Unified Access and Aggregation Network Allowing Fixed and Mobile Networks to Converge

D. Breuer[(1)], E. Weis[(1)], S. Gosselin[(2)], T. Mamouni[(2)], J. Torrijos[(3)]
(1) Deutsche Telekom AG, Innovation Laboratories, Winterfeldtstr. 21, 10781 Berlin, Germany
(2) Orange Labs Networks, 2 avenue Pierre Marzin, 22307 Lannion & 4 rue du Clos Courtel, 35510 Cesson-Sevigne, France
(3)Telefónica Investigación y Desarrollo, Don Ramón de la Cruz 84, 28006 Madrid, Spain
Author e-mail address: d.breuer@telekom.de

Abstract: A new concept for unified access and aggregation network architecture allowing fixed and mobile networks to converge is proposed based on the concepts of Next Generation POP combining structural and functional convergence.

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1. Introduction/Motivation

Fixed Mobile Convergence (FMC) refers to the ability of telecom operators to offer to their subscribers services that use wireline and wireless/cellular networks in a seamless way, unifying these two networks in a single access network for all kind of services. This idea is in practice much more difficult to achieve than it seems, because both networks, fixed and mobile, have grown up independently of each other and currently they are based on different technologies and protocols and work in different ways. Only during the last years a certain degree of convergence is appearing with the introduction of all IP services and IP Multimedia Subsystem (IMS) platforms.

Telecom operators are interested in FMC networks because this convergence will generate savings in CAPEX (e.g. a single fiber deployment for fixed and mobile users), in OPEX (e.g. using a single unified network leads to a more efficient network utilization), and in energy consumption (e.g. using Passive Optical Networks for mobile backhauling or disconnecting the mobile air interface when users are under Wi-Fi coverage). This will allow an efficient use of the network and will reduce the current high disparity in mobile backhauling solutions.

Telecom operators are facing the future traffic growth deploying new generation broadband access networks; for example, according to the FTTH Council Europe, 17 million households in the European Union will be connected to FTTH/B at the end of 2016 [1] and IDATE estimates that near 230 million FTTH/B subscribers will be connected worldwide at the end of 2016 whereas the number of LTE subscribers will exceed 900 million by the same time with 150 million only in Europe [2]; furthermore Cisco estimates that the number of devices connected to IP networks will grow from one networked device per capita in 2011 to three in 2016 [3].

Currently FMC is mainly based on the service level and operators have started to build a converged service control layer, but both fixed and mobile networks continue to work independently and they are composed of the same traditional network segments: access, aggregation and core in the first case and radio access network (RAN) and mobile backbone network in the second.

Current fixed networks are based on very different access technologies such as xDSL, CATV and FTTx that can span over distances of a few kilometers, combined with aggregation networks that typically cover distances of a few tens or hundreds of kilometers using traditionally SONET/SDH, Ethernet and MPLS. Moreover, mobile networks are also based on different radio technologies where the most promising are LTE and LTE-Advanced that provide high bit rates such as 100 Mbit/s or 1 Gbit/s respectively. Additionally, mobile networks require a fixed connection to connect radio access to the mobile backbone, and actually a kind of convergence between fixed and mobile networks has taken place through a simple backhaul using PDH, SDH and GbE point to point connections.

2. Approaches for converged network architectures

To achieve a global optimization of fixed and mobile networks, we propose a new access / aggregation network architecture organized 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. 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 idea is to find a better distribution of all essential functions, equipment and infrastructures of

convergent networks. The ultimate NG-POP-based 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,
- and the convergence of fixed and mobile infrastructures and equipment, which we call structural convergence.

2.1. 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. 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 Quality of Service (QoS), Quality of Experience (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.

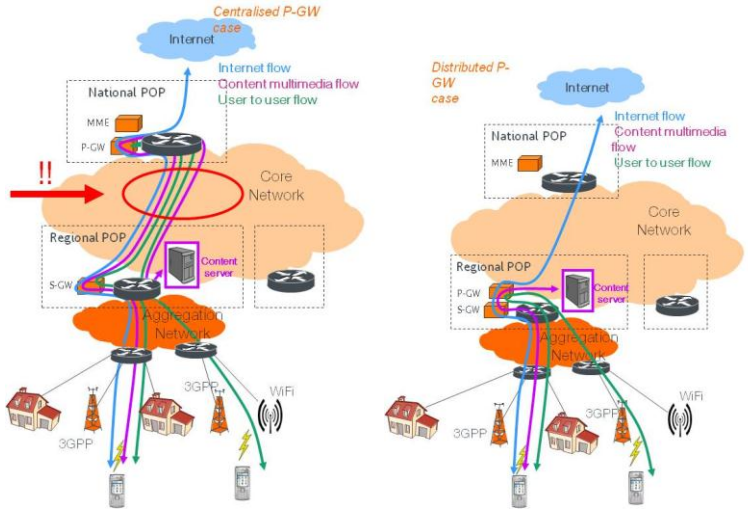

Fig. 1. Example of functional convergence: distribution of P-GW functionalities at regional level

