Challenges in Fixed / Mobile Converged broadband access networks

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Agenda

- Introduction: COMBO project
- Motivations and enablers
- Approaches to convergence of fixed and mobile broadband networks
  - Next Generation Point of Presence (NG-POP)
  - Functional convergence
  - Structural convergence
- Collaboration issues

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COMBO project

Key facts

- COnvergence of fixed and Mobile BrOadband access/aggregation networks
- Work programme topic: ICT-2011.1.1 Future Networks
- Type of project: Large scale integrating project
- Project start: 1st January 2013
- Project duration: 36 months

Partners

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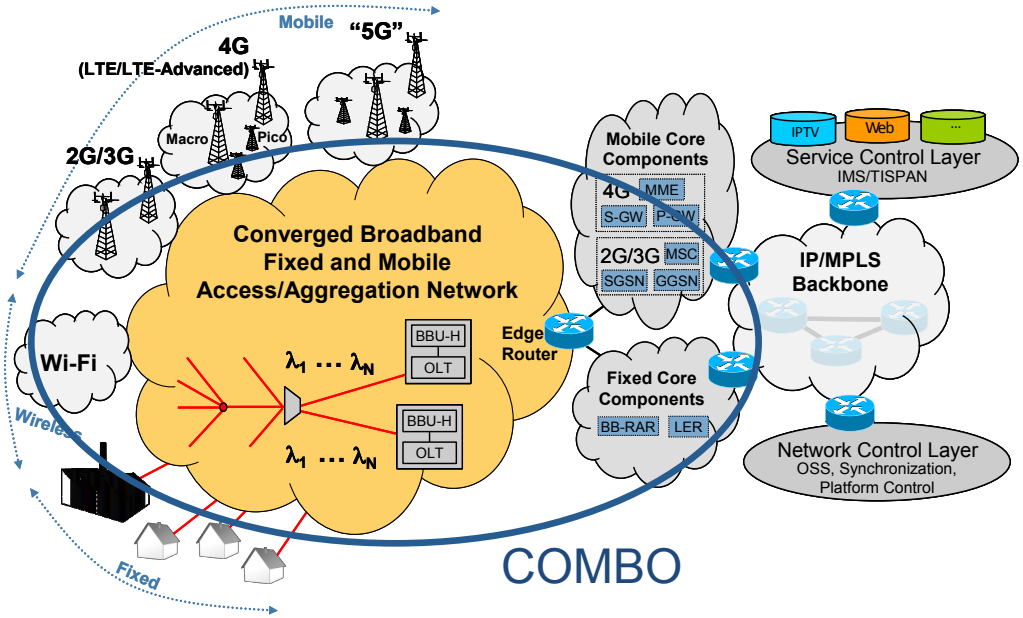
Motivations for convergence

Motivation

- In the past, fixed and mobile access networks have been optimized and evolved independently, with partly contradicting trends
- Access infrastructures represent long term *investments (> 50% of total ICT) and about* 90% of network energy consumption: a sustainable network evolution strategy is required for the next decade

Focus area

- Level of integration and functional distribution needs to be investigated and optimized



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Main target and objectives

Main target

COMBO targets a unified access and aggregation network by converging fixed and mobile networks (Fixed / Mobile network Convergence, FMC), enabling:

- optimal and seamless **quality of experience** for the end-user
- improved network structure ensuring reduced **cost** and **energy consumption** *while bandwidth is increasing*

Objectives/challenges

- Define optimised FMC architectures (L1-2 to 4)
  - Adapt network structure (structural convergence)
  - Determine where to place the intelligence in the network (functional convergence)
- Assess multi-operator FMC scenarios
- Drive standardization bodies with respect to FMC architectures
- Define sustainable business models
- Demonstrate experimentally FMC in lab tests and field trials

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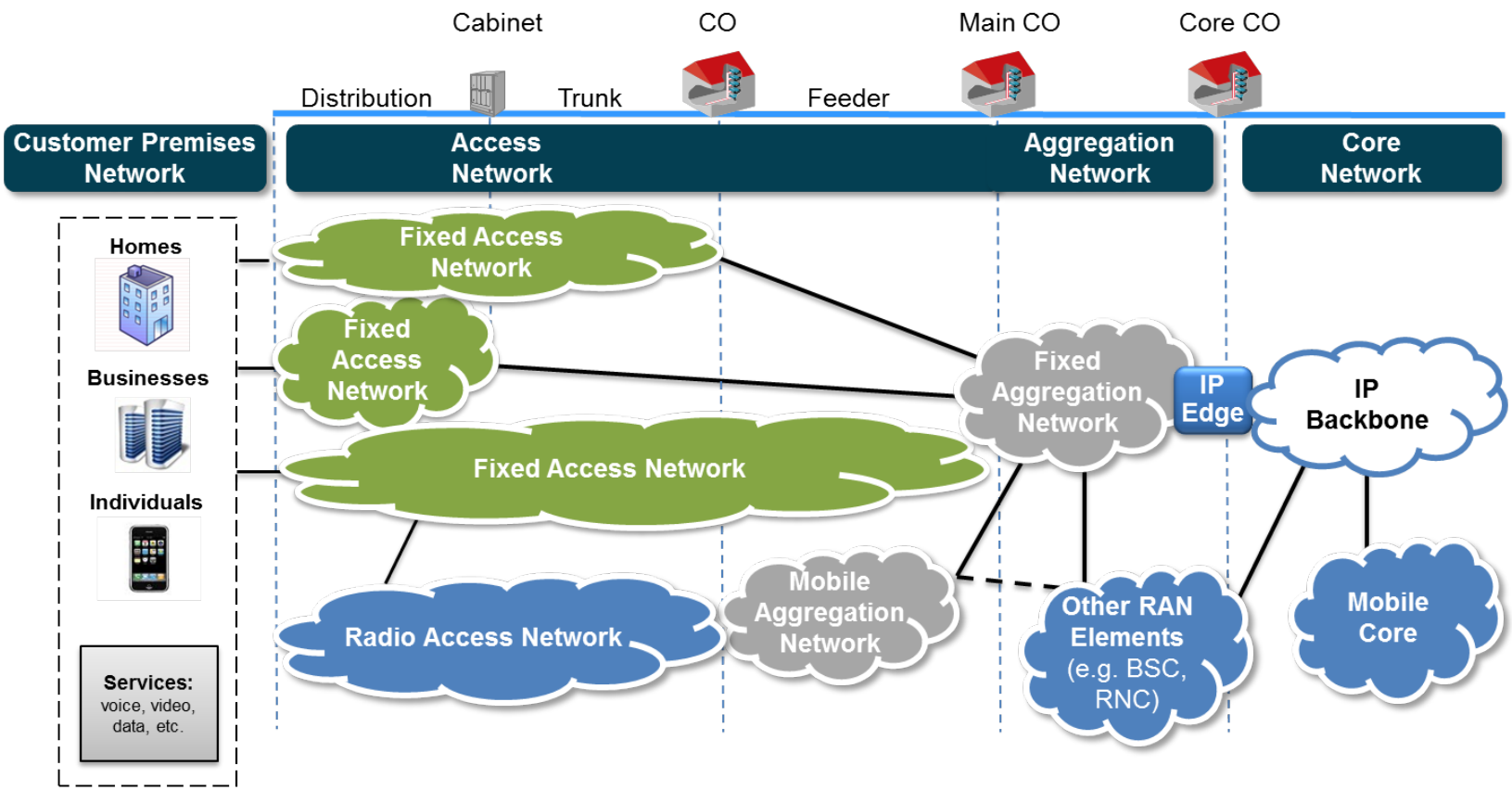
Reference framework



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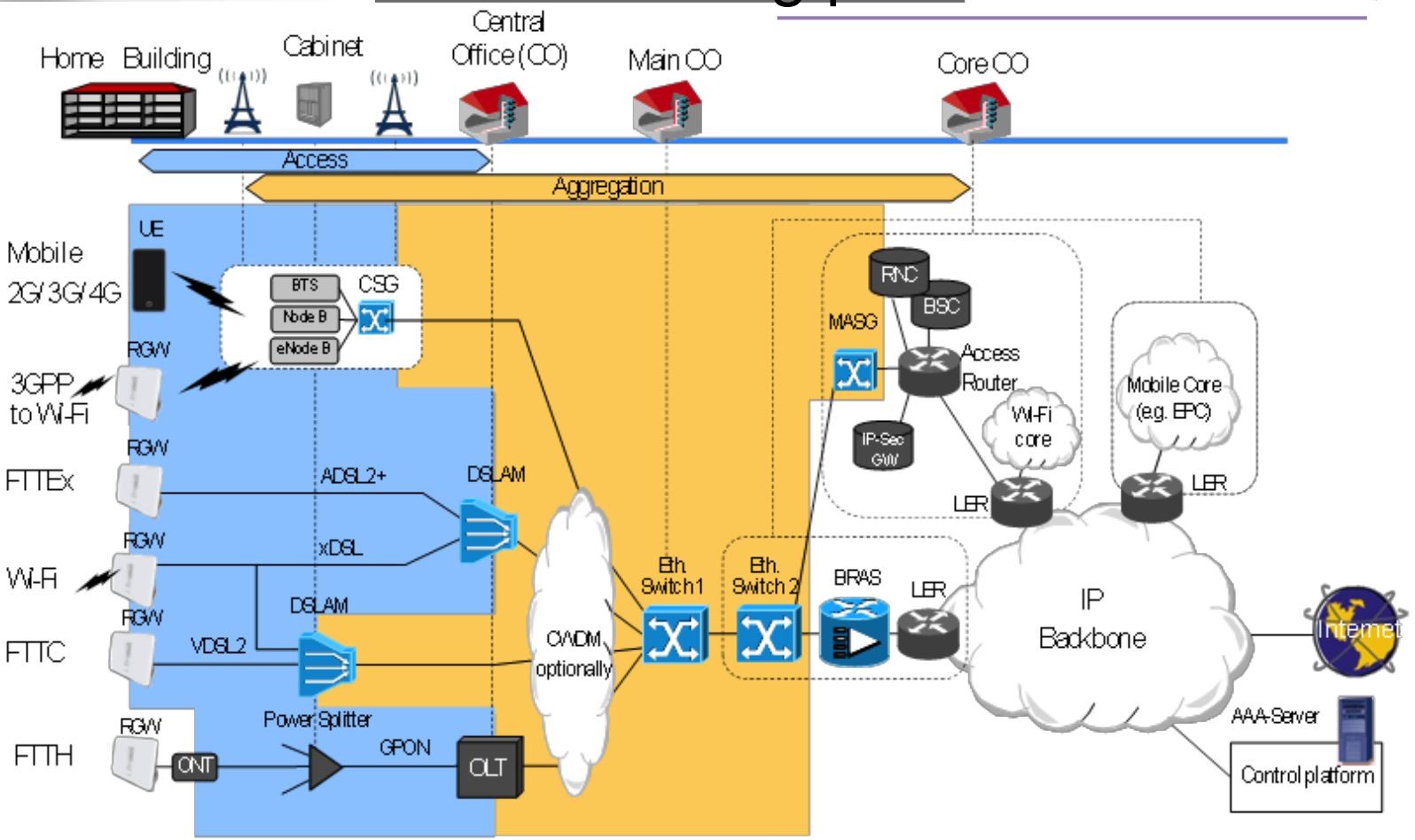
Current FMC network « big picture »



Some parts of the network (e.g. in aggregation) are already mutualized

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Some enablers for convergence

Functional convergence

- Unified control mechanisms
- Advanced sleep modes
- Streamlining of protocol stack
- Generalized 3D handover mechanisms
- Advanced network-level offloading schemes (fixed and mobile)
- Openness of network interfaces
- Harmonization of authentication and subscriber management

Structural convergence

- Optical access node concentration
- Heterogeneous radio access networks combining small and macro-cells
- BBU hostelling with resource pooling (C-RAN)
- Mobile fronthaul technologies based on Digital Radio over Fibre (D-RoF)
- Multi-wavelength and multi-service optical access and aggregation technologies

