Fixed-Mobile Convergent Networking for Service Oriented Telecom Architectures : A Case of Ethiopian Telecom Networks

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Abstract

Future networks are characterized by convergence at different technological and service levels. Convergence of fixed and mobile networks (FMC) is a network trend that is used to develop service oriented communication networks. This paper discusses FMC networking for providing service oriented telecom architecture (FMC-SOTA). It also identifies the main drivers and enabling technologies for FMC. Analysis of different existing FMC strategies for service orientation results in a near similar IP-Multimedia Subsystem (IMS)-based architecture for the case of Ethiopian telecommunications corporation (ETC) networks. The main FMC-SOTA migration and networking guidance parameters used are: capital and operational cost reduction, simplicity of introducing & managing new services, unified pricing & billing for revenue generation, smooth migration of legacy network, and adherence to international telecom standards.

1. Introduction

Fixed-mobile convergence (FMC), as the name indicated, is the convergence of mobile and fixed (or wireline) telecommunications services, terminal devices, and networks. Its ecosystem is comprised of several key components beyond network operators and service providers. There are several layers to this ecosystem and there are many specialized companies within the layers, but the key players are standard development and certification organizations, network equipment vendors, handset vendors, application developers, and consumer electronics companies. These all players have their own interest in and contribution on FMC. Therefore, the main drivers of FMC-SOTA are: fixed mobile substitution (FMS), operator/service providers, customers/end-users, equipment vendors, and technologies.

The explosive growth in mobile phone usage and the revenue generated by it is breaking all records. On the other hand, wireline telephone voice traffic revenue is decreasing. If this trend keeps up, there is a high probability that voice traffic will entirely shift from fixed to mobile communication leading to Fixed-to-Mobile substitution (FMS). However, whether the FMS trend also repeats itself for non-voice services such as internet access using Mobile IP and mobile broadband is yet to be seen. In [5] important technologies and key architectures have been identified for FMC based service oriented architecture (FMC-SOTA) for emerging markets in developing countries.

Convergence of the current packet and circuit networks and services over both fixed and mobile networks is becoming very crucial in order to satisfy customer needs and also to reduce cost and introduce new services for the operators. FMC services usually have one or more of the following characteristics: seamlessness, user flexibility in access methods, converged customer premise equipment (CPE), personalization, and best of mobile and fixed worlds.

In order to ensure the end user a continuity of experience, a total integration of the different access and core networks from the fixed and mobile sides needs to be achieved. Ovum [1] indicates four main stages of FMC development:

Stage-1: price bundling of fixed and mobile services. Bundles are delivered to customers at discounts, often via a single bill. The services and the networks which provide them remain separate.

Stage-2: Service convergence/orientation in which a few common services are offered over both fixed and mobile networks e.g. a single voice mailbox or linked email.
Stage-3: device convergence in which a common device offers both fixed and mobile network access with seamless handover.
Stage-4: network convergence in which fixed and mobile services run over a common IP transport network and use a common platform for service creation and control - the IMS.

Some countries like Italy, Denmark and United States are taking the lead in moving along the path of convergence [1]. Network convergence is an important step for the deployment of a common service platform allowing the development of integrated services and service oriented architecture. Access to services from a range of devices over both fixed and mobile networks is made possible leading to "anywhere anytime" communication. Where the subscriber is always best connected in terms of bandwidth, quality of service and price.

2. FMC Networking and Service Oriented Telecom Architecture

FMC includes convergence of services, networks, and end user terminals. Enabling standards to support FMC and the service orientation of the telecom architecture.

The standards focused are Third Generation Partnership Project (3GPP) and European Telecommunications Standards Institute (ETSI) Telecom & Internet Converged Services and Protocols for Advanced Networks (TISPAN). 3GPP is working on GSM networks evolution to IMS and ETSI TISPAN is developing standard for fixed networks migration to NGN taking IMS requirements into consideration. The two standard bodies are working together to build common IMS architecture for both fixed and wireless networks. IMS is built on layered architecture with open interfaces and it can provide IP multimedia services independent of the underlying access technologies.

2.1. IP Multimedia Subsystem (IMS)

IMS is being developed by 3GPP in collaboration with IETF, ITU-T, and ETSI etc. Initially, the main aim of IMS was to bring together the Internet and the cellular world, leading to service oriented telecom architectures (IMS-SOTA). To this end, IMS uses existing Internet protocols such as SIP (Session Initiation Protocol), AAA (Authentication, Authorization and Accounting protocol), and COPS (Common Open Policy Service) etc,… to meet the requirements of reliable and real-time data communication. Further, IMS include easy quality of service (QoS) management, mobility management, service control and integration.

