Network Architecture Evolution Strategy in Fixed Networks

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In today's competitive business environment, operators are seeking to simplify their network topology in order to cut costs and create a convergent network infrastructure that is secure, easy to manage, always available, and capable of adjusting to unpredictable future traffic loads and changing business needs.

The combination of IMS based control and IP-connectivity seems to be most promising for efficient deployment of new multimedia services, which will give operators new sources for revenues streams.

In this paper we will give an overview of the main evolution drivers, overview on full service broadband target network architecture as well as strategy how to migrate existing legacy networks to a convergent all-IP multi-service network. The standardization work by TISPAN and 3GPP is very interesting for operators and form an important foundation for the network transformation.

I. INTRODUCTION

Traditional PSTN/ISDN networks are slowly being substituted by voice over IP (VoIP) and mobile telephony while at the same time PSTN/ISDN services still constitute an important share of operator revenue.

The evolution strategy of many operators is a combination of directly countering substitutes with a VoIP (and other services) offering provided over a broadband access and at the same time protect legacy services and revenues over the POTS (Plain Old Telephony System) line.

Often operators identify a need to modernize legacy networks including transit layers to maintain service quality and reduce operating expenditures. Drivers for the increased cost are to a large extent ageing hardware with increased failure rates and difficulties with spare parts. Equipment footprint (site cost) and power consumption of old equipment also contribute to an increased OPEX (Operational Expenditure).

Fixed operators are also introducing broadband access to their POTS subscribers. With this development a fixed operator will be able to offer additional services to their subscribers and by this increase revenue. With the broadband rollout, the IP based transport network needs to be built out to a large extent. The coexistence of a TDM (Time Division Multiplexing) network for voice and a packet based network for broadband will increase the cost for the operator. Therefore, the advantage is to move the telephony network (TDM) onto the packet based transmission in order to obtain a situation where only one IP based transport network has to be supported.

VoIP (Voice over Internet Protocol) is typically offered in markets where broadband access coverage is high. In many markets, this type of offering has been available for quite some time.

Many different types of service providers are currently offering VoIP, for example:

- Competitive carriers offering fixed broadband and VoIP in a bundle, often included in triple play. This is a competitive offering to the PSTN offering from the incumbent operator. Broadband access technology could for instance be xDSL, FTx and Cable.

Examples of carriers include:

- Bredbandsbolaget, broadband provider in Sweden.
- ComHem, Cable TV provider in Sweden also offering broadband access.
- Mobistar in Belgium (owned by FT entering a new market)

- Incumbent operators offering VoIP to meet competition from carriers above, e.g.

- France Telecom with their Livebox offering in France

- Incumbent mobile operators offering fixed broadband access (xDSL, HSPA/LTE etc) as a competitive offer to the fixed incumbent, e.g.

- O2 in Germany
- Vodafone Portugal

- Unbundled VoIP operators offering VoIP telephony via any broadband access. Examples are:

- VONAGE in USA
- Megaphone in Sweden

Competition with traditional PSTN offering is often met with lower tariffs per minute, lower monthly subscription fees and free calls within the own network. Most operators above are targeting a first line replacement service. By means of number portability users can keep their old E.164 telephone number. Currently Network-to-Network interconnection is typically performed via TDM.

Many vendors are addressing the broadband VoIP market segment, often with proprietary solutions, but many of them have announced IMS (IP Multimedia Subsystem) intents. A low cost VoIP solution for small entry with possibilities to scale is often needed to address this market segment. Many of the current vendors are actually facing scalability problems when operators gain large subscriber uptake.

Although most deployments are for offering only voice services, there are a number of operators who’re also offering multimedia service, including presence, video telephony, file sharing. One good example is Optimus in Portugal who launched a multimedia PC client in May 2008.

II. CURRENT MARKET TRENDS

Broadband telephony is expected to grow to a mass market in 2011 with more than 200M lines penetration. The majority of these lines will be broadband VoIP (single media) initially and gradually over time IMS based Multimedia Telephony (MMTel) will take over as the dominant communication service offering additional multimedia capabilities.

The communication culture among young people is rapidly changing. In Internet communities e.g. MSN, Skype etc. communication trends such as presence-enabled chat and video sharing are seen. Communication behaviour increasingly revolves around the sharing of everyday life experiences – anywhere, anytime, and on any device.