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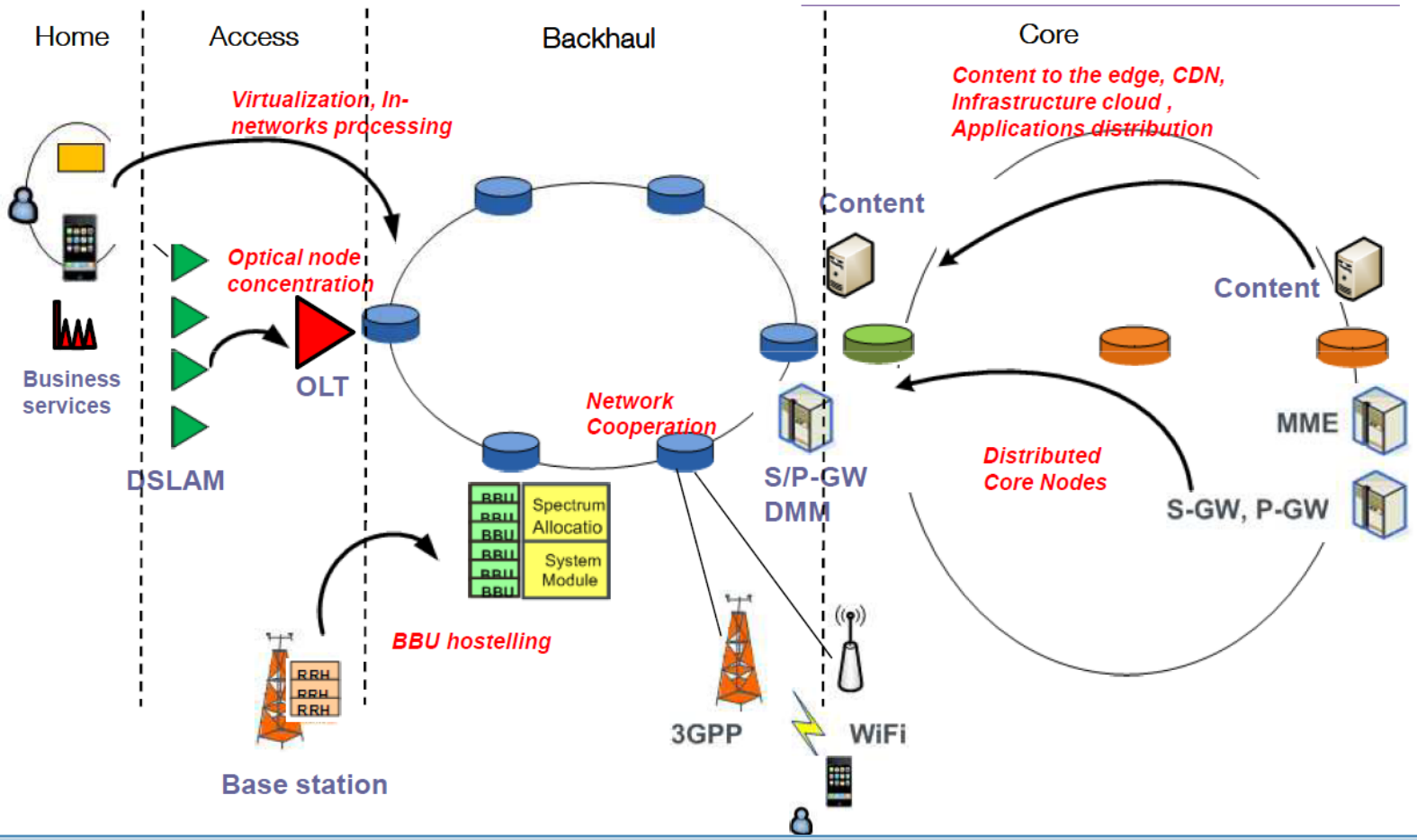
Network evolution trends



Concentration of functionalities in access and distribution of functionalities from core

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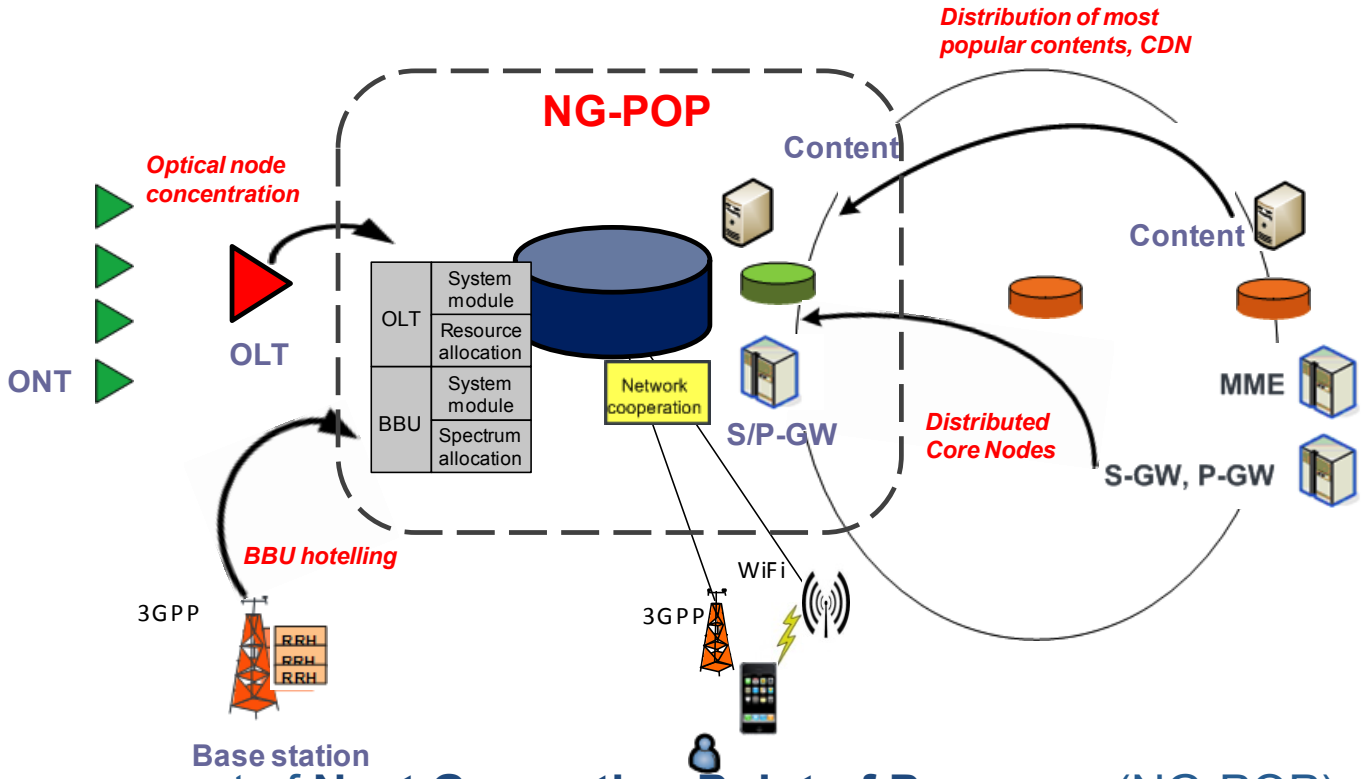
COMBO target architecture



- New concept of **Next Generation Point of Presence** (NG-POP):
  - **Functional convergence**, i.e. the harmonization and convergence of fixed and mobile network functions
  - **Structural convergence**, i.e. the mutualization of fixed and mobile infrastructures and equipment

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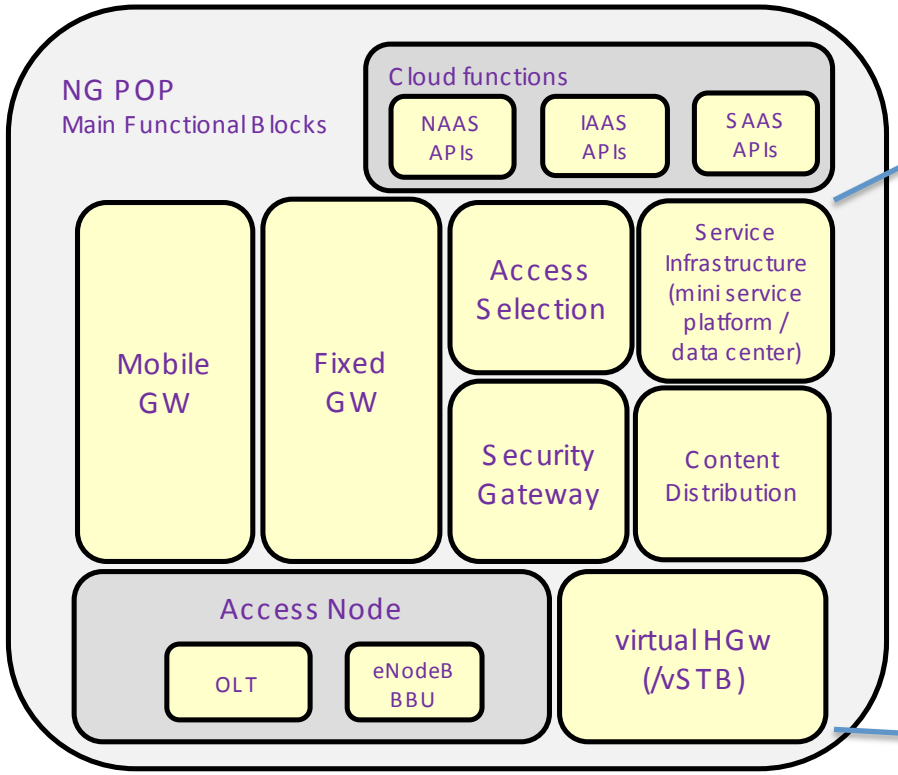
Example of NG-POP functional blocks



Logical components: mobile GW, Security GW, Home GW, content distribution,…

Elementary components: LI, session management, NAT, accounting, policy based routing, QoS enforcement, authentication, L2 forwarding, …

Resources: Computation, Storage, Forwarding

Several functional blocks of different nature need to be considered for functional convergence (access, networking, content, services)

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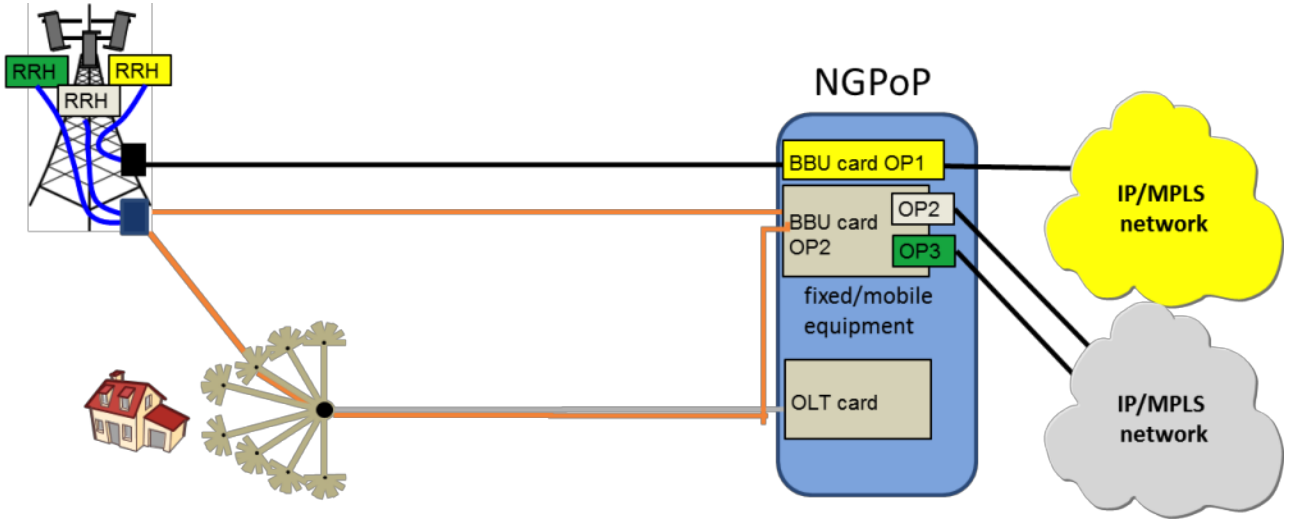
Structural convergence in a multi-operator environment



