO4.1: Initial concepts of new FMC architectures proposed to relevant standardization bodies	WP3, WP4, WP7	Y2	M3.2, M3.3, M4.2, M4.3, D3.2, D3.3, D4.2, D4.3, D7.3
SO4.2: Drive standardization bodies with respect to FMC architectures	WP3, WP4, WP5, WP6, WP7	Y3	M3.4, M5.2, M6.3, M6.4, M7.3, D3.4, D4.4, D5.3, D6.3, D7.4

B1.2 Progress Beyond the State of the Art

In this section we describe the State of the Art (SOTA) of access and aggregation network architectures in support to both fixed and mobile services, and we discuss the advances that the project COMBO proposes. To ease the exposition, we first treat the SOTA in the two network domains (fixed and mobile) separately, and then we discuss SOTA and progress beyond the current state as envisioned in COMBO in Fixed-Mobile-Converged architecture.

1.2.1 State of the Art in the Fixed Network Segment

The increasing traffic requirements for residential users and for mobile backhauling will put additional pressure on the *fixed network segment*, i.e., the current combination of access and aggregation networks in support to fixed services (e.g., Wi-Fi, residential services, etc.). In the rest of this subsection, we focus on the SOTA in the access and metro network segments.

As for the **access network**, today's most-adopted access network technology is the **Asymmetric Digital Subscriber Line** (ADSL), which is deployed over the existing telephone lines starting from the central offices (CO). With ADSL2+, ITU-T G.992.5, up to 24 Mbit/s in the downstream can be provided. The main limitation of ADSL is that the available bandwidth for the user depends heavily on the copper loop length and quality. For this reason, ADSL providers do not offer services to customers more than 7 km away from the CO. To overcome this limitation, operators have started to deploy fibre-to-the-cabinet solutions, based on **very-high-bit-rate DSL** technology (VDSL2 – ITU-T G.993.2), such that the used copper loops length can be significantly reduced to less than 1.5 km. This will enable a higher bandwidth, and up to 200 Mbit/s can be delivered in downstream for the most advanced band-plan. In a recently (February 2011) started ITU-T standardization project **G.fast**, the fibre is deployed to the last distribution point in the telephony grid, enabling access rates of more than 1 Gbit/s for short loops. Another alternative for fixed access is through **Cable Television** (CATV). CATV networks provide Internet services by dedicating some Radio Frequency (RF) channels in co-axial cable for data, offering up to 100 Mbit/s to be shared among the active users in a cable segment.

Another way of reducing access bandwidth bottlenecks is to deploy true **Fibre to the Home** (FTTH) solutions, providing the fibre directly to the home. For implementing FTTH typically two technologies are used. One is the **Point-to-Point optical Ethernet** technology with a dedicated fibre to the costumer, offering typically 100 Mbit/s or 1 Gbit/s access to customer. The other technology is based on **Passive Optical Networks** (PONs) [1], i.e., point-to-multipoint access network based on passive components such as optical power splitters or wavelength division multiplexing (WDM). Today's PON are based on TDM (Time Division Multiplexing) technique and typically support 32-64 users in order to share the network cost among multiple users.

Mainly, two PON solutions are deployed: the Ethernet PON (EPON) with 1 Gbit/s [2] and Gigabit-PON (GPON) with 2.5 Gbit/s shared among the users [3]. Recently, the Next Generation (NG-PON) solutions have been standardised by ITU-T and IEEE, enabling bit rate up to 10 Gbit/s. These systems [4] are called NG-PON1 (ITU-T G.987) [5] and 10GEPON (IEEE 802.3av) [6]. Currently the NG-PON2 working group at FSAN/ITU is looking into new solutions in order to improve PON system capabilities, achieving, e.g., higher bandwidth, longer reach and higher split ratios. A wide range of technologies will be studied, e.g., novel modulation formats, and architecture options as WDM-PON, but NG-PON2 is not expected until 2015. The candidate solutions can be based on the increased number of wavelengths (WDM-PON) [7], use of code multiplexing (CDMA-PON) [8], addition of sub-carrier multiplexing (OFDM-PON) [9], or a combination of these technologies, and even combinations with TDM-based technologies.

While the access networks described above span over distances of a few kilometres, the **metro network** typically covers distances of a few tens or hundreds of kilometres. Metro networks are traditionally based on a deep-rooted legacy of **SONET/SDH** ring networks. Recently, Ethernet technology has been largely adopted also in the metro segment. Ethernet interfaces are less expensive than an equivalent SONET/SDH interface and yet support high bandwidth and fine granularities. A pure **Metro Ethernet Network** uses only layer 2 switches, enriched with new functionalities such as transparent tunnelling of traffic through Virtual LANs, VLAN Stacking, and VLAN Translation. Additional carrier class features have also been added via IEEE 802.1ad (Provider Bridges, also known as QinQ or stacked VLANs) and IEEE 802.1ah (Provider Backbone Bridges, also known as MAC in MAC or PBB) and IEEE 802.1Qay (Provider Backbone Transport, also known as PBT or PBB-TE). Another competing technology in the metro segment is Resilient Packet Ring (RPR), IEEE 802.17, a standard designed for the optimised transport of data traffic. Finally, metro network may include other transport technologies, such as MPLS and MPLS-TP, each with its own resiliency and management solutions.

An emerging WDM-PON technology, called **Long-Reach PON** (LR-PON), promise to extend the coverage of standard PONs to 100 km and above by exploiting optical amplification and WDM. Note that PON reach extenders have also been standardised in [10], and they enable increased splitting ratio together with up to 60 km reach, eventually allowing the optical access technology to penetrate into the metro area. Compared with traditional metro solutions, an LR-PON consolidates the multiple central offices in one site (usually referred to as node consolidation), thus significantly reducing Capital Expenditure (CapEx) and Operational Expenditure (OpEx). The subject of LR-PON has been investigated in the OASE project and we plan in COMBO to evolve the knowledge developed in OASE to cover the role of such long reach optical access architectures where fixed and mobile network converge over the same infrastructure.

Two more trends in the metro/aggregation networks will have strong impact on the COMBO project. Firstly, it is envisioned that the current standard ring topology will evolve towards **mesh topologies**, which provide redundancy at a lesser cost than ring based topologies and new opportunities for integration between fixed and mobile networks. This will for example enable node consolidation coupled with the need to provide coverage to a larger number of mobile base stations. Secondly, video and content distribution servers have traditionally been placed in large data-centres positioned in the core area of the network. The trend today is place some video and content distribution servers directly in the metro area, closer to the customers, where they could be mutualized between fixed and mobile customers thanks to the COMBO architecture.

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1.2.2 State of the Art in the Mobile Network Segment

To support an explosion of both data and signalling traffic, new broadband access technologies are being developed in the mobile network segment; where the most promising are **LTE/LTE-Advanced** for cellular networks and **WiFi**,**WiMAX** technologies for wireless networks. These technologies are able to provide high bit rates to support broadband access for a large number of mobile users.

The **LTE technology** improves the throughput of cellular radio access up to 100 Mbit/s in the downlink and up to 50 Mbit/s in the uplink, respectively. The technology uses radio frequency (RF) channel bandwidths between 1.25 and 20 MHz [11]. The **LTE-Advanced** concept aims for peak bit rates of 1 Gbit/s in the downlink and 500 Mbit/s in the uplink with RF channel bandwidths up to 100 MHz [12]. In case of LTE-Advanced, the spectral efficiency comes close to theoretical bounds (the Shannon limit) due to the use of effective transmission schemes based on OFDM (Orthogonal Frequency Division Multiplex) and MIMO (Multiple Input Multiple Output).Moreover, 3GPP has also introduced new concepts in the LTE-Advanced radio access network (RAN) to increase network performance such as (i) the possibility of having cooperation between base stations (e.g. **Coordinated Multi-Point** (CoMP) [20]) transmission and reception) based on **meshed** interconnection topologies between the enhanced NodeB (eNBs), and (ii) the coexistence of different cell sizes (**macrocells**, **picocells**, **femtocells**) within the same area, so-called Heterogeneous Networks (**HetNets**) [13], [19]. For these features, the X2 interface is introduced to allow direct communication between eNBs, not only to speed up mobility procedures and radio resource management, but also to allow for fast exchange of data to enable coordinated multipoint (CoMP) or cooperative MIMO (e.g. exchange of baseband data for joint signal processing in a "network MIMO" fashion). Radio backhaul requirement for CoMP and for main-remote connections can be quite stringent. A LTE pico radio BS with CoMP requires a backhaul solution that can handle a bandwidth 150 Mbit/s + 30% around 200 Mbit/s with a delay of 8 ms while a main-remote connection using the CPRI protocol with a 3 sector RRU requires a bandwidth of 2.5 Gbit/s with a delay below 200 μs and jitter below 9 ns [20]. On the other hand, in the HetNet vision, a network of small base stations with reduced coverage is deployed in massive numbers as an additional layer to the macro network to provide capacity and coverage enhancements. They can be deployed in a loosely coordinated fashion (e.g. exploiting street infrastructure or at the customer premises) and can co-exist with macro network due to **Self Organized Network (SON)** capabilities providing a dynamic and efficient radio resource and mobility management.

Similar results as in LTE/LTE-A as for the efficiency of bandwidths may be potentially reached in the WiMAX technology. Thus, the standard IEEE 802.16e defines full mobility support in WiMAX. It provides data rates up to 75 Mbit/s. The IEEE was released the new standard, "IEEE 802.16m-2011", sometimes called **WiMAX II**, which is expected to deliver data rates up to 1 Gbit/s.

WiFi technology operates in the 2.4 GHz or 5 GHz bands that are designated as "license-free" [21], and is based on a set of standards, namely IEEE 802.11. The recently defined standard IEEE 802.11n-2009 allows essentially increasing network throughput up to 450 Mbit/s with the use of four spatial streams at a channel width of 40 MHz [22]. Moreover, upcoming "Next Generation" WiFi (NG WiFi) standards such as 802.11ac (operating at 2.4 GHz or 5 GHz bands) or 802.11ad (operation at 60 GHz band, mainly based on the WiGig industry forum specifications) will support data rates of multiple Gbit/s [23].Taking into account the limitations of the radio frequency resources and the rapidly increasing demand for higher data rates, the use of LTE and NG WiFi technologies may be considered as the most promising ones for the mobile network segment.

To support mobility of users between multiple heterogeneous access networks (generalized mobility), including both 3GPP (e.g. WCDMA/HSPA and LTE) and non-3GPP systems (e.g. WiFi, WiMAX or a fixed access technology), 3GPP defines an IP-based network IP core architecture called System Architecture Evolution (SAE) or Evolved Packet Core (EPC) [24]. The SAE/EPC architecture supposes a fully meshed approach between access gateways (AGs) and eNBs with tunnelling mechanism over the IP transport network [14], [15]. As the core has to handle very high volumes of aggregated traffic, increasing towards the Packet Data Network Gateway (PDN GW), a number of solutions are being conceived to offload the core network (EPC) by means of WiFi or small BSs. Some examples of such offloading solutions are LIPA, SIPTO, I-WLAN, IFOM, and MAPCON [16], [17], [18].

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1.2.3 Progress in Fixed-Mobile-Converged Network Architectures

COMBO will develop and assess **new schemes, strategies, scenarios for a novel FMC network architecture** based on the mutual dependencies and requirements of the fixed-network infrastructure and mobile/wireless access **to provide performance benefits, to develop correct deployment strategy, to improve the capacity of the network and the end user quality of experience as well as to reduce deployment costs and to minimize energy consumption**. In the remainder of this section, we first discuss the SOTA of the fixed-mobile convergence, and then we describe the advances that COMBO will bring in the field of FMC network, classified as advances in functional and structural convergence of Fixed Mobile Converged network architectures.

1.2.3.1 State-of-the-Art of Fixed Mobile Converged (FMC) Network Architectures

Nowadays, convergence of the fixed and mobile network segments becomes critical for network operators to effectively address the challenges arising with the ever-increasing traffic, the revenues stagnation, and the increasingly strong competition coming from OTT, device and OS makers [25].

Fixed Mobile Convergence (FMC) is often seen as a transition point in the telecommunication industry that eliminates the differences between fixed and mobile networks from the user's point of view: it enables customers to have seamless services on their terminal (PC, Smartphone or tablet) that uses a combination of fixed broadband and local access wireless technologies. Today, FMC is mainly based on the service level with introduction of all IP services and IMS operators have started to build a converged service control layer. With this restricted definition, FMC is already a fact. However, the fixed mobile convergence on the network perspective is still to come, since access and aggregation networks for fixed and mobile services have been traditionally designed, evolved and optimised independently from one another. Currently, there is a complete functional and physical separation from fixed line access/aggregation networks and mobile networks.

From a network perspective, **up to now, the interaction between fixed and mobile networks** was taking place **through a simple backhaul by tunnelling** the mobile traffic through the fixed network in dedicated CBR pipes. Since traffic is tunnelled, and all flows are treated the same way, e.g., being provided with the highest QoS class, operators have different options to implement mobile backhauling. Current modes of operation employ E1 (PDH) circuits over copper using point-to-point links or SHDSL, or over fibre using SDH with separate fibre pair (dark fibres). Alternatively, GbE over fibre can be used either standalone or, using STM-16 over SDH with separate fibre pairs or colour of light (WDM). Finally, microwave links are also common for mobile backhauling.

Nowadays, the traditional base station architecture containing control functions, baseband processing and modulation in the same equipment, and antennas located at a few tens of meters from the latter one, on a roof or on a tower, has evolved towards more distributed architectures with **Digital Radio over Fibre (D-**

RoF). A very simple device (the remote radio header) that mainly includes frequency conversion and power amplifier is put in the tower and all processing is centralised in the BBU. The link between the RRH and the BBU supports the digital transmission of the quantified baseband analogue signal (I and Q components). As the RRH is a very small and cheap device, it can be massively deployed to generate a large number of small cells and it is a very interesting off-loading solution for traditional cellular networks. Furthermore, as the RRH is technology agnostic, the same device can be used for LTE, WiFi, WiMAX, etc. This opens the way to the concept of **Cloud Radio Access Networks (C-RAN)**. Several initiatives for the standardization of these new architectures exist, such as the Open Base Station Architecture Initiative (OBSAI), the Common Public Radio Interface (CPRI) that specifies the D-RoF transmission between RRH and the BBU, and the OpenRadio equipment Interface (ORI) within ETSI that was created in May 2010 and is direct result of the work of the NGMN Alliance (OBRI, Open BBU RRH Interface). Several manufacturers already propose solutions compliant with CPRI like Alcatel with LightRadio [26]. C-RAN is a very promising solution but dramatically increases the load in the access network, as the required bit-rate is typically 100 Mbit/s to control one RRH supporting one UMTS 5-MHz carrier.

If D-RoF is rolled out, existing simple backhaul technologies will not work any longer, because of the very high bitrate requirements of D-RoF. Today, fibre-based high-speed links (e.g. 10 Gb Ethernet) are the most promising technology for D-RoF streams, but CPRI flows over a 2.5 Gbit/s microwave link has recently been demonstrated in an Ericsson internal project. Present fibre based backhaul rely on independent fibres used in the access network for the backhauling, which is an apparent waste of resources, and this trend will become even worse if one considers the strong increase in the number of base stations and remote antennas to respond to the high traffic demands. Therefore, converged network design of mobile networks together with FTTH network would allow significant cost savings and a much more efficient utilisation of infrastructures and systems.

The problem is then to define a strategy that enables an operator to offer the best service delivery by taking advantage of its infrastructures, i.e., fixed and mobile networks and service platforms, while allowing all other network operators and service providers to leverage network operators' infrastructures. Two possibilities can be envisioned for network evolution:

- Take advantage of 3GPP standardized network, connecting 3GPP and non 3GPP accesses (mobile and fixed) to 3GPP gateways as a smooth migration strategy from legacy networks [27], [28], [29], [30].
- Design a new core natively supporting any access network, i.e., truly enabling convergence between access networks.

For instance, the first scenario allows efficient offloading solution if needed. The second one is a long-term variant of this strategy where network architecture will enable natively and efficiently this optimised service delivery scheme: this is precisely the COMBO target. This fixed-mobile harmonization strategy can be built from two essential and complementary aspects of fixed / mobile network convergence: convergence of fixed / mobile network functions and convergence of fixed / mobile equipment and infrastructures. In the next two Subsections 1.2.3.2 and 1.2.3.3, we categorize the advances that COMBO will bring in these two complementary aspects.

[25] "Market Insight - Will mobile operators be able to change the business model and charge service providers to pay fees linked to usage?",http://www.mobixell.com/uploads/Newsletters/Newsletter_Jan_11.html, last access the 20/07/2011
[26] http://www2.alcatel-lucent.com/blogs/techzine/2011/lightradio-baseband-processing-and-backhauling/
[27] TS 23.402 "Architecture enhancements for non-3GPP accesses", R.10, v10.4.0, 2011
[28] TS 33.402 "Security aspects of non-3GPP accesses", R.11, v11.0.0, 2011
[29] TS 23.139 "3GPP system - fixed broadband access network interworking; Stage 2", R.11, v0.2.1, 2011
[30] Cisco, "Top 10 Considerations for a Successful Evolved Packet Core (EPC) Deployment", last access on 2011/25/08, http://www.cisco.com/en/US/prod/collateral/wireless/ps11035/ps11047/ps11072/white_paper_c11-609202_ns1076_Networking_Solutions_White_Paper.html

1.2.3.2 Progress on FMC Network Architectures: Functional Convergence

Sharing the infrastructure of an access/aggregation network implies that the control functions responsible for this infrastructure take into account both mobile and fixed traffics. In other words, **the control planes of the fixed and mobile networks have to converge**, at least partially, in order to efficiently allocate resources.

This convergence can be achieved at different levels, depending on how the infrastructure sharing is performed. For example, if the sharing is limited to the allocation of different wavelengths channels on WDM links, the control plane has only to ensure that a given wavelength channel is just allocated once, either to fixed or to mobile traffic. A more complex set of networking functions has to be designed for a more complete convergence with finer granularity, e.g. the sharing of a common new MAC (called here a Meta-MAC) in the aggregation network. Ethernet-based architectures, and in particular those considered for delivering Carrier-Ethernet, are likely candidates for the Meta-MAC, as they are currently used both for backhauling mobile traffic and for operating fixed metro networks. COMBO shall also specifically consider Meta-MACs designed for transparent optical transport (such as OBS and OPS) in order to take advantage of their energy-friendly potential.

Specification of a Meta-MAC: The set of networking function to be designed to facilitate functional convergence would potentially include the specification of filtering and marking rules, used to classify fixed and mobile traffic into Meta-MAC SDUs, prior to encapsulation into Meta-MAC PDUs. Meta-MAC scheduling and forwarding principles should be defined (i.e. functions belonging to the data plane of the converged network), together with control plane functions such as routing. The following major points shall be addressed:

1. **QoS support**: This support can be achieved either by offering all traffic a single transport-level QoS, sufficient for the most demanding traffic, or by designing a multi-class Meta-MAC. Class differentiation can be supported both at SDU and at PDU level.
2. **Protection support**: Historically, all traffic were protected in circuit-based SONET/SDH aggregation networks. Packet based transport allows considering the support of multiple protection-level QoS, as proposed e.g. in RPR based aggregation networks.
3. **Routing**: Traditional aggregation/distribution metro networks rely on fixed Hub and Spoke routing for both fixed and mobile networks. COMBO shall assess whether there are some advantages in considering different routing schemes, either relaxing the Hub and Spoke option in order e.g. to limit latency, or even considering dynamic routing that could be useful if a mesh aggregation network is considered.
4. **Handover**: a converged architecture should support horizontal handover (as in mobile networks) between neighbouring cells, vertical handover between access techniques (both fixed and mobile) and transversal handover between different operators and virtual operators.

Beyond functions controlling data transport in the converged infrastructure, other networking functions shall be considered:

5. **Remote Base Band Unit (BBU) or BBU hotelling**: COMBO proposes to enable new backhaul architectures that allow moving the mobile-traffic processing (which takes place in the so called Base Band Unit, or BBU) in a separated and possibly distant metro location, that can be far from the base station.
6. **Synchronization**: eNodeB require synchronization in order to coordinate and to efficiently operate handover functions. COMBO shall study both the location of master clocks, and the process used to carry synchronization to the eNodeB stations.
7. **IGMP snooping or proxying**: IGMP is an IP layer protocol used to select an IPTV channel. Allowing L2 (Meta-MAC) equipment to perform IGMP snooping or proxying helps in reducing channel-zapping time. More generally, all functions related to multicast support have to be distributed within the COMBO access/aggregation network.
8. **Video distribution**: The major source of traffic in the future is expected to be video related. An efficient support of video traffic is based on optimizing the location and operation of video servers. It is expected that storage facilities shall be distributed closer to the end-users, which implies the specification of both storing and distributing contents. COMBO shall propose such specifications that allow mutualizing video distribution for both fixed and mobile users.

1.2.3.3 Progress on FMC Network Architectures: Structural Convergence

Once specified, functions have to be distributed over network equipment. At the level of fixed-mobile convergence in the sense of equipment and infrastructure mutualization (which we call structural convergence), some work has been done in the context of the European FP7 ALPHA project on Analogue Radio over Fibre technologies [31], [32] (see Section 1.2.4 for more details). In COMBO, Digital Radio over Fibre (D-RoF) is of higher interest because it has no linearity constraints, an advanced standardization and it is widely implemented by mobile station vendors. Moreover, D-RoF opens the way to BBU hotelling and C-RAN [33].