The core network elements or nodes of IMS communicate with each other using specific protocols; each of these interfaces are identified using a reference point label. A detailed list of all the interfaces and their operation is available in 3GPP TS 23.002 [6]. Also another important characteristic of the IMS architecture is that it exclusively uses IPv6; it requires network elements such as NAT-PT (Network Address Translation – Protocol Translation) and IMS-ALG (IMS Application Level Gateway) to interoperate with the traditional Internet (which mostly uses IPv4).

Few applications and services that can be developed on the IMS platform include: presence related services, instant messaging, push-to-talk services, etc. The services that can be developed on the IMS platform are limited only by the creativity of the application developers and requirements of the customer.

3. FMC-SOTA: the case of ETC

Fixed-mobile convergence is getting attention from telecommunications industry as one way of getting a service oriented convergence solution (FMS-SOTA) to meet the demands of new services by consumers. There are also service & content providers interested in the potential benefit of using the network to generate revenue. Work is also underway in this area in standard organizations like 3GPP and ETSI-TISPAN. Migration to FMC-SOTA may be evolutionary or revolutionary. It is the evolutionary one that is appropriate particularly for developing countries. This is because it enables them to invest their limited capital on future-proof technologies by leveraging the previous investment on legacy networks. However, directly moving to the complete convergent platform, which is revolutionary, is not recommended. This is because it needs high investment cost, affect the huge investment on legacy networks, result in less customer experience for multimedia services, and so on.

FMC enabling technologies and architectures for service orientation are designed to meet the following requirements:

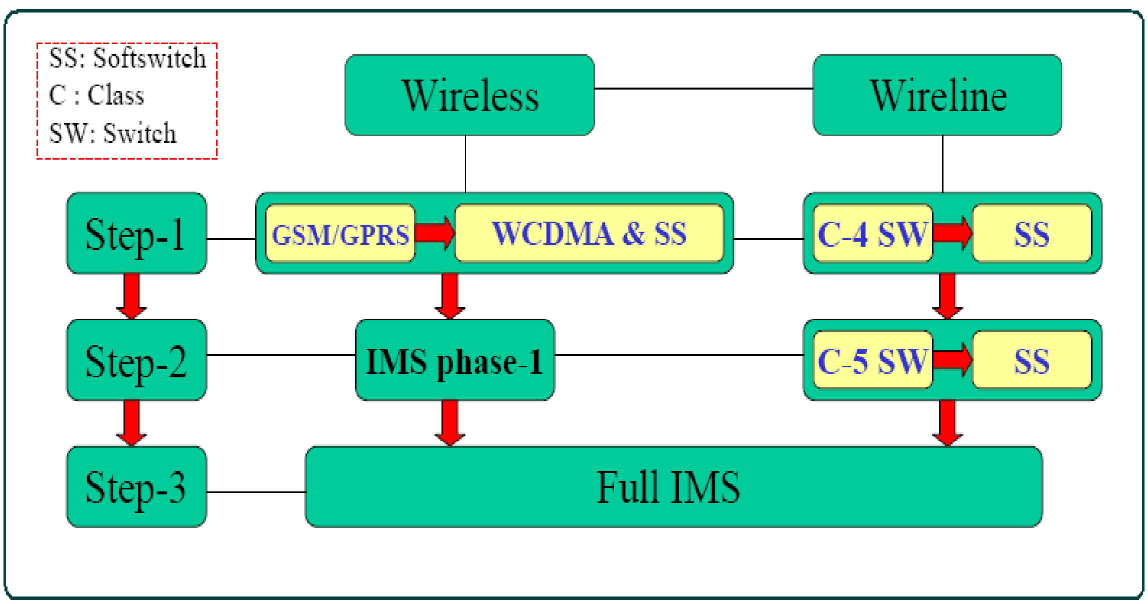
- Follow Telco. standards in order to meet the following advantages of open interfaces.
  - Easy service creation, modification and provisioning.
  - Service Provider & MvNO Interconection gateway nodes.
  - Telecom operators can buy equipment from any supplier. This enables operators to have the best-breed product with reasonable cost.
- Enable telecom operators to implement future-proof technologies step-by-step. This enables operators to:
  - Protect investment on legacy infrastructure.
  - Gradually build customer base for the future IP multimedia services.
- Flexible and scalable network architecture.
- Simplified network architecture that enables telecom operators to gain capital and operational expenditures (CAPEX and OPEX) reduction.
- High revenue generation that guarantee return on investment.
- Guarantee end-to-end quality of service.
- Inter-working with packet- and circuit-switched networks.