OP1	Mobile operator sharing NG-POP and tower of OP2 but using its own equipment
OP2	OP2 provides converged network to the other operators and hosts co-location point at NGPOP and tower
OP3	OP3 uses the co-location points of OP2 and also the FMC network resources and functions of OP2

- **Structural convergence** targets mutualization:
  - Mutualization of **locations** (NG-POP)
  - Mutualization of **fibre infrastructure**
  - Usage of the same **technologies (FTTH/BBU)**
  - Integration of fixed and mobile access **equipment**

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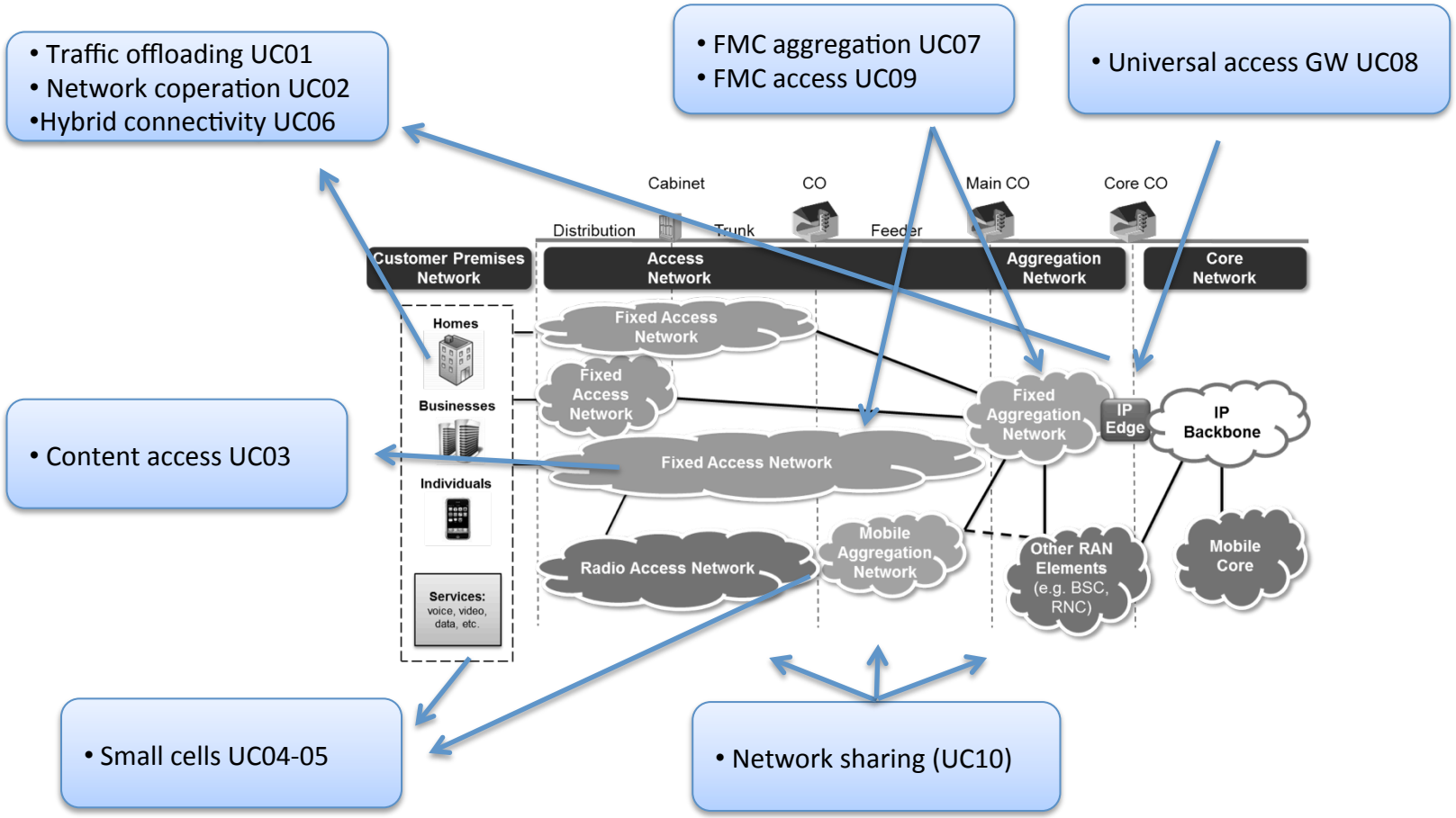
Currently defined use cases

- Use cases are focused on different network segments



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Link with techno economic analysis

- Assess and optimize **economic** efficiency
  - Cost estimation and minimization
  - Business ecosystems
- **Energy efficiency** (sustainability)
  - Energy consumption analysis
  - Energy saving strategies
- Specific requirements and “novelty”
  - Assessment includes optimized **network design**
  - Calculations based on maps and **geographic** data
- Focuses more on structural convergence, but addresses functional convergence too

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Possible collaborations

Consolidate work on different R&D challenges

- Exchange on informations on:
  - CAPEX/OPEX
  - Energy consumption
  - Traffic
  - Business models
- Any R&D topics covered by COMBO
  - Structural/ functional convergence
  - Streamlining protocol stacks
  - Traffic offloading
  - CDN
  - access-agregation network architectures/technologies
  - Traffic monitoring &performance management
- standardisation
- Common testbeds

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Conclusions

- Making fixed and mobile networks converge is a desirable though very complex target for network operators and vendors
  - Basic technologies present
  - Traffic constant increase
  - New actors positioning
  - FMC already happening in basic forms
- Better integration of fixed and mobile networks would result in both
  - an optimal and seamless quality of experience for the end user
  - an improved network infrastructure ensuring increased performance, reduced cost and also reduced energy consumption
- COMBO is designing a unified access and aggregation architecture leading to Fixed-Mobile Convergence
  - based on Next Generation Point of Presence
  - with a better distribution of all essential functions, equipment and infrastructures of convergent networks
  - enabling a network with better services at lower operational costs

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Some key questions and requirements

Key questions

- Which are the optimum levels of convergence?
- Which network functions and equipment should be centralized or distributed?
- How will convergence impact handover mechanisms?
- How will convergence impact data traffic?

Key requirements

- Increasing traffic and changing applications
- Reduced network cost and energy
- Openness of network interfaces
- Seamless performance monitoring and management
- Multi service flexible network to cope with future services

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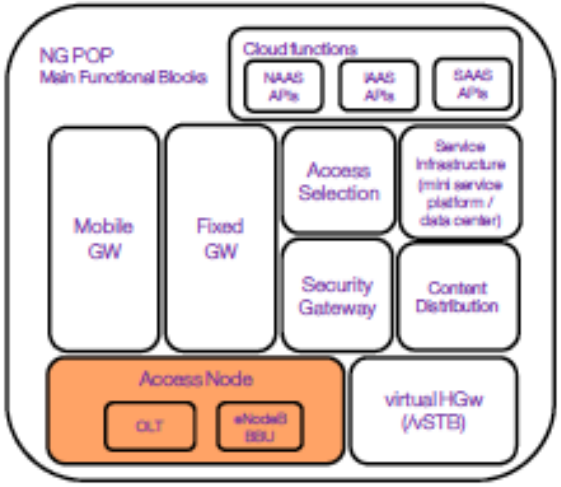
Toward Access Nodes Concentration in both Fixed and Mobile access



- Fiber access technologies will re-structure **fixed** as well as **mobile access** networks
  - FTTH capacity and longer reach compared to xDSL allow **Optical Access Nodes concentration in less central offices** (>80% of reduction)
  - C-RAN mobile access will leverage on fiber availability to **centralize Base Stations processing** from Layer 1, using Remote Radio Head
- **Different kinds of NG POP can be envisaged**, depending on local country existing network, regulation, operator's position…, e.g.
  - fixed/mobile access nodes deployed in central offices and "backhauled" to a more central POP with networking and services features
  - standalone NG POP integrating access, networking and services nodes functions
- We **focus first on the concentration of NG POP access nodes** (Optical and Cellular), as main **costs and energy issues are in the access**

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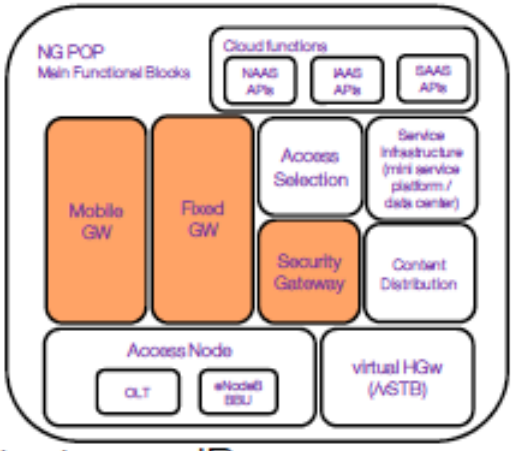
NG POP Fixed and Mobile Gateways



- Gateways at the Access Router level allow
  - **user's traffic routing flexibility**, e.g. towards local content, core IP network, CDN, Internet peering points,...
- Mobile core gateway: EPC nodes distribution
  - **S/P GW** distribution
  - intermediate steps considering core network offload solutions based **Local-GW** in the NG POP (3GPP SIPTO)
  - **Security GW** for untrusted access (e.g. WiFi, Femto, small cells, …)
  - Control entities (MME, HSS, AAA) not considered (in a first step)
- Fixed core gateway: BNG model
  - **per-user and per-session** traffic management
  - **WiFi GW** features included
  - **Additional services** functions

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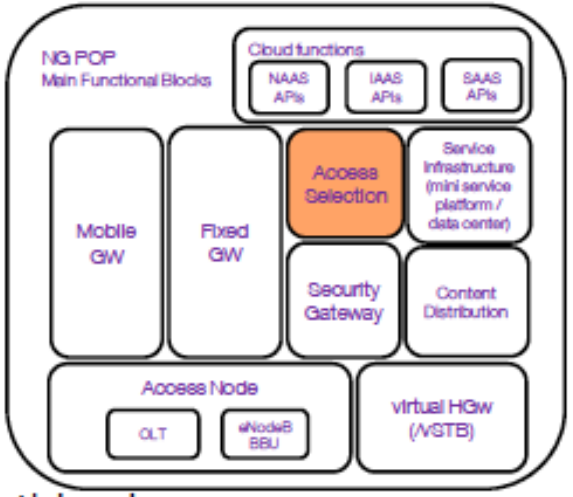
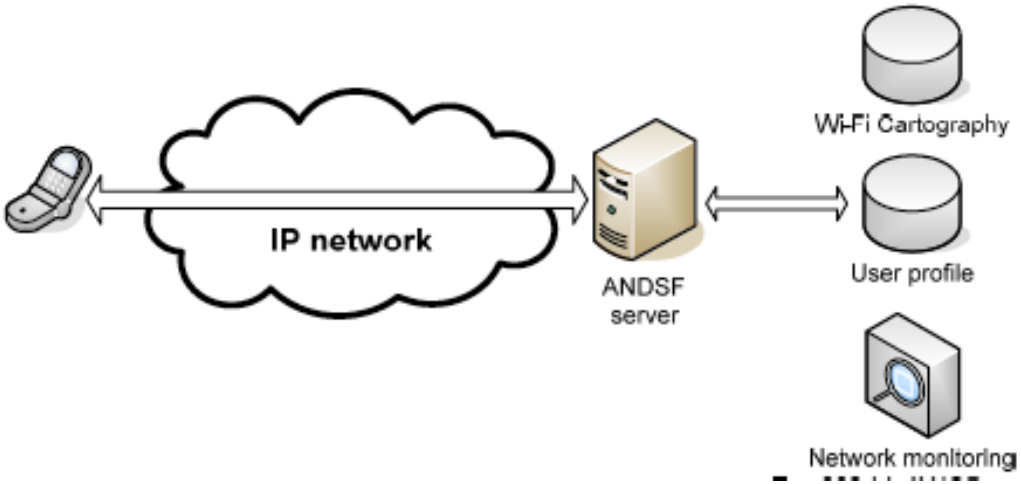
Access Selection functions in the NG POP



