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Fixed Mobile Convergence Options for the Enterprise

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One of the most exciting developments to come about from the new generation of wireless communications technologies is the idea of fixed-mobile convergence. Fixed-mobile convergence or FMC describes the ability to integrate cellular and private network services allowing calls to be transparently handed off between them. While FMC is often portrayed as a mechanism to hand off calls between WiFi-based wireless LANs and cellular services, in reality the "fixed" element in FMC can be any private network, wired or wireless.

It is no secret that mobile cellular telephone service has revolutionized the way that people communicate. Millions of consumers have chosen to do without wired telephone service for their personal use, and for many business people, their cellular number has become their primary number. For enterprise users who must rely on both a wired office phone and cellular service, the ultimate combination would be a service where they could be reached on a single number regardless of where they are located, and their calls could be passed transparently passed between cellular and any other environment with no interruption in the connection.

Many have assumed that providing this type of service would require that the cellular carriers fully embrace the concept and integrate non-cellular technologies with their services. In particular, the cellular carriers would have to treat those other networks like additional cells and handoff calls to them in the same way they pass calls between base stations within their own networks. With one exception, the US cellular carriers have not embraced FMC; the exception has been T-Mobile who has introduced a consumer-oriented FMC service called HotSpot@Home . Despite the cellular carriers' reticence regarding FMC, the manufacturers of business telephone equipment have developed a number of solutions that incorporate many of the elements and deliver many of the capabilities of FMC.

In this paper we will provide a structure for understanding and evaluating the various FMC solutions that have been introduced. We will begin by looking at the overall benefits that can be derived from an FMC solution, and then describe and categorize the various FMC products and services. In each case we will examine the configuration and operation of the solution, and identify the benefits it can provide. The goal is not to "sell" any particular implementation, but rather to provide enterprise users with a background and a level of understanding they can use in evaluating solutions to fit their particular needs.

Why Use FMC?

When the idea of FMC is introduced, the most obvious benefit that emerges is cost savings, particularly the ability to reduce cellular charges. Unfortunately our current solutions are more likely to increase rather than decrease our overall costs. The major benefit users should focus on is productivity. However a well-executed FMC solution can yield benefits in terms of convenience, control, and reliability.

- Accessibility: Often grouped under the general heading of "productivity", the first major advantage of FMC would be accessibility. One of the greatest inhibitors to productivity in a modern business environment is the case where critical people cannot be reached at critical times. An FMC solution can allow a user to be reached with one call to one number regardless of where they are located, and the addition of presence capability will provide the called party's "availability" status.

- User Productivity: As well as improving accessible, FMC can also enhance productivity for the user. Calls in progress need not be terminated when the user has to leave the facility. While that scenario will probably not arise very often, a continuously available voice service would allow the user to return calls, access voicemail, and do other telephony oriented tasks while moving between meetings or during what were formerly "dead times".

- Control of the Telephone Number: While often overlooked, control of the telephone number is a critical issue for enterprises. Today outside sales and support personnel often use their personal cell phones for routine contacts with customers. However, what happens if that person leaves the company? If a salesperson goes to work for a competitor, their customers will continue to call them at that number. If customers or prospects are calling, the enterprise needs to own the number or risk having those calls go to a competitor or to a disgruntled former employee.

- Cost Savings on Cellular: You will notice that cost savings is not at the top of the list of benefits. In reality, an FMC solution will likely cost more rather than less. The Enterprise-controlled alternatives will almost certainly result in higher costs. There are scenarios in which FMC could result in cost savings, particularly if the user is making international calls and can now route them through PBX-controlled facilities, but in the end, the focus of an FMC project should be about delivering a better communications capability.

- Improved Indoor Service: In an indoor environment, wireless LANs and wired telephone services can provide significantly better quality and coverage. Even with good radio coverage, digital cell phones deliver a mean opinion score around 3.5, which is considered "marginal". A well-designed WLAN voice solution can deliver enterprise-grade voice quality (i.e. MOS> 4.0).

FMC Solutions

The confusion that surrounds FMC today stems from the variety of ways in which it might be implemented, and the fact that most discussions address only a subset of those options. The major dividing line in FMC solutions is based on whether they are controlled by the cellular carrier (i.e. Carrier-controlled) or by the private telephone system (i.e. Enterprise-controlled). Within those broad categories, there will be a number of important differences, particularly with regard to how the calls are handed off between the two environments and the level of user and management functionality they can deliver.

There is more to fixed mobile convergence than simply transferring a simple phone call. Many of the solutions today look to mobilize the full range of IP PBX features so that mobile users can have a more functional and hopefully a more productive communications service.

As the US carriers have been reluctant to introduce FMC services for enterprise users, business telephone equipment suppliers have introduced a range of FMC-type solutions that provide many of the desired capabilities. The most important attribute of the Enterprise-controlled solutions is that they can be implemented today with virtually no action on the part of the cellular carrier.

Enterprise-Controlled FMC Options

The primary difference among the Enterprise-controlled solutions lies in how (or if) they hand off calls between the networks.

- **Non-Integrated:** The first class of solutions incorporates no network integration, and no handoff capability. Cellular and WLAN functionality can be built into the same handset, and the user manually chooses the network on which to place the call. Unless these dual-mode handsets are utilized in conjunction with one of the other solutions, the user will have two phone numbers and two voicemails, one on the cellular network and one on the WLAN. Also, the cellular carriers do not subsidize the cost of dual-mode handsets, so the enterprise will be paying the full cost. Finally, with this solution there is no way of insuring that the user will actually choose the WLAN to place calls when its available.

- **Simultaneous Ring/Manual Handoff:** In this type of solution, the customer's IP PBX is programmed so that all incoming calls to the user's business number ring simultaneously on both their cellular phone and their wired or WLAN phone number; the call can be answered on either. When one of the calls is answered, the IP PBX stops the ringing on the other (See Figure 1).

In the IP PBX this feature is typically called *Simultaneous Ring*, and a subset of these systems allow the user to transfer a call in progress from the IP PBX station to the cellular connection by pressing a key. Avaya, Cisco, NEC, Nortel, and Siemens all support simultaneous ring and most provide the manual handoff capability as well.

