WLAN-Cellular Integration for Mobile Data Networks

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ABSTRACT
The harmonization of next generation wireless networks is the responsibility of IMT-2000 whose specifications address things such as a unified seamless infrastructure to provide communication anywhere, at anytime, between different networks, with higher data rates, and an expanded range of services [1]. There are three mobility aspects of the IMT-2000 specifications: personal, service, and terminal mobility. This paper discusses the integration of WLAN (Wireless Local Area Network) and cellular data networks; to provide high-speed data services in areas known as “hot-spots”, with the use of one device that supports a seamless infrastructure between WLAN and data services provided by public cellular systems.

General Terms
Measurement, Documentation, Performance, Design, Economics, Standardization

Keywords
WLAN Cellular Integration, WLAN 3G Convergence, 3G networks, GPRS, CDMA 1X, Wireless LAN, IMT-2000, wireless networks

1. INTRODUCTION
The IMT-2000 effort is aimed to unite next generation wireless networks into common global specifications. One of the key mobility aspects, terminal mobility, is aimed to provide seamless wireless communication anywhere, anytime, between different heterogeneous networks as a terminal moves about within these networks.

A typical cellular data user today is spoilt with the high-speed internet at the office and/or home but is faced with slow connectivity to wireless cellular data networks such as GPRS and CDMA 1X. There exists a demand today to somehow provide higher data rates over wireless cellular data networks. This can be accomplished with third generation (3G) wireless networks; however, they are not expected to be deployed for years to come. An alternate solution to 3G networks is WLAN. WLAN has proven to be an excellent wireless network and can be used to provide high-speed wireless data in a small area.

The integration of WLAN into cellular networks will provide users in “hot-spot” areas to use the high-speed wireless network, and when outside a hot-spot coverage area, use the cellular data network. This is however not simple to implement as it must provide services such as: session continuity, integrated billing and authentication between networks, inter-carrier roaming, and most importantly, provide a seamless user experience. The European Telecommunications Institute (ETSI) has provided two generic approaches for interworking between WLAN and cellular data networks. Based on these approaches, leading telecommunication vendors have developed the necessary hardware and software to implement the interworking of WLAN and cellular data networks, specifically GPRS, UMTS, and CDMA 1X. The focus in this paper will be on GPRS and UMTS only.

This paper discusses the various aspects surrounding the WLAN Cellular integration with a look at the architecture of the integrated networks, including the different components of it. The focus will be on GPRS and UMTS cellular data networks and not CDMA 1X, although the general concept is similar. As well, a discussion is presented at a new idea termed “The ‘Mobile’ Hot-Spot” to provide high-speed wireless data access in rural areas.

2. BACKGROUND
Cellular data networks have existed for over 10 years now, but it is only recently that speeds have become somewhat fast with the introduction of GPRS (General Packet Radio Service) on GSM networks and 1X technology on CDMA networks. GPRS provides speeds up to a theoretical maximum of 171.2kb/s but in reality only 50kb/s, while CDMA 1X can provide speeds up to 144kb/s but 80kb/s in reality. Future cellular networks such as UMTS will provide speeds of up to 2MB/s however this is not expected to be deployed anytime in the near future in North America. WLAN provides a solution to this.

WLANs have existed for many years, but it is only recently that it is being recognized as a feasible high-speed wireless data access solution. With speeds up to 54 Mbps and cheap access points, WLAN can provide a wide area solution with the use of several access points. Several companies around the world have deployed access points in places such as hotels, airports, and coffee shops. These areas are known as “hot-spots”; areas where it is likely people will use the wireless service. With already millions of cellular users, the demand for higher speed wireless data access exists today and cellular service providers are seeking solutions to provide this to their customers. Since 3G (Third Generation) networks are not expected to be deployed widely in the near
future, service providers are looking to integrate their existing cellular data service (e.g. GPRS, EDGE, CDMA 1xEV-DO) with WLAN, as an alternative to provide high-speed wireless data access in “hot-spot” locations today. The following sections discuss the proposed WLAN-Cellular Integration architectures.