- Multi-access terminals need appropriate access networks detection and selection functions
- ANDSF foresees to properly assist the terminal in this aim
  - identification of the user and its location
  - selection of appropriate access networks according to user's profile, location and QoS obtained through access monitoring



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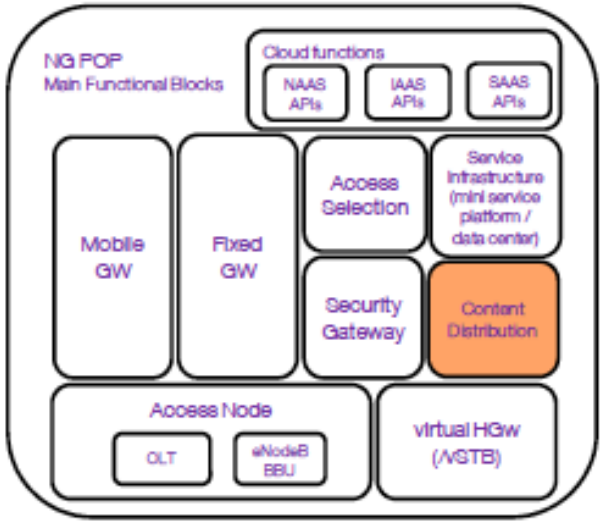
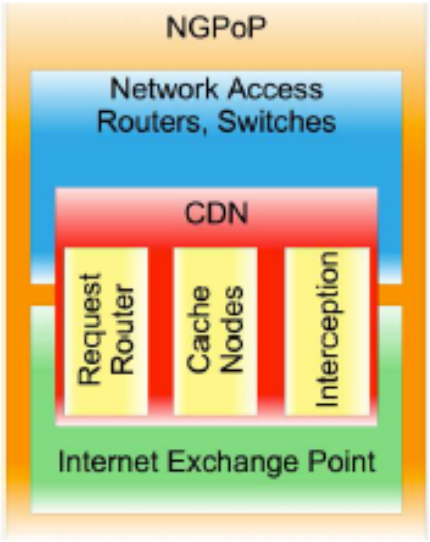
CDN functions in NGPoP



- **Cache Nodes** in NGPoP
- **Request Routers** integrated with Cache Nodes.
  Allow directing end users to the best nodes based on routing information
- In case Request Router is a separate component it should be connected in the same location as **Internet Exchange Points**
- Flexibility at **hardware resources relocation**
- Opportunity of **resource reservation** for specified content provider or set of content providers in case of Live and VoD



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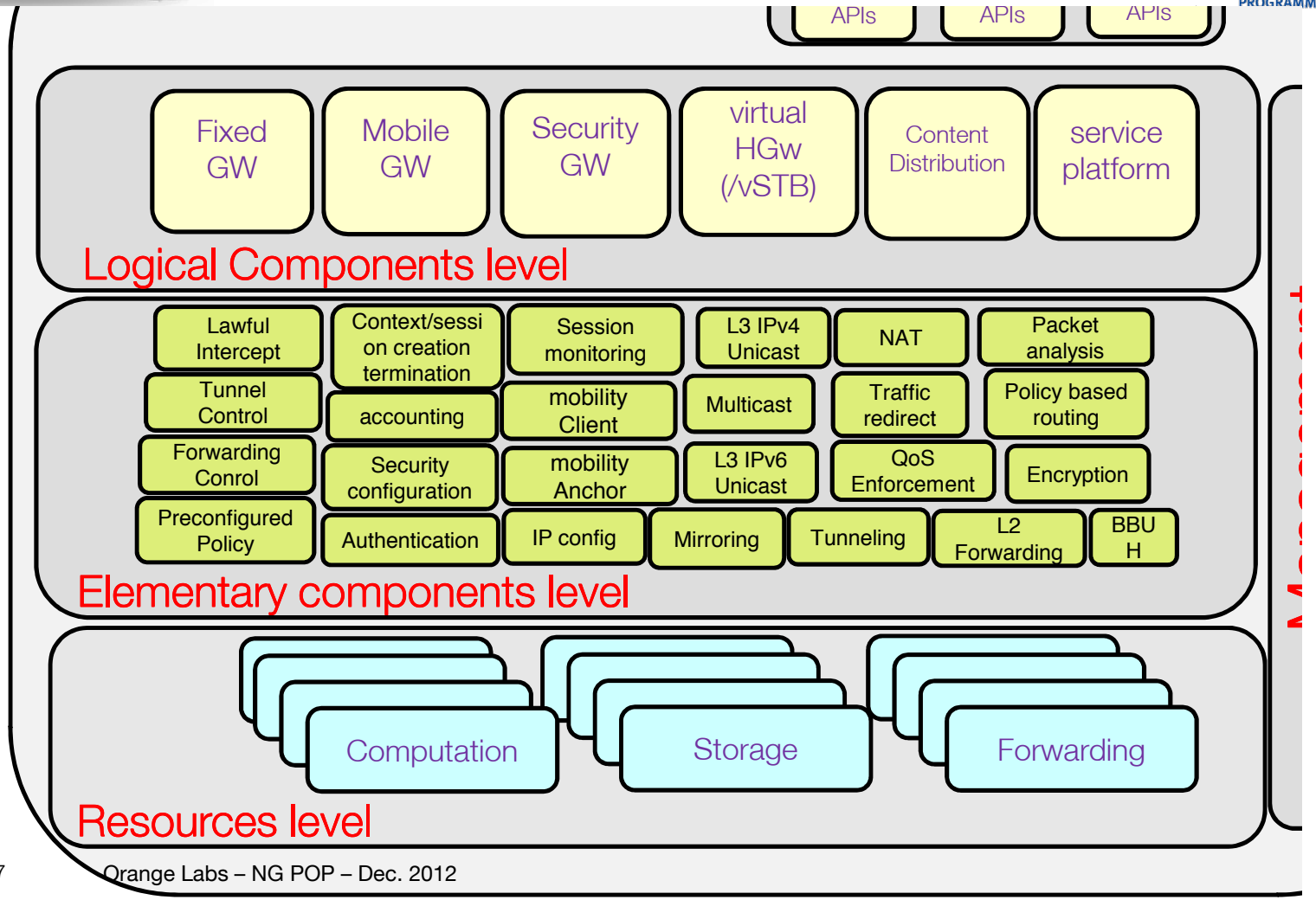

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WP2

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WP2 objectives and tasks

- WP2 is provides the initial project framework for FMC networks, including:
  - Definition of the reference architecture.
  - SotA and future evolution in both fixed and mobile networks
  - Provides the requirements for future FMC networks
  - Key Performance Indicators to measure and compare future FMC architectures
  - Converged fixed and mobile traffic scenarios analysis and modelling
- WP2 is divided in four tasks that will be developed mainly during the 1st

Task 2.1 Reference framework	• Definition of the reference framework and network use cases
Task 2.2 Fixed and mobile network evolution	• State of the art, evolution and independent roadmaps
Task 2.3 FMC traffic modelling	• Current traffic demands, forecast and traffic models
Task 2.4 Requirements	• Requirements and KPI for FMC networks

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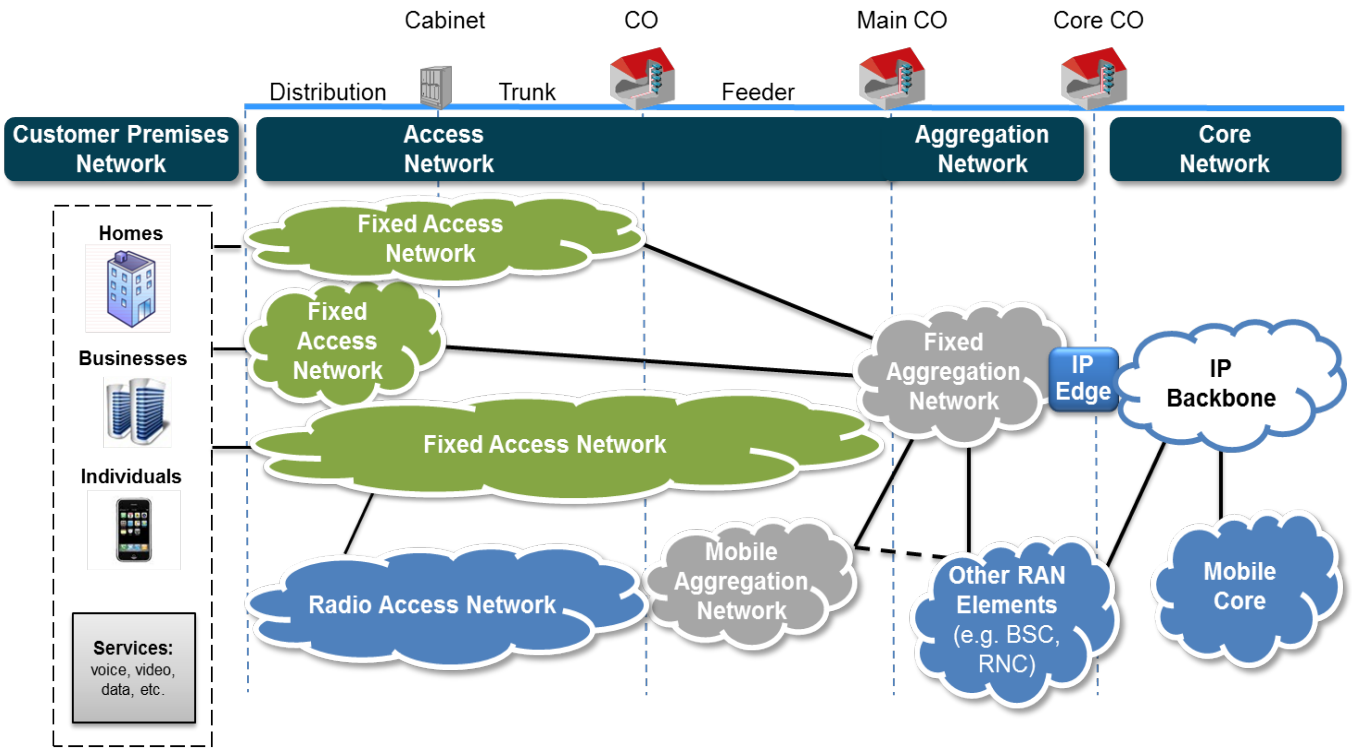
WP2 current status

- Reference framework has been defined (today's fixed and mobile network)
  - With main elements and functions and network segments



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WP2 current status

- Ten FMC network use cases have been specified
  - Use cases define the needs, i.e., detailed expectations from the network (WP3 will analyze them and will propose solutions)
  - Four basic areas of convergence between fixed and mobile networks

FMC area	Use Case
Unified Wireless Access Networks	UC01 - FMC access for mobile devices
	UC02 - Enhanced FMC access for mobile devices
	UC03 - Converged CDN for unified service delivery
Access Resource Sharing	UC04 – Reuse of infrastructure for indoor small cell deployment
	UC05 - Effective backhaul deployment for outdoor small cells
	UC06 - Common fixed and mobile access termination in hybrid connectivity for FMI customer services
Aggregation Resource Sharing	UC07 - Support for large traffic variations between public, residential, and business areas
	UC08 - Universal Access Gateway (UAG) for fixed and mobile aggregation network
	UC09 - Convergent access and aggregation technology supporting fixed and mobile broadband services
Operator Cooperation	UC10 – Network sharing

