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1 Introduction

Fixed-Mobile Convergence (FMC) is emerging as an ideal method to meet changing consumer demand for a wider variety of services delivered virtually seamlessly over both cellular and wireless accesses (e.g. Wi-Fi). The key to this value proposition is a dual-mode phone that can operate both as a conventional cellular handset on the road and as a WiFi device at home, in the enterprise, and in some cases at public Wi-Fi hotspots.

Handset manufacturers already have seen this opportunity. There are more than a dozen handsets coming in the market that combine Wi-Fi and cellular radios. Initially the focus is on radio related issues created by having the two different technologies in one handset. As the FMC market evolves, the capabilities of both the core network and an increasing array of handsets can evolve to deliver greater convenience to users and greater revenue and cost savings to service providers.

SIP Based Dual Mode Handsets for Fixed Mobile Convergence

The dual-mode handset is the public face of most FMC services, and provides subscribers with the flexibility of using the same device wherever cellular or Wi-Fi coverage is available. This is no small consideration for two important reasons. First, a single dual-mode handset provides simplicity to the user—it's simply easier to learn one device for access to directory information, messaging capability, feature access and general call functionality. A dual-mode handset gives the user consistent operation whether it's in the office, on the go, or in the home. In addition by taking advantage of calling patterns that reflect a majority of calls made from a Wi-Fi enabled home or office environment, FMC will shift a large portion of calling from high-cost cellular to low-cost (possibly free) Wi-Fi service—in other words, FMC can substantially reduce the phone bill. Because of simplicity and potential cost savings, FMC has become one of the most asked for emerging capabilities.

While every phone used in an FMC application will by definition be a dual-mode handset, the converse is not necessarily true. Some vendors will distribute dual-mode handsets that require manual intervention to switch between Cellular and Wi-Fi operation. Some may even automatically select a Cellular or Wi-Fi signal at registration based on the stronger signal at registration. However, for a true FMC application, the phone will not just support connection to both cellular and Wi-Fi domains; it can support full seamless handover between networks while maintaining consistency of features and functionalities.

Examining the FMC Handset Capabilities

A typical FMC handset/phone is a dual-mode device that will work in both unlicensed spectrum and cellular environments. When the handset is connected to unlicensed spectrum, it supports comprehensive SIP based VoIP functionality over WLAN. When the handset is connected to cellular, it supports either GSM or CDMA based connection via the cellular air interface and delivers service through the cellular core network.

There are two key technology challenges that affect the interaction of the dual-mode handset with the FMC core infrastructure:

- How to connect over two different radio networks.
- How to use credentials for authentication over the two radio connections.

FMC Handset Radio Attachment

A dual-mode phone designed for FMC will have separate radio technologies for cellular and unlicensed/Wi-Fi. That phone can operate in two ways: First, it can operate with both sets of radios functioning simultaneously. Both the radios are turned on and usable, and intelligence within the phone will determine which set is in active use at any one time. This method of operation is called Dual Attach (DA). The phone can also be designed so that only one radio is turned on and usable at a time, turning off the unused radio capability when not in use. This type of phone is referred to as Single Attach (SA). There are advantages and disadvantages to each approach.

In Single Attach mode, the user typically has the same directory number in both unlicensed spectrum wireless and cellular networks. The user profile with directory number is provisioned in only one network which is the home network of the user. The home network peers with the other network as a roaming network.

In Dual Attach operation, the user has two user profiles provisioned in both wireless and cellular networks—but typically only one directory number. Depending on whether the directory number is owned by the cellular or VoIP network, incoming calls are received at the one network and redirected to other network based on user preference or network connection status of the handset.