COMBO will contribute to the progress of the state-of-the-art of current separated fixed and mobile access/aggregation networks with a set of innovative architectural concepts:

- **Sharing of equipment supporting both fixed (OLT) and mobile (BBU) interfaces:** The advantages and feasibility of shared equipment supporting both fixed (OLT) and mobile (BBU) interfaces will be investigated. As an example, consider the problem of mobile backhauling. Nowadays mobile traffic is gathered from distributed sets of base stations typically with a dedicated backhaul. COMBO proposes to enable new backhaul architectures that allow moving the mobile-traffic processing (which takes place in the so called Base Band Unit, or BBU) in a separated and possibly distant location, which can be far from the antenna location (reduced to a Remote Radio Header or RRH). This kind of approach is usually referred to as **BBU hotelling**.
- **Node consolidation in a fixed mobile converged network**: Up to now, the availability of locations for mobile base station sites and for fixed network central offices are not re-considered by each other for new deployments. This leads to contradicting evolution paths. While the fixed networks access considers a node consolidation by reducing the number of central offices with pure passive long reach access up to 100 km, in mobile networks, a strongly increasing number of new active sites are expected. COMBO will provide new use cases and assessment tools for node consolidation in a fixed-mobile converged network.
- **Mutualization of equipment and infrastructures:** Other forms of fixed-mobile equipment integration can also be explored. These new approaches, by defining converged transport of fixed and mobile traffic, would allow large scale mutualization of equipment and infrastructures (e.g. cables, central offices, points of presence and all related networking and transmission equipment). This will be obtained through convergence of traditional PON access and dedicated wavelengths for mobile traffic backhauling on a single infrastructure, or through other forms of integration of mobile and fixed network functions in a single network object (see Figure 2 in Section 1.1.3). The technical challenges to develop such architectures are very compelling, since current architectures do not take into account requirements for backhauling of future mobile base stations (e.g., meshed fibre access networks with high throughput and very low latency).

In conclusion, to combine all benefits from fixed/mobile **functional and structural convergence**, COMBO will gather all proposed innovations in the concept of **Next Generation Point of Presence** (NG-POP). This NG-POP will thus gather, at local POP levels, all key functions and equipment of fixed and mobile access and aggregation networks, allowing a complete mutualization of fibre and equipment of access and aggregation networks, as well as an actual convergence of fixed and mobile network functions towards this NG-POP, including unified fixed / mobile control functions and distribution of content (Content Delivery Network). The overall target architecture of COMBO concept is depicted in Figure 2 of Section 1.1.3.1. This concept would bring large opportunities to network operators and service providers, by providing a unified open platform for future usages of ICT infrastructures, whether fixed or mobile or combined.

[31] F. Frank, B. Charbonnier, and C. Algani, "3GPP Compliant Downlink ACLR Performances Of PON Distributed Multiple UMTS FDD Carriers," in Access Networks and In-house Communications, OSA Technical Digest (CD) (Optical Society of America, 2010), paper AWA6.

[32] M. Popov, "The Convergence of Wired and Wireless Services Delivery in Access and Home Networks", Optical Fiber Communication Conference 2010, paper OWQ6, 21-25 March 2010

[33] China Mobile Research Institute "C-RAN - The Road Towards Green RAN", White Paper, Version 1.0.0 (April, 2010)

B1.3 S/T Methodology and Associated Work Plan

1.3.1 Overall Strategy of the Work Plan

WP1: Project Management and Coordination

This Work package will organise and implement decision-making, external and internal communication, administrative and technical control of the project. It will set the basis for coordination of the technical activities of WP2-7 and the interaction of partners, and establish links between project partners and the EU, as well as the ICT community.

WP2: Framework definition, Architecture and Evolution

This Work package will provide the general framework for fixed and mobile networks and assess current evolution trends. It will also identify the requirements and Key Performance Indicators (KPI) for COMBO project that will have to be considered during the FMC network architectures design.

WP3: Fixed Mobile Convergent architectures

This Work package will propose, define and technically assess candidate architectures for future Fixed-Mobile Convergent (FMC) networks. It will compare in detail (pros/cons analysis) the candidate FMC architectures with each other and with the reference framework defined in WP2.

WP4: Traffic and performance management

This work package will define the different measureable QoS parameters that reflect the FMC network optimization criteria, like capacity, quality and/or energy consumption. It will also develop a system for optimised network management based on performance monitoring and performance management tools.

WP5: Techno-economic Assessment

This Work package will quantitatively assess proposed FMC network architectures based on cost and energy consumption calculations, so as to determine the optimal level of convergence, which is the main goal of the project. It will also assess the impact of network convergence on business ecosystems.

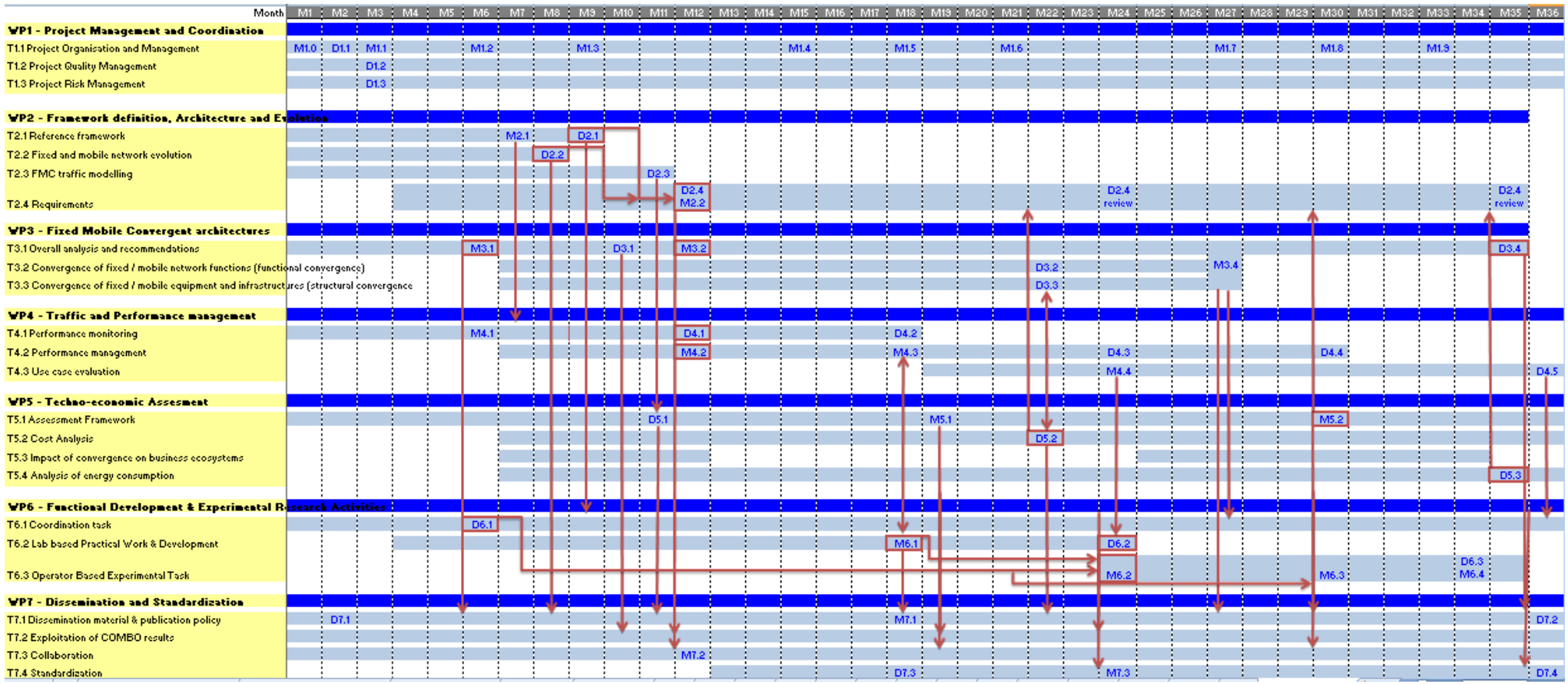
WP6: Functional Development & Experimental Research Activities

This Work package will bring vendors and operators together to demonstrate experimentally varying levels of network convergence identified within the project. This will include development of network functions beyond state of the art in the field of Fixed Mobile Convergence, based on a gap analysis.

WP7: Dissemination and Standardization

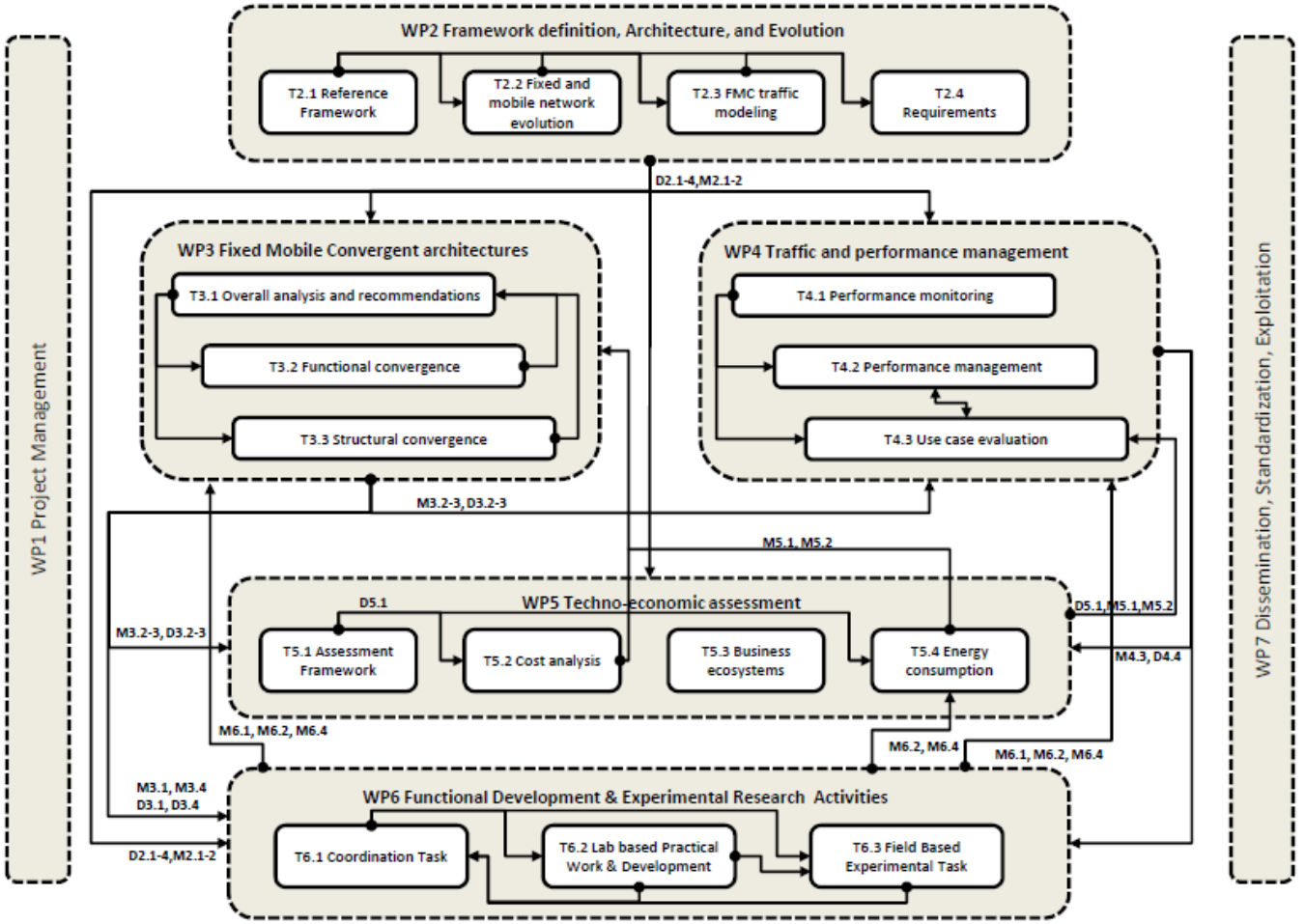
This Work package will coordinate and perform project results dissemination and exploitation. Particular focus will be on dissemination of the results and proposed FMC concepts towards different standardization and discussion fora.

1.3.2 Timing of the WPs and Their Components



Gantt chart

1.3.3 Task Interdependence



PERT diagram

B2. IMPLEMENTATION

B 2.1 Management Structure and Procedures

2.1.1 Overview

As detailed in the WP1 description, the management of the project has to ensure that the project is conducted in accordance with EC rules while reaching the objectives of the project within the agreed high quality level of work, financial budget and time scales.

The mandatory **Consortium Agreement** (CA) which main terms have been discussed and agreed during this proposal phase will be established before the start of the project; it will be maintained throughout the project's time life. In CA the detailed rules regarding composition of the COMBO project management bodies and their decision-making procedures will be described. In addition, the CA will define rights and obligations of the partners including, but not limited to, their liability and supplementing the provisions of the EU Contract concerning Access Rights. The CA will be supplementing, but not conflicting with the provisions of the EU Contract. In summary the Consortium agreement will follow the IPCA model, with some adaptations in accordance with the rules and organisation defined below.

The following deliverables produced at an early stage will establish the rules of project management: the Project Reference Manual, the Project Quality Assurance Manual and the Knowledge Management Guide. All the deliverables, the work and resources effort for the internal project management are covered and described in WP1.

2.1.2 Project Structure and Governance Scheme

The following Project Management structure adapted to the project size, and already implemented with success in past similar Integrating Projects has been agreed among the partners:
In a nutshell:

- The WP technical groups (chaired by the WP Leader) ensure day-to-day WP work.
- The Project Management Committee, chaired by the Project Technical Leader is the executive body of the project (under the guidance of the Project Steering Committee)
- The Steering Committee chaired by the coordinator establishes the main lines of the project
- The General Assembly chaired by the coordinator, approves the project budget and general annual objectives.

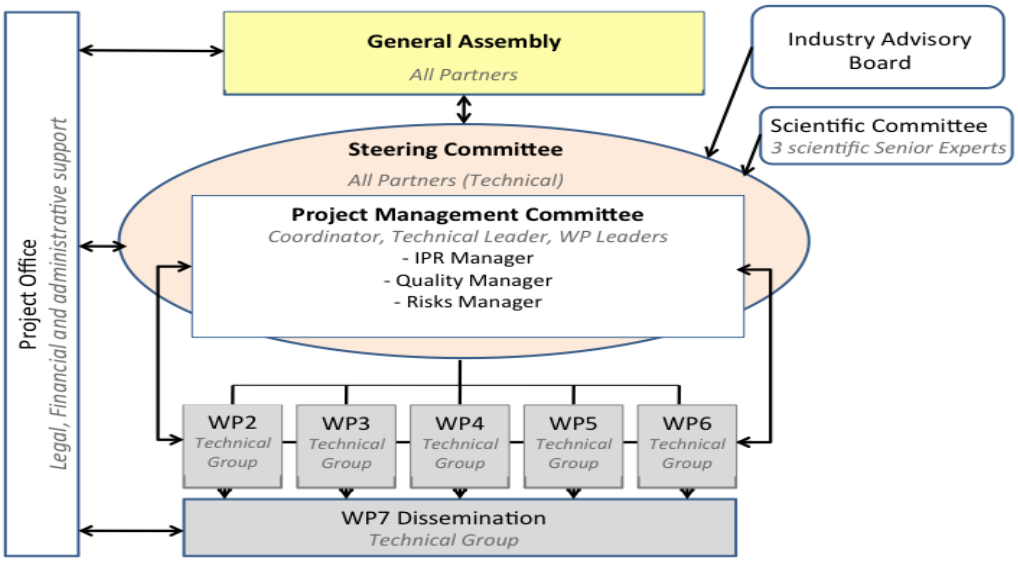


Figure 1: Project Management Structure

The operational groups are the following:

2.1.2.1 General Assembly (GA)

Composition

The GA comprises one representative of each Partner. Each Partner shall nominate a senior representative, with budget responsibility, able to make consistent decisions and to represent contractor's interests. The GA is chaired by the Co-ordinating Partner – JCP - and meets at least once a year.

Roles and responsibilities

The role of the General Assembly is to ensure the follow-up of the project and to take the major decisions mainly on the following contractual aspects:
Contract and Consortium Agreement amendment,
Termination of the contract and actions against underperforming partners,
Selecting new contractors to enter contract & consortium agreement;
Budget follow-up and eventual transfers,
The role and responsibilities of the General Assembly are detailed in the Consortium Agreement.

Decision making procedures

Decisions will be taken by consensus whenever possible; in case of conflict, decision will be taken by voting. In voting each Partner shall have one vote.

2.1.2.2 Project Steering Committee (PSC)

Composition

The Project Steering Committee is composed by one person (per partner) who is technically involved in COMBO. In its tasks, it is supported by the Project Office. The Project Steering Committee is chaired by the Coordinator.

Roles and responsibilities

The Project Steering Committee has the responsibility for the overall technical project progress and results in full conformance with the Description of Work and the decisions of the General Assembly.

The PSC decides on actions in case of deviations from project plan, and any changes of legal project documents if necessary.
In addition, the responsibilities of the PSC will address the following issues:

- Deciding on technical roadmaps for the project,
- Appointing the Quality Manager, the IPR Manager and the Risks Manager
- Approve the distribution of documents/publications outside of the project, Decisions on potential sub-contractors.

Decision making procedures
Decisions will be taken by consensus whenever possible. No voting will occur within PSC. In case of conflict or for decisions beyond PSC's responsibilities, PSC escalates it to the General Assembly.

2.1.2.3 Project Management Committee (PMC)

Composition
The Project Management Committee is composed of the Coordinator, the Technical Project Leader, the seven (WP1-WP7) Workpackage Leaders, the Quality Manager, the IPR Manager and the Risks Manager (see below). In its tasks, it is supported by the Project Office. The Project Management Committee is chaired by the Project Technical Manager.

Role and responsibilities
The Project Management Committee has the day-to-day responsibility and organisation for the overall project progress (objectives, schedule, milestones, etc), and approves project deliverables.
With the assistance of the respective Managers, the PMC also ensures the Quality, the management of foreground and IPR and the Risk Management aspects of the project.

Decision making procedures
Decisions will be taken by consensus whenever possible. No voting will occur within PMC. In case of conflict or for decisions beyond PMC's responsibilities, PMC escalates it to the PSC.

2.1.2.4 Project Coordinator

The Project Coordinator takes care of all the communication channels within the consortium to ensure progress and quality in the work and provides the Commission with technical, managerial and financial information. In this role, he is assisted by the Project Office and the PSC (see above). The project Coordinator will be Jean-Charles Point (JCP-Consult). The Project Coordinator chairs the General Assembly. His major tasks are:

- The preparation of the General Assembly, production of the minutes and follow-up of its decisions
- The Consortium Agreement coordination
- The collection of the audit certificates and supervision of distribution of EC's payments to partners
- The preparation with the support of the Project Steering Committee of the reports, cost statements and project documents required by the EC
- The organisation of EC review meetings
- The supervision of IPR and knowledge management (with relevant advice of IPR Manager)
- The Representation of the consortium to events
- The Coordination of the dissemination and communication activities

2.1.2.5 Project Technical Leader

The Project Technical Leader coordinates the technical activities of all partners in the project according to work plan. The Project Technical Leader is elected each year by the Project

management committee according to the CA rules. For the start of the project, **Dirk Breuer (DTAG)** has been assigned. He will have the following responsibilities:

- The chair of the Project Steering Committee and the Industry Advisory Board
- The liaisons between the Project Steering Committee and the General Assembly
- The technical relationship and coordination with other relevant R&D projects
- The supervision of the overall technical progress of the project
- The consolidation of the technical reports
- The follow-up and coordination of all technical work-packages
- Request for advices from the Scientific Advisory Committee

2.1.2.6 Quality Manager (QM)

To keep COMBO focused on its objectives of high quality technical outputs, market proximity and openness, the Project Steering Committee will appoint a Quality Manager. In the line of the **Quality Insurance Manual (D1.2)**, the Quality Manager will be asked periodically to review technical progress such that project remains innovative, open to collaborations and to market needs, forward looking. That will ensure that COMBO is producing work of high technical quality.

2.1.2.7 IPR Manager

An IPR (Intellectual Property Rights) Manager will be appointed by the Project Steering Committee. The IPR Manager will assess all IPR relevant information that are brought or developed in the project. In accordance with the Grant Agreement and the Consortium Agreement rules and based on the ownership of IPR, access rights and use of results shall be determined and regulated. The IPR Manager gives recommendations to the General Assembly on the handling of the assessed IPR issues. In his/her tasks, the IPR Manager may request the assistance of experts with IPR background recruited from the consortium partners. Knowledge management discussion will be planned on each PMC agenda.

2.1.2.8 Risks Manager

Having in mind that risk may have an impact on the project schedule and project objectives and finally may lead to contractual issues, a Risks Manager will be appointed by the Project Steering Committee. He/She will be asked periodically to review the project progress and the risks items table to ensure that COMBO remains online with its main technical objectives. He/She will be in charge of keeping up-to-date the Risk Management Plan that will be produced by the WP1.

2.1.2.9 WP Technical Group

Composition

The WP Technical Group, chaired by the WP leader; is composed of the Work Package Leader (WPL) and the technical representative of each partner involved in the Work Package. In its tasks, it may ask for the help of the Project Office.

Role and responsibilities

WPL responsibility is to plan, manage co-ordinate and follow-up the work within the work package; the WPL ensures the work is done in full accordance with the Description of Work and proposes proper actions when required. He/She represents the Work Package interests and interfaces with other Work Packages through the PMC meetings. Work packages are further broken down into tasks; responsible persons are appointed and co-ordinated by the WPL.

Decision making procedures
Decisions will be taken by consensus whenever possible. No voting will occur within WP Technical Group. In case of conflict or for decisions beyond WP responsibilities, the WP leader prepares a description of the problem and its possible solution and he refers to the PMC.

2.1.2.10 Advisory Boards

Industry Advisory Board (IAB)

To guarantee maximum proximity to market needs, in addition to involved industrial Partners, Consortium will create Industry Advisory Board, whom main role consists in monitoring the industrial impact of the project. The industry board is chaired by the Project Technical Leader and consists of representatives of industrial companies, end users and large stakeholders on the requirements produced by WP2 and the choices made by the project. The purpose of this board is to gather views and directions from main stakeholders.

All partners can propose candidates; project partner consensus is needed to admit each new member. In case of commercial conflict each project partner has the right to reject invitation of new board member. Industry board analytics, recommendations will be reported to the Project Management Board for verifying or modification of the project (if necessary). Such policy will be followed during whole project life cycle. The changes of work plan and budget estimation are then submitted to the General Assembly for approval.