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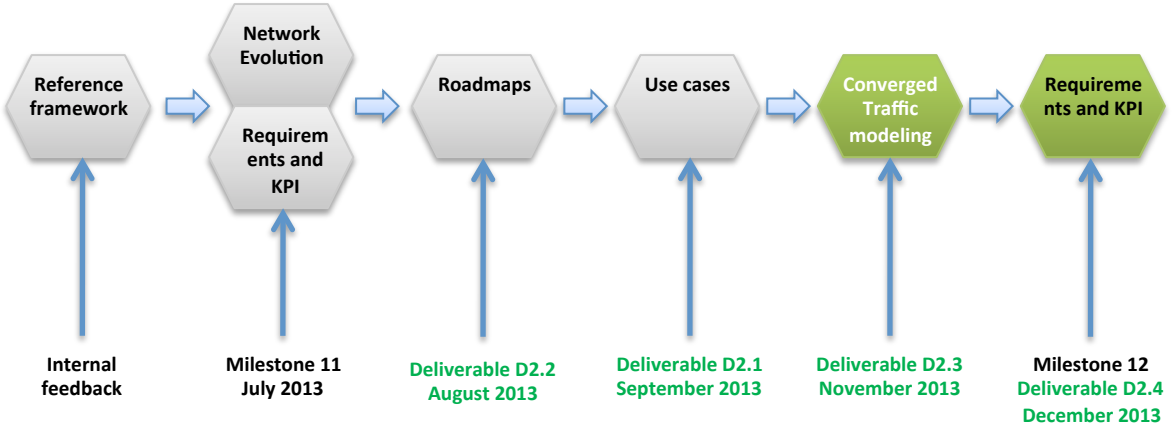
WP2 current status

- State of the art, evolution and independent roadmaps for fixed and mobile network have been completed
- An initial set of requirements and KPIs have been delivered based on the network use cases

- Currently working on:
  - Analysis of traffic models and studies about how traffic will evolve in different FMC network scenarios
  - Final set of requirements and KPIs



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WP2 uses cases

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WP2 current status

- Each network use case provides the following data:
  - Goal: what do users or operators need?
  - Today's situation: to explain better what are the main changes proposed
  - Potential impact: impact of this FMC use case on the network in terms of benefits
  - Convergence classification: functional or structural convergence
  - Flow: explain how this use case works with an example

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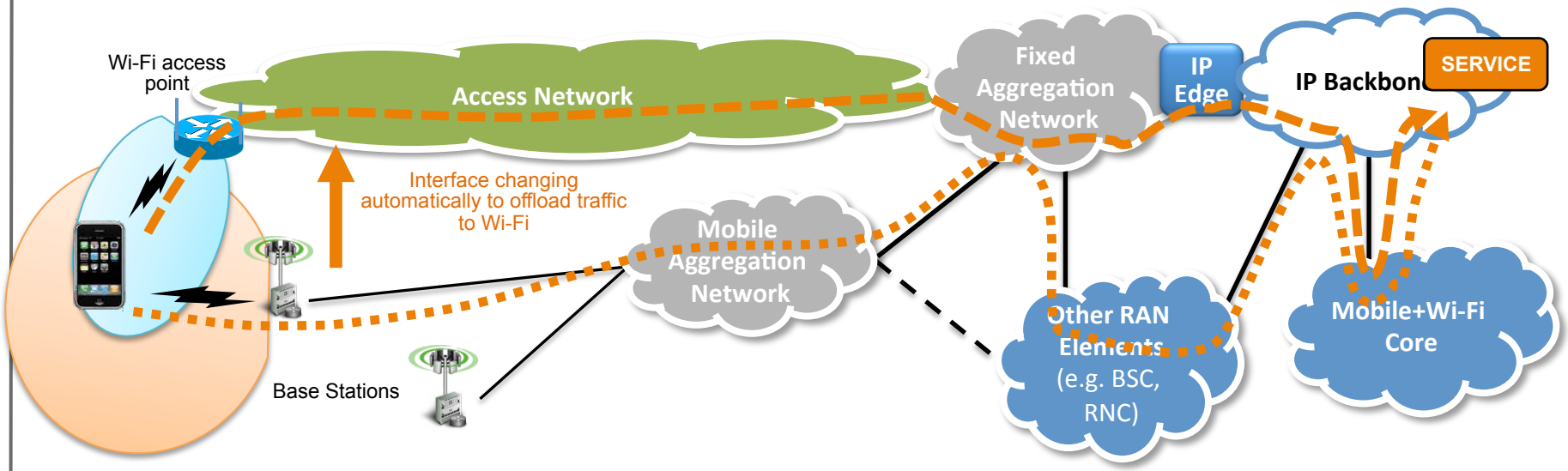
WP2 current status

- UC01 - FMC access for mobile devices
  - Wi-Fi smart offloading solutions to divert mobile traffic into Wi-Fi networks



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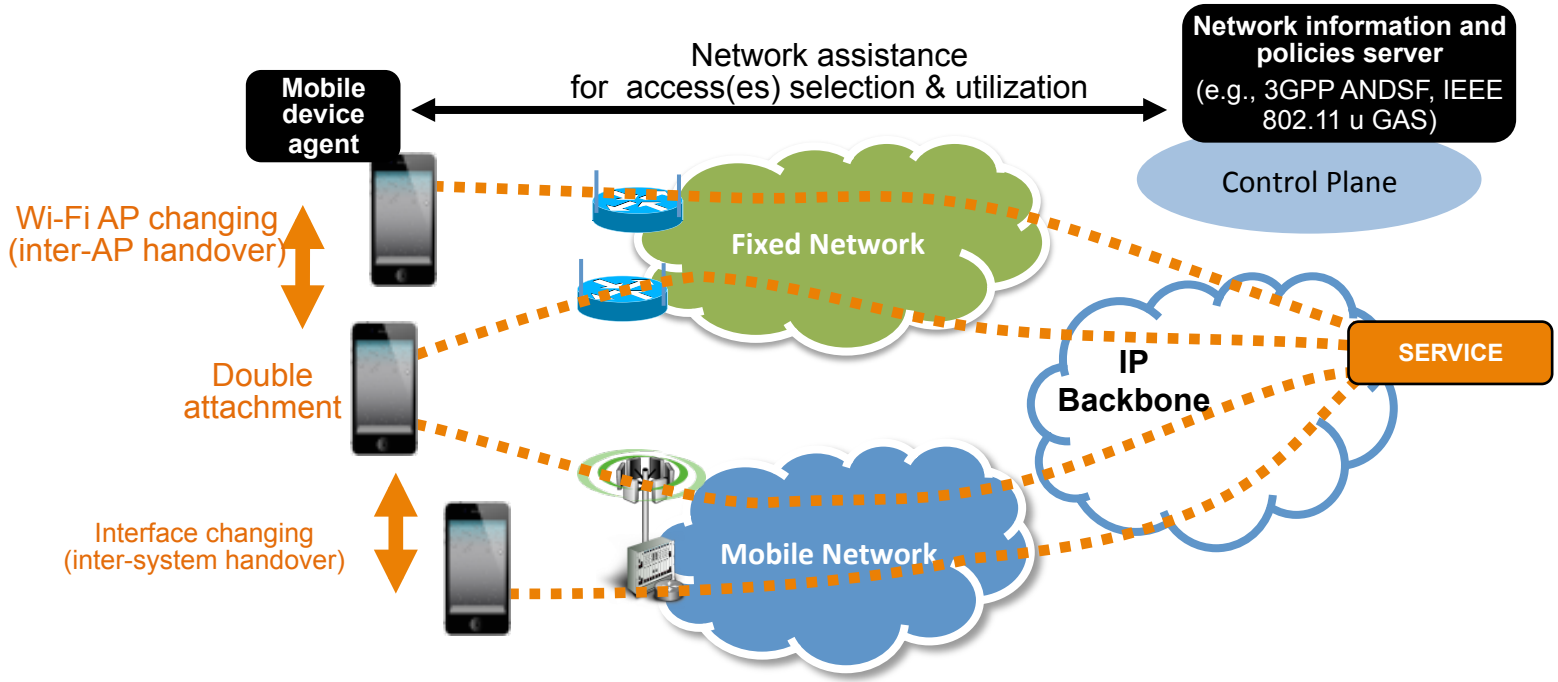
WP2 current status

- UC02 - Enhanced FMC access for mobile devices
  - Enhance Wi-Fi and Mobile networks cooperation by providing double attachment and mobility features with a smart network assistance to the mobile devices



WP2 - Task 2.1 - Action Point: FMC network use cases 32

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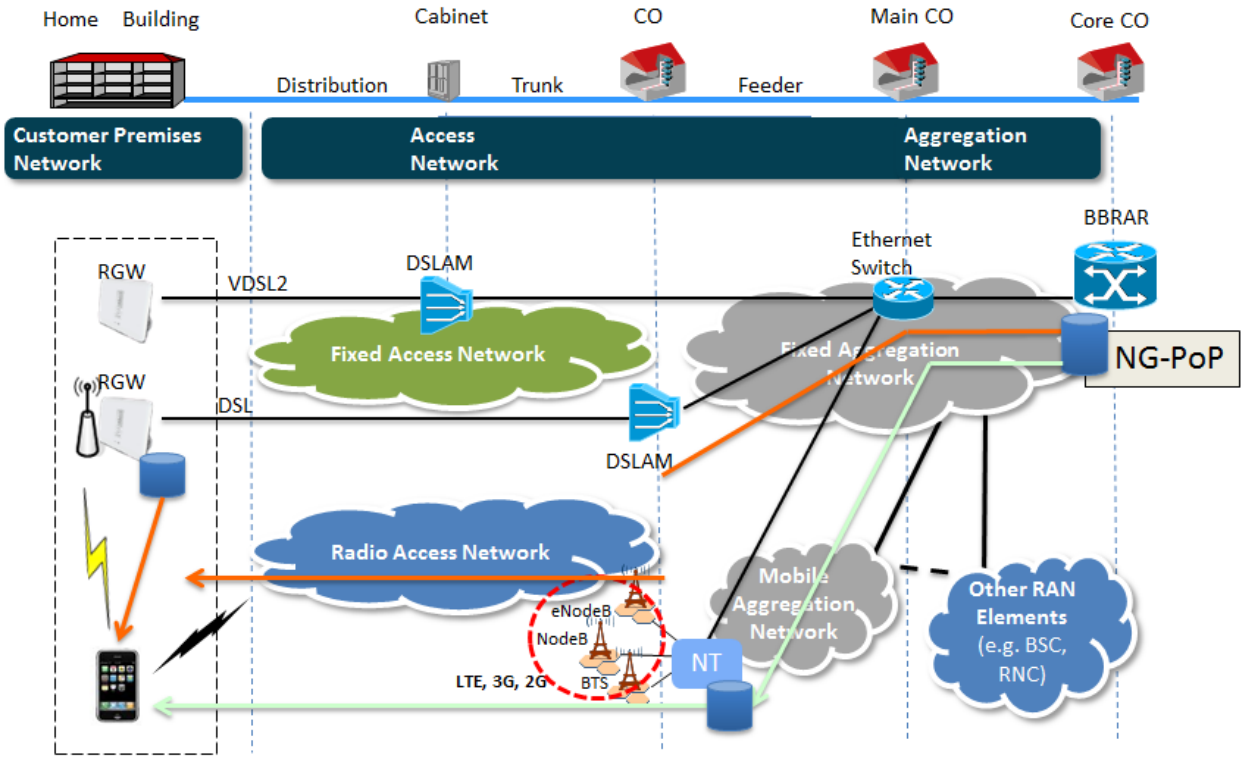
WP2 current status

- UC03 - Converged CDN for unified service delivery
  - The target is to offload and cache frequently requested content close to the users. Collaborative caching among fixed / mobile access network