The advantages of either option are summarized in the table below:

	Single Attach	Dual Attach
End User	1. Longer battery life (N1)	1. More handset choice 2. Quicker Handover (N2) 3. Advanced call control options (N3) 4. Flexible usage of handset/softclient (N4) 5. Dual number phones (N5) 6. Customized use of both radios (N6)

	Single Attach	Dual Attach
Service Provider	1. Longer battery life (N1) 2. More efficient use of radio and network (N7) 3. Better aligned with Cellular roaming model (N9)	1. More handset choice 2. Quicker Handover (N2) 3. Advanced call control options (N3) 4. Flexible usage of handset/softclient (N4) 5. Dual Number phones (N5) 6. Customized use of both radio (N6) 7. Lower CAPEX, leveraging GSM features e.g. SMS, E911 (N8)

Additional Notes on Single Attach Benefits

N1: Longer Battery Life – If only one radio is turned on at a time, battery capacity is preserved. Since only one radio is active, handover between wireless domains will take longer as the idle set of radios needs to initialize before any authentication with an alternate network can take place. This delay may result in degraded service, especially when one radio signal fades abruptly.

N7: More efficient use of radio and network – In Single Attach, the operator may pre-configure the phone to work in “Wi-Fi preferred” mode, so that whenever possible, the wireless network is used to save more expensive cellular radio. The cellular radio is typically more expensive than the wireless radio, especially for multimedia applications.

N9: More aligned with Cellular roaming model – If a phone is attached to only one radio at a time, the wireless network can peer with cellular network as a roaming network. Since features in the cellular network follow this network model, convergence of cellular features across network boundaries may be easier technically.

Additional Notes on Dual Attach Benefits

N2: Quicker Handover – Since both set of radios are active, the handset is connected with both networks at the same time and handover can be completed more quickly, creating a more seamless user experience, especially when one radio signal fades abruptly.

N3: Advanced Call Control Options – A user can decide which network to use based on criteria such as the nature of the call, related tariff, or associated features. A user can change options down to a per call basis. This is true not only for outgoing calls, but also for incoming calls. An incoming call can be routed by the network, based on user preferences defined in the user profile.

N4: Flexible usage of handset/softclient – With a Dual Attach model, FMC can be

implemented using multiple handsets if the user prefers so. An example where this may be the preferred approach is in using the current cellular phone while adding FMC capability through the incremental addition of a softclient on a device like a PC or PDA. The user shares the same number, uses both the phones interchangeably or at the same time.

N5: Dual Number Phones – In some markets, legal requirements or consumer preference requires two separate telephone numbers—one in the cellular domain and the other for unlicensed wireless. Although, this can be realized by a Single Attach phone also, a much better user experience can be provided by a Dual Attach phone. A user can decide which network/number to use based on the nature of the call, related tariff, associated features, etc. A user can make these selections on a per call basis.

N6: Customized use of both radios – An FMC user can use both the radios at the same time. For example, a user can download music from a Wi-Fi hotspot while at the same time receiving a voice call over cellular.

N8: Lower CAPEX, leveraging GSM features e.g. SMS, E911– There are features native to the cellular technology that are not yet fully standardized for wireless access, and implementation of such features for wireless access may be technically challenging or result in interoperability issues. If both networks are accessible at the same time, such features can be continued to be supported over the cellular network, simplifying network design, reducing the CAPEX for FMC services.

User Authentication

The network needs to authenticate an FMC user to provide services. However, for authentication, a user can have only one set of credentials for both the wireless and cellular networks, or two separate sets of credentials, one for wireless and the other for cellular.

The choice of user credentials for the cellular network is defined by the cellular technology the phone supports, such as 2G, 3G, etc. Typically, such credentials are stored in the SIM/USIM cards.

However, the user credential on the unlicensed wireless side has multiple options, and no single leader has emerged. Out of the various options, the most common is the use of SIP MD5 Digest username/password, stored in phones internal permanent memory. The phone works like a regular VoIP SIP device in the unlicensed wireless network. The second option is to reuse the cellular credentials stored in the SIM card. Two options under this category are using EAP-SIM for AAA over WiFi and “cellular authentication over wireless”, in which the authentication over unlicensed wireless is performed similar to the cellular network. A third method is to use two separate sets of credentials, stored in the same SIM card. Finally, two separate credentials can be maintained in two separate SIM cards.

Although there are many technical possibilities, we will categorize the authentication options at the wireless side into just two broad categories: Single Credential (SC) and Dual Credential (DC). As their names imply, SC uses only one set of credentials used for authentication over both unlicensed and cellular wireless networks, and in Dual Credential mode, two separate sets of credentials are used. The most typical case of SC is the use of SIM credentials for both cellular and wireless. On the other hand, the most typical case of DC is the use of MD5 Digest credentials of phone’s internal memory for the wireless network and the SIM credential for the cellular network.