While not as elegant as an automatic handoff, these solutions do provide many of the required features including:

- One number accessibility
- Single voicemail
- Integrated cellular and wired/WLAN service
- Enterprise maintains ownership of the number

Importantly with these systems, the caller is dialing the user's business number; the user's cellular number is stored in the IP PBX. So when the employee leaves the company, their business calls stay with the business. Further, a simultaneous ring solution does not require dual mode WiFi/cellular handsets.

One problem that persists is however is enforcement. If the user is sitting at their desk, they could still answer the call on their cell phone which would result in the call costing more than if it were placed directly to their cellular number.

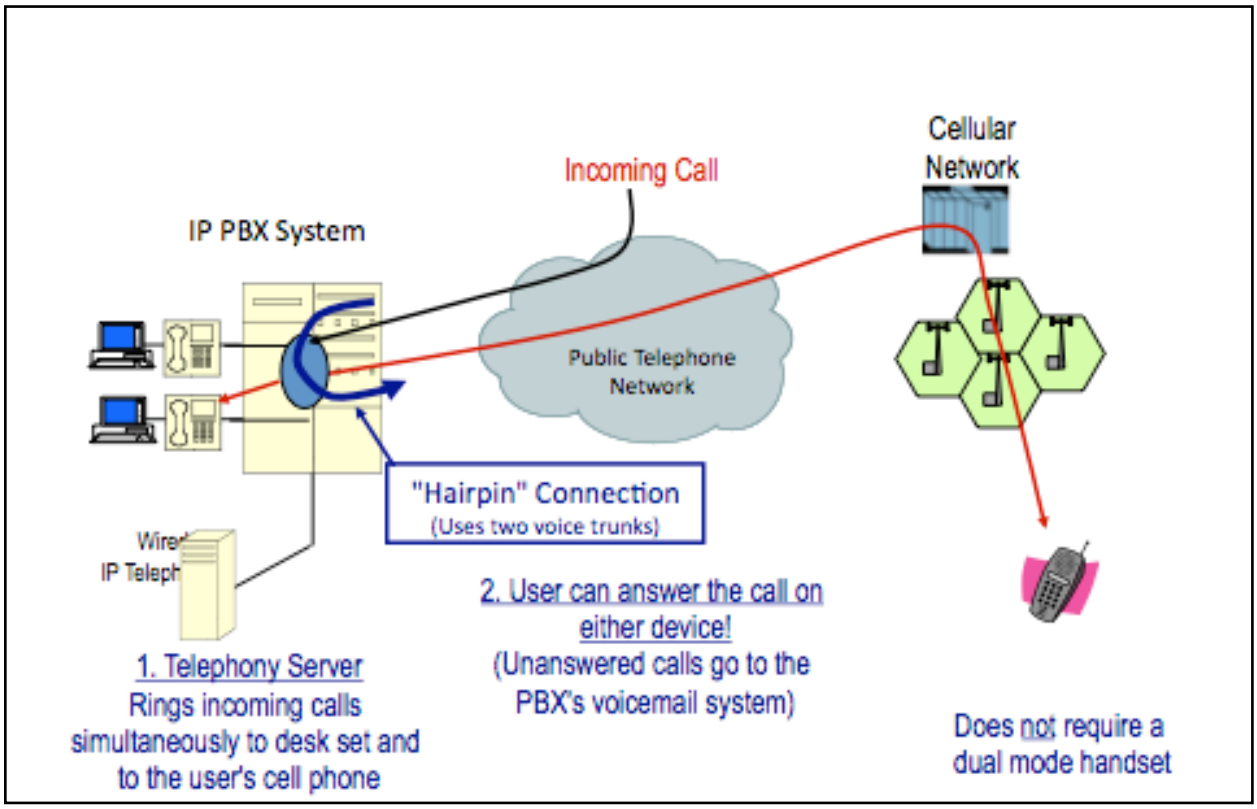

FIGURE 1: Simultaneous Ring- Manual Handoff Solution

- **Automatic Handoff:** Automatic handoff systems utilize dual-mode WLAN/cellular handsets with special software that works in conjunction with a mobility server connected to the customer's PBX. When the dual mode handset comes within range of a WLAN on which it is registered, it sends an alert to the server that it is available to receive calls over the WLAN; the server in turn alerts the IP PBX system of that status. When a call is received (or if the user initiates a call), it is automatically routed over the WLAN.

  The mobility controller continuously monitors the stations that are reachable over the WLAN. Most systems do this by querying the station regarding the strength of the WLAN signal it is receiving, though some like Agito utilize sensors at all building exits so they can recognize when a registered user is leaving. When the user moves out of WLAN range, the IP PBX is instructed to deliver that user's calls via the cellular network. Further, if there is a call in progress when the user leaves, the IP PBX calls the user at their cellular number, and the call is transparently transferred to the cellular connection (See Figure 2).