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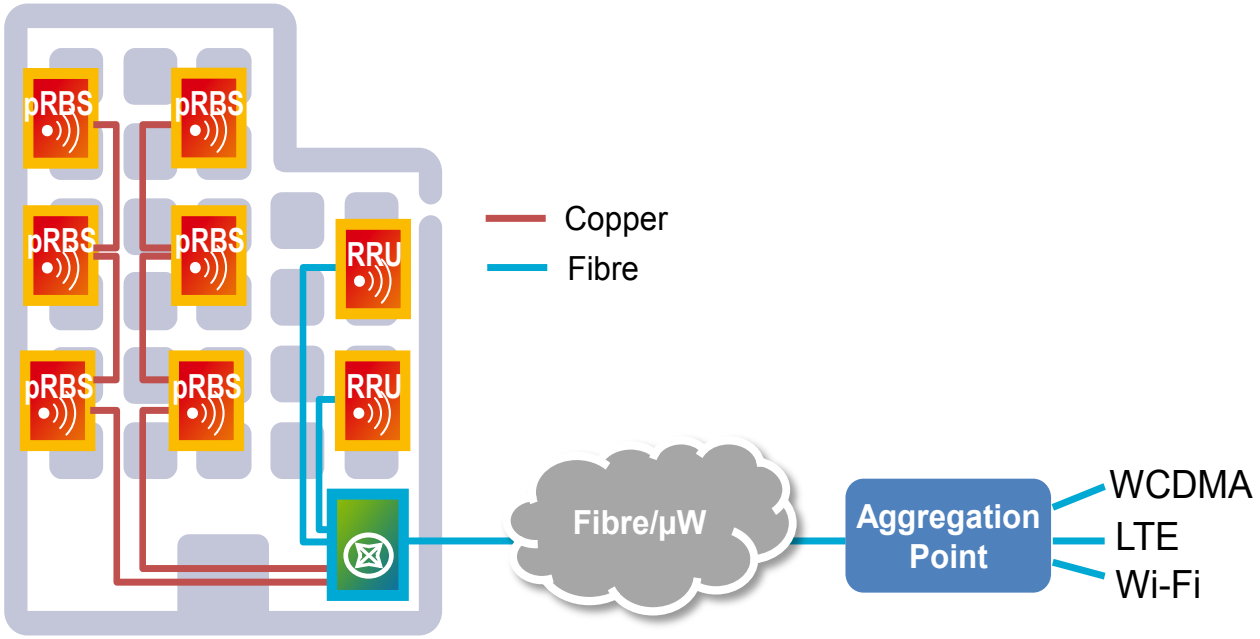
WP2 current status

- UC04 – Reuse of infrastructure for indoor small cell deployment
  - Reuse existing residential and business indoor copper/fibre infrastructure to reduce small cell deployment time and costs



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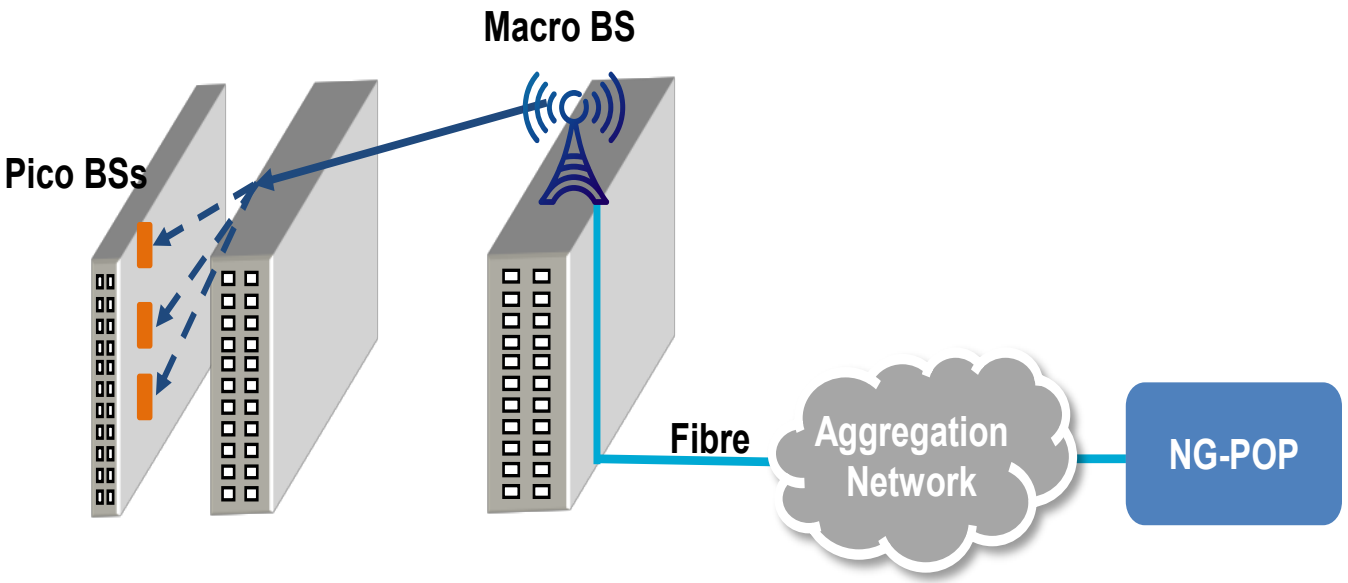
WP2 current status

- UC05 - Effective backhaul deployment for outdoor small cells
  - Deploy backhaul/fronthaul connection for outdoor small cells quickly and easily



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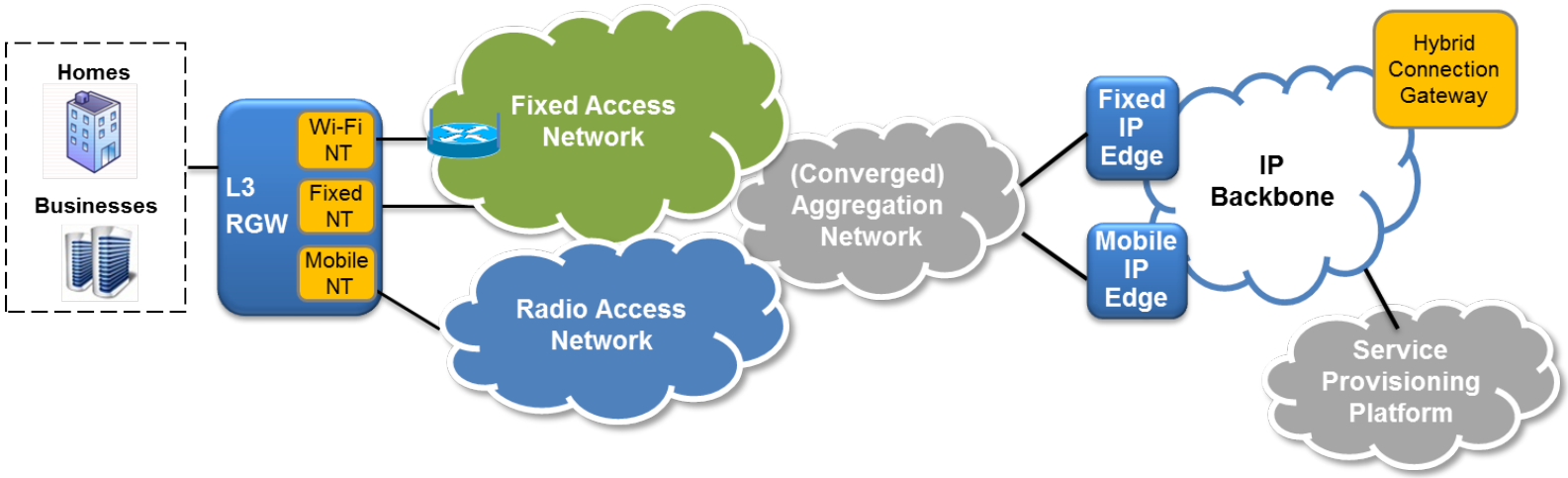
WP2 current status

- UC06 - Common fixed and mobile access termination in hybrid connectivity for FMC customer services
  - Provide to the user dynamic optimum bandwidth and efficient resource via available fixed, cellular mobile, and wireless LAN technologies



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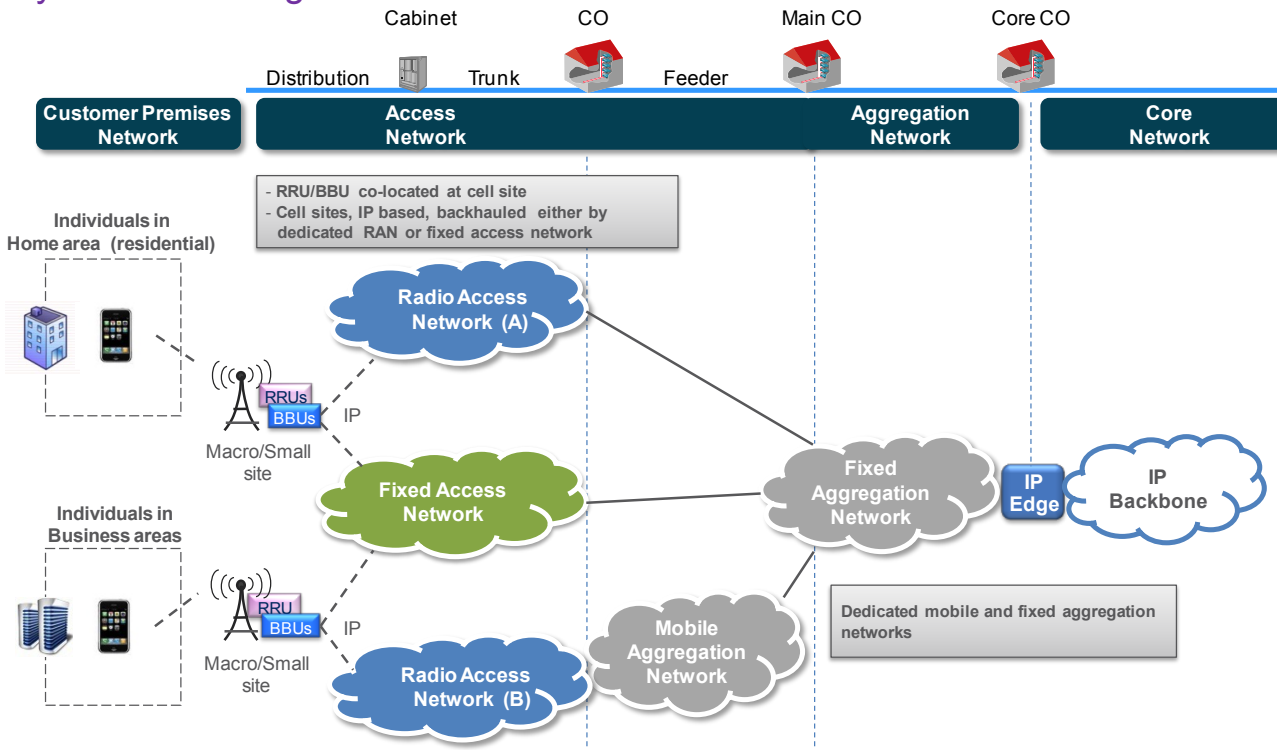
WP2 current status

- UC07 - Support for large traffic variations between public, residential, and business areas
  - Common fixed-mobile aggregation network for all services and types of access networks with dynamic handling of network resources