IMS Multimedia Telephony gives the telecom domain a corresponding type of service but also with support of essential functionality of the telecom world: e.g. the operator can remain service aware (i.e. take part in the service delivery and charging of the service), the operator can support regulatory services.

The Internet communication trend is seen for PCs accessing Internet over fixed broadband access but in the future it is also expected that devices accessing Internet over mobile broadband access will develop the same communication behaviour. IMS Multimedia Telephony will in that perspective, be a vehicle for the operator community to also offer new multimedia services.

However, contrary to the best effort services offered by internet players, IMS Multimedia Telephony will be a telco grade service, i.e. the service will have attributes such as quality, interoperability, reliability etc.

Further chapters explain in more details why, how and what are the risks when migrating existing legacy networks to a convergent all-IP multi-service network

III. EVOLUTION DRIVERS

We can identify several main evolution drivers in few main areas that are of significant impact on the evolution of the network architecture.

Commercial drivers

1. **OPEX and CAPEX (Operational and Capital Expenditures)**

- Operators in general want to reduce OPEX and CAPEX whilst adding new technology in parallel to existing networks
- Operators want to reduce the cost of sales and R&D resulting in a drive for re-use of products and system services
- Operator and network consolidation (inter- and intra-region consolidation, operators from either fixed or mobile side are aiming to provide both fixed and mobile services, delivered by one single convergent network)
- The cost for system integration increases rapidly due to requirements for multi-vendor environment to reduce operator's risk and CAPEX

2. **New and evolution of user services**

- Personalization of services, e.g. TV channel subscriptions as well as personalized service bundling and look and feel
- Take up of IPTV
- Emergence of “Web 2.0”, e.g. shift towards user- and client-generated content.
- Legacy voice services in parallel to expanded voice service including POTS to VoIP migration

3. **Business structure**

- Changes in business relations and business roles, e.g. bit-pipe provider, broker role and service provider.
- Changes in revenue models and revenue streams
- Trend towards flat rates and bundled offerings

4. **Regulatory**

- Requirements on emergency services in various accesses
- Stricter regulatory requirements on security and lawful intercept
- Greater harmonization and regulatory consistency across Europe including network and technology neutrality

Technology drivers

1. **Stand-alone technology drivers**

These are drivers that stem primarily from the evolution of the technology itself

- Increase of complexity due to the growth of networks in residential premises
- Mass-market SW & HW that drive down cost for new technology and consumer products

2. **Implied technology drivers**

These drivers are implied by one or more of the business drivers, primarily OPEX/CAPEX, new user services and business structure

- Emergence of managed IP services in parallel to best effort Internet
- Increased focus on automation and commonality in user & service management including plug-and-play and auto configuration
- Standardization of open interfaces to build industry and encourage competition

Having all listed drivers in account, the global trend with European operators is to introduce new IMS based convergent network that can easily be added to existing TDM network. In that way they can keep the existing revenues from the PSTN/ISDN services while they can enrich their offer with new multimedia services.

IV. EVOLUTION TO IMS MULTIMEDIA TELEPHONY TARGET NETWORK ARCHITECTURE

The evolution towards packet and IP based accesses and services is continuing, which in turn makes it more and

more suitable to use the same service engine for different types of accesses. Consequently the networks evolve towards Full Service Broadband (FSB) architecture. The FSB architecture allows services to be transparently available across different accesses with common authentication and security, with seamless mobility and full Quality of Service (QoS). The FSB architecture is included in the long-term target functional architecture, illustrated in Fig. 1.

Figure 1. Target network architecture model

The change of user behaviour towards multimedia communications, which originates from internet applications like MSN and Skype, force the telecommunication industry to jointly develop the TISPAN (Telecoms & Internet converged Services & Protocols for Advanced Networks) and IMS Multimedia Telephony (MMTel) specifications.

Vendors strategy is to build and sell products based on these specifications to become a global mass market service. The wanted position is that IMS Multimedia telephony becomes the key solution offered by vendors to help its customers, the telco operator community, to handle the migration of today's architecture that only allows for single media and single access circuit switched (CS) telephony into an architecture that allows for a standardized multimedia and multi access telephony solution.