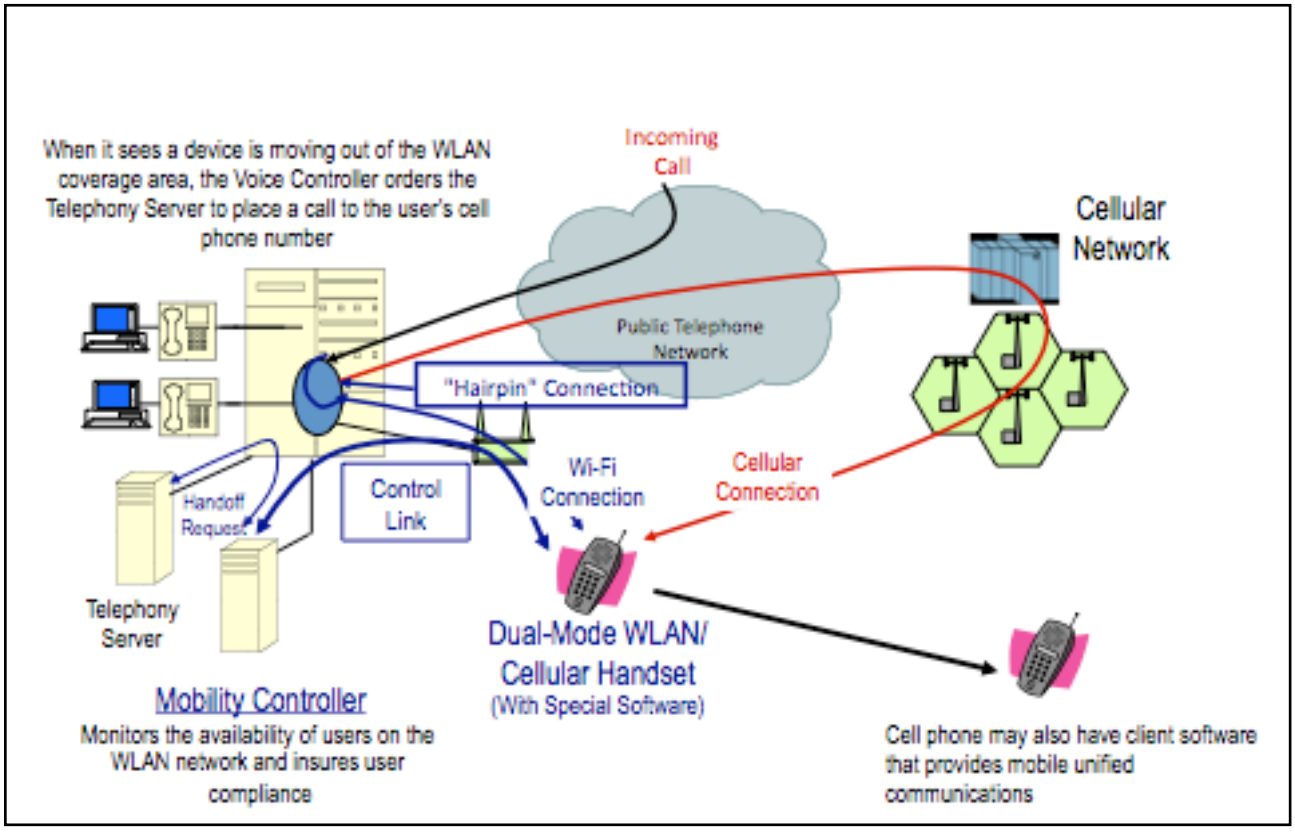

FIGURE 2: Enterprise-Controlled Automatic Handoff Solution

Like a manual handoff solution, the user gets one-number accessibility, single voicemail, and the business maintains ownership of the number.

Besides the convenience factor, the other major capability of this implementation is assured compliance. If the handset is within range of the wireless LAN, the user's calls are automatically routed that way, so the user is not free to ignore the availability of the more cost effective solution. The downside is that the vendors will have a limited range of dual mode cell phones on which they can install their software, and the cellular carriers do not subsidize the cost of those dual-mode handsets. Finally, the user's WLAN infrastructure must be voice capable and have sufficient capacity to support the volume of WLAN voice traffic generated.

Automated handoff systems can be purchased from the IP PBX vendors or from third-parties. Avaya, NEC, Nortel, and Siemens currently offer this type of solution though the NEC and Nortel systems are actually provided by FirstHand Technologies. Cisco is reportedly working on an automatic handoff capability. Along with FirstHand, Agito and DiVitas Networks also build automatic handoff systems that can be used with any vendor's IP PBX.

Mobile Unified Communications

Thus far we have focused on the task of handing off simple voice calls between cellular and other networks, but there is another important development in business telephone systems, *Unified Communications* or *UC*. Initially this enhanced functionality was limited to users who were at their desks, but mobile unified communications is extending many of these same capabilities to cellular and WLAN voice users. The level of functionality will vary depending on the UC product being used and the mobility option employed.

The cellular UC solutions depend on a special type out-of-band signaling. The user's voice calls will be carried over the regular cellular voice service, but signaling messages are exchanged over the cellular data service (See Figure 3).

Among the mobile unified communications features we typically see are:

- Corporate Directory Access: Allows a mobile user to get access to the online corporate telephone directory including the ability to view presence status on a mobile handset and then click to dial.

- True Caller ID: True caller ID provides the name and number of the actual caller rather than the PBX number when a call is forwarded to the mobile.

- Visual Voicemail: Allows the mobile user to view voicemail messages as alerts and play them in any order they choose.

- Four-Digit Dialing: The mobile user can call another station on the PBX by simply dialing the four-digit extension number, just as they would when

making a station-to-station call on their PBX desk set.

- Desk Set Features: Mobile users can get access to the major desk set features available through the PBX including multi-party conference, transfer, and the ability to place calls over the bulk rate voice services connected to the PBX.