Scientific Advisory Committee (SAC)

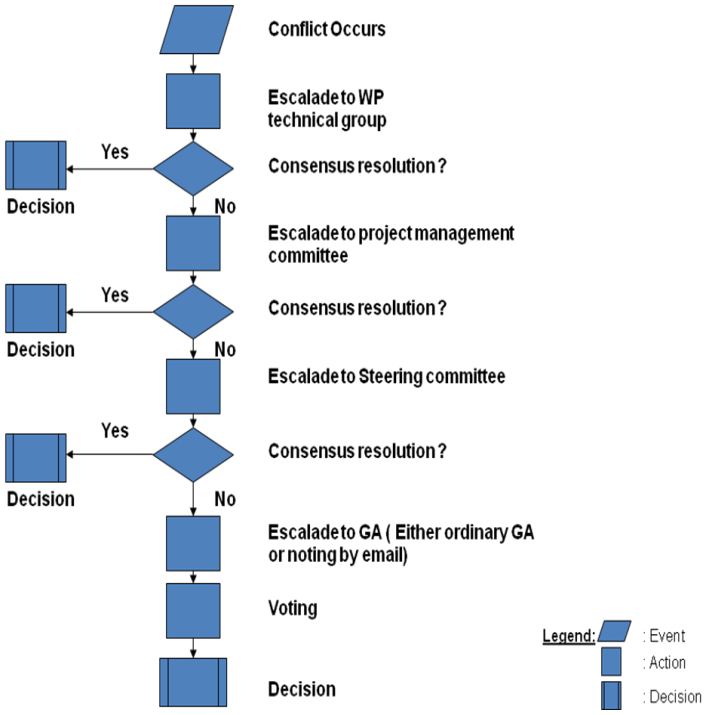
The Scientific Advisory Committee role is to assist the Project Steering Committee in assuring a technical excellence for the project work. Three Senior Experts on COMBO matters will be recruited within the Consortium but not directly in charge of any part of the project. Their advices requested when a scientific refereeing is considered as needed by the Project Steering Committee.

Project Office

This last group has a functional role. A Project Office (PO), comprising a staff familiar with administrative, legal, financial, communication and IPR issues will support the several decisions-making groups in all the non technical tasks. The Project Office tasks will be managed by the Coordinator. It will get advises from financial, legal, IPR specialists whenever required.

2.1.2.11 Conflict Resolution

- A clear decision making procedures will allow a simple conflict resolution process.
- When a conflict occurs in a WP technical group, consensus seeks to solve the problem. If the problem cannot be solved it is escalated to the Project Management committee: the WP leader prepares a description of the problem and its possible solutions.
- If consensus cannot be reached within the Project Management Committee, the Technical Project Manager escalates it to the Steering Committee, using the same process as described above.
- If the problem cannot be solved by consensus, the steering committee escalates it the General Assembly and a vote occurs, requiring a simple majority.



In practice the conflict resolution process can be very fast, as:

- Extraordinary GA meetings can be organised using audio-conference (with the terms and delay defined in the Consortium Agreement),
- Email voting is allowed (again according to the rules defined in the Consortium Agreement).

2.1.3 Operations and Communication Tools

2.1.3.1 Planning

Drafting coherent plans for the project work is an essential prerequisite to enable the work to progress. The current document only presents a high-level overview of the project, setting out the ground rules on which the project will proceed in terms of objectives, technical approach and time scales.

At the project start, a consolidated planning will be produced and maintained by the Project Steering Committee. A detailed work plan will be produced for each sub-task level to avoid redundancy in tasks, to ensure all the tasks are covered and to allow an efficient follow-up of progress. The work plan can be revisited only with the approval of the PMC.

2.1.3.2 Meetings and Travel Management

Three plenary meetings are organised at minimum per year; WP TG meetings and ad-hoc technical meetings will precede them. The grouping of the meetings guarantees maximum efficiency: immediate inputs and feedbacks from one meeting to another one, possibility to call ad-hoc meetings, easy informal contact between all parties concerned, and minimum travel cost.

At the project start, the PMC defines a provisional planning either for meetings and teleconferences. The calendar (time and place for one year) of the various meetings will be defined during the kick-off meeting, and from then, one year in advance.
Regular Teleconferences are scheduled. They will occur with the minimal following period:

WP technical group: once per month

Project Management Committee: Once a month, 1 week after WP teleconferences.

Project Office: one plenary teleconference with all the partners will be organised at least every quarter after the release of the internal Quarterly Management Report (Milestones M x)

2.1.3.3 Monitoring, Reporting Progress and Documenting Results

Communication tools

The usual tools (Fax, E-mail, collaborative tool) will be used for the exchange of documents/information. They will be complemented when needed by audio-visual conference systems.

Internal reporting Process

An internal monthly report will be requested allowing each partner to keep his progress and the related MM expenses on track.

Reports to the Commission

The Project Coordinator (with Project Office support) will coordinate and consolidate quarterly, annual and final activity, management and financial reports, which need to be submitted to the Commission. Every Partner will provide audit certificate when needed (according to FP7 rules, each time a partner requested grant is equal to 375 000 €) prepared and certified by an external auditor selected by the Partner, certifying that the costs incurred during the period meet the conditions required by the grant agreement.

The COMBO Collaborative tool

The Consortium will use for its internal communication an interactive Web collaborative Platform. This site is secured and enables the consortium to manage the diffusion of the information, to convene to meetings and teleconferences, to follow resources and allow easy exchanges between partners.

All project documentation will be stored electronically in the collaborative platform (with secured access) and as paper copies. It can be made accessible for the Commission and reviewers with personal level of access rights.

B 2.2 Beneficiaries

Participant Number	P01	Participant short name	JCP	
Participant full name	JCP-Consult			

Short description of the organisation

JCP-Consult is a French SME, created in 2002, with expertise in networking and audiovisual. The company activity is R&D on (QoS, CDN and data compression), which led to an IP data compression product. The consulting activity covers management and dissemination of R&D projects (20+ European projects), techno-economics and business modelling, standardization (the company is active in ETSI, 3GPP and DVB and has experience in IEEE). The main location is Rennes, France. The company has also office in Estonia and Brussels.

Attributed tasks

JCP will be involvement in overall management of the project (WP1). In R&D activities, JCP will be involved in T3.2 on storage, CDN and CCN issues; it will be active in T5.1 and T5.2 in techno-economics and T5.3 in business modelling. JCP will be heavily involved in all WP7 dissemination activities: leading T7.1 on general dissemination, be involved in CaON cluster as COMBO representative in T7.2, contributing to T7.3 in exploitation and T7.4 in standardization.

Relevant experience

JCP-Consult has a long track record of being involved in the financial, project and technical coordination and dissemination of R&D project owning to objective 1.x (OASE, Accordance, SociaSensors, isearch, Diconet, mobithin, MediaNet, BroadWAN, BREAD, chorus, chorus+, Mobile Game Arch, …). In technical activities related to COMBO, JCP has been involved in access network architecture and control plane, multimedia QoS transport in past French R&D projects (scalimage, VOD@IMS, nextv4all, locomotive), and is involved in CDN/CCN activities in SocialSensors. Concerning business and techno-economics, JCP has a track record in the industry (DivX, Windriver, Bluestreak), and techno-economic analysis in BREAD, OASE and consulting activities for operators.

Profile of key personnel

Jean-Charles POINT has a large management experience and R&D expertise in the cable, wireless and fibre access areas, as well as in IP architectures for multimedia services, and has exercised key executive positions in the Industry (SAIT, SEE, Thomson, and COM21)prior to JCP-Consult. Jean-Charles has been involved for more than 10 years in R&D European and national initiatives (managing financed programme participation in Thomson) and holds a Master of Science degree and graduated as “civil engineer telecommunication” in Faculté Polytechnique, Mons, Belgium.

Yaning LIU, R&D consultant in JCP-Consult, participating in the research in Europe FP7 projects and specializing in mobility, content cache and applications in Content Centric Network (CCN). She received her PhD degrees from Beijing University of Posts and Telecommunications (BUPT) of China and Telecom Bretagne of France in 2010 and 2011 respectively. She also worked as a network engineer in CHINA TELECOM for five years. Her research interests include CCN, Green Network, Network

Measurements, Peer-to-Peer Video Streaming and Distributed Systems.

Patrice SILVANT holds a Master's degreee in computer sciences (Marseille II university) and is finalising an executive MBA (Rennes International School of Business), Patrice is a seasoned executive manager who has led to success a number of projects ranging from strategy and business modelling consulting to contractual negotiation and innovative product development in a multifunctional and International environment. He has a large industry background in Thosmon where he led major industry projects.

Participant Number	P02	**Participant short name**	DTAG	
Participant full name	Deutsche Telekom AG			

Short description of the organisation

DTAG is one of the world's leading telecommunications and information technology service providers offering millions of private and corporate customers all over the world the entire spectrum of modern information technology and telecommunications services. Deutsche Telekom AG is represented in about 50 countries around the globe. Within the Deutsche Telekom (DT) Group, corporate research and development activities are coordinated and operated by Deutsche Telekom Innovation Laboratories (T-Labs) in agreement with "Zentralbereich Product & Innovation (ZB P&I)". T-Labs are legally formed as a so-called "An-Institut"; a private scientific institution, closely affiliated to Berlin's Technical University. It integrates DT's research and development activities with those of the Technical University (TU) in Berlin.

Attributed tasks

The Fixed and Mobile Broadband Access Networks groups at DT Laboratories are involved in this project. The objective of both groups is to cover broadband access networks to develop FMC solutions. Based on the offered expertise, DTAG will participate in the framework definition and network evolution, the development of FMC architecture and performance management for these architectures, the techno-economic assessment, experimental work and in the dissemination activities.

Relevant experience

Deutsche Telekom together with its division has a long tradition in participating in European R&D since RACE, ACTS, TAP up to IST and FP6. The current references in FP6 and FP7 include projects such as Daidalos, Muse, Nobel, E3, 4Ward, OASE and Trilogy.

Profile of key personnel

Dirk BREUER received the Dipl.-Ing. and Dr.-Ing. degree in electrical engineering from TU Berlin. During his PhD, his main research interest was in high capacity optical transmission systems with bit-rates of 10 and 40 Gbit/s. In the Technology Centre of DTAG he was involved in several national and international research projects focusing on optimization strategies for the optical transport network of DT. He is involved in developing upgrade strategies towards next-generation broadband access networks.

Erik WEIS received the Dipl.-Ing. degree in electrical engineering from the TU Dresden. In the Research Institute of DTAG he was involved in national and international R&D projects on optical and hybrid optical broadband access and DTAG's internal projects dealing with the short and mid-term development of access network concepts and strategies including the development and techno-economic assessment of different network scenarios. He is involved in projects developing upgrade strategies and concepts towards next-generation broadband optical access networks.

Gerhard KADEL received the PhD in Electrical Engineering from the University of Darmstadt. He is working in the area of radio communications research within the DT Group. His expertise is related to broadband mobile and wireless technologies, wireless network planning & optimization and connectivity solutions for public and private vehicles. Currently, he acts as Senior Expert, Project Manager and Leader of the Project Field "Wireless Technologies & Networks" at Telekom Innovation Laboratories.

Eckard BOGENFELD is the Senior Expert and Project Manager on Wireless Technologies and Networks at Telekom Innovation Laboratories. He received the Dipl.-Ing. degree in 1987 and the Dr.-Ing. degree in 1992 from University Kaiserslautern. In 1993 he joined the DT Group. He is the author of numerous conference papers in the field of wireless communications. Dr. Bogenfeld was active in several international R&D projects of EURESCOM and EU funded research projects.

Participant Number	P03	**Participant short name**	TID
Participant full name	Telefónica Investigación y Desarrollo		

Short description of the organisation

Telefónica Investigación y Desarrollo (I+D) is the innovation company of the Telefónica Group. Owned 100% by Telefónica, this subsidiary was formed it 1988, with the aim of strengthening the Group's competitiveness through technological innovation. TIDSA employs over 600 persons, of whom 93% hold a University degree. Telefónica's innovation process, which is largely based on the activities of TIDSA, is based on four fundamental lines of work: infrastructures, development of new services, deployment of the so-called "personal digital environment" and, a series of common elements which play the role of for the rest of activities. All the activities in TIDSA are carried out conforming to an in house Project Development and Management Methodology, which has been awarded an ISO 9001 Certification since 1994, updated to the new ISO 9001:2000 in 2001. More information about Telefónica Investigación y Desarrollo (TID) can be obtained at http://www.tid.es

Attributed tasks

The Fixed and Mobile Broadband Access Networks groups at Telefónica I+D are involved in this project. The objective of both groups is to cover broadband access networks to develop FMC solutions. Based on the offered expertise, TID will participate in the framework definition and network evolution, the development of FMC architecture, the techno-economic assessment, the technology practical work and in the dissemination activities.

Relevant experience

TIDSA is and has been involved in a number European projects: RACE I, RACE II, ESPRIT II, ESPRIT III, TEN-IBS, TEN-ISDN, CTS, COST, EURESCOM, BRITE, ACTS, IST, Ten-Telecom, e-Ten, e-Content, EUREKA (ITEA, MEDEA & CELTIC). The Telefónica Group participates in the principal standardization forums for fixed, mobile and wireless communications, convergence, etc. (ITU, GSMA, MEF, OMA, MPF, IEEE, IETF, IPv6Forum, W3C, TISPAN, OSGI, …).

Profile of key personnel

Rafael Cantó Palancar received his MS Eng. Degree in Telecommunication Engineering in 1998 from the Polytechnic University of Madrid. He joined Telefónica I+D in 1998 where he has been involved in the design and evaluation of different network access technologies and on network dimensioning and planning. He has participated in different European research projects such as BLISS, ANTIUM, MEDEA+ MARQUIS and SURFACE. Currently he is the Head of the Fixed Access Networks Group in Telefónica I+D, where he is leading different innovation activities related to access networks in the Telefónica group.

Jose Alfonso Torrijos Gijón has a Computer Science degree from the Polytechnic University of Madrid in 1992. In 1994 he joined Telefónica I+D working in different projects for Telefónica regarding IP, DTV, xDSL and Satellite technologies. In 2004 he joined the Broadband Access Technologies Division managing ARTES-1 and FP6 projects such as SATLIFE and SATSIX. In 2008 he started to work in fibre optic projects for Telefónica Spain regarding FTTH access and photonic networks where he is currently involved.

Participant Number	P04	**Participant short name**	FT	
Participant full name	France Telecom SA			
Short description of the organisation				

The France Telecom Group is contributing to innovation through Orange Labs in France and worldwide, in order to anticipate technological revolutions and new uses, to offer customers the best from telecommunications, and to imagine tomorrow's technologies, networks and services. Orange Labs collaborates with operators, manufacturers, universities, and R&D centres in several European projects. It also contributes to standardization and regulation bodies such as 3GPP, FSAN, BBF, IETF, IEEE and ITU.

Attributed tasks

France Telecom will participate to technical coordination of the project, will lead WP3 on fixed-mobile convergent architectures, and will participate to several other workpackages. It will in particular propose,

define and assess new architectures for convergent networks, host a field trial in Lannion to evaluate technical solutions prototyped by vendors, and disseminate COMBO results into standard bodies, e.g. 3GPP, FSAN, BBF and IETF, targeting convergence of viewpoints in these various standard bodies.

Relevant experience

France Telecom has been working for a number of years on the architectures and technologies for both fixed and mobile access and aggregation networks. It has been very active in 3GPP, FSAN, ITU, BBF on architectures and technologies for fixed and mobile networks, and has participated to key European projects on mobile networks and technologies (e.g. ARTIST4G, WINNER, WINNER+), fixed networks and technologies (e.g. FP7 ALPHA, SARDANA) and network architecture and control (e.g. MEVICO, TIGER2).

Profile of key personnel

Stéphane Gosselin joined France Telecom R&D in Lannion in 1993, where he first studied fast free-space optical switching systems. He worked on WDM networks from 1997 to 2007. He is now leading several research projects on broadband communication systems and networks in Orange Labs. He was/is involved in several European projects (e.g. DEMON, TOPRATE, e-Photon/One & BONE). He was a co-author of the second European Strategic Research Agenda in Photonics.

Tahar Mamouni joined Orange in 2005 after being graduated in telecommunications and networks domains and with an engineer diploma from the Supelec school. He was first engaged in development projects on mobile devices, before moving to the Mobile Core network area, working then in subscriber management (HLR, HSS, AAA…). Back to R&D, he had training on fixed and mobile network architectures. After managing a research project on Fix-mobile networks harmonization since 2010, he is now involved in research activities on the NG-POP concept.

Anna Pizzinat received the Ph.D. degree in 2003 at the University of Padova, Italy. Until 2005 she was responsible for the Photonics laboratory at University of Padova working on polarization mode dispersion and 40 Gbit/s systems and contributing to IST ATLAS project. In 2006 she joined Orange Labs where she is engaged in research on the next generation optical home and access networks. She has actively contributed to FP7 ALPHA (2008-2010) and French ANR BILBAO (2006-2008) projects and leads the French FUI8 ORIGIN project (2010-2012).

Joseph De Biasio has been Network Architect at Orange Labs since 2006. He is in charge of various studies on fixed-mobile convergence and impacts on fixed broadband access networks (especially regarding QoS aspects). He lead a project on Wireless-LAN Interworking with 3GPP architecture implementation at Orange France and technical support for roll-out phase scheduled mid-2010. He contributed to FP6 MUSE project from 2006 to 2008 (multiservice over access evolution, fixed-mobile convergence Task Force), and to Celtic project RUBENS in 2009 (Broadband fixed architecture evolution and CDN introduction for IPTV service).

Participant Number	P05	**Participant short name**	ALU-I	Alcatel·Lucent
Participant full name	ALCATEL LUCENT ITALIA spa			

Short description of the organisation	

Born with an unparalleled ability to offer end-to-end communications solutions to our customers, we are focused on enhancing client relationships and enriching the lives of people through communications with a clear vision of where networks are going, a deep understanding of customer needs, and an energetic culture of technical excellence and innovation. We employ the largest and most-experienced services team in the industry, with operations in more than 130 countries. Alcatel-Lucent Optics Division, participating to these projects, is achieving the transformation of optical transport from legacy technology to packet, supporting a broad range of services and applications such as triple play, Gigabit Ethernet connectivity, 3G mobile backhauling and delivering products that match customers needs in the fixed, mobile, submarine and vertical markets. Commercial products include: Transport Service Switch (TSS - the industry's first universal switching platform packet/circuit scalable), WDM solutions, optical cross-connects and management suite. The HQ and main R&D teams of the Optics Division are located in Italy as well as some R&D divisions involved in solutions and applications for fixed and mobile customers.

Attributed tasks

The optics product group of Alcatel Lucent Italia is involved in the project COMBO with overall focus on new optical transmission technologies and solutions for the aggregation segments in the fixed and mobile market. The global involvements will be on the physical layer and data plane impacts including new configuration of nodes at the border of the network for NGA and high capacity optical backhauling. The impact on CPRI requirements and related exploitations are also further interests.

Relevant experience

Development of breakthrough photonic integrated circuits (PICs), designed to provide simpler and more flexible optical networks. It provides customer solutions through close collaboration with Bell Labs complemented by a wide range of research programs conducted with leading universities and research institutes in addition to playing a key role in standard bodies for several access and transport technology applications. ALU-I currently involved in the following projects: ECONET, GEYSERS, ETICS, ERMES and FI-WARE FI PPP

Profile of key personnel

- Ing Antonio Cimmino (LEAR) graduated in electronic engineering in Napoli (I). Trainer at the Italian AIR force in telecommunications and air-navigation systems. In 1991 he joined former Alcatel Italia, working in the radio mobile research department, primarily involved in mobile research activities: system definition and network architecture on Mobile Broadband System project (MBS / 60 GHz), UMTS – Monet, OBANET and Moicane (FP5). Recently involved in preparation and co-ordination of FP6 / FP7 research projects (WEIRD, Onelab, ephoton+, Nobel 2, Geysers, Etics and Smart Santaders) for ICT area.

- Giancarlo Gavioli received his PhD from the Optical Networks Group at University College London. He has been awarded the Institute of Electronic and Electrical Engineers, Lasers and Electro-Optics Society Postgraduate Fellowship Award for his research on SOA-based optical processing as well as the 2-year Leverhulme Early Career Award to support his research activities in the area of digital signal processing for high bit-rate coherent optical transmission. In 2008, he joined the Optcom group at Politecnico di Torino where he led the optical system laboratory working on advanced modulation formats for high bit-rates coherent transmission. Since 2010, he is with the Technology team in ALU-I, working on the design of next generation coherent transponders for metro-core optical networks. Dr. Gavioli is co-author of more than 30 papers in leading journals and conferences. Dr.Gavioli has also been involved in several European research projects (Nobel, CORONA, Bone, Eurofos) and national research

projects in UK (Prince, E-Photon One).

- Alessandro Iachelini received his MS degree in Physics from Universitàdegli Studi di Milano and holds a qualification in Electronics Technologist received from Istituto TecnicoIndustriale Statale in Milano. He has been working in Alcatel-Lucent Italy since 1989 (formerly Alcatel Italy and formerly again Telettra) and covered several functions in Access Division and Optics Division spanning through Research, Research & Development (board designing), System Architecture design, Chief Technology Office, WDM Product Line Management and Technology Pathfinder. Currently he has been working on New Business Ventures for Metro Access and Aggregation developments. He is a (co-)author of some patents and publications in the field of WDM technologies.

Participant Number	P06	**Participant short name**	IT-TB	
Participant full name	Institut Telecom / Telecom Bretagne			

Short description of the organisation

The IT-TB team is composed of participants from the "Computer Science", "Optics" and "Networks, Multimedia and Security" departments of Telecom Bretagne, located in Brest and Rennes (France). Telecom Bretagne is part of the Institut Telecom and is both one of the main French graduate Engineering School in Information Technology as well as a Research Centre in that field. Telecom Bretagne conducts high-level research projects in most aspects of Information Technology ranging from hardware technologies to usages.