The end user experience and also that of the service provider might vary depending on the option chosen. The advantages of either option are summarized in the table below:

	Single Credential	Dual Credential
End User		1. More handset choice (N10) 2. Two phones, PC softclient (N11) 3. Local SIM while roaming (N12)
Service Provider	1. Simplified provisioning, SIM plug-and-play (N13)	1. More handset choice.

Additional Notes on Dual Credential

N10: More Handset Choice – The dual mode handset market is at its very early stage, especially for converged services. IMS handsets are not yet available in large scale. The general trend is to merge (not converge) an existing cellular phone and SIP phone into one physical device. On the wireless side, the phone works just as a regular SIP phone. Similarly, on the cellular side, it works as a regular cell phone. Basic support for convergence of services, such as handover is typically available on top of this merged architecture in the handset.

N11: Two phones, PC softclient – Because the credentials at wireless side and cellular side are decoupled, the applications of FMC can surpass the boundary of dual mode handset and include two separate phones, say one plain old cellular phone and another just a PC softclient. The user shares the same number, uses both the phones at the same time or uses only one.

N12: Local SIM while roaming – Though service providers not always promote this option, often travelers (especially International ones) prefer to use local SIM cards to avoid steep roaming tariff. Decoupling of cellular and wireless credentials facilitates use of local SIM cards. An FMC user can buy a SIM card from the local market (of course gets a new number) and use for cellular calls. When wireless network is available, he still can use VoIP calls using his old number. There are certain potential trade-offs when a local SIM card is used. If the local cellular provider does not have any business agreement with the user’s service provider at home, service convergence may not work seamlessly.

Additional Notes on Single Credential

N13: Simplified Provisioning, SIM plug-and-play – Through the use of a single credential, for example the GSM credential in the SIM card, the service provider can decouple handsets from customers – in the same way the GSM works. The service is granted based on the SIM information on both cellular network and wireless network.

Conclusion

We have discussed various dual mode handset options for FMC networks. The dual-mode handsets are categorized into two major categories – Single Attach and Dual Attach. The handsets are further divided into Single Credential and Dual Credential. We have discussed the major advantages and disadvantages of each category from end user and service provider perspective. In early FMC deployments Dual Attach, Dual Credential handsets should dominate based on wider handset choices and superior end user experience.

The UTStarcom Solution

UTStarcom is one of the leaders in recognizing the great value of FMC, and have developed a solution that provides a complete end-to-end solution, leveraging our vast experience in handset and core network development. UTStarcom FMC solution is branded as Continuity®. It supports dual mode handsets with GSM/CDMA and Wi-Fi/SIP. It is geared towards achieving the expectation of service providers, consumers and equipment manufacturers and supports working with all options of dual mode handsets described in this paper.

Acronyms

AAA	Authentication, authorization and accounting
CAPEX	Capital Expenditure
CDMA	Code Division Multiplex Access
DA	Dual Attach
DC	Dual Credential
FMC	Fixed Mobile Convergence
GSM	Global System for Mobile
IMS	IP Multimedia Sub-system
PDA	Personal Digital Assistant
SA	Single Attach
SC	Single Credential
SIM	Security Information Management
SIP	Session Initiation Protocol
VoIP	Voice over Internet Protocol
Wi-Fi	Wireless Fidelity, IEEE 802.11
WLAN	Wireless Local Area Network



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UTStarcom is a global leader in IP-based, end-to-end networking solutions and international service and support. The company sells its broadband, wireless, and handset solutions to operators in both emerging and established telecommunications markets around the world. UTStarcom enables its customers to rapidly deploy revenue-generating access services using their existing infrastructure, while providing a migration path to cost-efficient, end-to-end IP networks. Founded in 1991 and headquartered in Alameda, California, the company has research and design operations in the United States, China, Korea and India. UTStarcom is a FORTUNE 1000 company. For more information about UTStarcom, visit the company's Web site at www.utstar.com

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