Fixed-Mobile Convergence:

Understanding the Marriage of Wireless and Wireline Technologies

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1. EXECUTIVE SUMMARY

Fixed-Mobile Convergence (FMC) is a complex and multi-faceted topic. It is a technology trend impacting almost all communications and information industries. It promises great changes to the way we as customers consume communications services – anytime, anywhere, any device. It is comprised of four key components – service, terminal, network, and industry convergence – all of which are interrelated and critical to the success of the others.

Services in a Fixed-Mobile Convergence environment will deliver ubiquitous, personalized services across multiple domains. Fixed-Mobile Convergence, by its very nature, necessitates a new value chain, market structure and a different way of defining end-user subscriber value. Service providers must explore how to move beyond traditional boundaries and ensure all facets of a subscriber's service needs and experience are being met. Operators who do not embrace convergence and enable the delivery of third-party content could risk reducing the value of their network to that of a bit pipe.

Convergence is also focused on the need to decrease operating costs and to provide cost-effective migration to an all-IP network. From an operator's perspective, the network convergence goal is to migrate today's separate circuit and packet switch core networks to a unified core network that supports existing access technologies in both the fixed and mobile domains. This evolution will obviously take some time to complete, but will be key to an operator's ability to reduce OPEX in the long term and increase competitiveness and profitability. A key feature of this strategy is the use of common components and service specific extensions that reduce the cost of service development and implementation. This is best achieved using IMS as the service delivery engine within the unified core network. The result is a unified network that is optimized for: (1) the efficient delivery of services to users, (2) ease of interworking with business partners and other networks, and (3) effectively managing the operator's day-to-day operations.

Fixed-Mobile Convergence will require the introduction and integration of a variety of key technology enablers. These include:

- SIP.
- Voice over IP (VoIP).
- IP Multimedia Subsystem (IMS) (including VCC, ICS and network selection).
- Unlicensed Mobile Access (UMA).
- Fixed & Wireless Broadband.
- UMTS/HSPA.

As these technology enablers are deployed, the full benefit of FMC can be leveraged. Yet many of the technologies rely on standards to create the common framework required for ubiquitous interoperable deployments.

There is no single standardization body responsible for Fixed-Mobile Convergence or Next Generation Networks (NGN). Instead, there is a high level of co-operation between various standards bodies. One common theme amongst all these bodies is adoption of the 3rd Generation Partnership Project (3GPP)-defined IMS as a central part of the NGN architecture. A large cross-section of the operator and vendor communities are active participants in many standardization bodies including the main NGN standardization bodies like ETSI/TISPAN, 3GPP, IETF, ITU, ATIS and OMA.

Today's existing service providers have spent enormous sums of money over the past decade upgrading their networks to deliver new services and to support the added traffic associated with the growth in their subscriber bases. As service providers migrate toward an ever-converging environment, they need to carefully consider a phased strategy for evolving their networks that starts to address end-user requirements now and positions the operator for converged multimedia service-capable networks in the near future.

2. FIXED-MOBILE CONVERGENCE OVERVIEW

Fixed-Mobile Convergence (FMC) has traditionally been used by the telecom industry when discussing the physical integration of wireline and wireless technologies. Simply defining convergence as how wireless technology should integrate with wireline technology effectively misses the broader importance and implications of Fixed-Mobile Convergence, which is also about convergence between the media, datacom and telecommunication industries. The real questions are what do people really want from communications and media, and how can converged technologies, trends and drivers be leveraged to deliver on those needs? This paper will analyze this broader definition of Fixed-Mobile Convergence and offer an explanation of what convergence aims to achieve for end-users and a discussion of its drivers, enablers, primary challenges and obstacles, as well as provide insight on how operators plan to implement FMC.

The broader and most encompassing definition of Fixed-Mobile Convergence is that it has the potential to become a “mega-trend” – it involves many industries, many companies, and many technologies, and touches almost all end-users. This movement has been fueled by the pervasive use of IP protocol in all facets of the communications, media, entertainment, IT and consumer electronics industries. The use of IP has created a common foundation upon which many can envision seamless access to anything, anytime, anywhere with any device. Add to that ubiquitous and competitive broadband access, advanced wireless technologies, and other innovative access methods, and one sees that convergence is becoming a reality. It is now clear that both the industry and technology are able to provide a multitude of differentiated and integrated converged services using a multitude of converged devices over a multitude of converged networks. Fixed-Mobile Convergence is driven by end-user needs as well as the operational efficiencies created by network modernization, the unification of core networks and multiple access synergies.

Overall, Fixed-Mobile Convergence should be seamless to the end-user and it must involve personalization: my services delivered to my device using whatever access network is appropriate. Fixed-Mobile Convergence involves a unified core network and multi-radio terminals as well as other terminal devices such as PCs and a common multi-access aware service delivery platform. However, success or failure will be determined not by networking technology, but by user acceptance.

3. INDUSTRY LANDSCAPE AND OPERATOR SEGMENTATION

Converged services deliver ubiquitous, personalized services across multiple domains. By its very nature, FMC necessitates a new value chain, market structure and a different way of defining end-user subscriber value. Service providers must explore how to move beyond traditional boundaries and ensure all facets of a subscriber’s service needs and experience are being met. Moving across the value chain, we see that end-users will demand the same level of service in all areas, whether at home, at work, or on the road.

End-users will likely seek out a simplified provider interaction in order to attain a simplified source relationship with a single bill. The service providers will be at the center of the value chain and will be confronted with a changing business model. Service providers who can integrate into the value chain will “own” the subscriber by being the single point of control that provides all communication and entertainment needs, thereby reducing subscriber churn. The service layer will be critical in delivering voice and data requirements with the highest level of reliability and quality. The media layer will provide the content to fill the broadband pipe. Service providers will need to partner with content providers (such as TV networks, film and broadcasting studios), develop this content in-house or work with application developers to provide capabilities for end-users themselves to exchange media (e.g. through social networks). The successful service provider will offer end-user value in the following ways:

- Consolidation — All multimedia services become available via a single subscription — device and client. The end-user experiences reduced complexity and hassle when managing communications.
- Simplification — The overall service is simplified with a consistent look and feel, single address book and Web-based provisioning. The end-user finds the overall service more usable.
- Enrichment — The entire service set can be enriched with presence, personalization and network-based content.

For service providers, the ability to respond rapidly to marketplace demands and opportunities while controlling operational expenses will be critical to success and profitability. Deploying new blended, managed, differentiated value-added services quickly will strengthen customer loyalty and drive subscriber growth and service usage. With subscribers demanding delivery of consistent multimedia communications across various access technologies anytime and anywhere, service providers need a common service delivery environment that is both scalable and flexible to provide revenue-generating services. Major strides in global standards over the past few years have established a framework that will cause all existing service types, both fixed and mobile, to converge into a single network. Convergence into a single network will result in a new converged operator as well as new operator relationships that will allow operation of services across multiple domains.

Facilitating an environment in which voice, data, and media are harmonized and efficiently delivered across an all IP-based architecture, network convergence aims to transform the service provider business model from one focused on delivering connectivity to one that focuses on delivering services to generate increased revenues. It is important to note here that standardization is a critical component of industry convergence; otherwise, significant fragmentation will occur. Fragmentation to this extent would have rather negative impacts on the adoption and utility of convergence. Many different proprietary ways to bring convergence to the market by significant vendors would depress the now-emerging convergence marketplace.

The vision is promising and certainly worth pursuing, yet what matters in practicality is how to migrate from the current envirnonment to the target vision. The typical question is not whether to eventually aim for the vision, but what are the manageable stepping stones to this future, and also, what is the first stepping stone that can start us in this direction. As a first step, service providers may consider bundling and business integration before true technology convergence. There are multiple examples of ambitions and intent, offering integration in the short term and naturally leading to convergence in the medium or longer term. This all depends on the provider's ability to move, and desire to exploit the technology and work in partnership with its suppliers. A likely second step is more central to the operator's architecture – IP network convergence. This, in effect, is the unifying of service and network islands into an end-to-end IP network targeting cost efficiency and enabling new service delivery. Lastly, once networks are unified by IP, true service convergence becomes realistic and convergence reaches its full financial potential for operators.

In most markets, competition for telephony is intensifying, both for fixed and mobile network operators. New players such as cable TV companies and dedicated VoIP application vendors are also entering the telephony segment. As a result of this increased competition, traditional operating boundaries are fading as most network operators and other players in the market start to address areas outside their traditional offering in order to grow their business or replace ARPU from the commoditization of existing services or the encroachment of converged operators. These new offerings are created by combining previously disparate offerings.

It is not possible to specify a single path forward for each operator category, as each operator must take into consideration much more than just the current business operation when defining its strategy. However, it is obvious that convergence will be an important aspect for all operator categories.

3.1 Mobile Only

The wireless industry experienced significant growth over the past several years and many markets are reaching a point of saturation for voice-centric revenues. As growth rates slow, operators are becoming more aggressive in their efforts to find subscribers, and this has led to a price war atmosphere. The end result is a slight decline in monthly average revenue per user (ARPU), as well as an increased likelihood that their subscribers will abandon the current provider for the next wireless provider that offers a sweeter deal -- thus the wireless operator's need to aggressively seek new ways to generate revenue and maintain their existing subscriber bases. The first step in that direction has been the deployment of high-speed wireless networks that will support data services; however, operators are finding that the real challenge is to find compelling applications that will drive usage on these new networks, then find a way to differentiate them in a crowded market.

Mobile-only network operators are striving to offer mobile customers more advanced services to provide a competitive alternative to fixed network services, and increase market share in that way. In the U.S., this is about increasing Fixed-Mobile substitution and defending market share. Others focus on offering convergent services to the enterprise segment, including mobility. Mobile operators will also explore adding combinational services atop baseline voice such as PoC, see-what-I-see, location-based gaming and the like.

3.2 Fixed Only

Wireline operators are facing a difficult challenge as they have watched their traditional voice subscriber base slowly erode over the past few years. Two factors have led to the substitution of alternative services for wireline services. The first is the dramatic decrease in prices for wireless voice services leading to subscribers to choose their wireless device over their wireline device for many or all of their calls. The second is the availability of broadband internet access supporting alternative technologies, such as VoIP, which again provides a lower cost option than traditional wireline service. Many non-traditional providers such as cable operators and VoIP start-ups are now providing VoIP-based services that are drawing customers away from wireline providers. The result is a marked decrease in revenue for the wireline provider leading to the need for them to take aggressive steps to protect the existing subscribers that they have and seek replacement of lost revenues. These other networks have more flexibility in adding services (e.g. SMS, MMS) to existing terminals where as traditional analog POTS Fixed networks do not have this flexibility. As such, fixed operators have endevoured to upgrade users to "triple play" bundles (voice, video, data), and have lowered DSL prices to counter the threat from faster cable broadband access.

For many operators, fixed services are regulated, whereas wireless and VoIP are not, allowing wireless/VoIP service providers to changes prices quickly to gain and keep subscribers. In contrast, regulated Telco’s must apply to regulatory bodies for price increase and decreases, and often struggle to have their own VoIP offering classified as unregulated. The unbundling of the loop in many countries is also leading to churn away from the incumbent to start-ups that offer unregulated services.