Attributed tasks

Tasks 3.1 (functional analysis of non-FMC and FMC scenarios), 3.2 (protocols and algorithms for FMC), 3.3 (encapsulation and control plane issues for various metro/access technologies), 4.2 (selection of control plane tools and analysis of their operation mode, relationship between these tools and SLA) and 4.3 (evaluation of use cases). Coordination of Task 3.2.

Relevant experience

The IT-TB team relevant expertise addresses the following fields:

- Design, mathematical modelling and performance analysis of access and metro optical networks
- Fixed and mobile network architecture
- Resource allocation for wireless networks
- Teletraffic analysis of broadband fixed networks and hierarchical cellular networks

Profile of key personnel

Annie Gravey is Head of the Computer Science Department at Telecom Bretagne. Before 2000, she spent 20 years with France Telecom R&D where she designed mechanisms for specifying and controlling broadband traffic and conducted extensive activities in standards and network deployment. Her current research interests include traffic engineering for broadband access/metro networks, QoS specification and management, and also Content Centric Networking and its application to Cloud Computing.

Xavier Lagrange is professor in the "Networks, Multimedia and Security" department of Telecom

Bretagne and has been with Institut Telecom since 1991. His domain of interest includes resource allocation, medium access control and performance analysis for 3rd and 4th generation cellular networks and wireless systems. He is a senior member of IEEE.

Philippe Gravey joined France Telecom R&D in Lannion in 1980 to work on holographic techniques applied to optical interconnections. Between 1993 and 1997, he was in charge of the "Photonic Switching Processors" department. He joined Telecom Bretagne in 2000. Its present research interests include optical networks, optical packet switching and performance monitoring.

Michel Morvan joined France Telecom R&D in 1989 as a research engineer in the field of advanced optical transmission systems and optical networking. In 2000, he joined Sycamore Networks as a SDH/WDM network architect. Since 2002, he is an Associate Professor in the Optics Department of Telecom Bretagne. His research activities are focused on optical transmission and optical network architectures.

Participant Number	P07	**Participant short name**	EAB	ERICSSON
Participant full name	Ericsson AB			

Short description of the organisation

Ericsson AB is a company in the Ericsson Group (Ericsson). Ericsson is the world's leading provider of technology and services to telecom operators. The market leader in 2G and 3G mobile technologies, Ericsson supplies communications services and manages networks that serve more than 750 million subscribers. The company's portfolio comprises mobile and fixed network infrastructure and broadband and multimedia solutions for operators, enterprises and developers. Ericsson is advancing its vision of 'communication for all' through innovation, technology, and sustainable business solutions. Working in 180 countries, more than 90,000 employees generated revenue of SEK 203 billion in 2010. Founded in 1876 and headquartered in Stockholm, Sweden, Ericsson is listed on OMX Nordic Exchange Stockholm and NASDAQ.

Attributed tasks

The Broadband Technologies unit at Ericsson Research will focus on development of C-RAN and heterogeneous dense urban area broadband solutions (WP3), including performance management (WP4). Furthermore, EAB will contribute with lab trials and field demonstrations in cooperation with the operators in order to evaluate the solutions developed in COMBO (WP6).

Relevant experience

The organisation within Ericsson which will be engaged in the project, called Ericsson Research, provides Ericsson with system concepts, technology and methodology, to secure long term competitive product provisioning. World-class innovation is achieved through cooperation within Ericsson and with partners, customers, universities and research institutes. The groups participating in COMBO cover research in the areas of access technologies and signal processing, radio network and radio interface architectures, network management, including algorithms, protocols, performance as well as sustainability aspects of wireless communication and ICT in general. Ericsson AB is host of the core of Ericsson Research.

Profile of key personnel

Kåre Gustafsson graduated from the Royal Institute of Technology in Stockholm in 1980 with a M.Sc.

degree in applied physics. He joined Ericsson as research engineer the same year and has held a number of management positions in different part of the company since then. He has been head of the Materials Laboratory at Ericsson Telecom, he started and headed the Micro Interconnect Research Center and was General Manager for Optoelectronic components. Kåre was coordinator for the Fixed Mobile Convergence sub-project within the MUSE (I + II) FP6 projects. Kåre's present position is manager for a research unit for Mobile Backhaul and Performance Management within Ericsson Research in Stockholm.

Daniel Cederholm received a M.Sc. degree in engineering physics and a B. Soc. Sc. in Business from Uppsala University, Sweden in 2007. He is currently working at Ericsson Research as a work package leader and a senior research engineer within the field of performance management, in particular DSL line testing and copper-plant management. He has experience from the European research project MUSE and has also published several patents and standardization contributions. He is active in Broadband Forum standardization and is currently editor for a document about DSL Quality Management.

Neiva Lindqvist received her B.Sc. (2004), M.Sc. (2005) and Ph.D. (2009) in Electrical Engineering – Telecommunication from the Federal University of Para – UFPA (Brazil). As a continuation of her Ph.D. studies, Neiva performed her postdoctoral research and worked as a technical project leader at Lund University – LTH (Sweden), within the area of management and performance optimization of fixed access networks. Since 2011, Neiva Lindqvist holds a position as an experienced researcher at Ericsson Research, working with fixed/mobile broadband technologies and mobile backhaul.

Participant Number	P08	**Participant short name**	ADVA-UK	ADVA Optical Networking
Participant full name	ADVA Optical Networking Ltd.			

Short description of the organisation

ADVA Optical Networking is a global provider of intelligent telecommunications infrastructure solutions. With software-automated Optical+Ethernet transmission technology, the company builds the foundation for high-speed, next-generation networks. The company's FSP product family adds scalability and intelligence to customers' networks while removing complexity and cost. With a flexible and fast-moving organization, ADVA-UK forges close partnerships with its customers to meet the growing demand for data, storage, voice and video services.

Attributed tasks

Advanced Technology team members from the UK bring experience and expertise in packet technologies to the COMBO consortium. ADVA-UK will engage in FMC architectural discussions within WP2 and WP3. Work on Quality of Service, Performance monitoring and performance management will be in focus during WP5. ADVA-UK will also be active in WP6 performing a gap analysis, and performing practical work in support of proof of concept development and operator based testing. ADVA-UK will support COMBO standardization and dissemination activities within WP7.

Relevant experience

ADVA-UK has a history of involvement within funded research projects via the UK Technology Strategy Board and also has currently active EU projects in the related fields of broadband access, Ethernet (business) access, and backhauling. EU Funded projects include OFELIA (OpenFlow based test bed development) and the EU FP7 project IMPACT as part of PIANO+. ADVA-UK is the original centre of design for ADVA's Ethernet Access programs and is now involved in Advanced Technology work

covering Ethernet Aggregation, Carrier Ethernet, Synchronization over Packet Switched Networks, and WDM-PON packet functionality for fixed and mobile networks. ADVA-UK is currently involved in the specification of protocol functionality relating to broadband access targeted towards our WDM-PON investigations. ADVA-UK attends and monitors work within the standards bodies for these areas including ITU-T SG15 Q13, IEEE 802.3, IEEE 802.1, and the IETF.

Profile of key personnel

Anthony Magee has worked in both public and private sector since graduating in 1998, and has worked in a multidisciplinary capacity in the field of Ethernet Access & Aggregation and protocol design. Research interests include synchronization in next generation networks and emerging protocols. Having being in Advanced Technology since 2008, Anthony has participated in two UK TSB projects and is involved in EU project IMPACT. Contributions to industry include IEEE Comms Magazine, ISPCS, ITSF and standards such as ITU-T, IEEE 802 and IETF.

Peter Turnbull has worked within a number of private sector organisations in various R&D and technology capacities since graduating in 1986. Since 1997 the focus has been on networking technologies, with particular focus on packet based technologies, and latterly on synchronisation and timing in packet networks. Peter is named co-inventor of a European patent on phase locked loop design, and has contributed to standards activities in ITU-T in the field of synchronisation and timing.

Participant Number	P09	**Participant short name**	ULUND	LUND UNIVERSITY
Participant full name	Lund University			

Short description of the organisation

Lund University was founded in 1666. Today it is an international centre for research and education that has approximately 47 000 students and 6 300 employees, which makes it to one of the oldest and largest universities in Scandinavia. Lund University is respected as one of the best universities in Sweden, with cooperation with 630 partner universities in more than 50 countries. The Faculty of Engineering (LTH) is one of Sweden's largest higher educational institutes for the technical and engineering sciences. The Broadband Communications group at the Department of Electrical and Information Technology focuses on broadband access and core networks, on all layers. The research areas are applied signal processing, DSL systems, and network design. The group has a system-centric approach, where system functionality and maintenance are the main focus. It has a long history of research cooperation with academic and industry partners both in Sweden and international. The group has been actively involved in several projects, both on national and European level, for example the FP6 projects MUSE and MUSE2 and the CELTIC projects BANITS2, TRAMMS, R2D2 and 4GBB.

Attributed tasks

The main contribution from Lund University will be in WP4, related to performance monitoring and management of the FMC network. The focus will cover optimization on e.g. capacity, power consumption and service assurance, as well as fault localization. Lund University is also active in traffic modelling and setting up KPIs, as well as the architecture description and the dissemination of the project.

Relevant experience

Lund university has been actively involved in several projects, and still is, both on national and European

level, for example the FP6 projects MUSE and MUSE2 and the CELTIC projects BANITS2, TRAMMS, R2D2 and 4GBB. Researchers have been actively publishing papers in international peer-reviewed technical journals and conferences. Several PhD Dissertation and MSc Thesis have been produced and supervised.

Profile of key personnel

Stefan Höst has a position as Associate Professor at the department of Electrical and Information Technology at Lund University, where he is currently working in the Broadband Communications group. His main interests are access networks in general, viewed from the lower logical layers up to the network layers, and a speciality in physical wireline technologies. He has been involved in the FP6 project MUSE2 and the CELTIC projects BANITS2, TRAMMS, R2D2 and 4GBB. In the years 2001-2008 he was head of education for the Master's programme Information and Communications Engineering at Lund University.

Per Ödling: Professor of telecommunications at Lund University. His research interests focus on signal processing and statistical communications, but range to the convergence of data- and telecommunications and technical regulatory issues. He has published more that fifty journal and conference papers, thirty standardization contributions, and a dozen patents. He was Associate Editor for the IEEE Transactions on Vehicular Technology for two years. He has worked in several EUREKA/Medea and EUREKA/Celtic projects. He is also a member of the Industrial Research Committee of the Royal Swedish Academy of Engineering Sciences and presently appointed Secretary of the Royal Swedish Academy of Engineering Sciences.

Participant Number	P10	**Participant short name**	CTTC	
Participant full name	Centre Tecnològic de Telecomunicacions de Catalunya			

Short description of the organisation

The Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), which is located in Castelldefels (Barcelona), is a private non-profit R&D center with substantial funding support from the autonomous government of Catalonia (Generalitat de Catalunya) along with research and development partnership with industry. Research expertise is mainly focused on technologies related to the lower layers of communication systems, being that activity organized into six areas, namely, Intelligent Energy, IP technologies, Communication subsystems, Radio communications, Access technologies and Optical networking, each of them featuring key staff with both R&D and engineering skills. Main activities at CTTC consist of long term research and development projects related to the areas indicated above. Two advisory bodies, Scientific and Business, supervise CTTC's activities. Two research areas participate in the COMBO project, namely, the Optical Networking Area and the IP technology Area.

Attributed tasks

The CTTC's Optical networking and IP technologies research areas provide solid expertise and background in both controlled optical transport and mobile and wireless networks, respectively. The participation of CTTC focuses on: WP2, WP3, WP4, WP5, WP6 and WP7 addressing the study of new FMC architectures, deployment of a unified control plane, integrated QoS for FMC, traffic offloading, RRM/load balancing strategies and their energy savings analysis within RAN and routing in wireless

meshed backhaul.

Relevant experience

The CTTC Optical Networking Area (ONA) has been involved in several Spanish and European public-funded R&D projects: national fundamental research (RESPLANDOR, DORADO) and European FP7 ICT NoE BONE and IP STRONGEST, FP6 IST IP NOBEL and NOBEL2, and EUREKA CELTIC TIGER2, 100GET, and ITEA TBONES. ONA participated in some industrial contracts with KDDI R&D Labs and Telefónica. The CTTC IP Technology area has also participated in different public funded Spanish and European projects/actions: IST WIP, ICT BeFemto, ICT NoE Acropolis, EUREKA Planets, ICT NoENewcom++, COST Dynamo, and COST TMA. In the context of industrial projects, the IP technology area has conducted medium/long-term collaborations with Orange and Cisco. Researchers of both CTTC areas are and have been actively publishing papers in prestigious journals and international conferences and serving as members/chairs of their technical committee programs. Several PhD Dissertation and Msc Thesis have been produced and supervised.

Profile of key personnel

Ricardo Martínez, PhD, is a Research Associate at the CTTC´s Optical Networking Area (ONA) since 2007. He has actively participated in several Spanish, EU-funded (EU FP6, FP7 and CELTIC) and Industrial projects in the context of optical networking. His research interests cover controlled packet and optical transport networks. He published over 80 journal and conference papers in this field.

Andrey Krendzel, Research Associate of IP Technologies Area (CTTC) since 2006. PhD: received at Tampere University of Technology (Finland); Candidate of Science (licentiate): received at St.-Petersburg University of Telecommunications, (Russia). The main research line: mobile and fixed network planning. Related projects involved: BeFemto (IST-FP7), WIP (IST-FP6), Femto-Core (industrial), WIMSAT (national), DYNAMO (COST Action 295), et al. Grantholder: Nokia, Finish Cultural Foundation, TISE, CIMO.

Participant Number	P11	**Participant short name**	DOCOMO	
Participant full name	DOCOMO Communications Laboratories Europe GmbH			

Short description of the organisation

DOCOMO Communications Laboratories Europe GmbH (DOCOMO Euro-Labs) was established in November 2000 in Munich, Germany, in order to conduct research on leading mobile communications technologies that can respond to the requirements of a highly advanced multimedia age. DOCOMO Euro-Labs is committed to collaborate with operators, vendors, universities and research institutes in Europe, and contribute to the R&D activities on IMT-2000 and beyond IMT-2000 systems to ensure their further development. NTT DOCOMO, the mother company of DOCOMO Euro-Labs is Japan's largest mobile operator, renowned for its strong commitment to research. DOCOMO Euro-Labs' research expertise spans a range of topics, including advanced mobile access, optical mobile backhaul network, mobility management, network virtualization, mobile traffic management, service delivery platforms.

Attributed tasks

The infrastructure research group in DOCOMO Communications Laboratories Europe GmbH is involved in this project. The group will contribute to WP2, WP3, and WP7. They focus on the study of defining requirements for Fixed and Mobile Convergence and designing its architecture, which will also enable to

efficiently accommodate various types of wireless access technologies such as LTE/LTE-A and 5G.

Relevant experience

DOCOMO Euro-Labs has been involved in a number of projects in the 5th, 6th and 7th Framework Programme (ICT), such as EARTH, BeFemto, Artist, SAIL, MEDIEVAL, Ambient Networks, Winner, Simplicity, SPICE, SmoothIT, and MobiLife. Since 2009, DOCOMO Euro-Labs' research is focusing on the design of a Next Mobile Network (NMN) targeting a deployment in 2020. NMN research includes research on Optical Mobile network, Network-centric MIMO, network sharing, network virtualization, traffic management and service platform issues, and is closely linked with and done in collaboration with research activities with European partner companies and academic institutions in Europe.

Profile of key personnel

Kazuyuki Kozu is a research manager at DOCOMO Communication Laboratories Europe GmbH. He received his B.E. and M.E. degrees from Yokohama National University in 1995 and 1997, respectively. He joined NTT DOCOMO in 1997. He has worked for NTT DOCOMO in the field of mobile core networks. The activities covered designing network architecture and 3GPP standardization. Since 2010, he is a member of DOCOMO Communication Laboratories Europe GmbH and involved in research on next mobile networks.

Changsoon Choi received B.S., M.S., and Ph.D. degrees from Yonsei University, Seoul, Korea, in 1999, 2001 and 2005, respectively. He is now with DOCOMO Communication Laboratories Europe GmbH, Germany, where he is working on cooperative MIMO systems for LTE-A, and energy-efficient cellular networks. His industrial experience includes affiliations with the IHP microelectronics GmbH, Germany, and the National Institute of Information and Communication Technology (NICT), Japan, where he worked on next-generation Gbit/s wireless LAN/PAN systems.

Participant Number	P12	**Participant short name**	POLIMI	
Participant full name	Politecnico di Milano			

Short description of the organisation

Dept of Electronics and Information (DEI) of Politecnico di Milano is one of the largest European ICT departments. The four department sections cluster consolidated competences in systems and control, computer science and engineering, electronics, and telecommunications. DEI has a large experience in participation to EU-funded research projects ; it has been the coordinator of the FP6 NANOSPAD, HICAM STREP projects and FP7 MULTICUBE, SCENIC, OMP, 2PARMA, ERMES STREP projects in the wide ICT area.

Attributed tasks

Politecnico di Milano has been attributed various tasks in the project: it will develop analysis of traffic scenarios in FMC architectures, it will devise new mechanisms for integration/handover among different wireless technologies, it will perform cost and energy analysis of FM architectures based on mathematical

and simulative approaches.

Relevant experience

Politecnico di Milano will bring to the project its expertise on access/aggregation networks and wide experience n the energy-consumption evaluation of different network architectures. Tools to be used will be from the fields of probability theory, stochastic processes, queuing theory, Markov chains, combinatorics, graph theory, simulation, and network experiments. POLIMI group has been developing an industry-strength optimization package, CPLEX, and also enhancing its simulation capability by expanding on the ns-2 and OMNET simulation platforms, as well as developing own simulation software.

Profile of key personnel

AchillePattavinais Full Professor at "Politecnico di Milano", Milan (Italy). He has been author of more than 200 papers in the area of Communications Networks and of the book *Switching Theory, Architectures and Performance in Broadband ATM Networks* (John Wiley & Sons). He has been leader of the POLIMI research unit and also WP leader in many EU-funded projects (FP6 MUPBED, e-Photon/One, e-Photon/ONe+, FP7 BONE, STRONGEST, Leonardo da Vinci Train2Cert/InCert).

Stefano Bregni is Associate Professor at Politecnico di Milano, where he teaches telecommunications networks and transmission networks. He is author of about 80 technical papers and of the two books *Synchronization of Digital Telecommunications Networks* (John Wiley & Sons, 2002), *PDH and SDH Transmission Systems – Multiplexing* (McGraw-Hill, 2004, in Italian). His current research interests focus mainly on traffic modelling and optical networks.

Massimo Tornatore is Assistant Professor at Politecnico di Milano, where he received a PhD degree in Information Engineering in 2006. He also holds an appointment as visiting assistant professor at the University of California, Davis where he served as a post-doctorate researcher in 2008 and 2009. He is author of more than 100 publications in the field of design, protection and energy efficiency in optical transport and access networks and group communication security.

Participant Number	P13	**Participant short name**	BME	Logo
Participant full name	Budapest University of Technology and Economics (Budapesti Mûszakiés Gazdaságtudományi Egyetem)			

Short description of the organisation

The Budapest University of Technology and Economics (**BME**) founded in 1782 maintains its leading position in the training of engineers and in the technical development of the country. BME currently has more than 23 000 students in 8 faculties, 76 departments, 14 doctorate schools. BME has taken part in 121 FP6 and 81 FP7 projects out of which 60 and 31 respectively were in the area of ICT. On behalf of the BME the High-Speed Networks Laboratory (**HSN*Lab***) of the Department of Telecommunications and Media Informatics (**TMIT**) will take part in the COMBO Project.

Attributed tasks

In IP COMBO BME will focus on defining FMC architectures in WP3; on performance and availability optimization and service management in WP4; on defining the assessment framework based on real geographic data and performing cost analysis of various architectures and various cases as well as on evaluating and minimising energy consumption in WP5; and on dissemination in WP7.

Relevant experience

Research areas of the HSN*Lab* at the TMIT include network design and routing with resilience and energy saving (green aspects); modeling and optimization of networks and of their services; techno-economic assessment. TMIT participated in numerous projects tightly related to the IP COMBO including NoE e-Photon/ONe and BONE; IP MUSE, NOBEL and EARTH; CELTIC PROMISE and TIGER II; COST 266, 291, 293.

Profile of key personnel

Geza Paksy received his M.Sc. degree from the BME. In 1992 he joined Hungarian Telecom. Ltd, where he was the head of Transport Networks Development Department. He participated in EURESCOM research projects on optical networking. From 2004 he is with the TMIT involved in different R&D projects with particular focus on the broadband optical access network planning and cost analysis. He is author of 30 technical papers and of 5 textbooks on telecommunication theory and praxis.

Tibor Cinkler has received M.Sc.(1994) and Ph.D.(1999) degrees from the BME where he is currently associate professor. His research interests focus on cost-, energy- and availability-optimization of routing, design, configuration and dimensioning of heterogeneous networks. He has led Hungarian participation in COST 266, 291 and 293; in IP NOBEL I and II; in NoE e-Photon/ONe, ONe+ and BONE; in CELTIC PROMISE and TIGER II; He is author of over 230 scientific publications including 4 patents.

Attila Mitcsenkov has received his M.Sc. (2006) degree in informatics from the BME where he is just finishing his Ph.D. He has spent one semester at the Lund University (Sweden) and he has been involved in the IP NOBEL and in the NoE BONE FP7 projects, and contributes to the EU & ERFA supported NGAdesigner project. His research interests include optimization and algorithm design, network planning (topology design) for optical access networks as well as resilience and routing.

Participant Number	P14	**Participant short name**	AITIA	AITIA www.aitia.ai
Participant full name	AITIA International Inc.			

Short description of the organisation

AITIA International Inc's predecessor was established in 1995 and was reorganized into its current format: AITIA International Inc. on January 1st, 2005. The telecommunications division of AITIA focuses on research and development of network monitoring and analysis, and has special expertise in testing the core of mobile telecom network and developing value added network solutions. Over the years AITIA has been involved in over 15 successful research consortiums both at the national and European levels. AITIA's associates are highly qualified research developers. In addition to our ca. 45 full-time employees we occupy thirty undergraduates and Ph.D. students via tenders and university cooperation. AITIA holds several technology and business-related awards. Deloitte Technology Fast 50 ranked AITIA

as the 9th fastest growing Central-European IT company in 2007, then 12th in 2008 and 9th again in 2009, when AITIA made ranked 1st on national level.