IP multimedia subsystem (IMS) can provide multimedia services over common IP backbone irrespective of the underlying access technologies and it is the one that meets the above requirements. Therefore, the migration path to IMS-based FMC architecture that is developed for ETC's network is described by the following steps:

Step-1: Network consolidation and building a foundation for IMS infrastructure

Step-2: Upgrading the consolidated platforms or injecting new IMS elements

Step-3: Full IMS deployment



Telecom operators should plan migrate their networkto fixed-mobile converged and service oriented architecture. The migration process could be financed by revenue from new services, and cost reductions from network consolidation and optimization. The following three steps have been identified for smooth migration of ETC's network. This may also apply for other emerging markets planning to migrate to fixed-mobile converged network architecture as shown in figure-1.

Each step is justified by the gains due to service orientation, the ease to create new services and the advantages brought from network consolidation.

4.1 Step-1: Network Consolidation

This step involves network consolidation and building a foundation that will allow telecom operators to create flexible IMS architecture and hence to capture Capital and Operational Expenditure (CAPEX and OPEX) efficiencies. Through consolidation, it is possible to gain scale and reduce the number of network elements making the network more IMS-ready.

The existing ETC's mobile network is providing basic voice service based on GSM 900/1800 MHZ. It is also capable to provide short messaging service (SMS) and GPRS services. During this step, mobile network consolidation can be achieved by introducing wide-band code division multiple access (WCDMA) in the base station subsystem (BSS) and softswitch in the core network. 3GPP Release-99 [7, 8] basically introduces a new type of radio access network called UTRAN (UMTS Terrestrial Radio Access Network), which enhances the downlink & uplink speeds to about 2Mbps. 3GPP Release-4 [16] is defined to facilitate the evolution of the Release-99 circuit switched core network architecture into an IP transport development with a separation of control (MSC server) and bearer (media gateway) planes easing the introduction of packet switched backbone technology in the circuit switched domain. This is a pre-IMS phase so that the cellular network will be ready for initial IMS implementation.

The current trend in the telecommunications industry is the migration from voice-optimized switched circuit networks to multi-service packet networks. This migration will provide benefits in terms of economies of scale and revenue from new services. One of the greatest challenges in this migration is creating a packet-based infrastructure that will preserve the ubiquity, quality, and reliability of voice services while allowing the greatest flexibility for use of the new packet technologies. In practice, this means the retaining of current telephony-related services or the transparent offering of existing public switched telephone network (PSTN)-bound services on new packet-based deployments [9].

Telephony soft-switch solutions can be deployed to support today's legacy call-oriented traffic over an IP-based infrastructure, with telecom-grade scalability and quality of service. Beyond voice services, IP-based networks open up opportunities for integrated voice applications and services – such as Video Telephony and presence aware telephony – that would be impossible (or prohibitively expensive) using traditional Time Division Multiplexed (TDM) technology [18].

ETC's fixed network is providing basic telephony service and supplementary services based on class-based TDM switches and signaling system #7 (SS7). During this step, it is recommended to replace class-4 switches, which are national tandem switches, by softswitches. Class-4 switches represent a smaller investment for the service provider and with less functionality than a Class-5 switch, means a simpler and therefore lower risk point at which to move to packet voice.

4.2 Step-2: Upgrading the consolidated platforms or injecting new IMS elements

By enabling and upgrading the consolidated platforms created in step one and/or injecting new IMS elements into the network, ETC can enhance the existing services and/or launch new IMS powered applications and services. This step basically involves the initial deployment of IMS in mobile network, and providing voice over packet up to the access level and other high revenue generating value added services by upgrading the softswitch in fixed network. It is the first step towards using IP session control mechanisms in the packet switched domain, which is IMS, enabling flexible session negotiation for multimedia applications in mobile network.

In mobile network evolution of step one above, the GPRS main components (GGSN and SGSN) that brings packet data services to the mobile network, the UTRAN in Release-99, and the softswitch (MSC server and media gateway) in Release-4 have been introduced. This resulted in a good mobile network foundation for IMS implementation. The basic introduction of the IMS network arrives in 3GPP Release-5 set of standards, while enhancements such as PSTN and IPv4 inter-working are added in Release-6, which will be discussed in step-3. IMS is an overlay control network that reuses the packet domain of the Release-99/Release-4 networks. For details see [10].