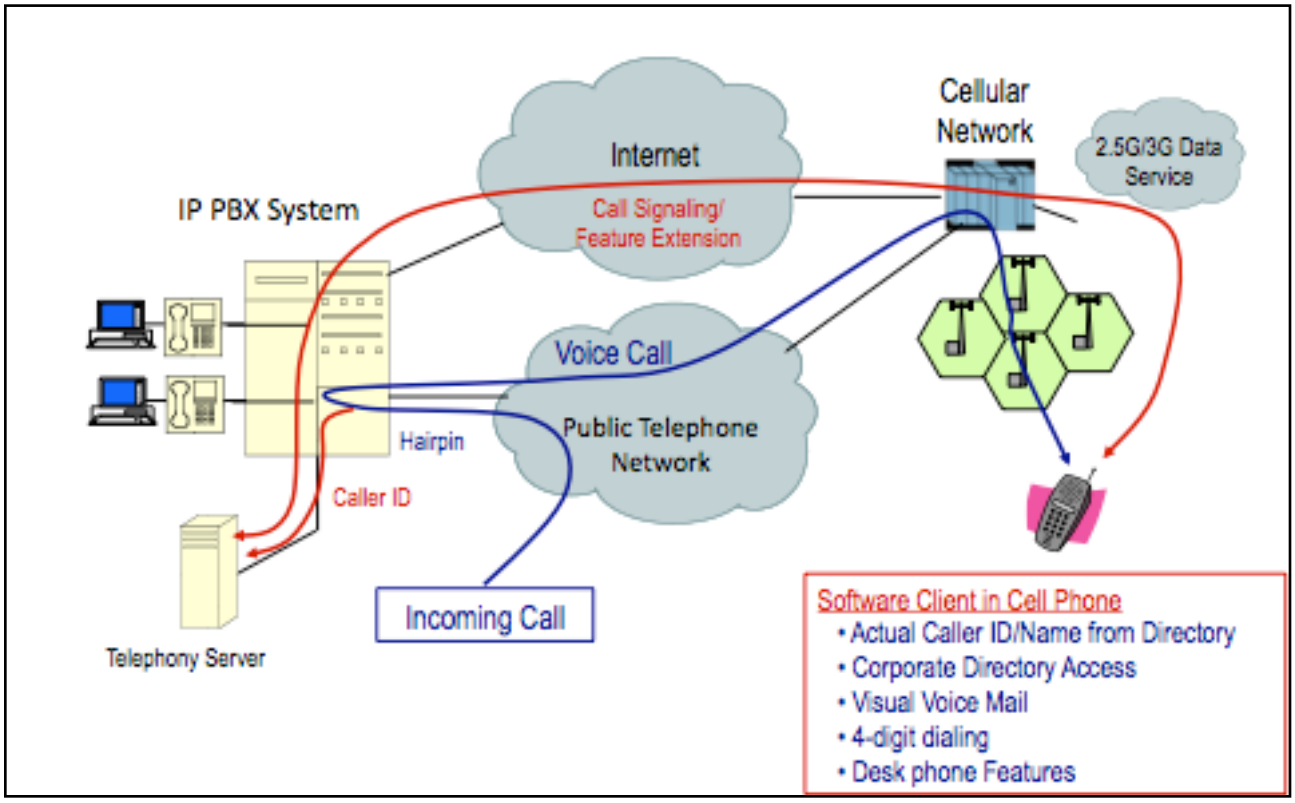

FIGURE 3: Mobile Unified Communications

To implement mobile UC over cellular networks, the handsets require special software. This type of solutions is available from Avaya, Cisco, NEC, Nortel, and Siemens. Most support a range of Nokia and RIM handsets/smartphones, and the PBX manufacturer provides the software for both the handset s and the telephony server.

Detailing the Costs

Each of the Enterprise-controlled FMC capabilities will involve a different set of elements that will contribute to the cost of the calls made and received by the mobile user. In an Enterprise-controlled solution, whether the call is forwarded by a manual or an automatic process, the cost elements involved will typically be the same:

Incoming Call to the Mobile:

1. Outgoing local call to the cellular from the IP PBX
2. Incoming cellular call to the mobile user
3. "Hairpinning": The call will also tie up two trunks on the PBX, one to carry the incoming call, and one to carry the outgoing call to the cellular number (See Figure 1).

Outgoing Call From the Mobile:

1. Outgoing cellular call to the IP PBX
2. Outgoing local or long distance call from the PBX to the called party. That outgoing call will be billed at the standard wired call rate and can be routed over the discounted long distance services connected to that IP PBX. This can be particularly cost effective for international calls
3. "Hairpinning": The call will also tie up two trunks on the PBX, one to carry the incoming cellular call and one to carry the outgoing local or long distance call.

Note: In some configurations, outgoing cellular calls could be placed directly, but that will expose the cellular number to the called party causing the enterprise to lose control of the number.

Cellular-to-Cellular Calls

In most cellular services on-net cell-to-cell calls are free, but now those call would involve an outgoing and an incoming cellular call charge, as well as hairpinning a connection through the PBX.

In short, when estimating the cost of a PBX-based FMC solution it is important to ascertain the actual cost of each of these elements, estimate the number of calls in each of these categories, and then determine what the total cost of the solution will be.

Carrier-Controlled FMC

There are fewer FMC options on the carrier side, and they fall into two primary categories: Unlicensed Mobile Access (UMA) and IP Multimedia Subsystem (IMS). There is another closely related option that the carriers are evaluating called femtocells, but that is not truly an FMC solution as it uses cellular technology exclusively.

Whichever FMC solution the carrier is deploying, it will utilize voice over IP (VoIP) technology as part of the solution. When the call is transitioned off the cellular network it is converted to VoIP in a gateway, and the packet stream is carried over an Internet service. The final delivery could use wireless LAN technology, cellular technology (in a femtocell service), or even a wired telephone (See Figure 4).