Attributed tasks

AITIA will take part in WP2 tasks 2.2, 2.3 and 2.4 in order to contribute to the FMC framework in both architectural and traffic analysis aspects. In WP3 AITIA plans to contribute to all tasks (3.1-3.3) focusing on FMC architecture. Since AITIA has strong network monitoring and traffic analysis background, all tasks of WP4 (4.1-4.4) are targeted by AITIA. In WP6, task OAM and SLA verification also fits the focus, and 6.1 and 6.5 also requires AITIA contribution, as well as the dissemination tasks T7.1 and 7.2.

Relevant experience

The main areas of research are based on AITIA's experience in network monitoring, traffic analysis, and performance management in both fixed and mobile networks. AITIA plans to provide reference traffic measurement results in mobile and fixed network trends, in both CS and PS domains. The experience in high speed traffic generators using real-life traffic dialogues helps providing insights in converged traffic scenarios and modelling. Based on the experiences in complete protocol analysis for network monitoring and traffic analysis, COMBO tasks related to protocol convergence will remain in AITIA's focus. As a general performance management model, studies and experiences with the Knowledge Plane fit in WP4. The extensive research already applied in relation to media QoE versus QoS and SLA verifications supports activities in WP6. AITIA can help providing (parts of) demonstration platforms related to traffic measurements, performance management, QoE issues and power efficiency (and its measurements).

Profile of key personnel

Peter Tatai is the president and founder of AITIA International Inc. He has graduated at BME Hungary, in 1964 - where he is currently associate professor, and the Head of Telecommunication Signal Processing Laboratory. He previously worked for the Research Institute for Telecommunications, Budapest as the Head of Code Modulation Division. He has published over 100 scientific papers, and received over a dozen innovation and research awards from Hungarian, European and International organizations.

Pal Varga is the head of Telecommunications division at AITIA International Inc. Besides, he is associate professor at BME Hungary, where he got his M.Sc. and Ph.D. degrees from. His main research interests are switching and routing, service and network management, network performance measurements, mobility management, fault localization, traffic classification, e2e QoS and SLA issues. He has been involved in European projects including IST-MUSE, CELTIC TIGER-2 and ARTEMIS SCALOPES.

Participant Number	P15	**Participant short name**	TELNET	
Participant full name	Telnet Redes Inteligentes S.A.			

Short description of the organisation

Telnet is a young and dynamic Spanish Company in the Telecommunications sector. Founded in Zaragoza in 1994, by Mr. Manuel Villarig Tomás, whose expertise was gathered over twenty years as R&D Director of "Cables de Comunicaciones". From the first days, TELNET Redes Inteligentes SA has a firm commitment to Research, Development and Innovation, TELNET has about 150 employees and has

achieved a wide and consolidated catalogue of products and solutions.

Attributed tasks

Telnet will contribute in task 2.2 to study the optical access network evolution. Also contributions in the WP3 are expected concerning new FMC in access network technologies, as well as contributions about QoS/QoE concepts in task 4.3. The main contribution of Telnet is expected in WP6, since Telnet is a manufacturer and new equipment will be designed and developed to be integrated.

Relevant experience

Telnet most relevant expertise are the technologies related with optical fibre, due to decade-long activity in this area, especially in xWDM and FTTx technologies. Telnet portfolio has for example OLT, ONTs, VPON, RF-ONT, GPON traffic and protocol analyzer and reach extenders, and NGPON and WDM-PON are current research topics. Telnet has also expertise in RF electronic design and mobile networks, due to its activities as mobile antennas manufacturer and several prototypes such as mobile network indoor repeaters. Telnet has also participated in several cooperation R&D projects, in national and European consortiums, which have led Telnet to an advanced expertise in several different areas.

Profile of key personnel

F. Javier Cortés: PhD by the Zaragoza University currently holds CTO of TELNET. In TELNET-RI, he has been responsible for developing broadband equipment, as well as CWDM and DWMW equipment. Currently, he coordinates Telnet research in network equipment, optical access network and mobile network. He is an author of several publications and scientific and technical documents.

Amador Pozo Espinosa graduated as Telecommunication Engineer. He joined Telnet-RI in 2008, at optical network devices area of the R&D department. His expertise areas are FTTx, Ethernet and related protocols, Linux, embedded systems and low-level programming. He has managed in Telnet some national and European public-funding research projects, such as VISION, R2D2, 100GET or Queen.

Sergio Perales Tornero graduated as Telecommunication Engineer. From 2007 he works in Telnet Redes Inteligentes in different radiofrequency and networking projects (UMTS repeaters, Jamming Detectors, Demarcation Equipment) in the software-firmware (FPGA, DSP, Microcontrollers) development.

Participant Number	P16	**Participant short name**	ADVA-DE	ADVA Optical Networking
Participant full name	ADVA AG Optical Networking			

Short description of the organisation

ADVA Optical Networking (FSE: ADV) is a global provider of intelligent telecommunications infrastructure solutions. With software-automated Optical+Ethernet transmission technology, the company builds the foundation for high-speed, next-generation networks. The company's FSP product family adds scalability and intelligence to customers' networks while removing complexity and cost. With a flexible and fast-moving organization, ADVA Optical Networking forges close partnerships with its customers to meet the growing demand for data, storage, voice and video services. Thanks to reliable performance for more than 15 years, the company has become a trusted partner for more than 250 carriers

and 10,000 enterprises across the globe. For more information, please visit us at www.advaoptical.com.

Attributed tasks

Advanced Technology team members from Germany bring experience and expertise in physical layer, optical networking and high speed optical access to the COMBO consortium. ADVA-DE will be present in WP2, WP3, on discussion and analysis on the architecture and concepts in FMC, as well as providing input to energy consumption within WP5. ADVA-DE will also be active in WP6 on the subject of fronthaul and backhaul, and in standardization and dissemination in WP7.

Relevant experience

ADVA-DE is and has been involved in several relevant research projects and further activities in the related fields of broadband access, Ethernet (business) access, and backhauling – such as EU FP7 projects OASE, C-3PO, and PIANO+ (both, IMPACT and TUCAN) and German BMBF-funded project ADVAntagePON. ADVA-DE also has a massive track record in WDM-based (wireline, XDSL, MSAN) backhaul and in (carrier, synchronous) Ethernet access for business applications. In both areas, relevant developments have been made in the recent years (e.g., 4-Gbit/s CWDM and passive-WDM backhaul technology, synchronous and carrier Ethernet functionalities). Currently, ADVA is developing an advanced WDM-PON which will be based on low-cost tunable lasers. Tuning mechanisms and various other components of such a PON have already been successfully investigated. ADVA is also involved now for 2 years in the FSAN NG-PON2 working group, and in ITU SG15 Q6 standardization.

Profile of key personnel

Dr. Klaus Grobe worked over 20 years in the fields of lightwave guides and WDM. He authored and co authored more than 80 scientific publications as well as three book chapters on WDM and PO technologies. He is member of the IEEE Photonics Society, the German VDE/ITG, and ITG Study Grou 5.3.3 on Photonic Networks. He serves the OFC Technical Subcommittee 10 on Transmission Subsystem and Network Elements and represents ADVA in FSAN. He holds 20+ (pending) patents.

Dr.Jörg-Peter Elbers is globally responsible for technology strategy and innovation projects in ADVA. He has authored and co-authored more than 70 scientific publications and 15 patents. Jörg is a frequent reviewer of technical publications and head of the VDE expert committee for optical communications engineering. He has worked at various companies and research organizations in Germany and the USA. Currently, he is a Director Advanced Technology at ADVA Optical Networking, Germany, directing and performing physical layer research. He has (co-)authored more than 100 peer reviewed papers and conference contributions and holds more than 30 patents. He is a Fellow of the OSA and a Senior Member of the IEEE-PS.

Participant Number	P17	**Participant short name**	FON	
Participant full name	FON Wireless Ltd			

Short description of the organisation

Fon is a company founded in 2006 by CEO, entrepreneur and internet pioneer Martin Varsavsky with the goal of blanketing the world with WiFi that is free for everyone. Even though it is a SME it has nearly 5 million hotspots in 170 countries across the globe and partnerships with world's leading Telcos. This

makes us the world's largest WiFi network. Fon's network usage has evolved from laptops to mobile devices in the last few years. Mobile devices are the main consumers of Fon's networks nowadays and this has made Fon adapt as much as possible to give seamless access to this devices. This is in fact an effective approach to mobile data offloading to the fixed line. Fon has had to integrate its network (both at control and data levels) with heterogeneous networks and operators, acquiring a very valuable expertise that could be beneficial for the consortium.

Attributed tasks

The contributions from Fon side will be done mainly in the COMBO framework definition, as well as in the current market description to help picturing AS-IS situation, taking into account their experience in the field (both in mobile and fixed networks). Moreover, Fon will contribute on the new definition on business models to convergence of data networks, based on actual existing examples (such as their own) and foreseen needs and possibilities of the market.

Relevant experience

Fon has specialized in the last years in building effective, low cost and seamless networks to allow mobile world devices to connect through the fixed line. In this evolution, Fon has gained great expertise and know how on the type of devices, data patterns, user stereotypes, use cases etc. related to both the mobile and the fixed network. The integrations with the many operators that partner with Fon give us background and expertise on the network and backbone interconnection. Fon has experience participating in FP7 projects such as ULOOP: User-centric Wireless Local-Loop.

Profile of key personnel

Xabier Iurgi Arginzoniz is Head of Engineering at Fon. Iurgi oversees the development of the company's full range of WiFi products. Iurgi is a WiFi technology expert and has been with Fon since its inception. Prior to Fon, Iurgi worked as the technology manager for Air Bites, a Swisscom AG venture. He led the development and systems teams and was responsible for technical client relationships. He is fluent in four languages. Iurgi received a degree in Telecommunications Engineering with a specialization in Telematics from the School of Engineering (ESI), at University of the Basque Country, Bilbao.

Valentín Moreno got a degree in Telecommunication Engineering (2005) from the University Carlos III, Madrid, Spain. He has large experience in the Telecommunication Industry, having been part in several companies in the field. He worked for Spanish telecommunication company Ya.com until 2007, when he joined Fon as software engineer. He is the current manager of the Billing System team, where he supervises the design and implementation of IT systems related to payments, invoices and involved tasks, as well as taking part in R&D projects such as ULOOP.

Juan Parodi will participate with an administrative and operational role. Juan has a vast experience in project management.

B 2.3 Consortium as a Whole

The consortium involved in COMBO come from best in class telecom operators and vendors as well as academic and project management organisations. A large number of participants have been active together in other collaboration work and this establishes a firm setting for the COMBO project. The mix of operators within the consortium ranges from large incumbent, to emerging service offerings such as WiFi offloading, while the mix of vendors ranges from large system integrators to smaller more focused SME vendors. This broad range of experience and focus from industrial participants provides maximum coverage of the fixed/mobile market and complimentary views to be brought into the consortium. The addition of academic partners brings a balance to the consortium, providing a mechanism to bring new concepts from academia into the industrial mindset.

The consortium as described in detail below provides the ideal platform to consider the challenges of Fixed/Mobile convergence, generate new structural and functional concepts, and a firm base for the demonstration of new concepts and the dissemination of such concepts into wider industry.

2.3.1 Consortium Composition

The COMBO work plan will be carried out by a consortium consisting of 17 partners. As reflected in the number of industrial partners (12), the consortium is industry driven and dedicated to solving industrially relevant problems for which also substantial input from the academic research community is required.

In addition to R&D technical work, there is a strong focus on techno-economics, cost and energy consumption aspects where both industry, operators and academic expertise is required. This strong industrial focus, accompanied by excellent academic support was the main criterion for selecting the partners in this project.

The strong presence of fixed and mobile operators is ensured by DTAG, FT, TID and DOCOMO. Incumbent and non-incumbent operators are represented as TID, DTAG and FT are operating worldwide as non-incumbent. The FON operator brings its expertise in WiFi community networks, including standardization, and also its disruptive ideas on business modelling. COMBO operators are in particular strongly active in most of the standardization bodies relevant to fixed and mobile networks.

Strong representation of fixed and mobile vendors is ensured through Ericsson, ADVA (UK and Germany), and Alcatel-Lucent. In addition to their R&D skills in the different areas they ensure product design, standardization and exploitation of the developed COMBO solutions.

SME community is strongly represented with FON, AITIA, TELNET and JCP, with expertise in the different fields of COMBO (R&D in fixed and mobile, techno-economics, equipment design), and are well committed to the exploitation of the results.

Industry partners are also strongly supported by some of the best European academic labs in various areas related to COMBO such as fixed and mobile network architectures, control plane, techno-economics, performance monitoring and management: BME, POLIMI, IT-TB, CTTC and ULUND will thus bring their complementary skills and will also commit themselves to COMBO targets.

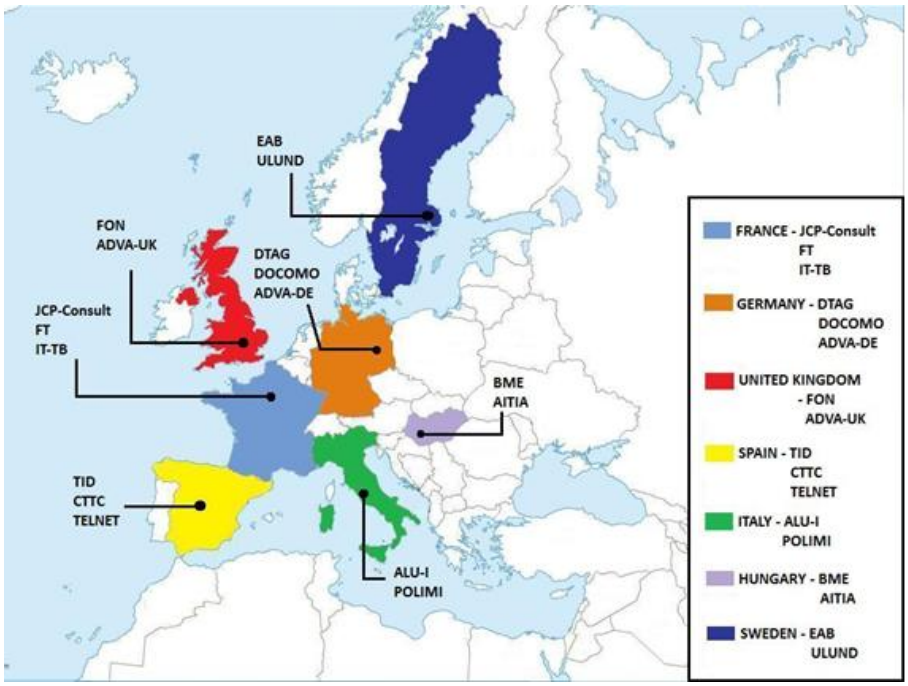


Figure 2: Partners and countries participating to COMBO

2.3.2 Core Competences

Addressing fixed-mobile convergence aspects in COMBO requires following competences shown in Table 1.

Care has been taken that the core competences (shown in the following table) required for the good project execution are covered in the consortium, both from the industrial as well as from the academic viewpoint, thereby ensuring solid synergy in the consortium. Covering the core competences by leading experts in the field is a major asset of the project; through which its ambitious objectives can be attained.

Table 1: Core competence coverage

Required core competence	DTAG	FT	TID	DOCOMO	FON	JCP	AITIA	TELNET	EAB	ALU-I	ADVA-UK	ADVA-DE	BME	POLIMI	IT-TB	CTTC	ULUND
Access/metro network architecture	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X
Mobile backhaul/backbone network architecture	X	X	X	X	X		X		X	X	X	X				X	
Functional architecture	X	X	X	X			X	X	X		X	X	X		X	X	
Network protocols	X				X		X	X			X				X	X	X
Fixed and mobile equipment design							X	X	X	X	X	X					
Fixed network MAC & PHY layer	X				X		X	X	X	X	X	X	X	X	X		X

Required core competence	DTAG	FT	TID	DOCOMO	FON	JCP	AITIA	TELNET	EAB	ALU-I	ADVA-UK	ADVA-DE	BME	POLIMI	IT-TB	CTTC	ULUND
Mobile network MAC & PHY layer	X				X		X		X						X	X	
Storage/ caching/CDN	X	X				X									X		
Control plane		X				X	X			X				X	X	X	
Traffic /performance monitoring	X		X		X		X	X	X	X	X				X	X	X
Traffic modelling	X	X		X	X								X	X	X	X	X
Performance management					X		X		X		X		X	X	X	X	X
Techno-economics, business modelling and business case evaluation	X	X	X	X	X	X				X		X	X	X		X	
Network planning, topology optimization& resilience	X	X	X	X		X			X			X	X	X			
Standardization	X	X	X	X	X	X			X	X	X	X					
Dissemination	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

2.3.3 Contribution to Project Targets

As can be deduced from the effort estimates in the work plan description, each of the partners has a clear role in reaching the project's targets outlined in section 1.1.4 of the proposal. Table 2 makes this relation more explicit.

Table 2: Partners contributing to the project's targets

Project targets See section 1.1.4	DTAG	FT	TID	DOCOMO	FON	JCP	AITIA	TELNET	EAB	ALU-I	ADVA-UK	ADVA-DE	BME	POLIMI	IT-TB	CTTC	ULUND
Definition of optimised FMC architectures	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Assess multi-operator FMC scenarios	X	X	X		X	X	X		X	X	X				X	X	
Experimental demonstration of FMC in lab tests and field trials	X	X	X				X	X	X	X	X	X					
Drive standardization bodies with respect to FMC architectures	X	X	X	X		X			X	X	X	X					

2.3.4 Complementary Partnership

To avoid unnecessary duplication of work, whilst still ensuring coherence in the project, partners have been selected of essentially complementary expertise and focus. As illustrated by Table 7, industrial and academic coverage is ensured for each competence area, and care is taken that sufficient critical mass is present in the consortium to allow exchange of ideas, approaches and concepts. As can be seen in Table 2, every major project target is covered by both industrial and academic partners.

2.3.5 Industrial/Commercial Involvement to Ensure Exploitation

The COMBO consortium is strongly driven by major industrial players in the field of fixed and mobile networks and infrastructures. The work plan itself implements a number of tasks directly relating to exploitation of results, once the project has completed successfully:

-Task 5.3: this task will identify innovative scenarios and associated business models to realise an architecture and ecosystem with strong business potential;

-WP6: in addition to validating the project's approach, the experimental work and trials will also serve to attract business interest for the project's results and will be backed by a solid business case;

-Task 7.2: this task is entirely dedicated to taking initiatives for further exploitation of results. Building this task into the work plan (rather than adding such activities ad hoc in another task) ensures proper attention will be paid to these aspects;

-Task 7.4: an important outcome of the project will be standardization, where important consortium industry partners are main players. As a matter of fact, one of the four COMBO targets will be to strongly push in several standardization bodies (in particular BBF, 3GPP, IETF, FSAN, ITU) a uniform and detailed vision of fixed/mobile network convergence, so as to foster a consistent approach in key standards related to fixed and mobile network architectures. Network operators and vendors of the consortium will be strongly committed to this goal and ensure that COMBO solutions will be standardised through the active and joint involvement of their respective delegates.

2.3.6 Opportunities to Involve SMEs

The consortium strongly believes in combining industrial efforts from large companies as well as from SMEs, both being complementary in approach and impact on the market. Therefore, COMBO includes four SMEs in the consortium (AITIA, TELNET, FON, JCP). These SMEs are strongly involved into R&D tasks, but also strongly committed to exploitation, via their active role in implementation (WP6) and dissemination/exploitation (WP7).

Figure 6 summarises the repartition of the partners, by their status. Industrials and SMEs are strongly involved in the COMBO project, leading to strong business driven objectives.

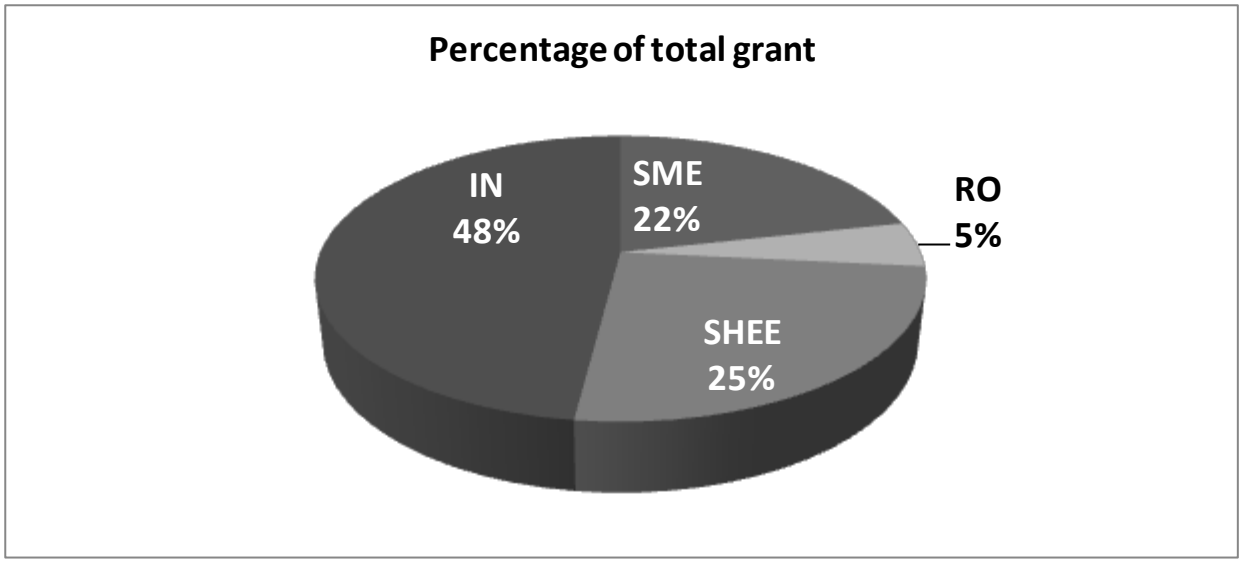


Figure 6: Repartition of the partners, by status

2.3.7 Other Issues

Sub-contracting: The website creation will be subcontracted by JCP for 15,000 euro from an external source.
Other countries outside of the EU Member states: NONE.
Additional as-yet-unidentified partners: NONE.