3. WLAN-Cellular Integration Architectures

The integration of WLAN and Cellular Networks is not as simple as it may seem; many issues exist for which solutions are required. Session Continuity, integrated billing and authentication, inter-carrier roaming, developing a dual band device (WLAN & cellular data), and providing a seamless user experience are some of these issues. The 3GPP (3rd Generation Partnership Project) has provided a standard for GPRS and WLAN (802.11b) integration and the 3GPP2 (3rd Generation Partnership Project 2) has introduced a standard for CDMA 1X and WLAN (802.11) integration. These standards have arisen from ETSI’s two generic approaches for interworking WLAN and cellular GPRS/UMTS data: loose coupling and tight coupling. They differ in the method by which they are connected to the cellular data core network (GPRS/UMTS).

3.1 Tight Coupling

The ETSI approach known as tight coupling is wherein the WLAN is directly connected to the GPRS/UMTS core network. In this architecture, all the WLAN traffic goes through the GPRS/UMTS core network giving the ability to the service provider to exclusively own and operate the WLAN network. The benefits of such an architecture is it reuses the cellular data core infrastructure, hence alleviating the need of separate authentication and billing systems, while also providing access to core services such as SMS (Short Message Service) and MMS (Multimedia Message Service).

3.2 Loose Coupling

Loose coupling is the other ETSI approach for interworking WLAN and GPRS/UMTS cellular data networks. In this architecture, the WLAN network would be an access network “complementary” to the cellular data network; it would not be connected directly to the core GPRS/UMTS network. This gives rise to problems such as billing and authentication that are overcome by providing WLAN direct access to external data networks and having a common location for this. The only benefit of this approach is it allows for easy roaming between various third party WLAN and cellular data networks, which is an important requirement as many service providers exist.

4. THE “MOBILE” HOT-SPOT

The integration of WLAN and cellular data will provide a user with a dual mode device the ability to have high-speed wireless data access in hot-spots, and to fallback to the cellular data network when outside hot-spot areas. What solution can be provided to introduce WLAN to non-hot-spot areas such as small towns or villages where they may be a special event occurring that demands a high speed wireless data access network? Is it possible to set up a hot-spot but that would require time and the demand is only temporary for a short term. The concept of a “Mobile” Hot-Spot would provide a solution for this as it would be a temporary hot-spot that is quick to set-up and tear down. It differs from a regular hot-spot in that it is connected to the cellular data core network by a wireless interface rather than a wired interface. Such a hot-spot would give the ability to provide high-speed wireless data access quickly, anywhere, at anytime where there is a cellular data network such as GPRS, EDGE, CDMA 1X, or UMTS. There is however one major problem that exists; the wireless cellular interface is much slower than the WLAN, hence creating a bottleneck. This can be overcome by combining several voice channels and using inverse multiplexing to increase the data rate. The disadvantage of this technique is it will reduce the number of voice calls that can be made. This trade-off decision will be required to be made by the service provider to determine what is feasible. In theory, the concept of a “Mobile” hot-spot is possible, however it must first be determined if there is a market for this and to assess the trade-offs that will exist.

5. CONCLUSIONS

The demand for high-speed data access over wireless networks exists today and since 3G networks are not expected to be widespread for years to come, cellular service providers look to integrate WLAN with their current data network as an alternate cheaper solution to provide high-speed wireless data access in hot-spot locations today. The hardware and software to accomplish this already exists and later this year, many cellular service providers such as T-Mobile and AT&T Wireless will have deployed WLAN hot-spots that will be integrated with their existing GSM cellular network. Other companies such as Bell Canada have already deployed WLAN hot-spots that are integrated with their existing CDMA 1X network. The concept of a “Mobile” Hot-Spot is an idea that can provide a temporary high-speed wireless data solution to areas that demand it. There is currently no work being performed on this and hence no solution exists. As the new integrated WLAN and cellular networks become more widespread, there may perhaps be work done for “Mobile” Hot-Spots.

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7. REFERENCES