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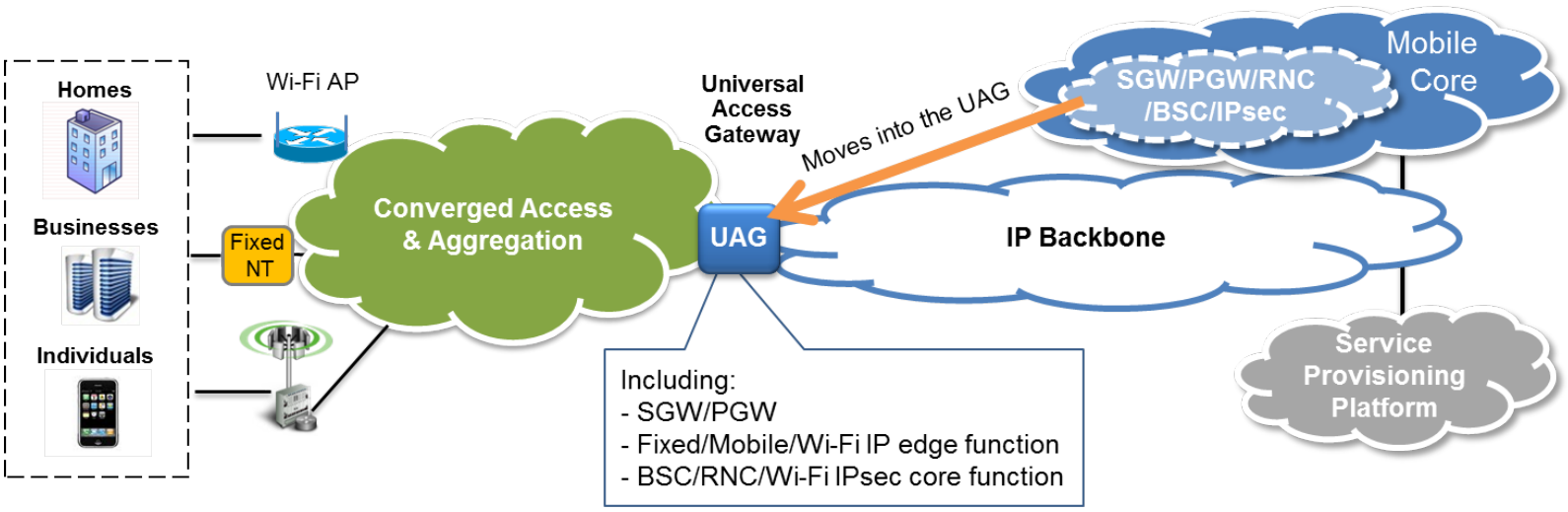
WP2 current status

- UC08 - Universal Access Gateway (UAG) for fixed and mobile aggregation network
  - Integration of fixed and mobile IP edge functionality in order to realize an efficient transport/ control and optimize costs by reducing the number of network elements



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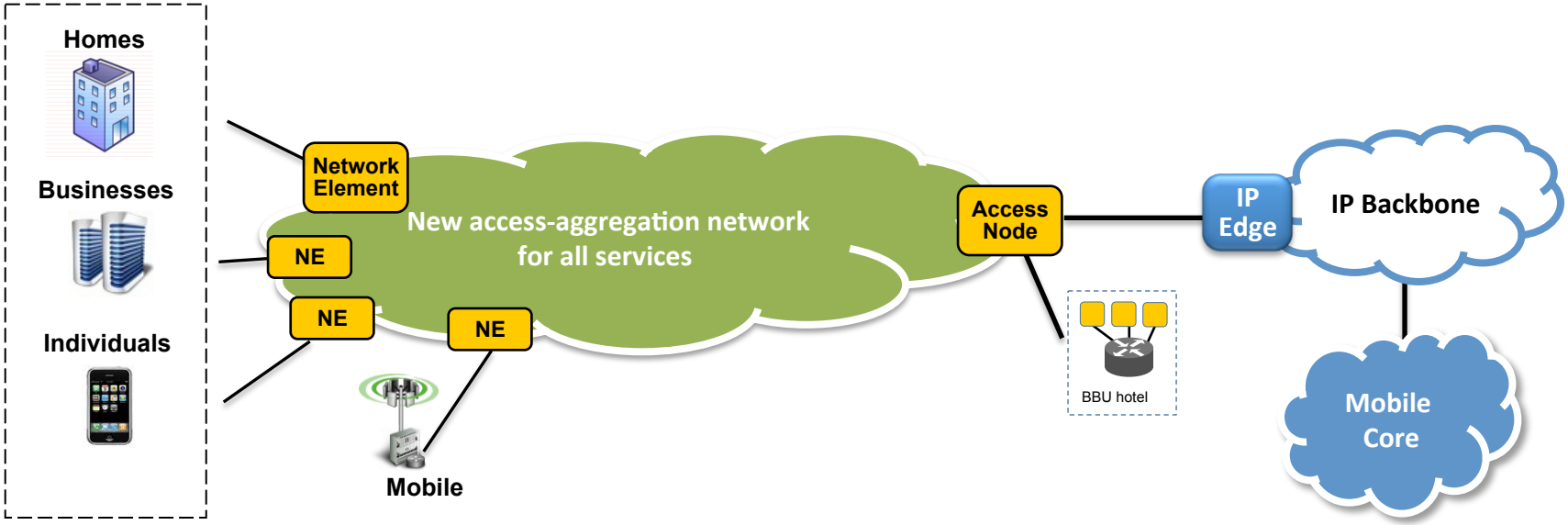
WP2 current status

- UC09 - Convergent access and aggregation technology supporting fixed and mobile broadband services
  - Use the same network for a single model of access and aggregation network able to support all types of services: residential, business and mobile backhauling



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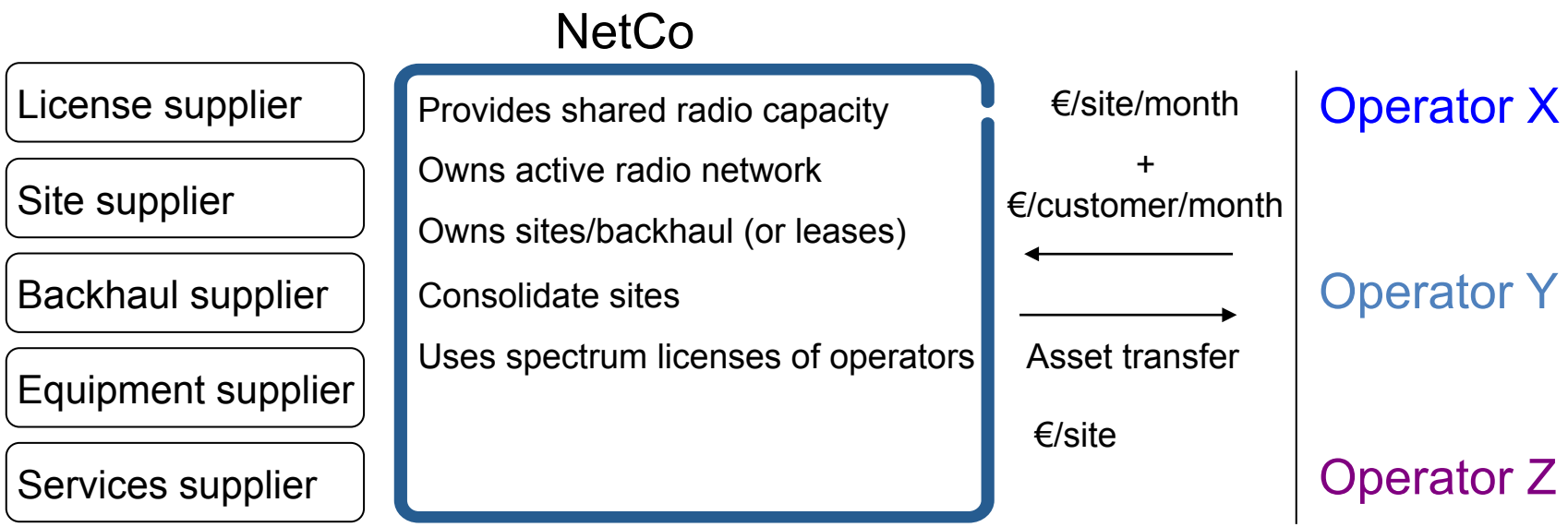
WP2 current status

- UC10 – Network sharing
  - Enable multi-operator network capabilities to reduce costs and support more flexible business models by utilizing existing infrastructure for both fixed and mobile services



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WP3 BACKUP SLIDES

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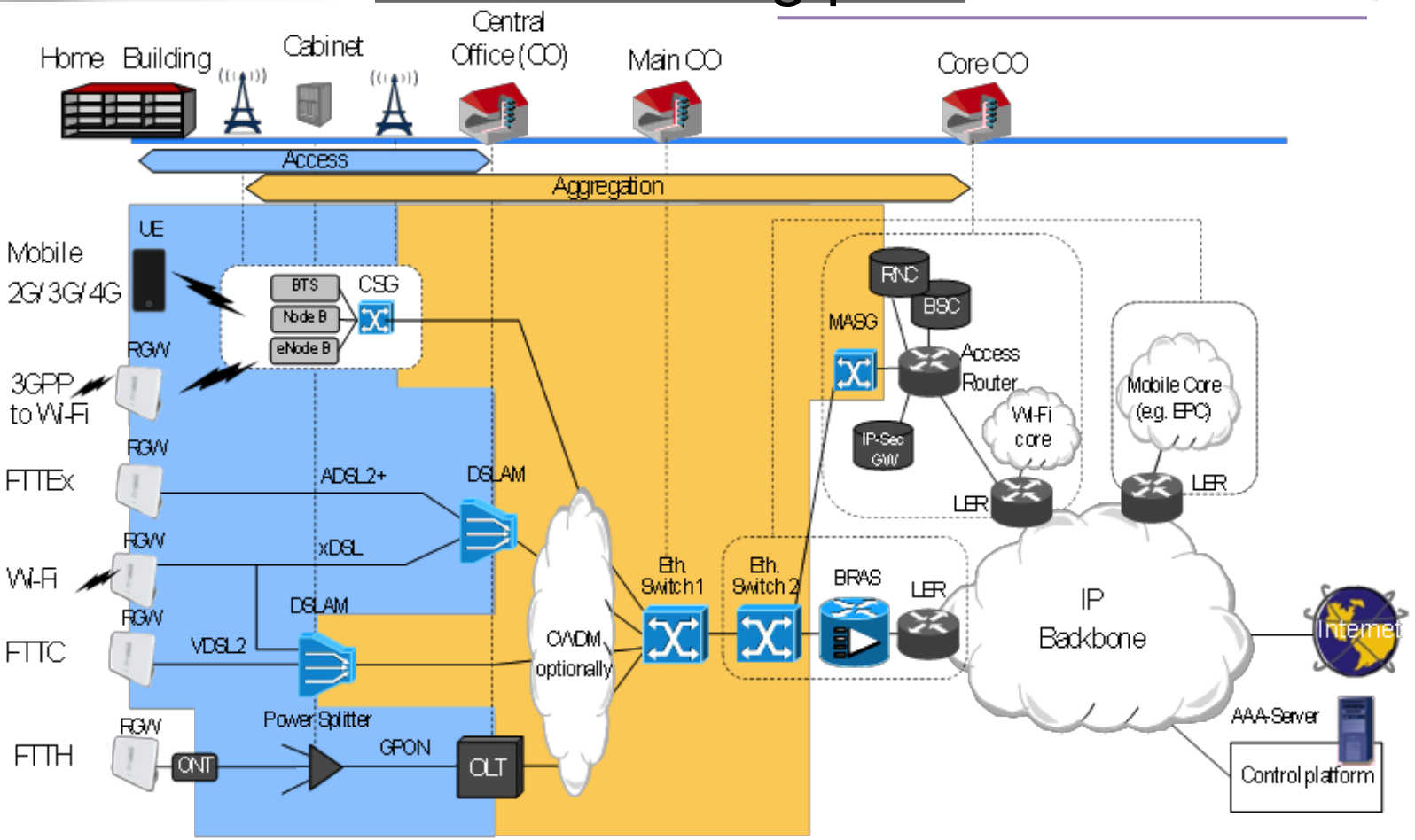
Current FMC network « big picture »