B 2.4 Resources to be Committed

This section provides details of the budget for the COMBO project as well as providing insight relating to other resources that participants can bring to the consortium that are outside of the scope of EU funding, such as logistics, meeting rooms, related experience, equipment and lab facilities.

2.4.1 Overall Budget

The total effort foreseen for the project amounts to 943 person months (for the project duration of 36 months). The project cost amounts to 11,090,344€, and the requested EC funding is 7,435,445€.

The consortium succeeded in limiting the budget for the project, by:
- Selecting partners with strong track record and expertise in the field, thereby making reuse of extensive existing background knowledge
- Seeking liaison with other FP6 and FP7 initiatives, to reuse results rather than developing solutions from scratch
- Avoiding overlap in competences contributed by the different partners in the project
- Mobilisation of additional resources

Considering the effort in terms of person months, 4.82% is used for project management and 7.89% is dedicated for dissemination, exploitation and standardization of project results, leaving 67.32% for the technical activities of the project and 19.97% for integration and demonstrations. A high-level breakdown of this effort, according to the nature of the activity is shown in the table below.

Technical activity	Effort share (%)	Tasks/WPs involved
Project Management	4.82	WP1
Dissemination, exploitation, standardization	7.89	WP7
Demonstration, integration	19.97	WP6
RTD	67.32	WP2, WP3, WP4, WP5

2.4.2 Other Major Costs

Although most of the equipment required to perform the experiments is already available at partner's laboratories, materials for prototype's manufacturing, as well as required consumables, will be purchased. Some partners require also measurement equipment, but only the depreciation cost of this equipment will be requested.

The table below summarises the estimation of needs in consumables, materials and equipment:

Partner	Element	Estimated cost (euro)
FON	FON routers (called Foneras)	5000
ADVA-UK	Four FPGA development boards (NetFPGA or Xilinx ML605 for example)	5600
	Four Host PCs (Linux Based)	2400
	6-port Gigabit traffic generator	1300
	Sundries (SFP's/fibres/consumables)	8000

TELNET	Depreciation of purchased equipment (generators, analysers and measurement devices)	14000
	Optical passive elements (filters, splitters, AWGs)	8000
	Optical active elements (XFP, SFP, EDFA, ROADM and RSOA, for example)	19000
	Materials for board prototypes (chips, components, PCA, consumables, etc.)	11000
	Chassis and mechanical elements	3000
	Software licenses	2000
	Sundries (fibre links, consumables...)	2000
IT-TB	Computers for 2 PhD students	2000
	Work station for simulation platform	3000
	Simulation software (OPNET) license	15000
JCP	Subcontracting (website)	15000
	Dissemination (event organisation, conferences	30000
DTAG	Dissemination (workshops, congresses, exhibitions)	40000
BME	AccessPlan Server for planning and optimization	4000
	Plotter A0 + Large Display	5000
	VPI license for 3 years; MATLAB license for 3 years; CPLEX license for 3 years	8000
	GIS databases & maps for topology calculations and economic analysis	3000
TOTAL		206300

There are no additional major costs charged to the project: main funding is requested for project staffing, overhead, travel and auditing.

2.4.3 Balance of Resources

Figure 7 and Figure 8 show the distribution of the resources per partner and per country:

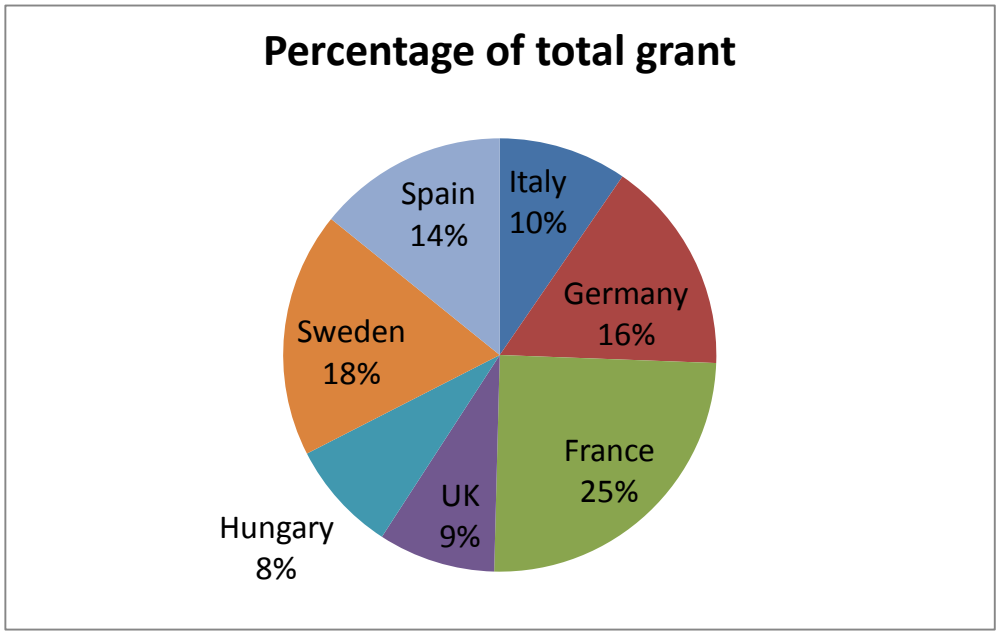


Figure 7: Distribution of resources by country

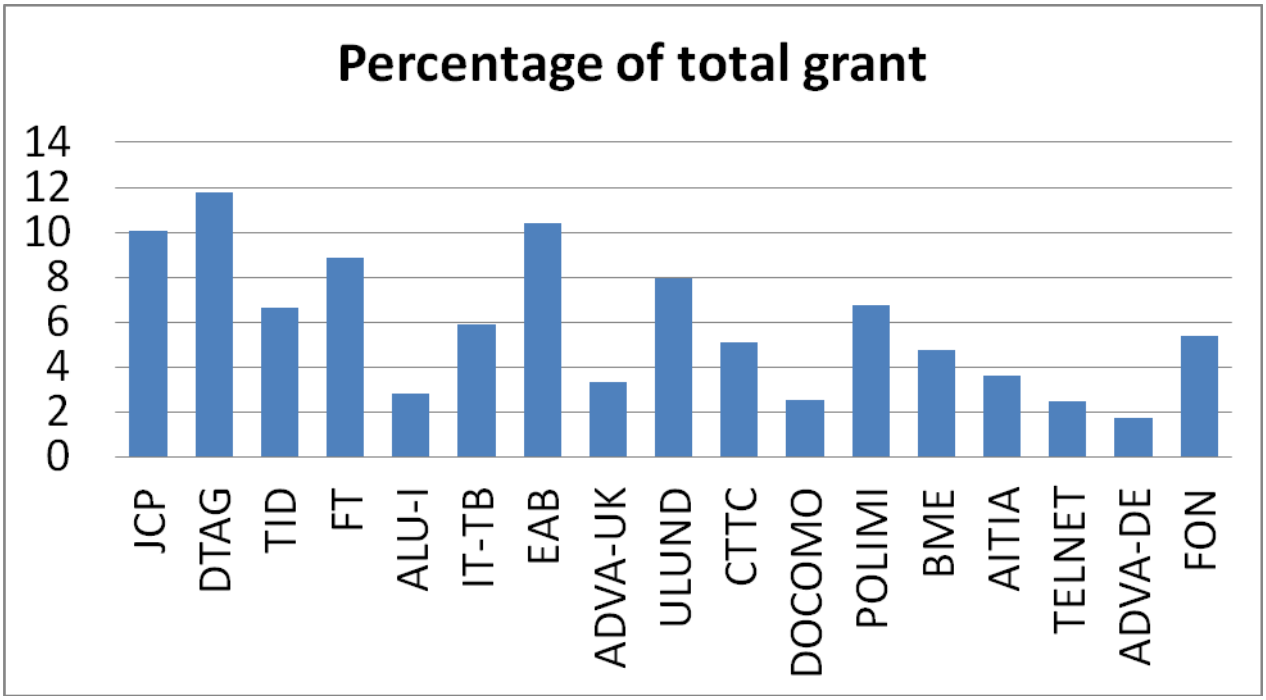


Figure 8: Distribution of resources by partner

2.4.4 Mobilisation of Resources

Reaching the ambitious project objectives is only possible by mobilising additional resources for the project. The partners bring significant expertise to the project:

JCP: R&D expertise acquired on network and QoS from previous R&D projects (scalimage, VOD@IMS, nextv4all, Locomotive, SocialSensors) , involvement in OASE project on topical access. Business and techno-economic expertise gained through involvement in both R&D and industry projects. Management and dissemination expertise acquired in 20+ R&D national and European projects.
TID: Current and previous projects related to fixed and mobile networks such as ACCORDANCE, ARTIST4G, ALPHA, BeFemto, Geysers; The techno-economics people from TID with a strong experience in network issues will participate WP5; TID will benefit from its experience in testing and validation network solution, as well as its participation in internal and in European collaborative trials; Some TID people that are attending main standardization bodies (FSAN, BBF, 3GPP, …) will contribute to WP7 or will be in direct contact with TID's COMBO team.
FT: previous involvement in network design collaborative projects such as Celtic MEVICO, FP7 ETICS, ALPHA, ARTIST4G; An FT expert on techno-economics, having a strong experience with an access network planning tool, will contribute to COMBO WP5; FT experience in previous access network field trials such as FP7 SARDANA will benefit to COMBO for the experimental activities planned in task 6.3; Some FT delegates in standardization bodies (FSAN, BBF, 3GPP, IETF) will contribute to COMBO WP7
ALU-I: FP6 WEIRD, FP5 SMACS, FP7 ETICS
IT-TB: Involvement in previous national projects or industrial research contracts on metro and access fixed network architectures; Direct industrial research contracts on new mobility management procedures in mobile networks; Experience in standardization (ITU, ETSI)
EAB: Partner in the FP7-OASE (Optical Access Seamless Evolution); Sub-project leader for fixed mobile convergence within FP6 project MUSE; Participation in CELTIC projects BANITS, BANITS2, TRAMS and R2D2 as well as EU FP6 project MUSE. Several years of research within the area of layer 1 testing of xDSL and PON; Market leader in 2G, 3G and 4G mobile technologies Vendor and Integrator of MBH solutions.
ADVA-UK/ADVA-DE: Links from other Projects incl. OASE and IMPACT from Piano+; Standards Expertise in FSAN
ULUND: CELTIC-TRAMMS, CELTIC-R2D2, CELTIC-IPNQSIS, FP6-MUSE, CELTIC-4GBB, EIT ICT Labs, CELTIC-BANITS II; Publications by the research group Broadband Communication: 9 books/chapters, 57 journal articles, more than 180 peer-reviewed conference papers
CTTC: Evolution of metro/core network towards packet transport network (ICT STRONGEST project), evolution towards all-wireless mobile network architecture (the IST-FP6 WIP project). Evolution of cellular networks (ICT FP7 BeFemto project); Application and design of GMPLS control to multiple technologies such as MPLS-TP and WSON (CELTIC 100GET, CELTIC TIGER2, ICT STRONGEST; Exhaustive Performance evaluation/validation of GMPLS protocol enhancements and advanced mechanisms (e.g, routing algorithms, PCE) within CTTC ADRENALINE testbed, network traffic modelling (the ICT-FP7 BeFemto project), radio resource & mobility management (mIO Spanish project, DESSERT & IPANEMA Cisco grants), routing in wireless mesh networks (ICT-FP7 BeFemto and WIP projects); Network planning and node dimensioning aspects (the WIMSAT project - convergence of WiMAX, IMS and Satellite); Development of proof-of-concepts and demonstrations (IST NOBEL2, ICT FP7 BeFemto& WIP projects, DESSERT & IPANEMA Cisco grants), interconnection with other parties through IPSEC tunnels (ICT STRONGEST); Publication in notable IEEE and ACM international conferences (ECOC, OFC, Globecome, ICC, MSWiM, VTC) and scientific journals (IEEE/OSA JLT JOCN), panel discussions within Mobile World Congress, seminars with industrial partners.
POLIMI: NoE BONE, e-Photon/One

BME: NoEePhoton/ONe, NoEePhoton/ONe+, NoE BONE, IP MUSE, IP NOBEL, IP NOBEL II, IP EARTH, COST 291, COST 293, CELTIC TIGER 2; Experience in presenting results at conferences and in Journals and magazines; Organization and logistics expertise in project meetings, workshops, summer schools and of numerous conferences of various size.
AITIA: Special expertise in protocol analysis and development; Special expertise in Knowledge Plane, from CELTIC TIGER2
TELNET: Previous participation in different projects, such as European CELTIC projects or national funding projects. Concerning this topic, the most related projects are R2D2, 100GET and VISION, were the same technologies were proposed for different purposes.
FON: Previous participation in ULOOP project (FP7)

In addition to the expertise brought into the project, partners are willing and able to commit the following resources to the project:

Human Resources
FT: 2 PhD students from FT will work full time on Combo network architectures, whereas only half of their time will be accounted for as Combo manpower
IT-TB: 42 person months from PhD students; 5 person months from Post Doc students
EAB: Master's students
ADVA-UK/ADVA-DE: Standards guidance from our internal Standards Development team
ULUND: PhD student (part-time/scholarship), Master students
POLIMI: 1 PhD student
BME: PhD students (1-2) with state funding; PhD/MSc students (2-3) with state funding, contributing to SW development
AITIA: MSc students with external funding
TELNET: Administration staff of Telnet will manage the billing and justification issues; project in order to manufacture prototypes, manage stocks, logistics and so on; several people (up to 20 persons) outside R&D team are often involved in each research project in order to manufacture prototypes, manage stocks, logistics, and so on.

Logistics
Meeting rooms from the following: JCP, TID, ALU-I, IT-TB, EAB, CTTC, DOCOMO, BME, AITIA, ADVA-DE, FON
Conference rooms from the following: CTTC, EAB, BME (July, August), POLIMI

In addition, **TID** offers laboratories, PON infrastructures and test devices and equipments will be available for the project. **FT** offers access network field infrastructures in Lannion (in Brittany). These infrastructures are composed of a metropolitan ring of 12 fibres of 18 km each (2 fibres will be made available for COMBO activities) and PON infrastructures connected to some of the ring nodes.

Equipment
JCP: a CDN testbed which will most probably be useable for COMBO free of charge for simulations and tests
DTAG: Tools to calculate capital expenditures; Tools for network dimensioning, topology optimization, availability calculations, etc.; Tools for physical layer modelling (e.g. VPI Transmission Maker) for system performance evaluation (optical and wireless); OPNET models for discrete event simulation to study different scenarios; OPNET SP Guru Transport planner for strategic planning of transport networks
TID: PON testbed will be available during WP6 activities, as well as other performance, measurement and communications equipments in order to build different FMC testing scenarios
FT: extended measurement equipment around the access network field infrastructures located in Lannion, in Brittany. This equipment will allow performing physical tests, performance tests,

residential services support tests, business services support tests, CPRI backhauling tests, mobile services support tests, power consumption measurements and system management tests.
ALU-I: TESTBED in ERMES project
IT-TB: IEEE Explore Access
EAB: Testbeds and lab equipment for physical layer testing of centralized BBU solutions and for physical layer testing of xDSL and GPON; Testbeds for MBH and centralized BBU solutions including microwave and WDM-PON links, network nodes as well as LTE MU and RRU for evaluation of synchronization
ADVA-UK/ADVA-DE: Lab facilities, test equipment
ULUND: Laboratory for fault detection and performance monitoring of access network
CTTC: ADRENALINE TESTBED – GMPLS controlled MPLS-TP/WSON network infrastructure, advanced Path Computation Element (PCE), web-server for allowing remote development and experimentation through an open API. CTTC EXTREME testbed: multi-purpose platform to experiment with wireless and mobile networks (WiFi, 3G, femtocells). LENA: LTE/EPC network simulator and emulator
DOCOMO: Simulators (MATLAB)
POLIMI: Lab facilities for simulation and optimization (PCs, workstations…)
BME: LTE-sim 2.1, CPLEX; SW experience and availiability: C++, Matlab, CPLEX, OpenStreetMap, VPI Component and Transmission Maker, AccessPlan access network planning and business case evaluation tool
AITIA: Hardware and software developed earlier for passive monitoring and protocol analysis; Hardware and software developed earlier for performance management and monitoring; Own lab and equipment for development and verification
TELNET: equipment for manufacturing electronic devices, including almost all the chain, from design to final equipment. Also, equipment for tests will be used, such as traffic generator and analyser, thermal cameras, racks, power sources, labs premises, multi-proposal probes, software licenses, installations, simulated networks, etc.
FON: Test Tools Hardware

Other
EAB: Cooperation with the Federal University of Para - UFPA (Brazil)
ULUND: long history of working closely together with leading industrial and academic partners in both national and international projects on broadband access and core networks, on all layers.
BME: Continuous R&D cooperation with Hungarian Telecom fixed line and mobile service provider in the field of fixed line and mobile network development
AITIA: Links with Hungarian Universities: BME, ELTE and University of Debrecen

B3. IMPACT

B 3.1 Strategic Impact

3.1.1 Introduction

Today, fixed mobile convergence is mainly realized by the implementation of IMS (IP Multimedia Subsystem) on the service layer which enabled to build a converged service control layer and thus shifting the way telecom services are created and delivered. COMBO, however, will go beyond this point and will develop optimised architectures for future converged fixed-mobile networks, impacting not only the service layer but also the network architecture in terms of location of network control functions, resource pooling and sharing and new equipment functionalities. As such, convergence can be seen as the ability of the network to serve the end-user with its services whatever the access network or terminal is. The end-user should not care about the network used or connected to; it should be automatically selected to offer the best quality of experience and/or quality-price ratio. For example, if the user can be best served for data services via a near-by WiFi location with fixed network broadband backhauling the network itself should be able to allocate the proper resources on this path instead of delivering a data service via the mobile network. Such a scenario, however, as a prerequisite needs an mutual information exchange in terms of performance monitoring and management capability between instances of both networks to decide what is the best suitable transport path.

Network convergence also raises the question of business model alignment between fixed and mobile data: a convergent charging policy may ease the control by the network operator of the network selection procedure executed by the end user device. Beside end user perspective, service provider needs have also to be considered. As it improves service attractiveness, convergence also improves the interest of cooperation between network operators and service providers. These convergent infrastructures will also provide added value and business opportunities to network operators and service providers in multi-vendor multi-operator scenarios. As an example, novel cooperation wholesale models in which separate-owned network segments may be shared between network operators/ service providers

In terms of network architecture, fixed-mobile convergence will also lead to smart and powerful ICT infrastructures with reduced cost and energy consumption. Network convergence will thus allow a better balance, in the Internet business model, between infrastructure providers and over-the-top players. In a sense, this might be a key of future European competitiveness in the ICT sector.

3.1.2 COMBO's Contribution Towards the Impacts Listed in the Work Programme

- Strengthened positioning of European industry in the fields of Future Internet technologies, mobile and wireless broadband systems, optical networks, and network management technologies:

Fixed mobile convergence is a key topic for the medium term future; moreover technologies are now available to achieve this, so it is the right time to define architecture and standards. COMBO project will provide a technical framework that will allow European industry and operators to face to a major challenge: to move from a fixed versus mobile paradigm towards a new convergent model supporting both managed and unmanaged services, whatever the access technology is. COMBO consortium is represented by major European vendors and operators which have the capacity to develop and

produce the solutions and deploy cost efficient networks after the project end, and provide the necessary momentum for COMBO concepts to be extensively adopted.

The consortium will enable agreement between major actors in order to have impact on standardization and future system solutions. The solutions promoted by COMBO will hence have a broad support in the industry community.

Joint mobile/fixed network optimization and the innovative concept of Next Generation Point of Presence (NG-POP) around which COMBO architectures are built will lead to major impacts in systems, mobile/fixed convergence and fixed access and mobile backhaul

As this evolution would lead to major impacts on network systems, it requires a European approach in order to generate significant volumes for the European telecom industry and to promote a single European model on the worldwide market. It is an opportunity for Europe to take the lead in future network architectures and systems.

In order to maintain technical leadership in the fast evolving area of fixed and mobile broadband networks, COMBO advances beyond the state of the art for fixed mobile convergence. The innovations will be aligned with the vendors and operators roadmaps for technologies and products and thus aligned with, and strengthen the company strategies. The joint forces in the project are aimed to achieve critical mass and achieve global impact.

Considering the impact on European society and the market potential for mobile and fixed broadband solutions, it is important for the European telecom vendors to maintain leadership for both fixed access and mobile backhaul. Thanks to research in previous and ongoing European research programmes, we have a good knowledgebase for future optical access that will be used as a base for the development of future internet and the integration of fixed and mobile transport.

COMBO partners will promote common contributions of project R&D results in standards. This will strengthen the European industry impact in standardization bodies and fora that are today often dominated by Chinese and North American players.

In order to be successful in standardization and in the promotion of the solutions, , COMBO will demonstrate project concepts and provide a framework for prototype performance verification in pre-defined use cases. Further, COMBO will perform a number of lab trials and a field trial in order to show end-to-end integration of developed architectures and demonstrate its interoperability.

- Developing the technology for the future generations of the European high-speed broadband and mobile network infrastructure.

COMBO project will define functional and structural models for converged networks and systems that will be directly used by European industrials as guidelines for the evolution of their products lines.

The COMBO project allows vendors within the consortium to liaise with operators and academic partners in way that brings a fresh view of the evolution of mobile and fixed networks to their respective roadmaps. Furthermore, the unique mix of experience from the different partners allows vendors to pool knowledge and experience on convergence of these areas and thus strengthens the roadmaps of European based vendors on the subject of Fixed/Mobile Convergence. Besides, vendors will be able to anticipate future demands, taking advantage in the market, having a privileged position against other companies and reducing time to market.