Fixed-only network operators are searching for ways to add managed and value-added VoIP solutions including mobility to their broadband networks, by becoming Mobile Virtual Network Operators (MVNOs) or exploring mobile license opportunities, to create bundled and integrated offers targeting enterprises, small businesses and consumers alike. They are building wireless access (WLAN) through hot spots using unlicensed spectrum. Fixed broadband operators are also installing fiber to the home and neighborhood as well as offering "triple play" (telephony, Internet and TV) services to utilize their bandwidth advantage. Furthermore, fixed broadband operators sell carrier capacity to other operators.

Many fixed operators are studying long-term convergence opportunities that leverage their long-term relationship with their customer base by utilizing new converged network technologies. These factors indicate the need for a long-range strategy and investment decisions that will reshape not only operators’ networks, but also their future success. It is hard to overstate the importance of making the right decisions. The ability to create and implement new services in very short times — to offer the market a comprehensive portfolio and to introduce new services in line with market requirements is the key to success. Without convergence, operators will not be able to match the needs of a communications-centric economy.

3.3 Mobile-Fixed Hybrid

Combined mobile and fixed network operators utilize their combined customer base through bundles and value-added offerings. They can streamline and align forward service delivery by both basing next-generation services integration and development on a common standardized framework like IMS, as opposed to using or evolving proprietary embryos from the Internet bubble. They can, of course, also target the same areas as fixed-only and mobile-only operators in some cases with greater ease and efficiency due to owned/shared assets. On the other hand, some operators have found it difficult to leverage the mobile/fixed synergies due to the traditional internal separation of business management and network assets. Quite often, regulation of the fixed entity has kept the fixed business seperated to ensure clear accounting of regulated revenues/costs and to maximumize flow of unregulated cash flows. It is a challenge for regulated operators to fully combine services which may fall into a regulated unbundled category. Regulatory reform may be required in future to address these issues.

3.4 Cable

Cable TV network operators have been effectively competing in the broadband and telephony segments now for years. With increasing competition from satellite and emerging IPTV offerings, they too need a means to keep churn down. It is anticipated that Cable operators will address mobility in a fashion similar to fixed-only network operators by exploring xVNO opportunities as well as convergence functionality to enhance their existing products. In the US, cable operators have also purchased spectrum with the intent of deploying mobile networks of their own. They have traditionally tended to focus on entertainment services where they have strong partner relationships. Therefore, as mobility becomes a given and convergent entertainment applications become a reality, they are clearly expected to play a role. While this role is not entirely clear, they do have the ability to partner amongst themselves given non-overlapping properties and will most certainly pursue convergent products first tying their existing portfolio even tighter and then taking it mobile. One potential advantage afforded to Cable operators that deploy in-region mobility networks is the ability to leverage the existing cable broadband infrastructure to provide low cost backhaul from mobility basestations that may be deployed within the cable serving area.

3.5 ISP / Internet

VoIP application providers are clearly an emergent segment in the marketspace of communications. Companies such as Vonage and Skype have attracted great attention, not to mention numbers of customers, by providing very low-cost voice. This business will continue to flourish as long as there is a wide price disparity between VoIP minutes through the Internet and dedicated networks. They are in effect exploiting the rapid growth of broadband IP data access and can be expected to drive the emergence of Voice-over-WiFi and Voice-over-WiMax dedicated telephony. QoS is always a concern here, as is E911 and emergency services, but their impact on the market is being felt. It does not take much to envision much of their portfolio of applications becoming converged with other wired Internet applications as well as mobility.

3.6 xVNOs

xVNOs are a broad category of service providers who do not own fixed or wireline facilities but instead become providers of service through leased capacity from licensed carriers. With the fragmentation and maturation of the mobile market, there are increasing opportunities for these virtual operators to differentiate. These operators pursue this business based on some value they believe gives them a unique proposition in the market (brand, distribution, etc.) or by customizing the service experience thereby delivering unique value the traditional operator does not provide. xVNOs can be fixed, cable or mobile-only carriers purchasing the service they are missing (e.g. Qwest's relationship with Sprint) or they can be entirely virtual service providers. There are several models that xVNOs can use to bring services to market – while most of these xVNOs are not yet pursuing convergent services several of the models contemplate the offering. The simplest model, the one that many on Sprint's xVNO network follow, is basically taking whatever technology the carrier provides and customizing just the customer experience and operational systems. In this model, the service provider is not differentiating at all with respect to the actual service, but is instead customizing based on service delivery and care. There are then models that contemplate the xVNO service provider actually deploying a complete core network to enable next-generation converged service such as IMS, UMA and the like. Other than those two ends of the spectrum, there are many different options depending on the extent of service customization the host carrier allows and the xVNO would like. One example is what Virgin Mobile USA has done with Openwave on Sprint's network to create a unique data experience unlike Sprint's core offering. The way the market currently sits, there are opportunities for xVNOs to play in the convergence game, but they will rely on the emerging models that tend to be closer to owning or renting the core network elements.

3.7 Content Providers

Content providers provide value-added services to the end-users. The content providers can provide the targeted content/service towards an end-user segment with a simple website or collection of content/services targeting multiple end-user segments via a portal. In the wireline world, the content providers have established a strong position where the network operators are mostly limited to being the bit-pipe providers.

End-users are associating more with the content and the value-added services. As a result, both wireline and mobile operators are trying to move up the value chain to increase ARPU and manage the end-user experience. Some of the content providers are working closely with the wireline and mobile operators to offer end-user services in a revenue share fashion. On the other hand, multitudes of content providers want to have more access to the end-users and the revenue. The content providers want to make sure that mobile operators do not limit the end-user access or reduce the end-user experience to their content. The mobile operators or wireline operators want to offer differentiated experience for the end-users subscribing to the content offered by the operators and their partners.

Some of the mobile operators have implemented “Walled Gardens” where the end-user is restricted to the content from the operator and their partners. On the other hand, some operators have conceded their position to be the bit-pipe provider and provide open access to all the content providers.

4. MOTIVATION AND DRIVERS FOR FIXED-MOBILE CONVERGENCE

4.1 Operator Drivers

Overall, so-called “traditional” telephony revenues and margins are in decline because of outdated regulation, competition and revolutionary technology shifts. Technology allows new players to penetrate the traditional voice service business. The market perception of inexpensive phone calls is fueled by the hype surrounding Internet telephony, but broadband access is enabling not only low-cost IP telephony, but also a wide range of new applications such as video telephony and video-on-demand. The traditional telco model is therefore being disrupted. New ISPs and entrepreneurs, who are agile and can see a profitable niche, are entering the market.

The business model is changing. Bandwidth has become more of a commodity, and this has led to the concept of xVNOs. These are virtual network operators that can be fixed (FVNO) or mobile (MVNO). And, apart from regulatory constraints, there is nothing to stop alliances that would allow a mobile operator, for example, from becoming a FVNO that offers DSL services.

The convergence spotlight is on voice and multimedia services and rightly so, given the number of users. However, the market for business services and applications generates high-margin traffic, has far less churn, and it is set for take-off. Even more significant is the fact that most enterprises and many Small Medium Enterprises (SMEs) have converged local area networks and IP PBXs that they have deployed in order to gain the cost and productivity benefits of IP telephony. This means that the business sector will compete with their network operator and push operators to implement very cost-effective, hosted voice services such as IP Centrex.

Operators who do not embrace convergence and enable the delivery of third-party content could risk reducing the value of their network to that of a bit pipe. New services and applications will become the norm. The technologies are in place and there is broad agreement about the need for standards-based service delivery platforms that deliver end-to-end solutions. Thus, no more communication island solutions, no more service silos. Instead, operators can create a dynamic service environment with the ability to introduce new customized services, quickly and economically.

Convergence is needed to enable the new personalized model, but is also focused on the need to minimize operating costs and to provide cost-effective migration to an all-IP network. From an operator’s perspective, the network convergence goal is to migrate today’s separate circuit and packet switch core networks to a unified core network that supports existing access technologies in both the fixed and mobile domains. This evolution will obviously take some time to complete, but will be key to an operator’s ability to reduce OPEX in the long term and increase competitiveness and profitability.

Operators need a strategy that defines their business objectives and solutions that map the various short-, medium-, and long-term goals. In other words, convergence needs to evolve along a well-defined migration roadmap. There are a number of milestones. The solution must support the introduction of IP-centric multimedia services that can be delivered to a variety of terminals. Delivery must be cost-effective and employ complementary access technologies. It must also bring operating costs down and allow traditional services and applications to be retained.

The first step in the evolution path is to optimize the circuit-switched core network in order to improve the delivery of regular voice services. The second is to enhance the packet core network in order to enable the ability to rapidly deploy new value-added IP multimedia services in the most cost-effective manner. A key feature of this strategy is the use of common components and service specific extensions that reduce the cost of service development and implementation. This is best achieved using IMS as the service delivery engine within the unified core network. The result is a unified network that is optimized for: (1) the efficient delivery of services to users, (2) ease of interworking with business partners and other networks, and (3) effectively managing the operator's day-to-day operations.

Voice services are still predominantly provided by circuit-switched technology in both the fixed and mobile domains, although the introduction of VoIP services is gaining ground in the fixed operator domain and is well established as an Internet service. The evolution of the mobile circuit-switched network as standardized by 3GPP allows control and user planes to be separated into MSC Server and Media Gateway functions. Media Gateways provide interworking between the IP core network and the PSTN / PLMN.

Media Gateways and the MSC Server System help drive voice penetration and usage and enable a new core network structure -- one that brings significant savings in both OPEX and CAPEX, thereby cutting the production cost of each voice minute. This is partly achieved by the use of IP as a transmission medium between multimedia gateways, reducing transmission network bandwidth requirements, and eliminating the need for transit switches based on TDM.

4.2 End-User Drivers

As users many times perceive some degree of imperfection in any service offering, these perceptions create expectations for improved services; more customized, blended, and user-aware services, each offering the user a simpler, but flexible service experience. Meeting these expectations will require convergence at many levels.

4.2.1 Desire for Customization

Historically, communications services have been configured for a subscriber and provided to device(s), which many times was shared amongst different users. Thus, services on such devices were not user-customizable. As devices have become more sophisticated, they now may have the ability to support multiple user profiles, much like a computer. If the device is only expected to be used by one person, then this device could be permanently configured for that user. If a user is participating as part of a group, such as a family, a business, or a social club, these users may want a set of features, configured for group communications. Beyond this, users need their services customized to their own preferences, a process called personalization.

4.2.2 Desire for Blending

Users are drawn toward services which offer them more convenience and effectiveness, and such services can be created as a seamless interworking of different services. Examples of such may allow services on a fixed terminal to interact with services on mobile terminal to program a PVR from a mobile phone, view a program guide from a mobile phone, or receive an incoming mobile call on a TV.

4.2.3 Desire for User-awareness

With traditional communications behaviors, users have become frustrated when dialing through a list of numbers before they reach their desired party. When that party's device is reached, they do not like to then learn that the desired party is busy or unavailable. The initiating user should be able to see the desired party's availability via the device(s) on which he or she is present before taking action, in order to make a more effective communications decision.

Presence is a key component for many converged services and allows a user to see recipient information before connecting (e.g. availability, geographical position). Presence also enables the user to see possible communication alternatives based on device and network capabilities, including the availability of video and voice capabilities for a particular user, based on where they are, what device they have, and what they are currently doing.

4.2.4 Desire for Flexibility

The market demand for convergent services will depend upon the flexibility of the device used, the ease of switching between devices, the cost benefit of using a particular device, and having a device best suited to the circumstance.