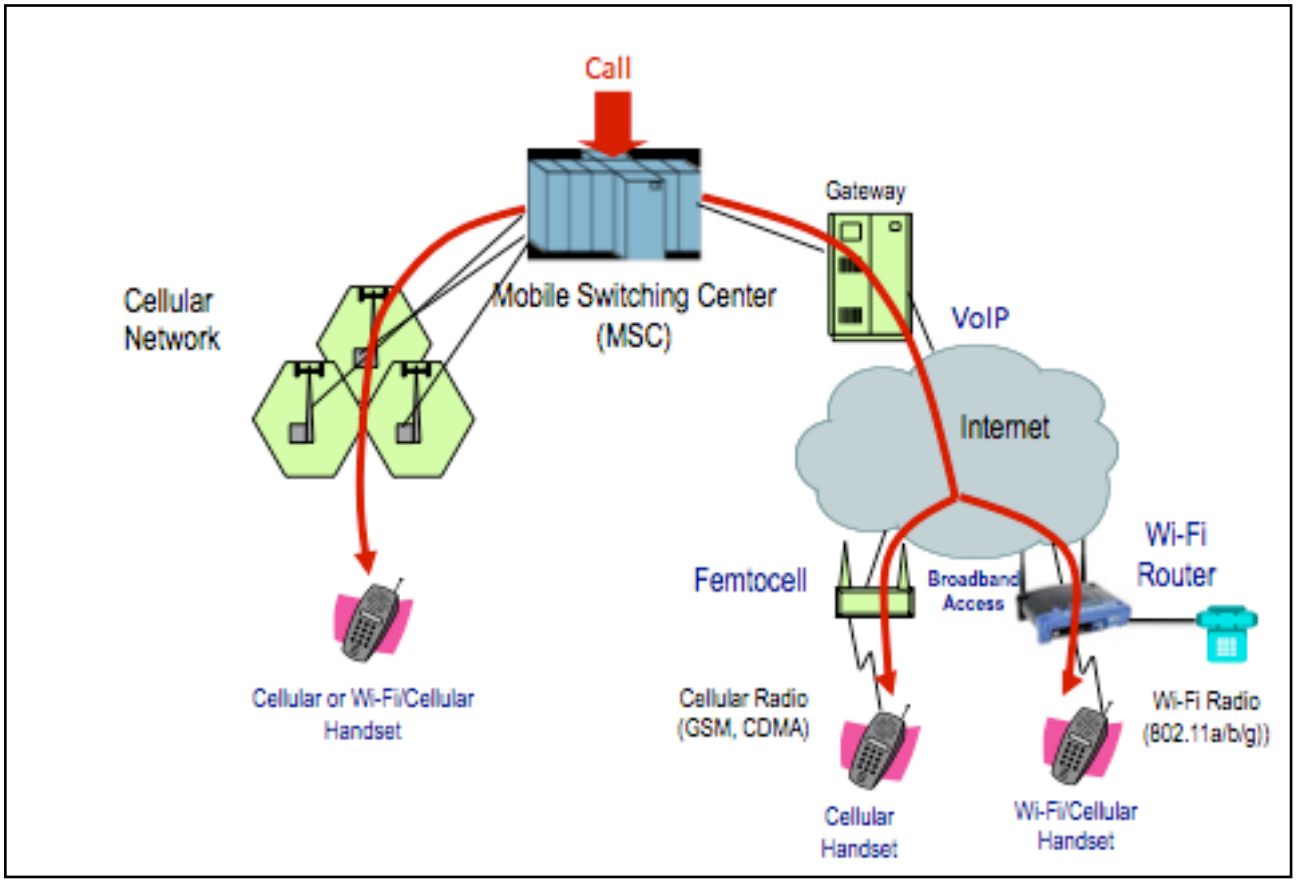

FIGURE 4: Overview of Carrier-Controlled Options

In their public comments on the potential for FMC, the carriers have expressed some concerns regarding the use of other network technologies. In particular they note that call quality might suffer if the calls are handed off to a poorly designed wireless LAN- as if their service quality was that good to begin with! Their larger concerns seem to center

on the potential impact on their revenue stream and how they will be compensated for traffic that finds its way onto another network service. At the root it appears that the cellular carriers feel that they have a unique franchise and fear any development that might put that franchise in jeopardy.

Unlicensed Mobile Access (UMA)

The two major carrier architectures for FMC are Unlicensed Mobile Access (UMA) and IP Multimedia Subsystem (IMS). The simplest comparison of the two would be that UMA provides a rudimentary FMC capability that is available today while IMS is one element in a much bigger plan, only parts of which have currently been deployed.

Kineto Wireless pioneered the UMA concept and introduced the first UMA Controller. The UMA concept has now been endorsed by the 3G Partnership Project (3GPP), and incorporated in the 3G standards. UMA is the basis for the first commercial FMC service in the US, T-Mobile's HotSpot@Home®.

As it stands today, the users would see little difference if their FMC service was provided with UMA or IMS. The cellular carriers have been investing in equipment to deliver IMS-based services, however that is being done primarily for operational efficiencies. A carrier can deploy IMS to every corner of their network, but the decision to provide an FMC service is completely independent. The cynical would observe that the carriers describe their "IMS vision" as they recognize the customers associate "IMS" with fixed-mobile convergence. So "IMS" can be used as a code word that allows them to hint at their intentions to offer FMC services without actually committing to do so.

T-Mobile's HotSpot@Home®

In mid-2007, T-Mobile became the first US cellular carrier to introduce a UMA-based FMC service called HotSpot@Home®. The service combines GSM cellular service with WiFi and offers transparent handoffs between the two environments. The plan is offered to existing subscribers with higher-priced (i.e. >$40 per month) cellular plans, and T-Mobile charges an additional $10 per month for HotSpot@Home®.

To utilize the service the customer must have broadband Internet service (ADSL or cable modem) and a WiFi router. The service supports a small number of WiFi/cellular handsets including models from Nokia, Samsung, and RIM (i.e. Blackberry). Besides the WiFi/cellular capability the handset also requires UMA software to operate on the service.

To provide the service, T-Mobile installs a UMA Controller at their central office or mobile switching center (MSC). That Controller provides the conduit between the cellular network and the Internet. When the user comes within range of their wireless LAN, the UMA software in the handset automatically sends a registration message through the WiFi/Internet link to the UMA Controller alerting the carrier that this subscriber is now available to make and receive calls over the VoIP service. If there is a call in progress, the connection is handed off to the VoIP service, and the cellular billing stops. The UMA Controller converts the transmission to VoIP (i.e. G.729A voice in RTP, in UDP, in IP) and forwards the packets through the Internet to the customer's home router that in turn delivers them via WiFi to the handset (See Figure 5).

While the user is within range of their wireless LAN, all calls will automatically be routed via the WiFi/Internet path, and there is no charge for those calls. The service is intended primarily for people who no longer have wired telephone service at home and had been using cell minutes to make and receive calls while at home.