The opportunity to perform experimental work in a cross-vendor and multi-operator allows functions

to be tuned and also progress beyond state of the art to be developed thus providing a foundation for external marketing of European based vendors, especially in conjunction with the dissemination activities within WP7.

- Increased economic and energy efficiency of access/transport infrastructures (cost/bit).

COMBO will propose a model that will allow operators to reduce drastically the number of their Central Offices (CO), both for fixed and mobile nodes. This will lead to significant network cost reductions which will be key to address the profound transformations needed to face data traffic explosion in the medium to long therm. In the short to medium term, convergence of fixed and mobiles nodes will lead to cost optimization and energy savings.

More precisely, the optimal level of convergence between fixed and mobile networks is in the main focus of the project. Optimality addresses three fundamental aspects: performance (technical quality), economic value (business opportunities) and energy efficiency (sustainability).

All three aspects are considered within the project, these are driving the efforts for FMC architecture proposals.

Techno-economic and energy efficiency analysis are the main tasks of the project, as these provide insights into further improvement of architectures and validate (justify) the proposal.

The techno-economic assessment is carried out using a novel and powerful methodology, the so-called geographic modelling, which increases accuracy of the evaluation. It incorporates network planning and optimization in the techno-economic assessment framework. The framework and the methodology are developed, improved and the fixed and mobile counterparts will be integrated in WP5, Task 5.1.

Based on the optimised network architecture, and using the developed methodology, economic (cost) analysis is carried out in Task 5.2, It employs detailed network models, which allow a bottom-up accurate cost calculation, based on the integration of the network planning process described above.

Energy efficiency analysis and optimization of energy saving strategies (including renewal energy sources) is the main focus of Task 5.4, which provides feedback on architecture and performance management proposals.

The impact of convergence and the multi-operator environment on the economic environment is addressed in Task 5.3, which clarifies the changes in business ecosystems, and new challenges faced by operators and potential regulatory aspects.

- Contributions to standards and regulation as well as the related IPRs, with a predominant role for Europe in standardization bodies and fora.

The COMBO work-structure schedules not only the development of new architectures or specific connectivities, but the contemporary implementation of system demonstrators. This project structure is particularly suitable to support actions in standardization committees because it aims at the demonstration of the operation in a real network environment. COMBO industrial partners will actively push COMBO concepts towards key to fixed and mobile network evolution standardization bodies, where COMBO partners (and specifically people involved in COMBO) are already particularly active.

Concerning optical domain, through the active involvement of the industrial and operators partners of COMBO (DTAG, FT, TID, ALU, Ericson, ADVA), there is the opportunity of influencing them to

incorporate the COMBO potentialities. Likewise, the COMBO designs will be aligned as much as possible with existing and evolved standards toward wide-spreading of next generation optical access node. Typical standardization groups are FSAN, ITU-T SG15 Q2 & Q6, IEEE 802.3 and forum WDM PON forum, Open Lambda Initiative, eth-wdm-phy group.

Concerning mobile domain as well, there are several fields were COMBO studies and demonstrators could help in pushing some of the projects outputs to the 3GPP, among which the distribution of the EPC network elements, the BBU hotelling in a local POP, or the cooperation between 3GPP and non-3GPP networks.

Through its industrial partners (DTAG, FT, TID, ALU, Ericson, ADVA, FON), project interaction with industrial and scientific community and standardization bodies is three-fold:

- Network operators of the consortium, together with vendors, will form a taskforce to jointly and strongly advertise COMBO solutions in the scientific and industrial community
- COMBO will stimulate interactions between different bodies on FMC issues, through coherent and aligned contributions in the respective fixed and mobile fora
- COMBO uniform and detailed vision of fixed/mobile convergence will be pushed through technical contributions to the relevant standardization bodies, fostering a consistent approach in key standards related to fixed and mobile network architectures.

If a collective benefit is envisioned, as an additional IPR strategy of the project, COMBO will foster the adoption of a patent pool so that the solutions provided by COMBO, when standardised, lead to simple and fair access and implementation by project partners and parties external to the project.

The COMBO project is focused on fixed and mobile networks, and the harmonization or the convergence between them. In this scope, the regulation aspect is very important, since there are limitations on infrastructure mutualization to ensure competition. Given current state of the art, it is necessary to be a convergent operator (such as the case of most incumbents) to extract the high benefits that a FMC scenario including infrastructure mutualization offer. Indeed, in countries like France, it is today difficult for fixed and mobile operators to merge their infrastructures because the regulator imposes a legal separation. The main reason is that some operators are fixed only or mobile only, so the competition is supposed to be unfair if infrastructures are mutualised. However, the telecommunication landscape is changing. Indeed mobile and fixed operators are all having activities in both types of network. The very last fixed broadband operator Free recently got a 3G licence so that, from early 2012, all major telecommunication operators in France will be both fixed and mobile. In this context, it can be expected that the regulation will be softened regarding infrastructure mutualization.

In other countries, such as Spain, one operator can transport fixed and mobile services in its network, but it is mandatory to have an accounting separation for the allocation of different fixed and mobile services, so the fixed network can be leased to other operators under the same conditions with a non-discrimination policy (same requirements, same price). Another regulatory constraint forbids operators to sell fixed and mobile services under a single invoice, but this current scenario can change soon because fixed-mobile convergence is under the CMT's 2012 action plan (http://www.cmt.es/es/actividades_en_curso/consulta_publica/anexos/ Plan_actuacion2012_def.pdf).

On the European level, regulatory uncertainty over the treatment of FTTH networks is widely acknowledged as a key factor that has prevented wider roll-out. The EU's Broadband Recommendation, which requires that all 27 EU national regulators apply a consistent approach to regulating Next Generation Networks, has substantially reduced this uncertainty, in both the EU and those jurisdictions that regularly look to the EU for public policy leadership in telecommunications regulation. In EU's Broadband Recommendation at Recital 21, it is stated in particular that « *Obligations imposed … are based on the nature of the problem identified without regard to the*

technology or the architecture implemented by a Significant Market Power (SMP) operator. Therefore, the fact of whether an SMP operator deploys a point-to-multi-point or point-to-point network topology should not as such affect the choice of remedies, keeping in mind the availability of new unbundling technologies to deal with potential technical problems in this respect. »

With this in mind, COMBO will foster the development of FMC architectures allowing various fixed and mobile applications to share the same infrastructures (e.g. a fibre) while still allowing strict separation (unbundling) to ensure flexibility, openness and collaboration with service providers. This FMC model will allow strong structural convergence of network infrastructures, enabling cost and energy efficiency while fostering competition, being compliant with European regulation at the same time, and will strongly and positively impact the evolution of ICT services, both fixed and mobile. COMBO results will thus foster a fine tuning of regulation inside the EU to achieve this positive impact.

- Industry adoption of **integrated all optical networks and of spectral-efficient broadband wireless systems**, novel Internet architectures and technologies

COMBO will develop fixed and mobile convergence (FMC) network architectures and their key components, which will lead to novel internet architectures and technologies.

The COMBO FMC architecture will be also designed based on future optical access technologies promising high energy efficiency and low-cost. In other words, COMBO will provide integrated all optical access and aggregation network architectures to the industry.

In addition, COMBO will design the FMC architectures enabling to accommodate a variety of broadband wireless systems, not only cellular radio systems such as LTE/LTE-Advanced and 5G but also other wireless technologies such as Wi-Fi. Moreover, provide the necessary capacity, flexibility, and capillarity to be able to support the coexistence of different cell sizes within the same area, so called heterogeneous networks. Therefore, COMBO will provide the industry with networking solutions to deploy spectral-efficient broadband wireless systems.

3.1.3 Expected Impact on the Technical Field

With the design concept of a Next Generation Point of Presence (NG-POP), COMBO will achieve technology innovation for the convergence of fixed and mobile access and aggregation networks going far beyond today's loosely coupled concepts. Fixed Mobile Convergence will not anymore be achieved on a service or management level, but integration, interworking and optimization will be realized on infrastructure and equipment level.

In addition to this technology innovation in network architectures, COMBO will also develop enabling technologies to support architecture realization manifesting the new steps in FMC technologies:

- Next generation optical access nodes based on next generation PON technologies
- Base band unit hotelling in local POPs
- Protocols and mechanisms for the synchronization of base stations
- Mechanisms allowing the cooperation between 3GPP and non 3GPP networks early in the network (before GW) based on a joint backhaul architecture allowing for better performing seamless handover
- High performance and optimised offloading mechanisms
- Distribution mechanisms for EPC network elements and their coordination
- New control functions converging between fixed and mobile control based on OpenFlow concepts

- New mechanisms for application support through media distribution based on servers in the aggregation network
- New concepts for network planning and joint optimization of shared network resources

3.1.4 Expected Impact on Operators

The evolution of fixed and mobile networks is necessary and even critical for network operators in order to take into account the numerous challenges that they have to face up to, including traffic increase and revenues stagnation. In particular, Over-The-Top players (OTTs) induce costs into network operators by creating novel application and services, which in turn increase traffic and cannibalize traditional telco services such as voice or SMS. As a consequence, nowadays most of the traffic of mobile networks are due to non-operator services. OTTs have large audience on their service platforms thanks notably to the introduction of application technologies coming from the Web services (HTTP streaming for videos, SIP for VoIP etc.) and are thus an important element in the added value chain of modern telecommunications. Regarding the usage tendency, it is a strong expectation from users to be able to access to their services from any access network and device (PC, Smartphone or tablet). For these reasons, and for the benefit of all players, network operators will have to build more cost efficient networks allowing mutualization of infrastructures (e.g. FTTH plants between e.g. fixed access and mobile backhauling) and to simplify architectures to reduce costs and energy consumption. This strategy will also enable operators to offer the best service delivery by taking advantage of their network infrastructures, i.e., fixed and mobile networks and service platforms, while also leveraging other operators' infrastructures. By solving this kind of issues, COMBO project will thus allow to boost growth in the European ICT sector and contribute to a better balance in the Internet business model, thus strengthening competitiveness of all European actors.

3.1.5 Expected Impact on Quality of Experience

Fixed Mobile Convergence makes it possible to make independent the service from the access technology and terminal, providing the best access technology to the end user and enough network resources for a concrete service level. Sustaining new usages, such as the rapid growth of audiovisual content, is also a main driver for FMC. COMBO network scenarios will optimise offload of the macro mobile stations by use of local stations (femtocells, etc.), and improve the coverage by use of enhanced radio technologies (cf. LTE-Advanced). They will also optimise offload of the 3GPP radio network by use of WiFi. Thanks to more distributed mobile gateways, fixed/mobile network resource mutualization, flexibility to use radio resources from different access technologies, and convergent control functions, ultimate FMC scenarios will allow network operators to shorten service access time and to more easily sustain traffic.

More specifically, FMC architectures may increase attractiveness of services in different ways, which also depends on the market conditions:

- the improved economic (and energy) efficiency of converged fixed-mobile architectures may have a significant effect on pricing:
  - the user may get the same service for a lower price, since the operators can achieve a lower marginal cost due to cost savings by convergence
  - the user may either have a higher level of service for the same price, if the operator decides to improve the service, instead of reducing the price
- the service level itself increases with technological development and convergence, among others due to:
  - seamless handover between different technologies, adjacent cells and also co-existent operators leads to increased flexibility and availability
  - convergence of fixed and mobile networks towards a converged broadband access architecture shortens the service delivery path and thus decreases service access time and latency

- exploiting optical transmission in the backhaul segment or even higher in the network increases the offered bandwidth

The technical opportunities are not limited to the above listed factors, however even these imply that the convergence of now separate architectures enables new services, functions and applications. COMBO will thus have a strong impact on the Quality of Experience of European end users.

3.1.6 Steps Needed to Realise This Impact

To guarantee the realisation of the COMBO ambition on project impact, it is needed to accompany the technical success through correct execution of the project technical work with a set of actions to promote project results. Therefore, the dissemination plan of the project (see Section 3.2) contains a set of well-balanced measures to maximise chances to realise the inherent promises of the COMBO approach, forming an integral part of the work plan of the project. All partners are strongly committed to the realisation of this plan, such that the anticipated technical successes have an equally successful impact and economic counterpart.
These measures include:

- Exposure of the project results to a variety of forums (concertation meetings, technology cluster meetings, trade shows)
- Active participation to standards meetings, thereby raising awareness and acceptance for the COMBO solutions. Targeted standardization bodies include 3GPP, TISPAN and FSAN.
- At the end of each phase, a review of business opportunities involving business divisions of the industrial partners as well as exploitation cells of the research institutes will be held to define internal and external actions to take to maximise the impact of the (intermediate) project results.
- The COMBO project will liaise with other FP7 STREPs/IPs. Some of these projects have already been identified: OASE, ACCORDANCE, Artist4G. However, there are no dependencies on these projects in the COMBO project plan. COMBO will also collect requirements for backhauling of future radio networks network from more radio oriented projects such as METIS, an intended project in this Call on Gen5 radio networks.

- As mentioned in Sections 1 and 2, an industrial advisory board will be set up. This will not only be essential in capturing industrial interest but will also serve as informal dissemination channel for the project, thereby contributing to the overall impact of the project. The role of this industry board will become important in the standardization phase during and after the project, and further deployment.

Vendors within the COMBO project who are working on the practical work within WP6, intend to provide data and experimental results towards the dissemination activities which will include presentations to standards bodies as well as external industry based presentations on the subject of Fixed/Mobile Convergence and especially in the context of the concepts proposed within the COMBO project.

Where project achieves progress beyond state of the art, and where validated in lab based and operator based test environments, press announcements will be made as and when appropriate in conjunction with the COMBO consortium to highlight the activities of the consortium. Thus, COMBO has included a strong practical and operator based experimental environment, in order to achieve this.

3.1.7 European Added Value

To address fixed-mobile convergence issues at the European scale is necessary for several reasons:

- Achieving the project's objectives requires a wide variety of complementary competences. The consortium has been formed to cover these competences by highly qualified partners. Bringing together excellent partners experienced in the domains covered by COMBO, requires collaboration at an international level (refer to section 2.3). Additionally COMBO addresses issues which cannot be limited to the national scale (like roaming, service continuity, techno-economics or business analysis)
- Reaching the industrial impacts mentioned in section 3.1.2will require deployment and product development which have to reach at least the European market. Therefore it requires consensus between the main operators and vendors in Europe, which are part of the COMBO consortium, supported by expertise of academic partners. COMBO tries to promote their solutions even beyond Europe, via the participation of DOCOMO to the project, European industrial partners operating also outside the European footprint and an Industry Advisory Board.
- Success in standardization, more particularly in the committees mentioned in WP7 requires as well consensus between European, if not worldwide consortia. Again, the strength and representation at the European scale of Operators and vendors is a MUST for COMBO to have a chance to succeed.
- Finally the project envisions identifying regulation issues, which again have to be considered at the European level and will require a European approach, and the expertise of partners in their respective countries.
- The mobility of end-users within the EU in itself requires technical solutions that allow seamless roaming capabilities for them, therefore the transmission and networking technologies must be harmonized at least on the European level: the same devices should be able to have (FMC) network connectivity everywhere in Europe. An EU-wide consortium is fundamental for reaching this goal, as they can bring together all the different aspects to fulfill end-user requirements in various countries, i.e. geographic, social, economic and technical aspects.

3.1.8 Interaction with Other National and International Research Activities

A list of relevant recent on ongoing FP7 projects has been provided in section 1.2.4. Taking into account the likely period of activity of COMBO, possible interactions with some of them have been mentioned in WP7 description. These projects are:

- STREP ACCORDANCE
- STREP ERMES
- IP OASE
- NoE TREND
- CELTIC-MEVICO.

In addition to this, fruitful interactions will be established also with other FP7 projects submitted (and funded) under the same FP7 call as COMBO.

For certain topics which are not in the focus of the aforementioned projects, COMBO will hold interactions with **industry fora or European Technology Platforms (ETP)** such as ETNO, FTTH Council Europe, GreenTouch, Net!Works ETP and Photonics21 ETP, on different topics listed in WP7 description.

To our best knowledge, there are no related research activities or forums in Japan with respect to FMC. On a National level, we have not identified specific projects addressing FMC convergence in the European countries.

Finally, regarding experimental networking platforms, most of them are addressing fixed network issues, including future Internet. Among existing platforms, the most pertinent one for a useful interaction with COMBO is probably the French Imagin'Lab platform, launched in 2011 in Brittany. Indeed this platform deal with both fixed (in Lannion area) and mobile (in Brest area) access networks and can provide connections between these two areas (http://imaginlab.fr/blog-en/). These areas are located close to two COMBO partners (Orange Labs and IT-TB). However, it is based on commercial equipment and network managers and more oriented on service evaluation. Therefore Imagin'Lagb is not suited for hosting the foreseen COMBO field trials but interactions of some specific issues, including COMBO inputs on possible evolution on the Imagin'Lab platform structure.

3.1.9 External Factors for Impact Achievement

External factor may affect evolution of Fixed and Mobile network Convergence and thus impact the project's objectives. These factors will be typically related to economic, market and regulatory issues:

- Current world economic situation over the last years, in addition to data traffic increase and stagnant revenues, is stressing telecom operator margins, which may in some cases affect investment strategies in new technologies, new concepts or future architectures.
- Having said that, complex economic environment will force telecom operators to look for new alternatives that may offer the capacity and performance requested by users, while decreasing CAPEX needed for extensive fixed/mobile ultrabroadband connectivity, and the OPEX required to operate them. In this scenario, the cost-efficiency provided by Fixed and Mobile Convergence will play a key role in the whole solution.
- Once a clear bet on FMC from network operators is perceived, telecom industry will trust and bet on future Fixed and Mobile network convergence, so new technologies can be developed to provide fixed and mobile services using a single network that can be deployed more easily and being able to reuse the network resources in a more efficient way.
- Another key external factor is the evolution of the regulation and policy in the telecommunications industry, which can foster or hinder the deployment of FMC networks, despite their technical and economic feasibility. Currently operators are interested in merging their fixed and mobile networks in order to be more cost efficient (and at the present time the industry is looking for solutions to do that), in which FMC solutions can help a lot to achieve that, but will not be possible (at least in a general scenario) if regulation requires independent fixed and mobile networks to promote the competence. Best way to ensure that FMC is a success is to develop it in a way that it embraces multi-vendor, multi-operator scenarios, thus fostering competition."
- Additionally over the last years there was a trend visible to merge business units for mobile and fixed network operations from a network operator perspective. Combining these units in a single business unit will drive the need for further consolidation of fixed and mobile networks and will enable an overarching view to optimize both networks into a combined network. It can be expected that also over the next years this will put some pressure on equipment vendors to further stimulate co-operation between their fixed line and mobile network departments to address network operator needs. Former independent business units for fixed and mobile will not be able to react independent anymore due to joint fixed-mobile requirements from operators.
- This can have a significant impact on the market availability of FMC enabled equipment and thus is a strong impact for FMC outside of the COMBO project.

B 3.2 Plan for the Use and Dissemination of Foreground

COMBO will ensure the dissemination of results of the project to decision and policy makers at national, European, and global level, to industrial business managers and market leaders, and of course to researchers, scientists, and innovators. These dissemination activities encourage, orchestrate, and assess the communication of the results of the project. Dissemination of results is undertaken via several routes like established channels for providing information on the project during its progress, and ensures that the project's results are in use during the project's lifetime and after the project has finished.

COMBO will:

- Set-up and maintain a project web-site that will act as an information and service portal, disseminating project results and providing access to standards, reference implementations, demonstration software, material explaining COMBO innovation, connection to other projects, press information, success stories and industrial transfer;
- Participate in national and European market fairs where the COMBO will be presented by its industrial partners;
- Set-up of an External Advisory Board involving relevant personalities in the field who are interested in different activities of COMBO;
- Cooperate closely with commercial, standardization and scientific interest groups and their organizations and create interest groups in the field of COMBO activities;
- Widely publish in international academic and trade journals, conference proceedings, and national publications;
- Organise industrial and academic workshops, seminars and conferences for presenting project results;
- Contribute to formal pre-standardization and standardization bodies, fora and industry groups exchanging continuously background information. This contribution to standards will be a key priority of COMBO project, since the dramatic network evolutions and revolutions required by fixed/mobile convergence will be made possible only when standardised. One of COMBO goals will thus be to strongly push in several standardization bodies (in particular BBF, 3GPP, IETF, FSAN, ITU) a uniform and detailed vision of fixed/mobile convergence, so as to foster a consistent approach in key standards related to fixed and mobile network architectures;
- Disseminate and exchange project results towards other European operators and vendors. For this purpose a combined effort by the three operators DTAG, FT and TID will be set up in terms of e.g. an operator task force.

The marketing material is adapted to the intended audience that is threefold:

1. Several communication actions will target the general public through press conference at the start-up of the project, press releases at major market fairs, presentations, booklets and flyers available in the information days and conferences e.g. FIA Mobile Summit, ICT and Horizons conferences, FTTH Conference, WWRF, ICC, ECOC, OFC, MobiCom, Fotonica;
2. The industrial partners are notified and their feedback is received through the Advisory board and the existing permanent boards of the academic and research partners;
3. The project is also advertised to the academic and scientific partners thanks to the usual and appropriate channels that are the newsletters, reports, workshops and conferences dedicated to scientific audience and the industrial channels. This will be orchestrated by project management teams.

The project management team will set up an active strategy to disseminate all the public project results. A complete project work package (WP7) is dedicated solely to the dissemination of results, including standardization activities. In total it will employ 73 person-months with a strong emphasize on dissemination, internal and external exploitation and collaboration with other national and

international projects and organizations as described in WP7. Totally, 4 deliverables will report on the results of WP7 as reflected in the List of Deliverables of the present document. Another important item to note with respect to starting discussions about COMBO results with project external partners is the fact that almost all deliverables are public and thus can be shared with the community enabling a consensus building process as a prerequisite for any kind of standardization activity. All these public documents will be made accessible on the project web-site for public access.