Flexibility of Device Selection
For any type of communication, at a given time and place, users would like the ability to configure & operate their services using the best of multiple available devices, not just one device.

Flexibility of Operating Location
The increased mobility of users has increased their desire to communicate in the most convenient way at the most convenient time, regardless of their location. The ability to access and use services anytime, anywhere, whether moving or stationary, is at the heart of what users are now expecting from communications.

Flexibility of Pricing
Many users are attracted to services which can be bundled and billed together, creating cost savings while simplifying bill interpretation. Also, users may find it to be more cost-effective to use particular devices in particular places, possibly at particular times; thus, real-time charging should be made known to users, so they can make better real-time decisions.

4.2.5 Desire for Simplicity

Users will find services more usable, cohesive, and compelling if the overall service is simplified by having such things as a consistent look and feel, simplified single address book, Web-based provisioning, and a single address per person.

Single Address per Person
Traditionally, many services have been associated with one device, to which has been assigned an address. As users have become more mobile, they have had to make use of multiple devices, forcing them to distribute multiple addresses to maintain a degree of reachability. Utilizing network intelligence and presence, as discussed above, will greatly simplify the user's task of making a successful communication on the first attempt.

Consistent User Interfaces
End-users are looking for a consistent experience across whatever network or technology their communications event is taking place. One way that this manifests itself is in the user interface. It is simply not acceptable for the interface to change for most services as the user moves from network to network. The same basics of the experience should remain with additional features being available as the user moves from a portable device to a more fixed device.

Consolidated Service Administration
Users enter more information into more devices than ever before, and they would like only to enter any given piece of user data once. Providers should take responsibility for ensuring that the user data is replicated and synchronized as required across network elements and other devices. They should eliminate the need for the user to personalize their service on each device. A single portal could enable users to personalize their services for all of their devices.

5. ENABLING TECHNOLOGIES

5.1 SIP

In the end, all aspects of communications will use the common framework of IP and the associated application layer protocols in order to enable applications and services that are completely compatible across all communication networks/devices. Common IP-based networks and applications enable a multitude of common functions and reduce the costs of development, integration and operations. Not only does this ultimately reduce costs for operators, but it also creates a standard and stable platform that is well understood, allowing innovation to go into the services area, as opposed to proprietary network and service technologies. SIP is a critically important application layer protocol for communication networks and services.

The Session Initiation Protocol (SIP) was originally defined by IETF and then adopted for mobile networks by 3GPP and 3GPP2. SIP is a peer-to-peer signaling protocol; it initiates, terminates, and modifies sessions. A session can be a two-way voice communication, a multimedia (text, audio, or video) conference collaboration, instant messaging, application sharing, or one of many other contemplated services. SIP does not provide a full vertical solution, but relies rather on other protocols for transport, QoS or accounting.

Once developed on an application server, the call forwarding service can be easily ported over different terminals, access and L2 technologies. One important point to note is the fact that SIP is independent of the actual capabilities of the terminal. For example, one particular implementation of the SIP Proxy, the Back-to-Back User Agent, allows two terminals without the same level of SIP capabilities to establish a session together, with the Back-to-Back User Agent emulating the "dumb" terminal for the unsupported capabilities.

IMS supports SIP clients (3GPP and IETF) and can be connected to any compliant device: mobile terminals, wireline PCs or WLAN devices. SIP and IMS enable the creation of converged, unified communication domains using any fixed or mobile packet access network. SIP can also reside as a client on an access node such as a DSLAM or on a terminal device such as an IMS Residential Gateway (i.e., an adaptor between terminals and IMS).

SIP-based session management and the IMS enable the applications in SIP devices to establish peer-to-peer (P2P) connections over any IP network. P2P connectivity is new for telephony but something we take for granted in the Internet. This development allows services with a relativity low penetration to stay profitable. Operators wishing to generate new revenue streams by introducing IP multimedia services need the IMS functionality to enable optimized mobility, centralized control, roaming, cost-efficient service delivery and interworking between operators.

Embedding SIP in various terminals allows users to select the device best suited for a particular task. A key feature is the use of a single number. These devices will connect to the converged core via the complementary access networks, i.e. the mix of xDSL connections, WLAN hotspots and cellular access. This represents a significant challenge involving issues such as access awareness, session continuity and service capability across different networks (e.g. service hand up and hand down across 2.5G and 3G networks).

5.2 Voice over IP (VoIP)

VoIP technology enables service providers to support voice services on an IP network as opposed to the traditional method of sending voice over a circuit-based network. From an end-user perspective, there is little difference in the actual service; however, from a service provider perspective, there is a significant reduction in the cost required to deliver the service on the core transport side. This lowers the entry barrier for new providers and drives down the cost of voice services to the end-user. This technology also enables a whole new set of features associated with the voice services that can be provided at very low cost such as call control portals, contact list management tools, and innovative conferencing tools to name a few. VoIP has recently seen significant adoption in wired enterprise applications. As enterprises realize the cost efficiencies inherent in VoIP and replace legacy infrastructure with IP-based infrastructure, they will inherently look to mobilize and converge that experience. Taking VoIP mobile in the enterprise with in-building Wi-Fi and embedded VoIP clients on mobile handsets (e.g. Avaya and Cisco VoIP clients) will create a disruption for operators – one parallel to, but less controlled than, UMA.

5.3 IP Multimedia Subsystem (IMS)

IMS is a key component of multi-service layered architecture. IMS is a subsystem supporting multimedia sessions, standardized by 3GPP and using the SIP from IETF. IMS is a common foundation for fixed, mobile, and enterprise services, delivering services over multiple accesses such as UMTS/HSPA, GSM, CDMA2000, fixed broadband and WLAN. Thus, IMS is a cornerstone in a converged solution.

IMS plays a crucial role in convergence, and with the use of SIP, allows the introduction of IP services, including Voice over IP (VoIP), video sharing and other multimedia services. It can also provide the same supplementary services for VoIP calls as we have today for circuit-switched calls, by connection to a telephony application server (TAS) or functionality from an IP PBX or IP Centrex. For fixed operators, the IMS solution compares very favorably against the replacement of fixed switches with a soft switch that may only replicate existing services.

IMS is designed to provide a number of key functionalities required to enable new IP services via fixed or mobile networks. This new realm of IP services must take into account the complexity of multimedia, the constraints of the underlying network, managing mobility, and managing the multitude of emerging applications. Although 3GPP IMS was initially focusing on mobile networks, it has now become the common IMS development SDO for fixed networks as well (e.g., CableLab, TISPAN, ATIS, 3GPP2). As such, IMS can also be used to provide services for the fixed or mobile network at the same time, providing a unique mixture of services with transparency to the end-user.

3GPP IMS is in prime position as the common standardized control and service enabling core network that can and should apply for all IP-communications services and all access networks everywhere (i.e. for both GSM-UMTS/HSPA MNOs, CDMA-2000-EVDO MNOs, DSL ILECs, DSL CLECs, Packet-Cable MSOs, enterprise's IP-PBX, etc). The reference control layer should be standardized on IMS and all involved in convergence should strive to standardize as much of the solution as possible allowing differentiation to occur in the application suite. A competitive world's aim is to differentiate, and it is the task of independent operators and vendors to exploit a standard IMS platform to reach user services differentiation with convergence of the core network, but differentiation of (converged) devices and (converged) services.

5.4 Unlicensed Mobile Access (UMA)

Unlicensed Mobile Access (UMA) was initially developed by an industry group consisting mainly of operators searching for new ways to expand and improve mobile access consistent with the stated advantages of Converged service offerings in leveraging wired/WLAN access in-building to save cost and reduce churn. The initial activity was centered on North American wireless operators eager for a cost-effective solution for serving residential areas. There was a great desire in this early work to develop a solution that would be cost-effective and would not have to rely on waiting for a full QoS-based VoIP solution to be widely available throughout the industry. The solution was to "tunnel" GSM voice over a broadband connection using either Bluetooth or Wi-Fi as the access interface. UMA is now part of the 3GPP standardization efforts.

The objective of UMA is to provide a solution to promote seamless service continuation for a positive end-user experience. UMA is effective in enabling operators to take the first steps towards using IP connectivity in a mobile terminal.

5.5 Fixed & Wireless Broadband

Great strides have been in the last decade in support of the deployment of both fixed and wireless broadband networks. To the extent that these broadband access networks all leverage IP technology, a wide variety of applications and services can be offered agnostic to the specifics of the access network, supporting Fixed-Mobile Convergence.

Wireline broadband networks typically utilize either DSL, PON or Cable based technologies. DSL is commonly deployed over existing copper loops in place to support wireline POTS service. DSL technologies such as ADSL2+ and VDSL can provide from 8mb/s to over 30mb/s for loop lengths less than 2.5km (shorter loops are required to support the higher data rates within the range).

PON technologies such as BPON and GPON extend fiber all the way out to the customer premises while using passive optical splitters to achieve cost-effective coverage to multiple subscribers in an area. These technologies are commonly used for new wired access network buildouts and can achieve from 622mb/s to >1Gb/s downstream and 155mb/s or greater upstream shared across a small set of subscribers (typically 32 or less).

Cable networks leverage a Hybrid Fiber Coax (HFC) access infrastructure that supports a high bandwidth analog/digital broadcast conduit to the premises. Two-way IP data traffic is supported using a DOCSIS based overlay that can support 40mb/s downstream and 10-30mb/s upstream (DOCSIS 1.0 - 2.0) shared across an engineerable set of subscribers. Even higher data rates are possible with DOCSIS 3.0.

In the wireless domain, standards work is proceeding to create a set of advanced OFDM-based wireless technologies such as LTE (3GPP), WiMax (WiMax Forum) and UMB (3GPP2). These new wireless access technologies are data-only consistent with the general industry movement to fixed and mobile converged services, and leverage OFDMA methods over the air to achieve improved performance and spectral efficiencies in both the downstream and upstream directions. These technologies enable downlink spectral efficiencies of approximately 1 b/s/Hz and uplink spectral efficiencies of greater than 0.4 b/s/Hz under typical configuration and usage situations (greater efficiencies can be obtained through various optimizations).

5.6 UMTS/HSPA

From the user's perspective, network convergence is very simple. It is the development that is set to deliver a unified and integrated voice and multimedia service experience. Network convergence dissolves the barriers that currently separate today's network islands, and both the access and core sides of the network are playing a key role in making this happen.

The traditional public wireless access network -- with the deployment of GPRS and EDGE, followed by UMTS, HSPA and beyond -- brings varying levels of capabilities and throughput. As the evolution proceeds, this allows new services to be delivered to mobile subscribers. Generally speaking, the higher the speeds and throughput, the better suited the network will be to deliver the real-time converged multimedia services that will drive new revenues in the network. Being able to combine voice, data, and video sessions simultaneously over the access network will also contribute to convergence of services.

UMTS Rel'5 provides wireless operators and consumers with the improvements they need for offering higher speed wireless data services with vastly improved spectral efficiencies through the HSDPA (High Speed Downlink Packet Access) feature. In addition to HSDPA, UMTS Rel'5 introduces IMS architecture that promises to greatly enhance the end-user experience for integrated multimedia applications and offer mobile operators an efficient means for offering such services.