IMS Multimedia telephony should supply low cost TISPAN/MMTel solutions to Wireline operators for modernization and OPEX reduction. It offers single media IP telephony for all types of accesses and devices. For example IMS Multimedia telephony may be used as an evolved service engine for single media telephony over a narrowband access (GSM, POTS). In these cases IMS Multimedia telephony provides an evolution strategy to offer the MMTel service and to be able to have an IMS multi-service solution when the operator adds broadband capabilities to the access network or in a mixed scenario have consistent user experience with the MMTel service over broadband.

To achieve a true end to end service that can help avoid fragmentation in the market place, the MMTel service is being standardized for all possible access types, e.g. cellular, wire-line and cable access.

The IMS Multimedia telephony solution has functionality to inter-work with circuit switched networks and thus ensures an efficient and seamless transfer of regular circuit switched based communications to MMTel based multimedia communications.

The Mobile Softswitch (MSS) and Telephony Softswitch (TSS) solution and the IMS Multimedia telephony related IMS nodes are able to be implemented in a common integrated site. This allows for investment/hardware reuse as existing MSS/TSS network equipment can be re-configured to IMS components when the IMS traffic grows.

The MMTel service shall be the driver for the telco operator community to evolve its interconnection from today's ISDN User Part (ISUP) based telephony to an IMS/IP based interconnection with well defined interfaces and agreements for the advanced services IMS Multimedia telephony can provide.

V. IMS MULTIMEDIA TELEPHONY ARCHITECTURE

The MMTel service is introduced to address a new user proposition in which the real time communication between people according to the telephony paradigm fulfilling quality of service, authentication, authorization, regulatory and efficiency requirements is evolved. The new user proposition includes a voice over IP telephony service that can use a set of simulated PSTN/ISDN supplementary services and add and drop a number of different media types during a session to adapt to the current communication need. Examples of media types that can be used in an MMTel session are:

- Voice, both narrow band and wide band quality,
- full-duplex or half-duplex video,
- text, where the characters are either transmitted in real-time when the user types or as pre-typed messages, and
- files, either as general files that are stored in the receiving terminals memory or files of known file formats, e.g. an image file that directly can be rendered on the receiving terminals display.

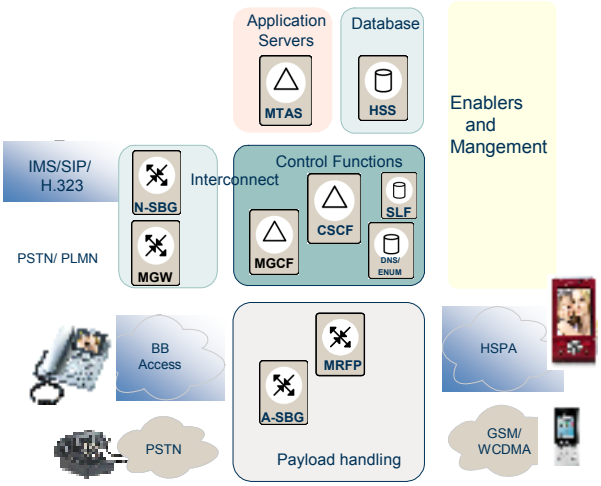

Figure 2. IMS Multimedia telephony functional architecture

When an MMTel subscriber registers the SIM/USIM/ISIM (Subscriber Identity Module/ Universal Subscriber Identity Module IP Multimedia Services Identity Module) or User name and Password can be used as authentication method. During the authentication process the I/S-CSCF (Interrogating/Serving-Call Session Control Function) will interact with the HSS (Home Subscriber Server) to get the credentials and an MTAS (Multimedia Application Server) will be dynamically allocated if the subscriber data shows a subscription of the MMTel service. The MTAS server will get the subscriber data from HSS.

When setting up an MMTel call P-CSCF/A-SBG (Proxy-CSCF, Access-Session Boarder Gateway) will authorize the Multi Access Edge to set-up bearer(s) for the service. The P-CSCF/SBG will be agnostic to whether it is a fixed or a 3GPP (3rd Generation Partnership Project) access type the call originated at. If the access is fixed a media proxy will open up with port mapping, and do NAPT (Network Address Port Translation) if needed.