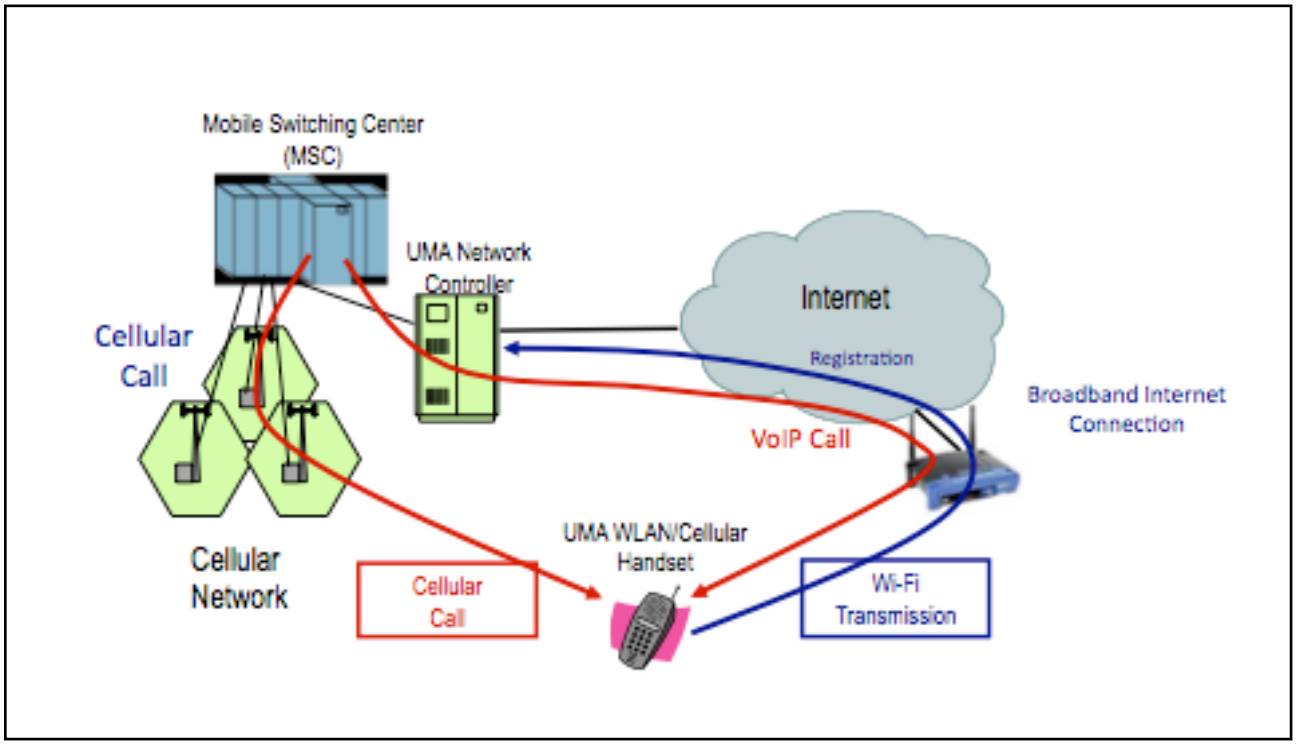

FIGURE 5: Unlicensed Mobile Access (UMA)

The major shortcoming with the HotSpot@Home® is that you have to keep your cell phone with you, and hope that the battery is charged when you need to make or receive a call.

To make the home service more like traditional wired service, T-Mobile introduced an alternative called Talk Forever Home Phone in early 2008. Like the HotSpot@Home®

service, it too depends on VoIP operating over the customer's broadband Internet connection, but it does not use the cellular number and does not hand off calls to/from the cellular service.

For the Talk Forever option, the customer must buy a special Linksys WiFi router for $50 and pay $10 per month for the service. The router has two analog telephone jacks on the back and can provide two phone lines; it also has slots to install two Subscriber Interface Module (SIM) cards. All of the calls made over the Talk Forever service are free and you can make and receive calls with your existing wired phones.