6. STANDARDIZATION WORK

There is no single standardization body responsible for Fixed-Mobile Convergence or Next Generation Networks (NGN). Instead, there is a high level of co-operation between various standards bodies. One common theme amongst all these bodies is adoption of the 3rd Generation Partnership Project (3GPP)-defined IMS as a central part of the NGN architecture. While some standards are finalized, such as 3GPP Release 7, these only contribute to part of the overall NGN architecture. Therefore, much of the standardization work can be considered as work in progress. A large cross section of the operator and vendor communities are active participants in many standardization bodies including the main NGN standardization bodies like ETSI/TISPAN, 3GPP, IETF, ITU, ATIS and OMA.

In addition to those standardization bodies listed below, standardization bodies in America, China, Japan and Korea also have focus groups on NGN. Also, cable operators are working on NGN in CableLabs. Today's industry FMC solutions are based mostly on the 3GPP IMS specifications and ETSI/TISPAN NGN specifications. Furthermore, 3GPP will develop the "common IMS specification" which will take into account the IMS requirements from other SDOs (e.g., TISPAN, Cablelabs, 3GPP2) as much as possible. Some solutions go further and take other specifications into account, such as OMA PoC or messaging.

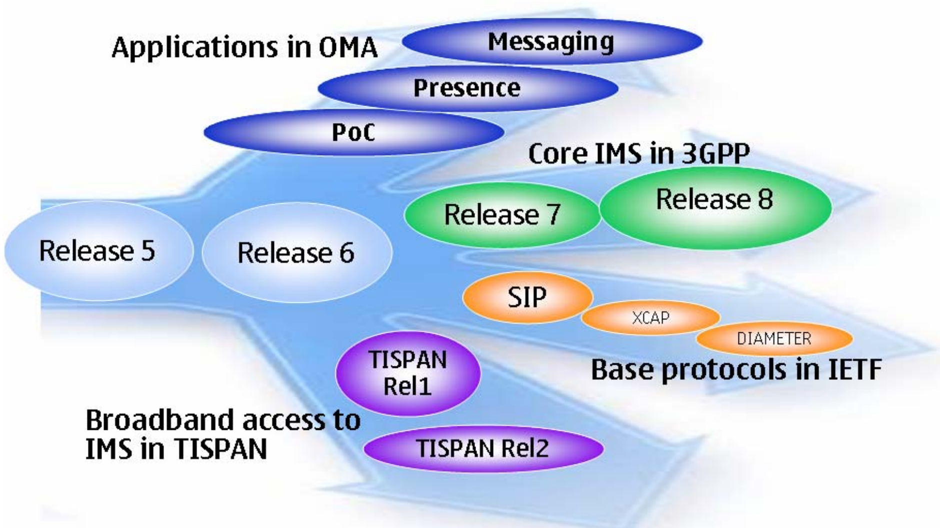

Figure 1: Standardization work split

6.1 3rd Generation Partnership Project (3GPP)

3GPP is a collaboration agreement bringing together a number of telecommunications standards bodies (ARIB - Japan, CCSA - China, ETSI - Europe, ATIS - America, TTA - Korea, and TTC - Japan) to prepare specifications for a 3rd Generation Mobile System based on evolved GSM core networks and the radio access technologies that they support (i.e., Universal Terrestrial Radio Access (UTRA) both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes), plus General Packet Radio Service (GPRS) and Enhanced Data rates for GSM Evolution (EDGE).

In September of 2006, 3GPP held a workshop to discuss with other SDO's how to enable the 3GPP IMS to be utilized as a common platform for IMS. The result of the workshop was to create a study group to explore and create recommendations to 3GPP for feasibility of such a concept.

Currently, the recommendations from the study group are being discussed in 3GPP, and thehy have agreed on the following definitions for "common IMS specifications":

- All parallel TSs and work items will be transferred to 3GPP.
- All TISPAN TSs and work items in Common IMS areas will be transferred to 3GPP.
- Any work in Common IMS areas will be done only in 3GPP.
- Other IMS work outside Common IMS may exist outside 3GPP.

There will also be a subworking group to collect common IMS requirements. It has not been decided whether this will be a new group or an existing group. The recommendations from the study group will enable better coordinated FMC standards to be developed due to TISPAN, Cablelabs, ATIS and other SDO's sending feature requirements which will be studied and combined for inclusion in the core 3GPP-based IMS from Release 8.

The 3GPP releases are:

- Release 99 – The first UMTS standard release introduces WCDMA radio technology that allows high data rates up to 2Mbit/s.
- Release 4 – MSC evolves to MSC Server and Media Gateway, enabling the separation of user plane and control plane.
- Release 5 – Introduction of IMS, Phase 1, plus the introduction of HSDPA for enhanced data rates.
- Release 6 – IMS Phase 2. IMS Messaging, IMS Group Management, Additional SIP capabilities, Interworking between IMS and Circuit Switched networks, Interworking with non IMS SIP networks, Presence, QoS improvements, etc.
- Release 7 – TISPAN Release 1 specific requirements are incorporated to the 3GPP IMS specifications, such as Fixed broadband connection to the IMS (Next Generation Networks). Other main NGN related work items are Voice Call Continuity between CS and WLAN, Supplementary services in SIP, SMS over any IP access network, IMS emergency sessions, Combining CS calls and IMS sessions, Evolution of Policy control and charging (PCC). The 3GPP release 7 is expected to be finalized during 2007.
- Release 8 – features under study include: TISPAN Release 2, Interworking with CableLab requirements, Interworking for Messaging Services, IMS Centralized Services, Service Brokering, VCC support for IMS Emergency Calls, Multi-Media Session Continuity, and IMS using Multicast Bearers.

6.2 ETSI – TISPAN

ETSI's work on NGN is being managed by its Technical Committee TISPAN (Telecommunication and Internet Converged Services and Protocols for Advanced Networking).

TISPAN focuses on fixed network evolution and works closely with 3GPP (ETSI is an Organizational Partner of 3GPP) on Fixed-Mobile Convergence, using the 3GPP defined IMS as the core network platform for service delivery. Other FMC issues being explored jointly by TISPAN/3GPP include: security mechanisms through the use of the SIM card for authentication, Network Address Translation (NAT) and firewall implications, IP address assignment and IPv4 & IPv6 support, security issues, charging, audio and video codecs, bearer QoS classes, service capabilities and the SIP profile. The TISPAN NGN will re-use IMS enablers such as Presence, Messaging and Groups Management and Conferencing. The concepts of WLAN/3G interworking have also been adopted as the basis for a generic IP access network to achieve true access technology independence in NGN. Other issues being addressed include Regulatory services, Location Information, IMS support for fixed line IDs as well as 3GPP IMS user identifiers.

TISPAN Release 1 (2005) reuses the 3GPP IMS as the basis for real time conversational services, Release 1 is based on 3GPP release 6 and release independent specifications of 3GPP Release 7. Broadband ADSL access technology is a prime focus, with WLAN connections possibly included. Main Release 1 content is:

- IP multimedia services with focus on real time conversational services such as voice and video telephony.
- Generic fixed access (xDSL).
- Supplementary services (SS) with IMS Application Servers (AS) or PSTN/ISDN emulation subsystem (PES).

TISPAN Release 2 (2007) Optimizes access resources usage according to user subscription profile and service use, plus corporate users' specific requirements. Also, IPTV is a focus.

With the TISPAN-mandated emphasis on fixed networks, TISPAN have defined a number of subsystems to complement the IMS, including a Resource and Admission Control subsystem, a Network Attachment subsystem, and a PSTN/ISDN emulation subsystem. PSTN/ISDN Emulation provides PSTN/ISDN service capabilities using session control over IP interfaces and infrastructure. It replicates a PSTN/ISDN network from the point of view of legacy terminals (such as analog telephones) by an IP network through a gateway. All PSTN/ISDN services remain available and identical such that end-users are unaware that they are not connected to a TDM-based PSTN/ISDN. This contrasts with PSTN/ISDN Simulation, which provides PSTN/ISDN service capabilities and interfaces using adaptation to an IP infrastructure. PSTN/ISDN Simulation provides services similar to PSTN/ISDN services to advanced terminals (such as IP phones) or IP interfaces. There is no strict requirement to make all PSTN/ISDN services available or identical, although end-users expect to have access to the most popular services. ETSI TISPAN also provides input to the ITU-T NGN Focus Group and works closely with other standards organizations (including ATIS) to ensure harmonization of the NGN initiatives between Europe and North America.

6.3 Alliance for Telecommunications Industry Solutions (ATIS)

ATIS is a United States-based body that is committed to rapidly developing and promoting technical and operations standards for the communications and related information technologies industry worldwide.

It published a North American framework of requirements for NGN, which has been submitted to the ITU-T as part of an effort to develop a global definition and set of standards for NGN.

6.4 American National Standards Institute (ANSI)

T1.679 from ANSI covers interworking between ANSI ISUP and SIP.

6.5 CableLabs

CableLabs is a standardization forum which specifies NGN for cable access and standards for the cable industry.

6.6 Internet Engineering Task Force (IETF)

IETF is the standardization body which defines the Internet protocols such as IP, TCP, email, routing, IPsec, HTTP, FTP, SSH, LDAP, SIP, MobileIP, PPP, RADIUS, Kerberos, secure email, streaming video & audio. IMS is based on SIP.

6.7 Open Mobile Alliance (OMA)

OMA facilitates global user adoption of mobile data services such as Push-to-Talk and Instant Messaging, ensuring service interoperability across devices, geographies, service providers, operators and networks. They work closely with 3GPP, in particular over the use of IMS based services.

6.8 The Parlay Group

The Parlay Group is a multi-vendor consortium formed to develop open, technology-independent application programming interfaces (APIs) that enable the development of applications that operate across multiple, networking-platform environments, primarily the IMS. Parlay integrates intelligent network (IN) services with IT applications via a secure, measured, and billable interface.

6.9 International Telecommunications Union (ITU-T)

The ITU-T NGN Focus Group was created in May 2004 to create global standards for NGN, adopting the 3GPP IMS architecture. Q.1912.SIP covers interworking between ITU-T ISUP/BICC and SIP, with H.248 for media control.

6.10 Open IPTV Forum

AT&T Inc., Ericsson, France Telecom, Panasonic, Philips, Samsung, Nokia Siemens Networks, Sony and Telecom Italia announced Open IPTV Forum to define an interoperable end-to-end specification for the delivery of IPTV services. This forum is in its infancy stage and at the time of publication of this paper, is closed to new membership.

The forum is focusing on development of open standards that could help to streamline and accelerate deployments of IPTV technologies and help to maximize the benefits of IPTV for consumers, network operators, content providers, service providers, consumer electronics manufacturers and infrastructure providers.

While standardization bodies are already addressing specific elements of IPTV, the pan-industry Open IPTV Forum will work to aggregate today's diverse standards into a complete delivery solution, with the goal of accelerating the full standardization of IPTV-related technologies. The Open IPTV Forum plans to establish requirements and architecture specifications as well as protocol specifications later in 2007.

The evolving IPTV service has many advantages, including personalization, interactivity and on-demand access for all forms of digital content. Unique possibilities exist for integration of content and communication services offered across mobile handsets and home devices. By ensuring the interoperability between consumer equipment and services compliant to the Open IPTV Forum's specification, the end-users can easily access their choice of content and services among multiple service providers.

With this scope in mind, the Open IPTV Forum will work on the basis of suitable open-standards technologies, and will also address key technology elements such as content protection, necessary interfaces that allow IPTV services to be delivered over both managed network environment and the public Internet, and adequate measures to ensure interoperability between such services and retail consumer devices. Candidates include, but are not limited to: IP Multimedia Subsystem (IMS) and Digital Living Network Alliance (DLNA).