Using the service identifier the I/S-CSCF can determine that session related signalling belongs to an MMTel call, and hence routes the call to the pre-selected MTAS. The MTAS executes the main part of the call control and supplementary services are invoked by the MTAS, if needed. If media manipulation is needed the MTAS sets up necessary resources in the MRFP (Media Resource Processor). MTAS can also use its northbound interface to link in special features via Value Added Services Application Servers (VASAS) for e.g. enterprise communication.

In the first IMS Multimedia telephony system interconnect between operators will be through N-SBGs and secure tunnels will be used. Interconnect between operators may also be provided via a broker operator (compared to a GRX (GPRS Roaming Exchange) operator in GPRS). The N-SBGs will generate data for accounting; enforce policies; map between Ipv4 and Ipv6 if needed; and do port mapping to hide internal architecture.

The IMS Multimedia telephony system will use DNS (Domain Name System), either with ENUM (E.164 Number Mapping) or URIs (Uniform Resource Identifier), to route calls. The DNS data will be local for each operator. To be able to route the call between operators, the N-SBGs (Network-SBG) will also use DNS for SIP URIs and E.164 numbers.

Inter-working with the circuit switched domain is required and an MMTel user will be reachable using the same number in both the IMS domain and in the circuit switched (CS) domain. This is achieved by service domain selection functionality in the MTAS. An MMTel user can also communicate with CS users via the inter-working functions MGCF/MGw (Media Gateway Controller Function/Media Gateway). The inter-working is achieved by reusing the soft switch solutions MSS and TSS as gateway. Later IMS Multimedia telephony releases will also provide service continuity when there is a dual radio terminal capable of e.g. parallel WLAN and 3GPP circuit switched or packet switched access.

The MMTel service can be used over any access providing IP connectivity. However, not all access types can handle the high bandwidth requirements of multimedia communication. As an effect, the IMS Multimedia telephony system will be able to provide "full MMTel communication capability" to:

- Wireline broadband users
- Mobile users using GSM EDGE evolution, WCDMA HSPA and LTE with different degree of optimizations of the air interface
- I-WLAN users (Interworking Wireless LAN)
- User with a relationship with IMS cable telephony

While "reduced MMTel communication capability" will be provided to

- Mobile users on 2G/2.5G systems such as GSM/EDGE where the "single media" CS service is used over the CS radio.
- Wireline POTS users when IMS Multimedia telephony is used as a narrowband access modernization (via e.g. MSAN (Multi Service Access Node) acting as an MMTel client)

VI. THREATS TO THE MIGRATION STORY TO IMS BASED ARCHITECTURE

IMS provides the possibility to deploy services over any access providing IP connectivity. This makes IMS Multimedia telephony a suitable telephony offering for operators' deploying new IP-only access technologies such as LTE (Long Term Evolution) or for operators only selling broadband subscriptions that have the ambition to move upwards in the value chain. However, established telco operators will have an installed base of legacy CS systems, both wire line and cellular systems. Due to the large investments made in the CS systems and the large customer base using the CS services, it is of great importance for the business success of IMS Multimedia telephony that vendors like Ericsson build on their installed base when introducing the MMTel service. Therefore, vendors must provide the telco operators with a story outlining a cost effective migration path from a CS core to an IMS based core and efficient IMS – CS inter-working solutions.

Despite the story of how to evolve from the CS service to the MMTel service, there are a number of threats that may lead the evolution of telephony in at least three other directions than MMTel.

1) CS telephony of today prevails. CS telephony may prevail by the introduction of tunnelling solutions such as UMA (Unlicensed Mobile Access) over IP accesses. Or by the fact that the telecommunication industry moves in the direction of introducing CS telephony over what first were considered IP-only access types such as LTE and WCDMA HSPA.

2) The so-called emulation services prevail also in an IMS environment. This means that telephony may become SIP/IP based over the transport network to reduce costs for transit. But the terminals still use legacy CS signalling and media methods over the access network. In this scenario it is evolved Mobile Soft-switch Solutions (MSS) and Telephony Soft-switch Solutions (TSS) that provide e.g. the 3GPP TS24.008 service set that will continue to be the dominating the service engines in the networks.

3) Peer-to-peer (internet) telephony may become the dominant communication method over wireless networks.