As the wireless segment of FMC networks can be composed of access nodes using different technologies (WiFi, 3G or 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 optimized localization and integration of functionalities to enable efficient network level load balancing schemes by means of dynamic routing. Energy aspects have to be also taken into account in such kind of meshed base stations deployment to enable network sleeping tools when possible. Moreover, effective traffic offloading strategies by means of IP flow mobility in multi-access environment should be implemented to solve network capacity problems and to avoid congestion in the network. As an example, a FMC network would enable a better distribution and localization of EPC (Evolved Packet Core) [4] advanced functions such as P-GW to decrease the load of the mobile core network, as depicted on Fig. 1.

From a business perspective, functional convergence is getting more familiar to the Telco market and it is one of the most important targets. Large Telco operators which combine fixed and mobile networks are seeking functional convergence, because it will enable differentiated products and services to offer to the users, and they will then be able to provide their customers wider QoS and QoE, paying only one subscription. MVNO´s 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.

2.2. 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), as depicted schematically on Fig. 2. This mutualization requires a deep understanding of both worlds and common network design targeting an overall optimum.

FMC enables new mobile backhaul architectures that allow moving the mobile-traffic processing equipment, which takes place in the so called Base Band Unit (BBU), in a separated and possibly distant location at a central office that can be far from the antenna location, which is then reduced to a Remote Radio Header (RRH). BBU hostelling is only possible if fiber connects the base station (eNodeB) with the central office. The radio signal is then digitally transported over fiber (Digital Radio over Fiber, D-RoF) on the so-called fronthaul link. This becomes now possible thanks to the deployments of FTTH and LTE, and opens the way to the so-called Cloud RAN [5]. Structural convergence will further optimize the use of the most costly part of fixed and mobile networks, and drastically decrease cost and energy consumption, thus improving the return on investment of access and aggregation infrastructures: it will also allow central office consolidation of fixed networks to be performed in strong synergy with the development of mobile access infrastructures. FMC can thus target convergence of traditional PON access and dedicated wavelengths for mobile traffic front-hauling on a single fiber infrastructure, or even on a single equipment, as illustrated on Fig. 2.

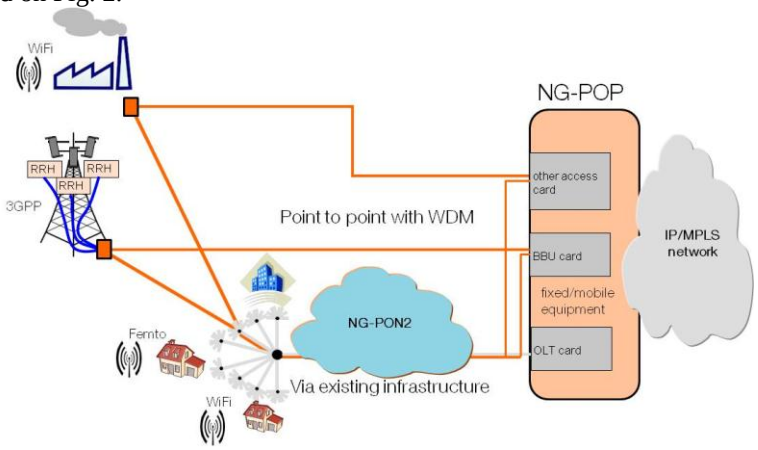

Fig. 2. Convergence of fixed / mobile equipment and infrastructures towards NG-POP

3. Summary

In summary, for achieving a new level of Fixed and Mobile Convergence in broadband access and aggregation networks a joint optimization of fixed and mobile access / aggregation networks around the innovative concept of Next Generation Point of Presence needs to be performed. This will lead to a better distribution of all essential functions, equipment and infrastructures of convergent networks and will thus enable a network with better services at lower operational costs.

4. References

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