6.11 Industry Focus Groups on Convergence

In addition to the standards and industry groups described above, there are a few other industry associations listed below that are promoting convergence:

FMCA

The Fixed-Mobile Convergence Alliance (FMCA) is global, non-profit organization focused on providing today's and tomorrow's Convergence customers with high-quality, seamless and easy to use products and services.

Representing a global base of over 850 million customers who stand to benefit from the development of Convergence products and services, its objective is to ensure, through collaboration with industry, that devices, access points, applications and underlying networks interoperate to deliver the best user experience possible.

MobileIGNITE

MobileIGNITE (Mobile Integrated Go-to-Market Network IP Telephony Experience) is an independent industry association of leading service providers and vendors that collaborate on accelerating the time to market for multi-vendor Fixed-Mobile Convergence solutions that work in existing fixed and mobile networks with a smooth transition to the IP Multimedia System (IMS) environment. Key initiatives include interoperability best practices, market requirements development and liaison with industry standards organizations and other industry groups.

7. LEGACY AND NEW SERVICES REQUIREMENTS

When considering convergence it is perhaps most important to understand what end-users are most interested in and how that can be manifested in a converged system. The simple evolution of communications and media has caused end-users to begin to think of their needs in new and emerging ways. Recent research has shown many interesting user trends that directly relate to convergence:

- Being in a particular location does not mean a restriction on what activities take place, e.g., sending and receiving emails when away from home or work.
- Arenas such as home and work are becoming less discrete, particularly as work "invades" the home space to varying degrees. Home is not just for personal time, leisure and entertainment any more.
- The future increase in ownership of personal and portable type devices (laptop, mp3 players, digital cameras) suggests a need and opportunity for content management in this space (e.g., online content sharing, online storage by operator).

- Driving uptake of convergent services hinges on the flexibility of the device used, the ease of switching between devices, the cost benefit of using a particular device, and having a device suited to the circumstance.
- The longer replacement cycle for TVs compared to mobiles and PC means that traditional TV as a platform for converged services will follow PC and mobile convergence. However, mobile broadcast and mobile video will offer new opportunities and experiences.
- Users expect most services to work in a consistent manner without having to consider which network is used. Services should adapt to the device and access characteristics being used, including simplified processes for identification and payments, as well as the ability to control cost.
- Users expect to be able to connect anytime, anywhere – also when on the move – with their device of choice. Users also expect to be able to specify in each situation whether the "best way" is defined by price or capability or some other parameter.
- Users expect reliability in all transactions, independent of access, and guaranteed connection quality. From a security point of view the user expects no viruses, no worms, no fraud, nobody listening in, and the ability to know who requests a communication session.

Thus, one of the most profound changes in the way we look at convergence today, as compared to a decade ago, is the increased end-user focus as a driver of convergence. Earlier, the focus was far more on operator and network efficiencies and limitations. These advantages still remain, however, and have gained increased importance as the new user and service requirements meet maturing technology.

7.1 Personalization

To end-users, communications is essentially about personalization. It is about having access to *my* data, through *my* preferred device, when I want it, where I want it. The entire service set can be enriched with presence and other compelling network-based content. Overall, the end-user experiences increased availability with greater personalized control of communications. Today, users are essentially living in an individualized world where they have customized options on nearly every purchase – to the point that we are now starting to expect it from our communications providers.

A tool that can be used to enable increased personalization in convergence is the use of an application using a network-based profile where the end-user has complete control of customization. A Call Agent based on end-user preferences will appropriately route and/or interact with a certain event. As an example, a user could set his or her status to "away" ultimately triggering the Call Agent to forward all voice calls to a particular number while sending an Instant Message to another user to notify of the call redirection.

7.2 Presence and Location

Presence is a key component for many converged services and allows a user to see recipient information before connecting (e.g. availability, geographical position). Presence also enables the user to see possible communication alternatives based on device and network capabilities including the availability of video and voice capabilities for a particular user based on where they are, what device they have, and what they are currently doing.

7.3 Content Distribution and Digital Rights Management

Access to media, be it broadcast or stored, real-time or time-shifted, is a desirable application in a converged solution. Many broadcasters are exploring the ability to make content more accessible to users on the go. New broadcast technologies hold the promise of being integrated into converged services to provide on-the-go live content accessible to a wide range of devices. Convergence also contemplates users being able to access their own personalized media store be it centrally hosted or locally held in their personal home digital media recorder (PVR/DVR).

Many issues around Digital Rights Management (DRM) will need to be addressed in these types of applications. DRM is a required element for content-based services in order to preserve the copyrights of the content providers. Yet, since multiple DRM schemes are being deployed, the lack of commonality and interworking between these schemes can compromise the ability to deliver content in a converged network.

A real-time video sharing service is a peer-to-peer, multimedia streaming service that can be offered entirely as a packet switched service or as a "combinational" service, combining the capabilities of the circuit switched and IMS packet switched domains. In a combinational scenario, for example, the service enriches the user experience during a circuit switched telephony call by exchanging pictures, video clips or live video over a simultaneous IMS packet-switched connection. This enables operators to leverage upon circuit switched infrastructure, telephony performance, user behavior and experience already in place. Even following the evolution to all-IP networks, circuit switched telephony enrichment will be maintained for the gradually diminishing circuit switched domain. In both combinational and full packet switched scenarios, the media is delivered and consumed almost real-time, with only a marginal delay, thus providing the experience of being there and "sharing the moment." The spirit is always live, even when sharing a stored video clip, since there is the possibility that users can have an ongoing voice conversation at the same time.

IMS video conferencing service extends the point-to-point video call to a multi-point service. Video conferencing requires an IMS conference bridge service which links the multiple point-to-point video calls together and implements the associated service logic. The video telephony connections are made point-to-point from the terminals to the conference bridge, which takes care of joining the point-to-point connections into a conference. The conference bridge is not concerned about the underlying infrastructure and client devices and assumes that audio and video connections are provided by the appropriate standard and that these connections are delivered over the IP network.

Video telephony is seen as a critical end-user service in mobile networks. The Session Initiation Protocol (SIP) enables voice and video telephony person-to-person and multiparty sessions over an IP network. The issues for VoIP and video telephony calls are around Quality of Service (QoS) in packet core networks, as well as interoperability with the PSTN (Public Switched Telephony Network) and legacy phones, and inter-working with existing domains for video telephony such as H.323 and H.324M.

Bandwidth requirements for video services are driven by the coding schemes in terminals and the video quality requirements of users. Thus, with similar coding schemes, packet-switched video telephony has similar bandwidth requirements as circuit-switched video telephony. However, packet switching gives more freedom in balancing the bandwidth and video quality requirements. The bandwidth and QoS requirements for the connection are requested from the network by the terminal at the connection set-up phase (PDP context activation).

7.4 Mobility

The ability to take your service with you so that you can connect anytime and anywhere, whether moving or stationary is at the heart of what users are now expecting from communications. As the proportion of mobile minutes pass landline minutes globally, it is clear that mobility in voice communications has inherent value and is in effect, an expected utility. This expectation of mobility will likely move from voice to all services though a converged communications experience.

Mobility is no longer limited to traditional licenced spectrum wireless users. Mobility now includes nomadic users getting wired and wireless access at many locations including hotels, airports, coffee shops, etc. Users are seeing an ever expanding array of access methods with various degrees of mobility. There is a great need to provide the user an access independent experience and shelter the user from the details of their access type and location.

7.5 Ease of Use

End-users are looking for a consistent experience across whatever network or technology their communications event is taking place. One way that this manifests itself is in the user interface. It is simply not acceptable for the interface to change for most services as the user moves from network to network or from one access type to another within a network. The same basics of the experience should remain with additional features being available as the user moves from a portable device to a more fixed device. The overall service is simplified by having a consistent look and feel, single address book, and Web-based provisioning. Elements like this make the service more usable, cohesive, and compelling.

Another element of ease of use is pricing and the consolidation of services in purchase and servicing. While bundling disparate services and providing one bill is a start, compelling consolidation of services will include a single subscription, Web interface, customization of features, and pooled minutes, for example.

7.6 Reliability and Security

Users expect reliability in all transactions including the almost-guaranteed connection quality experienced in traditional wireline voice. Connection quality expectations are quite low in mobile communications but will need to become unquestionably improved in order for services and applications to seamlessly exist in a converged communications world. Security, profoundly important in the wired and Internet markets, is just now becoming an issue in the mobile space. The end-user will expect the same or better safeguards for their converged communications as the best available in the lowest common denominator – wired voice. Users will want and expect that their services are as safe in the newly converged world – no matter what device or network – and that they will not be susceptible to spam, viruses, or fraud. It will also be very important to be able to identify who requests a communications session as well as the user's ability to accept or deny it.

Reliability and security must be provided in such a way that the user does not have to take special actions depending upon their access type and location. The user interface must be common regardless of access type, and this should include security aspects.

7.7 Service Transparency

Users expect seamless transparency of features and continuity of services as they roam between locations covered by WiFi, GSM, etc., as well as convergence between mobile and landline devices. Additionally, service transparency is needed to manage incoming and outgoing communications on any device based on a user's availability, location, terminal capabilities and ultimately preferences. In order to achieve this end-to-end perspective, QoS, SLAs, security, and access types are required. It is the IMS framework that guarantees transparent end-to-end aspects to the end-user: mapping QoS parameters and security methods, as well as applications methods.

7.8 Interoperability

Through standardization IMS provides interoperability between networks and network types. Interoperability must be provided using open and efficient techniques. Standardization and the use of SIP protocol for both end-user and inter-network signaling support this interoperability.

Interoperabilty is needed within the network as well as between networks. Standards support the building of multi-vendor networks with well-defined interfaces between network nodes. This is an important consideration for IMS networks that are not provided by non-standard and ad-hoc networks, even if they are SIP-based.

8. ADDRESSING CONVERGENCE

8.1 Network

Network convergence is simply the enabler – the means by which network operators facilitate better access to value-added services and applications. In fact, the goal of network convergence is to make all services portable, profitable, and enable multiple business models.

Network convergence is tied to service convergence because services that are easy to use quickly become popular and help to increase an operator's revenues. At its simplest, network convergence implies consolidation of the network to provide different user services via several access types with telecom-grade quality of service and an emphasis on operator differentiation and cost efficiency. Network convergence involves a unified core network, access networks that complement each other, and common multi-access aware service delivery platforms. Technologies such as UMA and VoIP, and enabling machinery such as IMS (IP Multimedia Subsystem), will be at the forefront of driving network convergence. This will enable operators in all segments of communications to attain cost efficiencies and launch new compelling services that span physical access networks.

8.1.1 NGN/IMS

IMS plays a crucial role in convergence, and with the use of Session Initiation Protocol (SIP) allows the introduction of IP services, including Voice over IP (VoIP), video sharing and other multimedia services. It can also provide the same supplementary services for VoIP calls as we have today for circuit switched calls, by connection to an Application Server offering the supplementary services.

8.1.2 WLAN/Femto Cell

An Access Point Base Station or femtocell is a stand-alone unit typically deployed in hot-spots, in-building or in the home. Femtocells are scalable, multi-channel, two-way communication device extending a typical base station by incorporating all of the major components of the telecommunications infrastructure. Application of VoIP allows voice and data services in the same way as a normal base station, but with the deployment simplicity of a WiFi access point.