In this second step of mobile network evolution, new IMS elements will be introduced in the already established network foundation. This involves the implementation of 3GPP's Release-5 [2, 3]. Some major release-5 items [10] are as follows.

- IP-based multimedia services (i.e. IP multimedia core network subsystem).
- Reliable QOS for packet switch domain (end-to-end QOS).
- Introduction of IP UTRAN.
- Introduction of High Speed Downlink Packet Access (HSDPA).
- CAMEL phase 4.
- Wideband adaptive multi-rate (AMR) coding.

The introduction of softswitch to legacy fixed network has been discussed in evolution step one. In first step, it was recommended that softswitch replaces the legacy class-4 or national transit switches and gradually offloads voice trunking traffic to the packet network. This also brings the advantage of network consolidation due to the distributed media gateways for trunking functionality while all can be controlled by centralized media gateway controller. Further more, the transport infrastructure in the core network may also be optimized due to the usage of IP transport.

In step-2 of fixed network evolution, the replacement of class-5 switches by softswitches is recommended to provide IP-based services to the end user. ETC should gradually replace these legacy class-5 switches due to the huge investment on these switches. This can be done in parallel with step-1, which places trunking gateways alongside existing class-5 switches to provide access to the packet network. Access gateways (AGs) can be used to supplement or replace existing TDM access nodes for voice connections to the packet network. At the end of life the remainder of TDM exchange equipment can be replaced by media gateways.

4.3. Step-3: Full IMS deployment

In the third and final step of the roadmap, ETC should move to full IMS deployment, utilizing the IMS enablers to create new multimedia services and applications not previously possible.

Bear-in-mind that in the previous step of mobile network evolution, the major achievements are 3GPP Release-5 enhancements like HSDPA and initial IMS deployment. In step-3, introduction of 3GPP Release-6 to mobile network is recommended. 3GPP Rel'6 is an enhancement of earlier 3GPP releases that continues UMTS momentum by enabling greater speeds, capacity improvements and new applications. It includes numerous new features such as:

- High Speed Uplink Packet Access (HSUPA).
- The second phase of IP Multimedia Subsystem (IMS).
- Inter-working with Wireless Local Area Networks (WLAN).
- Multimedia Broadcast Multicast Service (MBMS).

During this third step, IMS also serves wireline access. ETSI-TISPAN [11] drives the application of IMS for wireline access in its efforts on the Next Generation Network (NGN), in collaboration with 3GPP. The service definitions for NGN multimedia telephony will also be reused and adopted for wireless accesses by 3GPP. When all legacy equipment has been removed and SIP based IMS is fully introduced, the target network has been reached.

3GPP release-6 and beyond are basically characterized by enhancing or improving features of previous releases and also focus on inter-working with other networks such as PSTN and WLAN. ETSI TISPAN is also working on fixed network migration to NGN based on IMS architecture. Its first release provides basic architecture built on this concept [10]. Other consecutive releases that will add new features and/or enhance features of the previous release (release 1) are under way.

IMS is a layered architecture where service enablers and common functions can be reused for multiple applications. The architecture in IMS also specifies interoperability and roaming, and provides bearer control, charging and security.

For end-users, IMS-based services enable service orientation providing person-to-person and person-to-content communications in a variety of modes. These include voice, text, pictures and video, or any combination of these – in a highly personalized and controlled way. IMS provides services like presence, mobile internet, video telephony, and instant messaging that will bring quick return on broadband investments.

5. Conclusion

Fixed-mobile convergence provides many benefits to migrate to service oriented telecom architectures (SOTA). Standard bodies and different stakeholders in the telecom industry are making effort and contribution to achieve fully converged network architecture to make this possible. This is reflected in the convergence of 3GPP IMS and ETSI TISPAN NGN. The IMS standards are promising network development for fully converged fixed and mobile/wireless networks and service orientation.

FMC-SOTA enables telecom operators to use the mobility advantage of wireless networks and the Broadband infrastructure of the fixed network in a seamless fashion, to provide a platform for service orientation. In this paper a planned migration path towards fixed-mobile converged network architecture and services orientation was presented for the case of the Ethiopian Telecom Networks. The criteria used were protection of investment on legacy infrastructure, Service orientation: ease of developing, activating & billing of new services, lower network OPEX cost. Other criteria were adherence to international telecom standards & Inter-working with packet- and circuit-switched networks which guarantee smooth functionality.

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