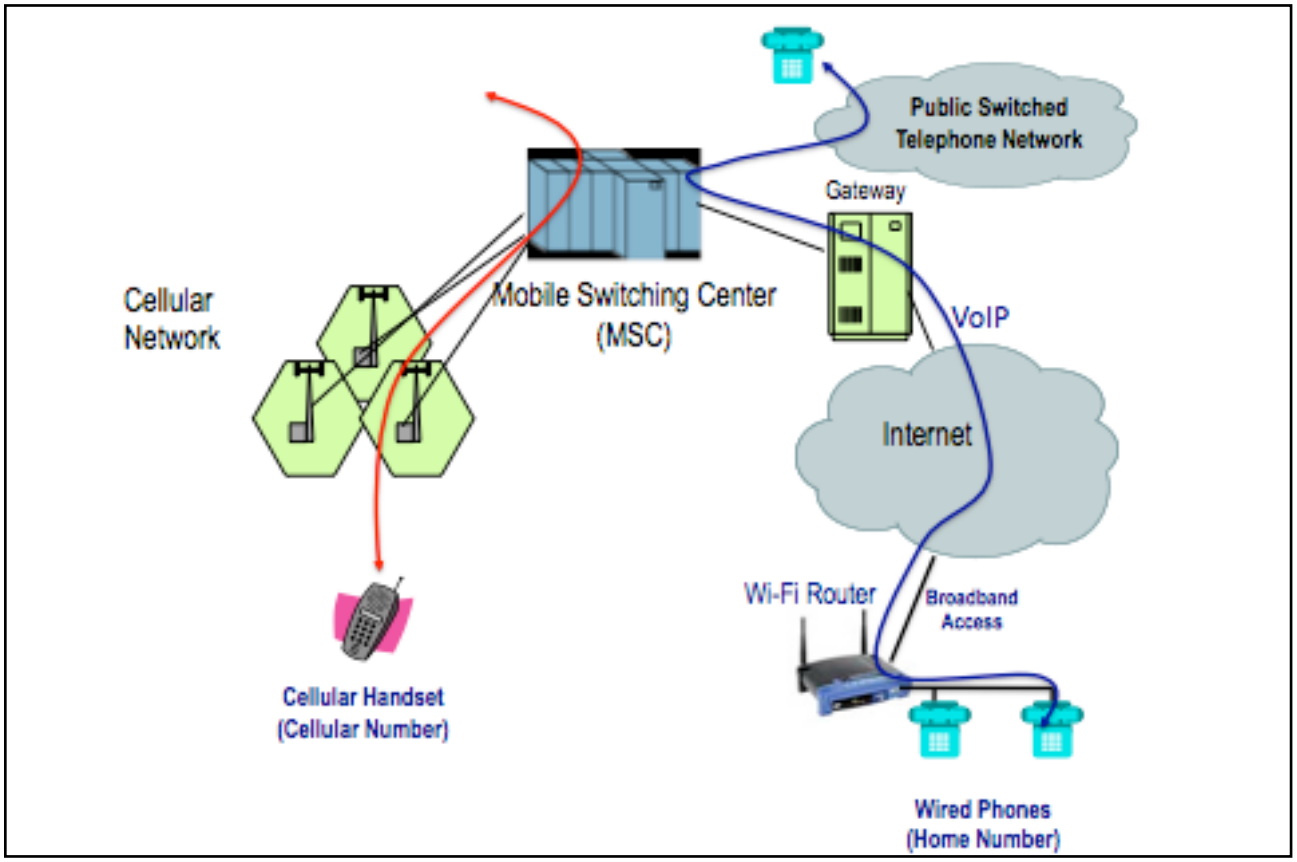

FIGURE 6: T-Mobile's Talk Forever at Home Solution

As it does not handoff calls between the cellular and WiFi networks, Talk Forever is not technically an FMC service, but you can see that it shares many of the same network elements with HotSpot@Home®. Essentially, T-Mobile is packaging the equivalent of Vonage's unlimited VoIP with their cellular service.

Enterprise UMA

While T-Mobile's new services have been widely reported, they are essentially consumer services. An enterprise implementation will have to support more than one or two phone lines. There have been attempts at getting UMA services, particularly HotSpot@Home®, to work in enterprise environments.

WLAN switch manufacturer Aruba Network has been trialing a UMA capability with their enterprise-scale WLAN equipment. In a deceptively simple trick, they substitute the network name or SSID of the corporate WLAN in the UMA handset. The solution requires the same UMA-capable WiFi/cellular handsets, and when the user comes within range of the company's WLAN, the handset register's with T-Mobile's UMA controller.

Rather than the UMA handset informing T-Mobile that it is capable of being reached over a home Internet connection and WLAN, it substitutes the corporate WLAN. As with the consumer HotSpot@Home® service, when the handset is registered as available on the WLAN, calls to that subscriber's cellular number are forwarded over a VoIP connection to the company's Internet address and delivered over the WLAN (Figure 7). The other advantage of the Aruba capability is that the user can roam anywhere within the coverage area of the corporate WLAN, and the call will be handed off from access point to access point.

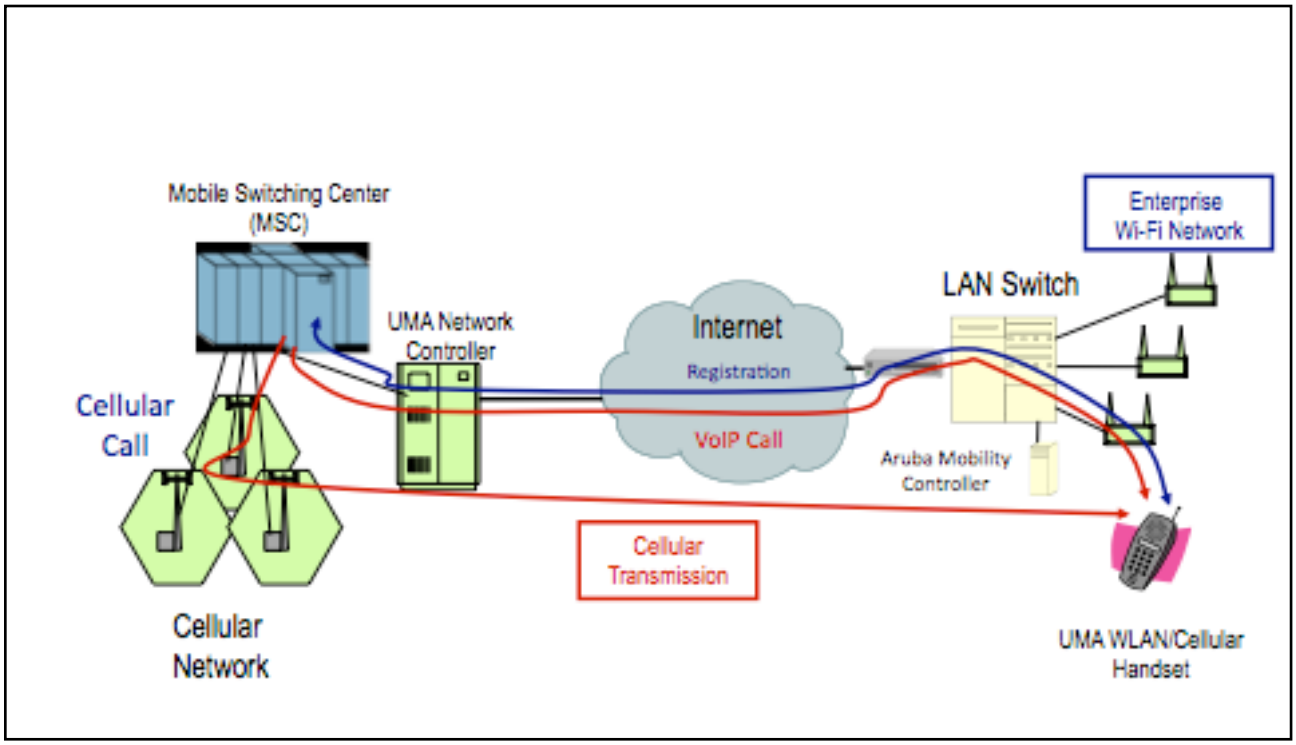

FIGURE 7: Aruba Networks' Enterprise UMA Solution

While the Aruba configuration does make UMA functionality available for enterprise users, it is linked to the user's cell phone number rather than a business number. Further, service is completely independent of the enterprise PBX system, and so has none of the Mobile UC capabilities like visual voicemail or four-digit extension dialing. However, it does demonstrate that this consumer-oriented service can be delivered to enterprise users as well.