An important enabler of the femtocell concept is the rapid proliferation of DSL or cable-based broadband access which in the femto concept is used as the backhaul solution. While the femto concept could be applied to any cellular technology, the industry is mainly focusing on 3G femtocell.

Femtocells provide operators with a better means of controlling the traffic generated at home and reduces customer churn by encouraging fixed to mobile substitution and attractive home tariffs. As new access methods are emerging and threatening the cellular operators' revenue from home traffic (WLAN, VoIP), femtocell will be an important weapon in the 'battle for the home.' In the GSM/UMTS/HSPA network, femtocells not only provides the home user with the higher bit rates but off-loads the macro network, potentially leading to cost savings in the overall network investment.

8.1.3 Technology Handoff

VCC makes it possible to offer voice services for a multi-radio terminal user via both Circuit Switched (CS) and Packet Switched (PS) to IP Multimedia System (IMS) access as preferred. For example, VCC devices can handover seamlessly between home WLAN networks to macro cellular GSM/UMTS/HSPA networks and vice versa while in a voice call and maintain "voice call continuity." VCC offers mobility for fixed network operator customers and supports alternative IP access technologies, also for mobile operators to do such things as improve the network coverage and capacity, or offer more services by IMS.

VCC provides the capability to transfer the path of a voice call (Multimedia is not within the scope) between domains (e.g. Cellular and WLAN). 3GPP Release 7 standards support CS system (GSM/UMTS/HSPA) and IMS with 3GPP defined Interworking-WLAN (I-WLAN), and vice versa. VCC touches the origination, termination, emergency call (part of 3GPP Release 8), and service aspects of standards.

The principle of VCC was first to focus in 3GPP Release 7 on WLAN and circuit switch cellular handover based on the "dual radio" concept. Dual radio support in the terminal means that both radio links (GSM/UMTS/HSPA and WLAN) are turned on simultaneously to support voice continuity when transferring from one domain to another (i.e., CS to IMS, IMS to CS). Later the radio concept was expanded to "single radio" VCC which enables IMS VoIP over HSxPA to 2G/3G in 3GPP Release 8.

For domain transfer to occur:

- The terminal must be both IMS registered and CS attached.
- Voice media and call signaling must be anchored in the IMS.
- UE initiated process.
- An IMS SIP application server supports handling of the VCC feature.
- IMS anchoring is supported via CAMEL.

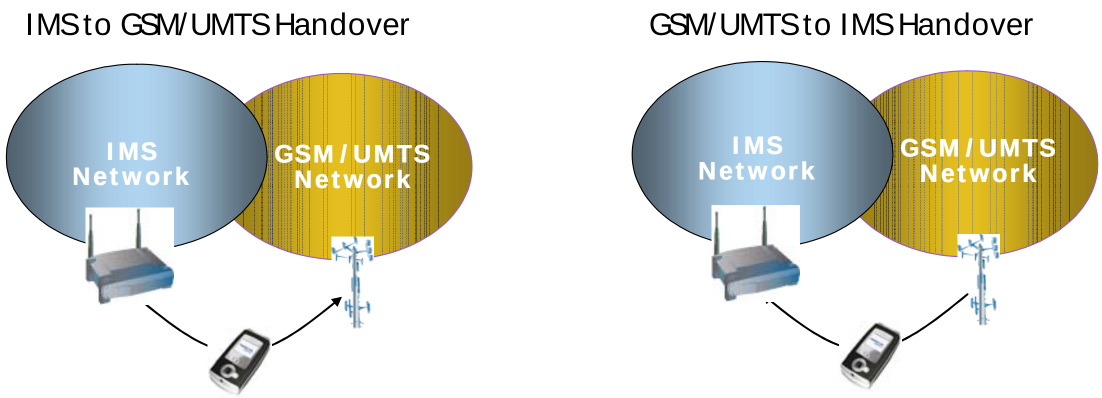

Figure X High-level VCC HO

Timeline:
3GPP standardization is planned to be finalized 1H2007 (as part of 3GPP Release 7). Other enhancements of VCC might only be part of Release 8, such as emergency call support, single radio VCC, etc.

8.1.4 Native IP Access

An IP-based access connection using the SIP protocol between the device and the unified core network – so called 'Native IP access' – allows voice, video and other multimedia applications over any access network. Native IP access supports a wide variety of applications in different devices, including mobile handsets, PC clients and SIP desktop phones. POTS phones too, can also be supported, via a connection to an SIP-capable DSLAM or analog terminal adapter (ATA). Native IP access architecture also allows the introduction of new rich IP multimedia services through IMS functionality, such as video streaming, media push, video calls, and various other SIP enabled applications, for further revenue streams for operators.

8.1.5 Operational and Business Support Systems

Operations Support Systems (OSS) and Business Support Systems (BSS) are moving from organizational silos into a common, centralized environment, so that different accesses, domains and services are all under one management umbrella.

Future management systems will consist of a common adaptation layer, with the common platforms and applications grouped together according to the most relevant operator processes. Moving towards an environment where services can be managed almost independently from the underlying network.

The transition from the current OSS and BSS to the converged environment should be made in steps, carefully evaluating an operator's needs and processes and protecting existing investments.

8.2 Device

Terminals, in particular, traditional cellular phones, have historically been devices optimized for one, or few, specific tasks. Over time, these terminals have been optimized to provide the most elegant solution for the task at hand. As convergence in consumer electronics takes hold, many functions are being combined into single devices. Early incarnations of converged terminals have had shortcomings in one or more of the added features. It is clear though, as technology advances, and these converged terminals are optimized to end-user requirements, they will become as usable as dedicated terminals for multiple critical tasks. It is also likely that the converged mobile device will become the preferred device providing my profile, my services, my interface and my data.

Beyond end-user applications and functionality, multi-radio and multi-access functionality will grow in importance from simple coverage enhancements (GSM+TDMA, GSM/GPRS+UMTS/HSPA or GSM/EDGE+UMTS/HSPA) to include new technologies like WLAN, UWB and Bluetooth. Multi-access will provide a host of opportunities for end-users to enhance their utility of devices, optimize their cost of services, and will likewise provide operators with similar challenges and opportunities. Finally, many advances will be made in device customization, memory, and battery life enabling convergent services to become a reality in the terminal. Overall, there is a clear need to enable ubiquitous access from the user's preferred device.

8.2.1 Multi-Radio

Multi-radio means that a device has more than one radio built in. Today there are a number of radio technologies available including AMPS, TDMA, GSM, UMTS/HSPA, CDMA, OFDM, WiMAX, FM, GPS, Bluetooth and WLAN. In the future, we fully expect to see LTE and UMB technologies deployed as well. Initial multi-radio devices leveraged AMPS with either TDMA or CDMA, serving a specific economic and functional purpose for carriers and end-users alike. In the past the purpose for these was coverage and performance, as carriers managed the transition to newer technologies. Moving forward, we fully expect to see the emergence of LTE and GSM/UMTS/HSPA devices to meet the need for LTE migration.

There are several well-known challenges with multi-radio terminals in that each new radio may mean additional silicon on the phone, additional antennas, more interference from the different radios, and increased power consumption. While Moore's Law may help with reducing the amount of silicon needed, this does not help with antennas and especially not with power consumption.

Some of the more interesting combinations of radios in terminals recently include the addition of Bluetooth and WLAN (802.11) accesses. While Bluetooth serves primarily an enhancement role, WLAN provides an opportunity to integrate a cheap and ubiquitous access mechanism into the mobile industry. This can be vividly illustrated with the now possible support for Unlicensed Mobile Access (UMA). This allows a mobile phone to use WLAN/Bluetooth to access the local fixed broadband to connect to the GSM core network. As IP and SIP-based telephony takes hold, the WLAN radio in terminals will play a significant role in changing end-user use cases and operator economics. A tangible example is the recently launched BT Fusion service in the United Kingdom.

8.2.2 Multi-Access

Multi-access is somewhat of a different, but related concept to multi-radio terminals. A multi-access network is a network that supports accessing network services through different mechanisms. For example, a typical corporate intranet can be accessed via Ethernet inside buildings or over GPRS, EDGE, UMTS/HSPA, Cable, XDSL, WLAN, and so on.

Putting together multi-radio and multi-access, we essentially have multi-access awareness for terminals. A multi-radio device needs to be able to access different services through different access methods. Being able to access your email via WLAN or GPRS from a smartphone, playing a game over Bluetooth with a friend in the same room and then inviting a far-away friend to join the game via 3G are examples of what now becomes possible.

A significant challenge enabling multi-access terminals is in usability. It is not apparent that users will be able to perceive the differences between radios that may connect to different service providers with different cost models. In order to simplify this, much attention needs to be paid to improving multi-access bearer selection, multi-access policy management and security awareness. A connection management function will need significant focus in order to tie modules in the phone together such as QoS, security, existing IP connections, control modules, and device management policies in order to activate (when necessary) or select the appropriate connection to meet the end-user's needs.

It is clear that some multi-radio technologies will sometimes be used concurrently and sometimes not. To be practical, selection of these different radios should be made with as little user impact as possible. To the user, it should seem that their applications just work, especially in critical scenarios.

8.2.3 Converged Device Design Features and Requirements

As they access their applications, end-users expect to receive a unique bill from their service providers, regardless of the devices and networks they used. They will select the most relevant device for a given application and expect that device to continually select the best network to support their personalized application.

This ever-changing combination of devices and networks requires an independent authorization system that tightly combines subscribers with service providers for each application. Many convergent devices rely on USIM cards to hold consumer subscription information and the associated access rights to network and services. As SIM cards have for years, USIM cards will enable consumers to migrate from device to device and to roam onto different networks. With their USIM cards, consumers access their services with a common identification and authorization system, provide the devices with the service settings, and personalize their applications with their personal data. Like today, consumers will be able to change devices and have them immediately functional to support their applications on the networks. Separating subscriptions from devices is essential to enable flexible provisioning and improved customer experience.

The USIM cards were designed to include multiple network access authorizations to support a heterogeneous and evolutive authorization environment. Based on a multi-application platform named UICC, the USIM card securely co-locates IMS access applications with UMTS/HSPA access applications and support CDMA access applications. It can also include other smart card applications designed for payment or mass transit to ensure reliable end-to-end transactions. The new SIM cards are portable tamper-resistant authorization tokens that monitor access to networks and services beyond the telecom arena. With the ability to support multiple authentication algorithms and keys, the USIM can provide access to multiple networks and services that are not necessarily sharing identification and authorization schemes.

With authorization and billing, the USIM cards also enable to transfer and synchronize user data and service settings among the various devices. The nomadic lifestyle of the end-user will require a convenient solution. The use of SIM card-based authentication will be expanded into new domains. One solution is wireless communication between a personal SIM card and the devices being used. The SIM card could be carried as a personal item and communicate with devices over a secure personal area network. Other solutions could include a superseding personal device that includes the personal USIM card while other devices rely on the personal device to gain service access. All these scenarios will enable full personalization and configuration of devices according to the service provider and the subscription identified by the USIM.

Mobile phone development has been rapid in the last decade, but new models will take increased advantage of technological imaging developments. They will have enhanced color displays and higher quality imaging, developments that are needed to support new services and applications. Display improvement has made great strides in recent years and the expectation is that it will continue as Moore's Law drives computing power and miniaturization drives form factor.

The explosion in memory capacity and exponential growth in processing power will also allow smartphones to replicate the applications currently employed in notebook PCs and PDAs. Many emerging devices now hold several gigabytes of data and still many more provide bays for removable memory.