This could happen if the telco operators decide to harvest on their CS telephony and do not continue to develop their service offerings.

In the cases 1) and 2) above, a multimedia experience could be provided through combining the CS session with other sessions (IMS or non-IMS based). This would, however, impose limitations, reduced flexibility and an increased complexity hurdle for an application developer compared with a single all-IP MMTel control session, such as providing multi-party services, providing services that require media synchronization, inter-working with fixed IP clients, ensuring that all network sessions end up in the same device etc.

VI. STANDARDIZATION

The innovative force of standardization in mobile networks and the flexibility and power of the IMS standard, have for some time attracted the attention of fixed network operators. At the same time, in many countries, small new operators spring into existence, claiming a niche with a certain quick-to-start IP-based service offering. This is making fixed operators realize that they need to have a way to meet the competition. Contrary to small, niche-oriented operators, however, large, nation-wide operators cannot afford to build proprietary island solutions vertically integrated for offering a certain IP-based service to a tightly defined segment.

Rather, a platform must be taken into account which lends itself to nation-wide and internationally compatible services, scales up to levels expected of a public operator solution and promises economies of scale and compatible offerings from various suppliers. In other words, fixed-network operators need a fully standardized solution.

This is where ETSI TISPAN comes into the picture. In the short term TISPAN's work created an understanding of how IMS will shape the future of networks both fixed and mobile, and in the long term, by filling the need for standardization of IP-services which is felt by both mobile and fixed operators, TISPAN contributes to the total erasure of borders between fixed and mobile core networks.

TISPAN reference architecture

Figure 3 below, with a few simplifications, is taken from the ETSI TISPAN NGN standard specifications. It describes the functional architecture without going in to detail.

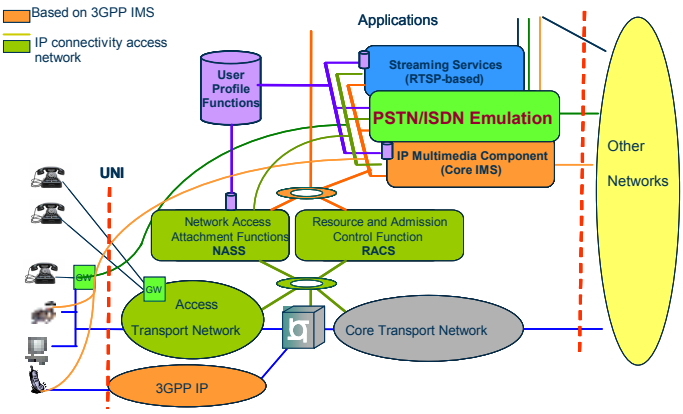

Figure 3. TISPAN reference network architecture

The "Core IMS" is a subset of the 3GPP IMS, which is restricted to the session control functionalities. Application Servers (AS) and transport/media related functions such as the Multimedia Resource Function Processors (MRFP) and the IMS Media Gateway function (IMS-MGW) are considered to be outside the "Core IMS". NASS (Network Attachment Subsystem) is providing the authentication and rights control, and RACS (Resource Admission Control Subsystem) provide the QoS assurance in the fixed access network.

The need to provide PSTN/ISDN-services in the reference architecture is addressed in two ways in the TISPAN standardization; PSTN/ISDN Emulation and PSTN/ISDN Simulation.

The official TISPAN PSTN/ISDN Emulation definition is: "Provides PSTN/ISDN service capabilities and interfaces using adaptation to IP infrastructure".

The official TISPAN PSTN/ISDN simulation definition is: "Provides PSTN/ISDN-like service capabilities using session control over IP interfaces and infrastructure

IMS based Telephony over IP service, defined by TISPAN, provides a similar, but not necessary identical, services as in PSTN/ISDN. It is a set of conversational services that includes voice but not limited to voice. This is often referred to as Multi-Media telephony (MMtel).

VII. CONCLUSION

The future multi-service convergent network will be characterized by rapidly changing traffic and business models. New services will be introduced at an increased pace, and they have to meet QoS-requirements and end-user expectations. The operator will face many challenges when transforming their current networks to a full service broadband network, such as technology availability/maturity, staff competence development, system integration, multi-vendor interoperability and last but not least how to secure current legacy investments and revenues.

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