Femtocells

The other quasi-FMC configuration the cellular carriers are testing is the femtocell; Sprint is reportedly testing a femtocell product from Samsung called Airave ®, and T-Mobile has invested in UK-based femtocell manufacturer Ubiquisys. The femtocell configuration looks much like T-Mobile's HotSpot@Home®, but the in-home wireless is cellular rather than WiFi.

A femtocell is a small cellular base station that is installed in the customer's home and connects back to the cellular carrier over the customer's broadband Internet connection (see Figure 4). When the user is out, their phone works on the cellular network. When they come home, the handset automatically registers with the femtocell and reports to the cellular carrier that they are now available to make and receive VoIP calls through the Internet and their home base station.

The different between femtocells and UMA is that the wireless connection in the home uses cellular rather than WiFi technology. As femtocells uses cellular technology rather than WiFi, there is no need to use dual mode WiFi/cellular handsets. However, like UMA, the femtocell approach is targeted at consumers rather than enterprise users.

IP Multimedia Subsystem

IP Multimedia Subsystem is a major infrastructure development in cellular networks. The overall intent is to aid the access of multimedia and voice applications across wireless and wire line terminals. IMS defines an IP-based core network that uses Session Initiation Protocol (SIP) based signaling as well as the traditional carrier-oriented SS7. The network architecture will incorporate signaling and media gateways to translate between any of the supported network interfaces.

The overall goal of IMS is: One number, one device, one voicemail, one feature set, and one bill. The FMC functionality is covered in what the IMS literature refers to as virtual call continuity (VCC).

While the cellular carriers are making investments in IMS, it is important to recognize that does not signal a commitment to actually an FMC service. IMS provides another way by which the carriers could deliver FMC service, but they still must decide if they will do so. Thus far only Sprint has conducted a publicly disclosed trial of an IMS-based FMC service called *Wireless Integration*. That service was targeted at enterprise users and included a special server installed at the customer's premises. The version that was demonstrated provided a manual rather than an automatic handoff capability.

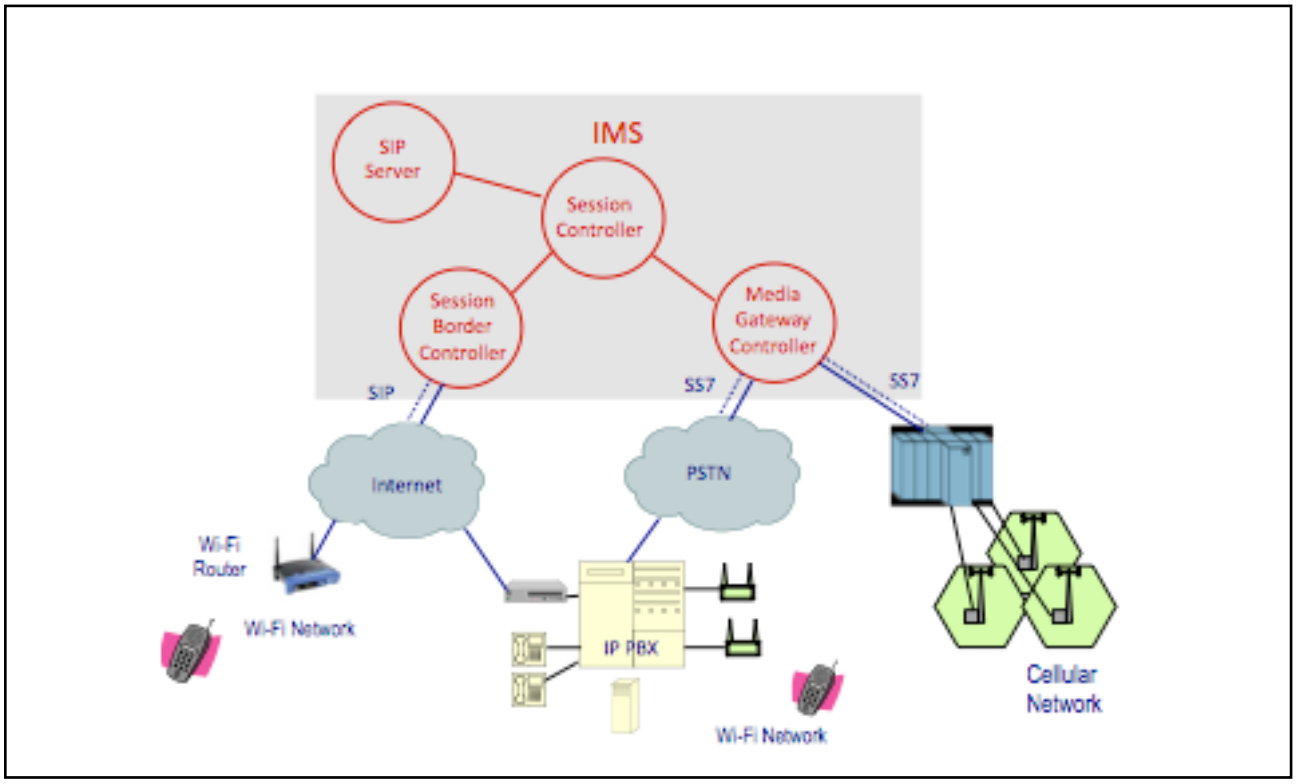

FIGURE 8: IMS Network Overview

Conclusion

As you can see, FMC capabilities can be delivered in a number of different ways using a mix of cellular, WLAN, and even wired telephone services. While the major cellular carriers in the US have been reluctant to move forward on these initiatives, there are any numbers of FMC-like capabilities an enterprise could deploy today and deliver many of the benefits with virtually no cooperation from the cellular carrier.

The challenge for enterprise users will be to understand the functionality their users require and determine the most effective way to deliver those capabilities. Further, it is essential to understand the capital and operating costs that are involved and budget accordingly. As an FMC solution will likely result in an increase rather than a decrease in net costs, a cost justification based on productivity savings might also be required to win management approval.

Fixed-mobile convergence represents an important development in network services and one that has generated considerable interest with our increasingly mobile workforce. Good information and a thorough analysis will be needed to insure that the full benefit is received.

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