We are more reliant than ever on our mobile devices, but battery life remains a problem. Improvements in battery capacity simply have not kept pace with ever-more-powerful processors. The drive for smaller factor devices with lighter batteries has also forced vendors to reduce the power consumed by the load. The greater energy density of Li-Ion batteries has contributed significantly to reduce the form factor and weight of terminals. However, the density of such battery technologies is not expected to increase much, and new technologies like fuel cells which promise a lot more power in a small package are several years from being widespread. Clearly, battery power, weight and size will need to be addressed in order for the many envisioned processing-intensive convergent applications to become reality. It is also important to note that fixed access points (e.g. the AP for WLAN access) associated with devices will also need to change to accommodate device power savings in WLAN devices.

8.3 End-user Services

8.3.1 Service Bundling

Service bundling does not provide any fundamentally new services for subscribers. It just provides a more convenient package for subscribers to get two or more of the same services that they enjoy today. Service bundling can therefore only be the first of a multi-step process towards network and service convergence. Service bundles are described more fully in the section on Operator Strategies.

8.3.2 Unified Services

Several services have already been available in the marketplace for many years that were early examples of convergent services. Services such as Fixed-Mobile SMS, unified messaging, single number, single voicemail had limited success for many reasons. They were often isolated pre-IP implementations, which demonstrated the concept but were not easily scaleable and were not heavily promoted. Many of these services are becoming available on IP platforms, so unified communications suites which integrated IM, email, SMS, fax and voicemail with voice to text are experiencing renewed interest.

8.3.3 Dual Mode Voice Services

Dual mode voice services such as IMS VCC, UMA or Mobile VoIP have been very early examples of converged services that have attracted much attention. The IMS VCC and UMA solutions consist of a suitable dual mode handset (GSM, WLAN) and a home based WLAN access point. The end-user can make voice (and data) calls on the cellular network when outside the home, and on the WLAN network when inside the home. The benefits to the end-user are better indoor coverage and reduced mobile call tariffs when inside the home. The operator benefits by offloading traffic to the fixed broadband network thereby freeing up capacity on the cellular network for little additional cost. As coverage and voice quality improves, so too does customer satisfaction, and subscribers are less likely to churn. Also, those users without DSI are required to upgrade, thereby generating revenue growth and/or market share gains. Additionally, the IMS based solution enables a wide range of IMS-based features in the future while leveraging a common IMS infrastructure for both fixed and mobile applications.

8.3.4 Converged Services

Service convergence focuses on end-user requirements and the service experience. The primary goal of service convergence is the concurrent delivery of all media types — voice, data, and video— to an easy-to-use graphical user interface, with mobility and access and device awareness. This means that a multitude of services (person-to-person, person-to-content, and content-to-person) can be provided to the same user over different access networks and to different devices. Research has shown that end-user behavior is rapidly changing due to globalization, and there is an increased value placed on individuality, emerging tribalism, new patterns of social networking and communities as well as an increasingly nomadic lifestyle. From a service perspective, the consumer and enterprise user expect convenience, ease of use, reliability, security and support to be always connected in the best way. Once user needs are understood, a variety of services can be developed within this demand framework including convergent voice, efficiency applications, alternative communications methods and entertainment. Finally, it is important to note that there will be significant differences between the end-user needs and the ultimate converged services of consumer and enterprise users. The true challenge that will make convergence real is marrying these needs to deliver converged services.

8.3.5 Blended Services

By blended services we mean the seamless interworking of different (often existing) converged services to provide added value to the end-customer. As noted above, the primary goal of service convergence is the concurrent delivery of all media types — voice, data, and video — to an easy-to-use graphical user interface, with mobility and access and device awareness. Once service convergence is achieved, customer value can be enhanced by interworking these services to provide a personalized user experience. For example, in a converged services environment, video content can be delivered to both the mobile handset and the large screen TV located at the customer premises in a consistent manner. In addition, both the mobile and the TV systems can be telephony aware and both may support telephony services. By linking the user identity information known by both the mobile user and the TV viewer, we can provide a blended service to a mobile subscriber who is watching the fixed TV such as “caller identification with user interaction” on the fixed TV when the mobile is alerted. This blending of mobile and fixed, telephony and video, is only possible in a fixed-mobile converged network architecture with common identity management capabilities.

As services/applications migrate to a converged environment, the ability to blend these services and applications in combination with network enablers such as presence, location and identity management solutions provides a wide range of opportunities for an enhanced user experience.

9. CHALLENGES AND OBSTACLES

9.1 Business Relationships

Initially, wireless was considered an extension of fixed service by both the industry and the regulatory bodies. After many successful years of operation and the freeing of additional spectrum for new entrants to compete, the tether to fixed line was severed as wireline companies in the mid 1990s focused on Long Distance erosion, M&A, and unbundling of Local Loop services. The introduction of 3G services and more spectrum in the late 1990s along with fiscal regulatory restraints which lead to auctions of spectrum enabled full mobile only operators and a further distancing of fixed and mobile operators. During this initial period, Fixed-Mobile Convergence services were limited.

With the success of wireless, governmental bodies as well as fixed line operators began to consider wireless as the preferred build strategy for select rural and third world deployments in an effort to bridge the digital divide. Additionally, in the mid to late 1990’s with the introduction of HTML, opening up the internet to average users, the dotcom buzz saw immense activity and uptake of IP services and new content players emerging. This in turn added new players to the value chain of service creation.

By 2000, operators were offering bundled packages of services such as the Triple and Quad play (Voice, Wireless, Internet, video) to reduce churn. Post-2005 signaled a shift in the telecom landscape, as operators re-evaluated their operations and focused on keeping existing customers while growing revenue with the emergence of Fixed-Mobile operators deploying converged services using technologies such as UMA. Expansion of Fixed-Mobile converged services will require additional work and relationships with WiFi Alliance (WFA) and broadband associations such as the Wireless

Broadband Association (WBA) and the GSMA. Traditional business relationships in these areas are changing as the paradigm is changing, from nomadic laptop users to mobile multimedia-based convergent devices. The value is changing from high bandwidth PC applications (email and browsing) to full remote office capabilities, including voice and IM, to personal extension of coverage. Existing Wireless Operators are looking for relationships to extent access to improve the customer experience with converged devices, and controlling operation costs in doing so. Similiarly, the WLAN operators are looking for new ways to boost ARPU, and drive customers to hot spot venues. The current business models based on time-based charging do not work well here.

9.2 QoS

IMS will provide an effective starting point for the implementation of real-time mobile IP services although, enabling Quality of Service (QoS) within a mobile IP network will be difficult for some time to come. Real-time mobile IP communication is complex due to fluctuating bandwidths which severely affect the transmission of IP packets through the network. In normal IP networks, IP transport would be what is known as 'best effort,' meaning that the network will do its best to ensure the required bandwidths, but there is no guarantee. The result is that real-time mobile IP services function poorly or not at all (i.e. voice quality is poor or garbled, video 'jitter', etc.) depending on the bandwidth availability and network congestion.

QoS mechanisms were developed in order to overcome these issues and provide some type of guaranteed level of transmission instead of 'best effort.' QoS ensures that critical elements of IP transmission such as transmission rate, gateway delay, and error rates can be measured, improved, and guaranteed in advance. Users are able to specify the level of quality they require depending on the type of service and the users' circumstances. The 'intelligence' required to enable QoS within a mobile IP network is specified in the form of an entity known as the Policy and Charging Rules Function (PCRF). The PCRF interacts with, and controls, the underlying packet network. The PCRF and associated QoS capabilities in the mobility gateway elements allow IP flows to identify, shape and afford the needed bandwidth and delay for the desired application. These capabilities can also be used to shape user traffic to provide fairness in the network.

9.3 Potential Regulatory Issues

Along with all of the technology changes that are sweeping the industry come changes in the regulatory environment that govern how service providers deploy and charge for these services. In the U.S., the emergence of VoIP has gone so far as to break down the barriers to entry, and the regulatory bodies governing telecommunications are now taking a hands-off approach to regulating IP-based services. The result is that new players in the industry are no longer subject to the regulations that could have proven detrimental to their businesses. The incumbent operators (RBOCs), may no longer be subject to bundling restrictions; however, they face a much more competitive environment from these new providers.

In the U.S., regulation of telecommunications convergence issues, and specifically VoIP, is currently in flux. Although the FCC has addressed the regulatory treatment of specific convergent services on an ad hoc basis, it has not yet established a comprehensive regulatory framework for convergence issues such as VoIP. Consequently, the scope and extent of regulation of converged offerings like VoIP is generally difficult to predict. In particular, the extent to which the FCC will ultimately impose regulations with social objectives like disability access, as well as whether and how it will impose regulations such as numbering and addressing requirements, Intercarrier Compensation, Universal Service, QoS, reliability, and network security obligations on VoIP providers is uncertain. Without a clear understanding of the level of regulation they will face, providers may be hesitant to invest in and deploy certain converged services. Some converged services will be deployed to test the regulatory waters and drive new regulations. Many Fixed-Mobile converged services, for example, provide various mechanisms to support E911. However, since the location of the AP may not be known, implementation is subject to operators interpretations of the regulatory environments. As a result, the evolution, benefits, and availability of such offerings may not be fully realized until the FCC and/or Congress acts to clarify the regulatory climate for converged services such as VoIP and other IP-enabled services.

The capability to provide voice service utilizing an Internet Protocol was virtually unanticipated by the U.S. Congress when it drafted and passed the 1996 Act. For this reason, the 1996 Act provides insufficient direction on how IP-based applications like VoIP should be regulated. Moreover, VoIP does not fit easily within the traditional analytical framework the FCC uses to classify new services and interpret the meaning of the 1996 Act's various provisions. The historical focus on determining whether a new offering is a "telecommunications service"[1] or an "information service,"[2] as those terms are defined in the 1996 Act, or identifying the jurisdictional nature of a new offering can be problematic. The distinction is often difficult to make. This is evident in the conflicting VoIP decisions issued in the last year by states and the FCC.

The converged IP-enabled services marketplace is the latest new frontier of our nation's communications landscape, and the Commission is committed to allowing IP-enabled services to evolve without undue regulation. Recently the FCC made a decision regarding VoIP which places obligations on interconnected VoIP service providers that are similar to traditional telephone providers in that they enable customers to receive calls from, and terminate calls to, the public switched telephone network (PSTN). It does not place obligations on other IP-based service providers, such as those that provide instant messaging or Internet gaming services, because although these services may contain a voice component, customers of these services cannot receive calls from, and place calls to, the PSTN. The Order by the FCC adopted in May 2005 reached the following conclusions:

1. Interconnected VoIP providers must deliver all 911 calls to the customer's local emergency operator. This must be a standard, rather than optional, feature of the service.
2. Interconnected VoIP providers must provide emergency operators with the callback number and location information of their customers (i.e., E911) where the emergency operator is capable of receiving it. Although the customer must provide the location information, the VoIP provider must provide the customer a means of updating this information, whether he or she is at home or away from home.
3. By the effective date, interconnected VoIP providers must inform their customers, both new and existing, of the E911 capabilities and limitations of their service.
4. The incumbent LECs are required to provide access to their E911 networks to any requesting telecommunications carrier. They must continue to provide access to trunks, selective routers, and E911 databases to competing carriers. The Commission will closely monitor this obligation.

Thus, we can expect that the FCC, Congress, and Administration will continue to monitor the effect of converged services on regulatory issues.