Some parts of the network (e.g. in aggregation) are already mutualized

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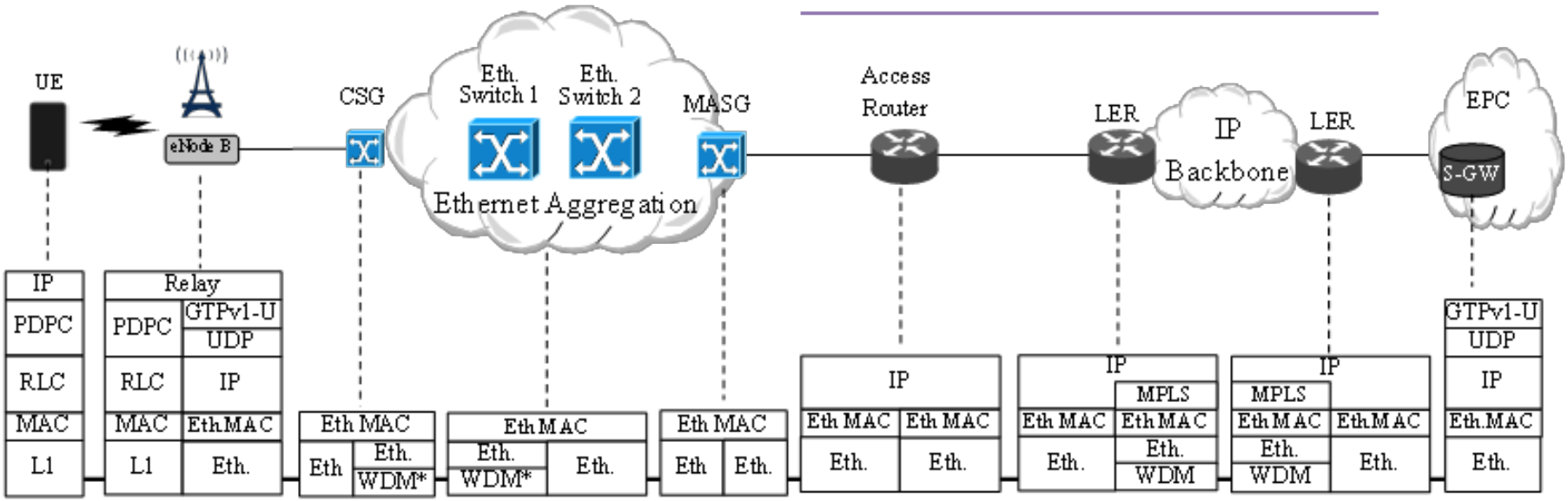
An example of current network mutualization



- Parts of the fixed network are used by the mobile network (here for the connection of eNode-B and S-GW)
  - But different protocols are used and encapsulated
- Harmonization of functions and mutualization of equipments should go further
  - Streamlining of protocol stacks should be targeted, as well as unified control mechanisms (functional convergence)
  - Mutualization of fixed and mobile equipments and infrastructures (structural convergence) could be more effective, in particular in the access

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WP4

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Traffic and Performance Management

Status of Performance management

- Performance monitoring state of the art
  - ♦ List of parameters and methods used today
  - ♦ Active and passive methods
  - ♦ Intrusive and non-intrusive methods
  - ♦ Monitoring on different OSI layers
    - QoS for different physical media and technologies
    - QoS for network layer
    - QoS and QoE for application layer

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Traffic and Performance Management

Current status

- Perfomance monitoring
  - Monitoring parameter relation to QoS/QoE and use cases
  - Leads to monitoring parameters for FMC network
- Performance optimization
  - Use cases for performance optimization
  - Leads to performance optimization for FMC networks
- Use case evaluation
  - Not started

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Traffic and Performance Management

Performance monitoring and optimization use cases covering e.g.

- Network adaptation to traffic demands
  - Small cell network hand over and vertical hand over
- Content delivery
  - Service assurance and core off-loading
- RAN-transport interaction
  - BBU hostelling and adaptive BBU-RRU connections
- Energy efficiency
  - Sleep modes in access network equipment and off-loading

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WP5

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WP5: Techno-economic assessment

- Assess and optimize **economic** efficiency
  - Cost estimation and minimization **[Task 5.2]**
  - Business ecosystems **[Task 5.3]**
- **Energy efficiency** (sustainability) **[Task 5.4]**
  - Energy consumption analysis
  - Energy saving strategies
- Specific requirements and “novelty” **[Task 5.1]**
  - Assessment includes optimized **network design**
  - Calculations based on maps and **geographic** data

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Methodology

- "*Macroscopic*" case studies
  - **Goal**: Estimate the cost of various network architectures
  - **Methodology**: Excel based dimensioning and estimation
  - **Scale**: "Core CO" area, few millions of subscribers
- "*Microscopic*" case studies
  - **Goal**: evaluate how a network architecture adapts to various environments and geographic conditions
  - **Methodology**: network planning, optimization of physical infrastructure & technology configurations
  - **Scale**: area of a single Central Office, up to 100.000 subscribers

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Current status

- Geometric estimation tool for macroscopic case studies ready for state of the art fixed & mobile
  - Refined geometric models
    A. Mitcsenkov el al., “Geometric versus geographic models for the estimation of an FTTH deployment”, Telecommunication Systems, 2013
- Software implemented for physical infrastructure optimization
  - Fixed network planning: scalable map-based network planning heuristics
    A. Mitcsenkov et al., “Geography- and infrastructure-aware topology design methodology for broadband access networks (FTTx)”, Photonic Network Communications, 2011
  - Mobile network planning: Okumura-Hata model
    - Interaction with METIS is more than welcome, especially for small cells!
- Technology optimization tool: COMBO fixed & mobile network scenarios implemented

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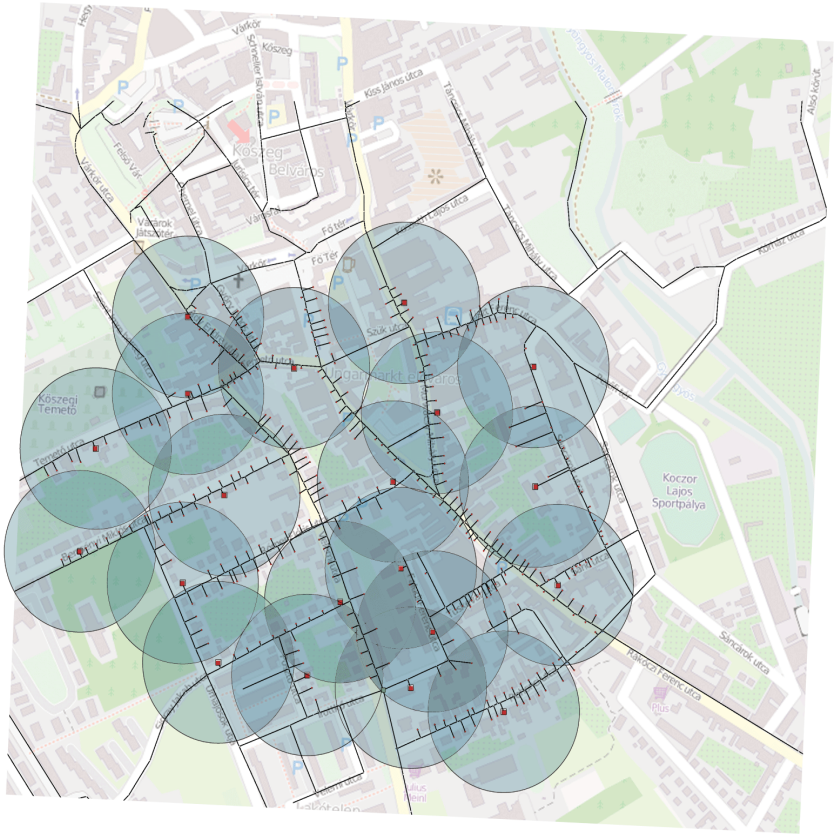
Microscopic case study DEMO

Step 4
Locate antenna sites (mobile cells)



“FMC” aspects:

- Co-located fixed & mobile network elements
- Backhaul network for mobile ~ fixed access
- …

(needs the network planning approach)

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WP6

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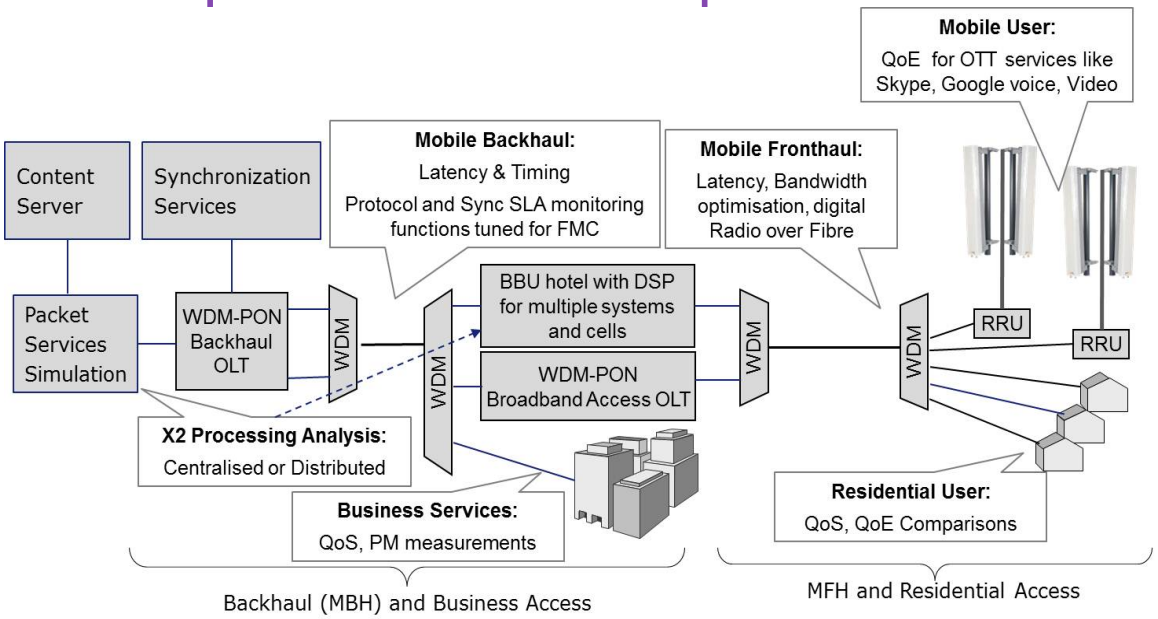
WP6 Overview

- **Practical/Demonstration Work Package**
  - Task 6.1 WP Coordination
  - Task 6.2 Lab Based Practical Work & Development
  - Task 6.3 Operator Based Experimental Phase



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WP Status

- Deliverable D6.1 Completed End of June
  - Captured partner intended activities
  - 11 Partners
    - 3 Operators
    - 6 Vendors
    - 2 Academic
- Partners now working in lab activities
  - Emphasis on progress beyond state of the art
  - FMC Solutions play-pen

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WP6 Topics and Next Steps

- Topics
  - Fronthaul, Backhaul
  - Synchronization
  - Layer 1 & 2 issues incl WDM-PO, MPLS-TP
  - WiFi Offloading
  - Energy Analysis
  - Control Plane
  - QoS, PM, QoE
  - Topology &n Architecture
  - NFV topics and performance benchmarking

- Next Steps
  - Lab Phase (inc. development, build of test beds) - until Jan 2015
  - Field/Operator based experiments – mid 2015 operational

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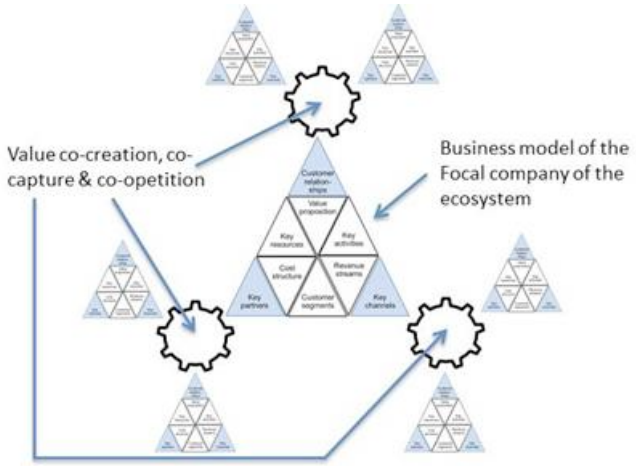
Analyzing a Business Ecosystem

Methodology:

- Specification and Analysis of:
  - Business ecosystem
  - Actors/roles
  - Business Model for each actor
  - Value streams and relations between different actors in the Business Ecosystem



Tools to be used (examples):

- Business Model Canvas
- Mactor
- Value Network analysis through cost-value allocation

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