The progress of the dissemination actions is in the responsibility of all partners. The activities are monitored by the WP7 leader who manages dissemination and exploitation in COMBO, and who produces a detailed plan of dissemination, identifies suitable events to focus resources, approves participation in and presentation at events, and reports on dissemination activities to the Project Executive Board. The overall goal for the exploitation of results of the R&D in the COMBO project is to contribute to business success by transferring results to the appropriate industrial players, to influence future technical developments, to enable the participation in emerging markets, and to support the reputation of the project as being innovative. Examples of such results are innovations that can be applied by industry, contributions to standards, patent applications and (cross-) licensing.

3.2.1 Establishing Connection with Other Initiatives

Different audiences will be targeted by the publications:

- Expert technical audiences will be reached through conference papers and journal articles. Several of the partners are frequently invited for presentations at most of the relevant conferences in the field of optical and mobile or wireless communications (like GlobeCom, OECC, ECOC, OFC, IEEE ICC, ACM MobiCom, and IEEE Wireless Communications and Networking Conference) ;
- Broader technical audiences will be targeted through announcements in well-read on-line periodicals such as IEEE Communication Magazine, Journal on Lightwave Technology, ITU News, Transactions on Networking, IEEE Transactions on Wireless Communications or similar;
- Breakthrough results will be disseminated to the broader public through press releases in local and international press;
- Partners will organise special events to allow coming into contact with their research community. Such events also are occasions to bring the achievements of the project to the attention of local actors;
- Partners also active in transversal initiatives or European Technology Platforms such as GreenTouch, Net!Works, or Photonics21 will advertise COMBO results inside these fora so as to reach the expected impact onto the industrial and research community.

Additionally there will be partner internal dissemination activities like:

- All partners in the project will disseminate project results internally in their organisations.
- In particular, vendor and equipment manufacturer will disseminate the results through industrial product development and dissemination of product information in papers, magazines and on the web.
- The academic project partners (universities and research institutes) will disseminate the project visions and results towards educational staff and students. The intention is that project ideas shall be integrated in different training activities like student projects, incorporation into lectures, etc.
  This will lead to a broader awareness of the project results and will manifest FMC.

The consortium will also be prepared to show to the Commission, and to those invited by the Commission, progress in any area covered by the project. The project expects to contribute to public demonstrations and exhibitions organized within ICT.

3.2.2 Open Events

As one way to further promote key project results, COMBO will organize open events on a yearly basis. This is seen as a possibility to reach a broader set of stakeholders in fixed and mobile networks in Europe and internationally. The events will be organized in the form of public workshops where the standardization proposals from COMBO will be openly discussed and particularly the stakeholders will be invited to present their view on needs and hot topics for FMC. This will ensure that on at least a yearly basis COMBO will gather additional input and potential direction from major stakeholders (e.g. operators and vendors) in the field of FMC.

The COMBO proposals and invitations for external presentations will be initially approved by the Industry Board (a smaller group of the stakeholders), and the ambition is that they will have a greater impact for COMBO standardization activities than any another single form of dissemination. Ideally the open event will be co-located with a major conference or venue regularly visited by operators and system vendors in the field of FMC.

3.2.3 Exploitation Plans of the Participants

All partners of COMBO will drive the dissemination of project results through internal and external exploitation of the results. In the following the different partners describe their activities as also shortly summarized in WP7 in the exploitation and standardization tasks.

JCP

Firstly, they will extend their ongoing research work on CDN/CCN and storage management in general. JCP is active currently in other European projects like social sensors where they investigate CCN/CDN use for multimedia content real time transport on mobile networks. Based on the outcome of the project, JCP will look into possible productisation with partners (which would lead to a new company creation), together with other available JCP products like IP compression software. Also, the knowledge acquired in CDN/CCN will be used for consulting and training purposes, as these are 2 ongoing activities of JCP.

Secondly, the work on business analysis and modelling will be used to increase JCP expertise and credibility on this domain, especially with the new methodologies used in COMBO. JCP has already an existing track record in strategy and business with small and large companies (DIVx, windriver, bluestreak,..) and operators, and will try to extend this activity.

Project management experience will be used in JCP consulting activities in national and industrial project, which is one main company activities. Standardization follow-up will also be an additional asset for JCP. JCP is very active in standardization in general with a full time presence in 3GPP-RAN, and support of standardization in different areas like networking, search, mobile gaming.

DTAG

The department of Deutsche Telekom (DTAG) which will be involved in COMBO, mainly performs internal strategic consulting for the different business units of DTAG group and the headquarter of DTAG. Therefore the results of COMBO will be primarily used in the mid- and long-term strategy towards a converged fixed and mobile access network evolution of DTAG. Several internal initiatives and projects of DTAG aim at preparing the next-generation access network strategy and related concepts with respect to network consolidation, convergence and optimization to address the growing traffic demands and new business models. For example, DTAG has announced cooperation’s with other network operators in terms of infrastructure deployment and cooperation. A variety of these important topics will be investigated in COMBO and the results will flow into Deutsche Telekom's activities.

Moreover DTAG is well represented in different standardization bodies and fora like ITU-T, FSAN, 3GPP, IEEE, and BBF etc. and will therefore fed the findings and results of COMBO into the appropriate standardization bodies, emphasizing the carrier's high interest in convergence of fixed and mobile networks not only from a service perspective but also from an network deployment point of view. Special attention will be paid to ensure an open standardised solution which enables mass market volume for the access and aggregation network and thus potentially low cost.

TID

Telefónica I+D (TID) is a 100% subsidiary of Telefónica S.A, being Telefónica's R&D arm. Telefónica is present in 25 countries with an average of 285,000 professionals and more than 299 million customer at September 2011: more than 231 million mobile phones accesses; more than 40 million fixed telephony accesses; more than 19 million Internet and data accesses and 3.2 million pay TV accesses. Research and development is essential to identifying those factors that are going to shape the future of telecommunications and the development of Telefónica's businesses. TID was created in 1988 to lead Telefónica's activities in this field. Its mission is to help improve Telefónica's competitiveness through technological innovation, broadening the range and quality of services on offer and making it possible to reduce operating costs.

TID underpins all of these operations from the results of research projects that can evolve into new services for their customers. TID itself obtains benefits from the technical know-how earned during COMBO project execution, enhancing its own portfolio of innovative products and services for end customers, and in providing the companies of Telefónica with tools and means to improve their business practices and open new markets. The multinational characteristics of some of these companies make possible abroad spectrum of applications for these improvements. Therefore, Telefonica I+D, as the R&D subsidiary of the Telefonica corporation, has close relationships with all the different business units of the Group, where many of them could be very interested in the results of this research project, that can evolve into new technologies to offer new services for their customers.

FT

Orange Labs' goal is to ensure the efficiency of France Telecom Group's technical foundation. It determines the key technologies to set up in order to adapt the technical architecture of the Group and anticipate the evolutions of the telecommunications industries. These preliminaries are necessary not only for the improvement of the quality of service and quality of experience given to the customers (coverage/accessibility and speed/comfort) but also to maintain our capacity to invest in future projects. With more than 3,500 engineers, researchers and technicians spread in 15 sites in Europe, North America, Africa and Asia, and a portfolio of more than 7700 patents, the R&D arm of France Telecom is implemented at international level that enables cooperation with influent industrial groups, the international scientific community, standardization and regulatory bodies. As a matter of fact, 70% of the products and services marketed by the Group are born in our labs.

FT contribution to COMBO will be carried out by the Access Network Architecture R&D laboratory, specialised in research, anticipation, standardization and deployment of all types of access and aggregation networks for all categories of customers. As for DT or TID, the results of COMBO will be primarily used by FT in the mid- and long-term joint operators' strategy towards a converged fixed and mobile access and aggregation network. Various internal R&D projects consider fixed/mobile convergence as an ultimate target, and the concept of Next Generation Point of Presence is currently being developed in Orange Labs as a key option to reach this target, including in particular access network node consolidation, BBU hotelling, distribution of P-GWs and CDN servers. All these key topics will be investigated in COMBO and the results will thus be directly exploited by internal FT projects, providing the guidelines to fixed/mobile network evolution in the 2020 horizon timeframe.

FT is also convinced that the key target of COMBO project is standardization of proposed converged fixed/mobile network architectures. Orange Labs are active in different pre-standardization and standardization bodies such as BBF, 3GPP, IETF, FSAN and ITU and will thus combine its efforts with the other industrial partners of the consortium to feed COMBO results into these standardization bodies, with the ultimate goal to reduce communication network costs and energy consumption, while ensuring network openness and a seamless and comfortable experience to all our customers.

ALU-I

Alcatel-Lucent's, OPTICS ALUI #1 worldwide in the Long Haul market segment and access network segment, has a strong market share of optical telecommunications equipment in all segments and regions, leveraging on its broad geographical presence, broad portfolio and diversified business.

COMBO project can provide guidelines and new solutions for the aggregation and backhauling segment of the network that will utilise optical transmission technologies. New configurations for the BTU and edge nodes would be designed in the project with advantages in terms of power consumption reduction and integration between electronic and photonic devices could allow a simplification of new transmission equipment. Last mile segment of the network play a fundamental role on both the performance/ quality of end-to-end future internet services thus the overall scope of passive optical networks shall be enlarged with new medium access techniques having the characteristic to also enhance the security and capacity (high leverage solution) of the access segment. The project gives the possibility to an industry like Alcatel-Lucent and other industrial partners involved to validate in advance the solutions and to define also in advance roadmap of these products already included in the R&D lines. Larger capacity fixed mobile convergent network design can result by exploiting the benefits of COMBO. As final result once the validation has been assessed the project can foresee that time to market can be reduced and more detailed industrialization and exploitation plan can be achieved. The partnership of the project can also lead to spin-off activities or new ventures around the market of the WDM PON and CPRI utilisation.

IT-TB

The exploitation plan from Institut Telecom – Telecom Bretagne includes scientific communication in major conferences and journals addressing the fields of fixed and wired network architecture and application of these innovative networking concepts for teaching and professional training in Telecom Bretagne. Moreover, whenever possible and technically sound, IT-TB will try to patent interesting new solutions generated by its research inside the project.

EAB

Ericsson is the market leader in 2G, 3G and 4G mobile technologies. The product portfolio comprises mobile and fixed network infrastructure and broadband and multimedia solutions for operators, enterprises and developers. The converged network solutions to be developed in COMBO will further strengthen our offers for end-to-end solutions. The COMBO studies on architectural solutions for node consolidation, functional split, convergence level and common usage, and optimization of resources will enable us to develop cost and energy efficient network solutions, which can handle the future needs for mobile broadband backhaul. The COMBO results will give an understanding of pros and cons of distributed versus centralized intelligence, and on architecture and network solutions enabling different levels of network sharing, such as transport sharing. Furthermore, will the developed performance management solutions ensure a high QoS in the network and that troubleshooting time and thus OPEX can be minimized. These outcomes will be fundamental for the development of new innovative converged architectures and solutions.

Regarding the technology demonstrators in COMBO, both the R&D results from COMBO as well as pre-existing know-how of nodes and link technologies will be used. Moreover, the demonstrators will allow Ericsson to evaluate new and potentially disruptive solutions that are built upon the combined strength of the COMBO partners. Successful part of the demonstrators can then be incorporated in our

technology product roadmap while less promising solutions can be removed from technology roadmaps without the risk of spending large resources on tacks that will not reach volume production.

ADVA-UK

ADVA Optical Networking is recognised as the global market leader in Ethernet Access Device market by Infonetics, and is recognised as a thought leader in Transport and WDM technologies. The Ethernet Access side of ADVA's business develops solutions for the mobile backhaul market and has a roadmap of functions to be developed in this area. ADVA-UK is a subsidiary of ADVA-DE and is the original centre of design for the Ethernet Access portfolio known as FSP150, and provides input to other areas within ADVA relating to requirements of future products. The requirements of a converged fixed and mobile backhaul network as studied within COMBO will be analysed and fed into our product development plans so that we can be confident of our feature set moving forwards. Development of proof of concept functions that are beyond state of the art will allow ADVA to remain at the forefront of technology in this area.

The practical and demonstration activities within COMBO will allow ADVA to validate the approach to some specific technologies in the area of fixed/mobile backhaul networking. Results from the COMBO project will feed directly into ADVAs roadmap and will also be used to underpin ADVAs input to standards community including MEF, ITU-T and Broadband Forum.

ULUND

The exploitation plan of the research group of Broadband Communications at Lund University includes publications of the results in peer reviewed scientific journals and conferences. The results of the project will also be exploited through the improvement of the academic degree of engineers by Master or PhD programmes, which will bring first-rate knowledge and expertise into industry.

CTTC

As a non-profit research institution, CTTC has limited (business) plans for direct, commercial exploitation of COMBO outcomes. By the nature of its activity, CTTC exploitation plans involve, potentially, technology transfer contracts for consulting and services as well as software licenses of developed components. Technology and "Know How" transfers are established on a case-by-case basis, developed in the framework of (bilateral) agreements given a customer specific needs and requirements.

DOCOMO

DOCOMO Euro-Labs is looking for innovative solutions contributing to the improvement of NTT DOCOMO's network. In particular, the research aspects addressed in COMBO should lead to advanced technologies for deploying energy and cost efficient mobile networks. The innovative solutions will impact our standardization activities towards future mobile networks. The dissemination activities of DOCOMO Euro-labs will include publication of key findings of the COMBO project in international conferences and journals as well as in standardization group such as 3GPP.

POLIMI

POLIMI is an education and research institution and its exploitation interests are mainly concerned with the use of project results in courses at Politecnico, new consultancy opportunities (technology transfer initiatives) in cooperation with CEFRIEL (the IT centre of excellence at Politecnico). The exploitable results of the project relevant for POLIMI are: (1) the experiences gathered in the definition, design, and implementation of the COMBO project; (2) the expertise acquired from tailoring models and methods for energy consumption and cost optimization in fixed mobile converged networks; (3) the expertise acquired from applying the concept of WDM-PON to converged backauling of mobile and fixed traffic. Exploitation actions related to consultancy services and courses will possibly start before the end of COMBO, but independently from the project itself.

In addition to this, POLIMI intends to train doctoral students through dissertation topics in the field of FMC networks.

BME

BME as the leading technical university of Hungary plays central role in educating future generations of telecommunication engineers, and also participates in various European and Hungarian research projects. The experience earned within COMBO is beneficial for both of these fundamental roles.

Research activity of BME is reflected in its journal and conference publications, and several research projects. Aiming research efforts at relevant topics of the near future is a key to efficient work in this field, and research projects such as COMBO help to identify the most important directions. BME is willing to increase its publication activity regarding assessment and energy efficiency of FMC networks, based on its project contribution.

Experience and close cooperation with industrial partners strengthens our competence in various telecommunications R&D activities, which on the other hand, indirectly improves quality of education. The education should cover the newest technologies and engineering solutions for telecommunication challenges, therefore cooperation with leading industrial partners is fundamental for the University, and having personal within projects such as COMBO is the best way to follow technical development.

AITIA

As an SME with strong research and development drive in the mobile telecommunications field as well as in high speed networking, AITIA aims to get ahead of the networking state of the art with COMBO. The main areas of contributions are traffic modelling, performance management methods, and SLA validation through passive monitoring and determination of QoE from traffic analysis. Lossless monitoring and complex analysis of high speed network traffic is a segment where AITIA is targeting to become a leader. COMBO allows the application of new results in the FMC area into AITIA's corresponding product line. This results in networking specialists choosing and using our products for either research, development or cutting-edge, live traffic analysis and manipulation. AITIA will take the following steps for dissemination and exploitation:

- include the project results in a scientific journal paper or in a conference paper,
- compile a white paper about how COMBO results are utilized by AITIA products,
- provide information on advances of COMBO in the company website,
- update the marketing material with features specific to FMC.

TELNET

Telnet Redes Inteligentes is a SME company located in Spain. Some of the main activities of Telnet are BTS antennas design and manufacturing, as well as access network equipment for FTTx architectures. These are two areas which require strongly efforts in research and development to follow the track of state-of-art. Because of cooperative projects like COMBO, Telnet is able to keep that track of SoA and develop new expertise areas, since otherwise we will be much more difficult. Apart from this purpose, obviously the main purpose of Telnet R&D department lies in finding new opportunities and markets, mainly uncovered by big vendors or specific developments by request of operators. Regarding our participation in COMBO, it is a great opportunity to get it, contribute to the future FMC network, and establish business relations with other partners, principally operator. COMBO will be also a nice opportunity to introduce to operators and validate WDM-PON equipment, avoiding the typical barriers that a small company has to tackle. Furthermore, Telnet has already experience in successful products in its portfolio that were born from projects similar to COMBO.

ADVA-DE

ADVA Optical Networking is a major equipment manufacturer serviceing Mobile backhaul, Business Services and fixed line networks. Its market leading transport solution FSP3000 is an optical transport and metro access solution encompassing WDM technology. As part of ADVAs roadmap, WDM-PON is identified as a key tool for reducing energy and simplifying next generation networks while providing the best option for scalability. ADVA is actively investigating WDM-PON technologies and intends to use the COMBO project to test the views of operators and to liaise with industry especially in the areas of convergence in the network.

ADVA intends to strengthen its feature set and market penetration plans for WDM-PON using COMBO to explore the fronthaul requirements of a converged network. ADVA-DE are present in standards activities including ITU and FSAN, and intend to use COMBO results and concepts to formulate its strategy in this area.

FON

From Fon's side, Convergence of fixed and Mobile Broadband access/aggregation networks provides the possibility to become the best alternative to the exponential growth in mobile data traffic demand. Its participation in this project offers to Fon the opportunity of discussing which are the most suitable billing and tariff mechanisms to support offloading mechanisms. Special interest would be also to come up to propositions that could be considered as engaging from a user perspective in becoming an active agent in the offloading process for the scenarios considered.

On the other hand, Fon will exploit this project from the standardization point of view, due to the fact that it should ensure that convergence of fixed and mobile broadband access is as much as possible compliant with the latest recommendations of the network standardization bodies.

Finally, and probably the most direct aspect in which offloading techniques will have impact, is the exploitation of the results obtained in this project to manage in a more efficient way the resources of the wireless networks.

3.2.4 Management of Knowledge and Intellectual Property

The handling of intellectual property (IP) issues (including rights), knowledge management and protection of confidential information shall follow the parameters and principles that will be provided under the COMBO Consortium Agreement. Nevertheless, in order to attain an adequate management of both IP and knowledge produced under COMBO, the consortium will also perform complementary activities that have been included in WP1 and WP7;such specific activities will be implemented by the project coordinator. ,It is important to mention that WP1aims at putting in place the processes by which such rules can be implemented in an efficient and lightweight way.

Having in mind the formulation of an overall strategy, COMBO partners have decided to set the following guidelines as basis to work upon to achieve such objective:

- Provide open and optimal architecture and solutions for fixed-mobile convergence, and introduce these solutions into standards
- Mainly exploit the results of the project through: future industrial developments for vendors, patents for research centres and academic partners, as well as deployed solutions for operators.

Based on the above, the overall strategy on IPR and knowledge management for COMBO shall be translated into the public dissemination (at least to the EC projects community) of all the deliverables deriving from WP2, WP3, WP4 and WP5.

The general rule with regards to the IP generated under the COMBO shall consist in its release within the consortium under the principles that shall be set-up in the consortium agreement. If relevant, the partners will study the possibility to group patents on a coherent manner, so that the solutions provided by COMBO, when standardised, lead to simple and fair access and implementation by parties external to the project. Therefore, patent pooling per technology or per solutions, within the project or within a larger group of parties, may be looked upon.

On a practical point of view, COMBO will follow a process that has been successfully implemented in past projects, which consists in keeping a record of all IP assets the project creates and plans to create, so that attention is focused on the protection of the most valuable IP by using patents or other methods (e.g. trade secrets). The latter shall be revisited through periodic discussions held by the COMBO management board, which shall review the IP asset list and make sure that appropriate exploitation paths are explored for the most valuable IP.

Moreover, protection of confidential information in a collaborative project is highly important, especially as commercial success often depends on being first to market; therefore, COMBO will develop a simple procedure for notification purposes, so that partners wishing to publish or otherwise disclose project activities and results notify the other partners in good time to allow obtention of the adequate IP protection vehicle if necessary.

As project innovation is an area to be nurtured and encouraged, it is important to avoid having too many processes that stifle creativity in the project. For this reason, publication notification and IP asset tracking procedures will be lightweight, requiring partners to fill in simple templates that will be shared via the COMBO web collaboration tools. Project innovation will be stimulated by encouraging partners to hold small, task related meetings, where they can brainstorm ideas collectively, and by having demo sessions at consortium meetings so that new results can be rapidly shared.

3.2.5 Concertation, Dissemination and Supplementary Reporting

a) Concertation

The project will actively participate in the activities organised at programme level relating to the ICT Future Networks area with the objective of providing input towards common activities and receiving feedback (e.g. from clusters and coordination groups), offering advice and guidance and receiving information relating to ICT programme implementation, standards, policy and regulatory activities, national or international initiatives, etc. Such activities may include Concertation meetings twice a year, in Brussels and the ICT Future Network and Mobile Summit. Participation in Future Internet Assembly events and related activities may also be relevant.

b) Dissemination Package

In line with its obligations regarding dissemination of results and achievements, the Co-ordinator ensures that all public documents (including, but not restricted to, the following material: video material covering experiments, trials; animations of "real-time" simulation results; presentations, animated/voice-over or not; promotional material (leaflets, posters, etc.); press releases etc.) generated by the project are duly collected in a Dissemination Package which is associated with the periodic reports.

The project undertakes to establish, not later than one month after the start of the project, a web site supported by the project partners, to provide a unified view of the Project; a copy thereof will be included in the Dissemination Package.

c) Supplementary Reports

In addition to the reports defined in article II.4 of Annex II to the contract, the Coordinator will submit to the Commission supplementary management reports every three months (QMR, Quarterly Management Reports).

The QMR will be in form of a condensed document of 4 pages: 1 page financial resources (actual vs. planned per partner per work-package and totals and an illustrating graph), 1 page human resources (actual vs. planned per partner per work-package and totals and an illustrating graph), 2 pages of well-written summary of main achievements and concrete key outcomes of the reporting period:

- The technical progress and achievements of the project
- The project status
- Work started
- Work completed
- Work delayed
- Status of deliverables
- Remedial actions required, if applicable