In Canada, new regulations on "New Media Broadcasting"[3] could restrict convergent Mobile TV applications from fostering and growing in Canada, while these same services are expected to grow in the USA. A new Multimedia Broadcast (MBMS) service or DVB-H or MediaFlo convergent devices with Wireless which can be used to efficiently send media streams to users is stalled until further regulatory review.

9.4 Device Availability

The availability of devices is a key requirement for the deployment of new services in a Fixed-Mobile Converged environment. However, services that constitute FMC are not standard and differ from carrier to carrier. This becomes more complicated when the radio technology choices differ from carrier to carrier. For device manufactures, this means different variants for each device type and

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[1] A "telecommunications service" is defined as "the offering of telecommunications for a fee directly to the public, or to such classes of users as to be effectively available directly to the public, regardless of the facilities used." 47 U.S.C. § 153(46). "Telecommunications" is defined as "the transmission, between or among points specified by the user, of information of the user's choosing, without change in the form or content of the information as sent and received." 47. U.S.C. § 153(43).

[2] An "information service" is defined as "the offering of a capability for generating, acquiring, storing, transforming, processing, retrieving, utilizing, or making available information via telecommunications, and includes electronic publishing, but does not include any use of any such capability for the management, control, or operation of a telecommunications system or the management of a telecommunications service." 47 U.S.C. § 153(20).

[3] CRTC ruled in a New media exemption order that the Broadcast of Internet based media was exempt from the Broadcast Act and regulations in April 2006 , http://www.crtc.gc.ca/archive/ENG/Notices/2006/pb2006-47.htm, however it revised the rules in February 2006 to clarify that unicast delivery was exempt, and multicast and broadcast was not http://www.crtc.gc.ca/archive/ENG/Notices/2007/pb2007-13.htm

hence economies of scale do not apply, increasing costs for all. This cost increase further slows the introduction of new services complicating the business case.

Key to a competitive device portfolio is a good understanding of the target segments, their behaviors, needs, and the value proposition to the end-users. Vendors and carriers must deal with this challenge on an ongoing basis for FMC services.

Standardization can help the situation by limiting the device variants. However, the slow pace of standards can complicate the situation. For example, standardization of VCC has been delayed, and hence many pre-standard solutions are in the market. It is challenging for device manufacturers to implement different pre-standard versions especially when they will also merge (hopefully) into a standard solution.

10. OPERATOR IMPLEMENTATION STRATEGIES

Today's existing service providers have spent enormous sums of money over the past decade upgrading their networks to deliver new services and to support the added traffic associated with the growth in their subscriber bases. These are capital-intensive moves that take a great deal of planning and time to implement. As the service providers address the new set of challenges outlined earlier, they once again face the issue of how to upgrade their networks in an economical way, without missing the market window for delivering new services. They can't afford to spend too quickly given the debt burdens that many carry, and they can't afford to spend too slowly and risk losing subscribers to alternative providers. Service providers need to carefully consider a phased strategy for evolving their networks that starts to address end-user requirements now and positions the operator for converged multimedia service-capable networks in the near future.

This evolutionary strategy can be viewed in four phases:

1. Service bundling.
2. IP network convergence.
3. Service convergence.
4. Operator and organizational convergence.

10.1 Service Bundling

Service bundling refers to two or more basic services offered together in bundles of services to end-users who previously purchased these services as separate entities. The most common type of bundle emerging in the market place is the “triple play” bundle offered by the fixed and cable operators. Here a combination of voice telephony, high speed internet access and TV/video services are offered. Bundling has also occurred in the Fixed-Mobile domain as operators have sold (or resold) wireless service along with fixed service. For the subscriber, the main benefit is that the carrier provides a discount on services if more than one is purchased. In addition, they receive one bill for all services and in some cases a single number and a single voicemail box. Hybrid operators who have both wireless and wireline assets can additionally offer mobile services as part of a “triple play,” referred to as the “quadruple play.” For the service provider, bundles create service loyalty by making it harder for subscribers to switch or churn to other providers.

Where a service provider is not able to provide these services in house, they must turn to partners or other business relationships to secure these services. For example, the US RBOCs (Regional Bell Operating Companies) have parternered with the satellite TV companies such as Direct TV to offer TV and video services to compete against the cable companies (while at the same time deploying IPTV in many areas). Similarly several major US cable companies without mobile assets formed a joint venture with Sprint Nextel to offer a quadruple play bundle.

In Europe, several mobile only operators have either acquired or have partnered with fixed broadband ISPs in order to be able to offer uadruple play bundles.

Service bundling does not provide any fundamentally new services for subscribers. It simply provides a more convenient way for subscribers to continue getting the same services that they enjoy today. Therefore, service bundling can be only the first of a multi-step process towards network and service convergence.

10.2 IP Network Convergence

The next step in the evolution for operators is IP network convergence. The goal of IP network convergence is to create capital efficiency for the operators. In today's network, wireline and wireless operators have deployed separate networks. In doing this, they have created redundancies across the assets required to deliver services to subscribers. For example, each provider has separate subscriber databases, voice mailbox platforms, and messaging platforms. In addition to being capitally inefficient, this also creates a different end-user experience for the subscriber accessing wireless service vs. wireline services.

With IP network convergence, wireless and wireline operators begin to deploy IP-based service platforms that work across all access domains. Given that they are IP-based, the end-user experience is the same regardless of whether that user accesses via a wireline or wireless IP endpoint. For the service provider, this creates a much more efficient approach to providing services. As new services are developed, there is no need to duplicate the service across domains. The converged operator deploys the service once and makes these services available to all types of endpoints. For example, an operator can deploy one Instant Messaging service that can be used for both wireless and wireline endpoints. They can deploy one set of Media Gateways that provide the interface between a VoIP network and a traditional PSTN network. For the end-user, the user experience is now identical across domains.

Again, as with service bundling, IP network convergence is not providing any fundamentally new services to the end-user. The basic goal is to improve the economies of how service providers deliver services to end-users. It is on this basis, however, that new services can be delivered as described in the next section.

10.3 Service Convergence

The last phase in the operator's network evolution is full service convergence. With full service convergence, the operator seeks to enable the convergence of voice and data services to provide new capabilities not currently available to end-users. An early example of a converged voice service is UMA. UMA is especially attractive to a fixed operator who wishes to offset the decline in fixed line voice revenues and subscriptions by upgrading to broadband DSL service. IMS VCC is the next logical extension toward full convergence as it enables both wireless and wireline voice services as well as new multimedia services on a common converged platform.

Service convergence provides a better user experience for the subscriber and makes the services easier to use. For example, users can be provided with a single contact list that spans all of their services so they no longer need to have one contact list for email, another for messaging and so on. Full service convergence also implies greater integration of disparate services. For example, a subscriber on a VoIP call with another user would be able to launch a multimedia session with that other user to enable the shared viewing of a video.

Market research has shown that there is a willingness among subscriber segments to pay for these types of converged services, especially if these services can simplify a subscriber's current lifestyle or business tasks. It is these types of services that operators must seek to provide in order to replace revenues lost as the ARPUs associated with traditional services declines.

Initiatives involving the IMS architecture and UMA as 3GPP GAN (Generic Access Network) have received a great level of interest amongst telecommunication carriers — even amongst traditional wireline and cable network segments and enterprise markets. The common principles and similarities shared between the various next-generation service architectures offer an unprecedented opportunity to achieve true convergence across services, media, operational support systems, and access technologies. Industry-wide adoption of unifying standards such as IMS and UMA will allow service providers to increase the applicability of their service offerings to broader market segments and achieve greater economies of scale, while allowing subscribers to experience a greater level of unification with newer services that was simply not possible in earlier-generation networking technologies.

10.4 Operator and Organizational Convergence

Several Operators today own assists in various domains. These operators are internally reorganizing to provide convergent services including:

- Single bill.
- Bundled service.
- Calling plans between users on each domain.
- Leverage of assets of each domain including transport facilities, IP facilities and human resources.
- Collapsing IT, Purchasing and Engineering functions.

Merger and Acquisition activity has also been used by some operators as they move into this space.

As operators' convergent strategies take hold, their focus in specific standards areas, and trade association will shift. As such, association and standards organizations will be required to modify their scope and charters to keep pace with the changing converged marketplace and varying membership needs.

11. CONCLUSION

As we have shown, Fixed-Mobile Convergence is a complex and multi-faceted topic. It is a technology trend, but also an industry trend impacting almost all communications and information industries. It promises great changes to the way we as customers consume communications services – anytime, anywhere, any device. It is comprised of four key components – service, terminal, network, and industry convergence – all of which are interrelated and critical to the success of the others. In the end, though, if convergence does not deliver on the basic end-user needs, its success will likely continue to be elusive. Convergence will need to simplify the customer's interaction with their information and communications data, provide multiple compelling devices and the ability to seamlessly move between devices while keeping consistent data and look and feel, plus simplify and optimize the network all at once. The effort and coordination required to make this type of revolutionary industry transformation happen will be massive. It will not happen overnight and many services and companies will fail in the process. Nevertheless, its promise is huge, and the impact on the industry, and most importantly the end-user, will be nothing short of revolutionary.

ACRONYM LIST

3GPP	3rd Generation Partnership Project
AMR	Adaptive Multi-Rate
ARPU	Average Revenue Per User
BTS	Base Transceiver Station
CQI	Channel Quality Indications
CS	Circuit Switched
CSCF	Call Session Control Function
DCH	Dedicated CHannel
E-DCH	Enhanced Dedicated Channel
E-DPCCH	Enhanced Dedicated Physical Control Channel
E-DPDCH	Enhanced Dedicated Physical Data channel
EDGE	Enhanced Data for Global Evolution
ETSI	European Telecommunication Standards Institute
FDD	Frequency Division Duplex
GPRS	General Packet Radio System
GSM	Global System for Mobile communications
HSDPA	High Speed Downlink Packet Access
HSS	Home Subscriber Server
HSUPA	High Speed Uplink Packet Access
HTML	Hyper-Text Markup Language
IMS	IP Multimedia Subsystem
IP	Internet Protocol
ISIM	IMS SIM
ISP	Internet Service Provider
ISUP	ISDN User Part
ITU	International Telecommunication Union
J2ME	Java 2 Micro Edition
LCS	LoCation Service
LMMSE	Least Minimum Mean Squared Error
LTE	Long Term Evolution
MAC	Media Access Control
MBMS	Multimedia Broadcast/Multicast Service
MRFP	Multimedia Resource Function Processor
MMS	Multimedia Messaging Service
NGN	Next Generation Network
OMA	Open Mobile Architecture
OTA	Over The Air
PCMCIA	Personal Computer Manufactures' Card Interface Adapter
PCS	Personal Communication System
PoC	Push-to-talk over Cellular
PLMN	Public Land Mobile Network
POTS	Plain Old Telephone Service
PS	Packet Switched
PSI	Public Service Identities
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
QoS	Quality of Service
RAT	Radio Access Technology
RNC	Radio Network Controller
SIM	Subscriber Identity Module
SIP	Session Initiated Protocol
SMS	Short Message Service
SRNC	Serving Radio Network Controller
TFC	Transport Format Combination
TTI	Transmission Time Interval

UE	User Equipment
UMTS	Universal Mobile Telecommunication System
USIM	UMTS SIM
UTRA	Universal Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access
WIM	Wireless Internet Module
WLAN	Wireless Local Area Network

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