15 UMA-based Fixed Wireless and Cellular Mobile Networking Solutions and Products

15.1 What is Unlicensed Mobile Access or GAN?

Unlicensed Mobile Access (UMA) is an architecture and a set of specifications that provides convergence of cell-based mobile radio GSM/CDMA networks with IP-based fixed wireless access networks. Examples of fixed wireless networks include IEEE 802.11 a/b/g WLANs, IEEE 802.16 WMANs (WiMAX), IEEE 802.20 Ultra Wideband, IEEE 802.15.1 Bluetooth WPANs, and Near-Field Sensor Networks. UMA subscribers are provided with total location, mobility, and service transparency.

UMA development was initiated in January 2004 by a group of mobile service infrastructure providers and mobile handset manufacturers: Alcatel, AT&T Wireless, British Telecom, Cingular, Ericsson AB, Kineto Wireless, Motorola, Nokia, Nortel Networks, O2, Roger Wireless, Siemens AG, Sony Ericsson, and T-Mobile. By mid 2005, key components of the UMA specifications, dealing with user, architecture, protocols, and conformance testing aspects were developed. These specifications were submitted to the 3G Partnership Project (3GPP), as part of a work item called “Generic Access to A/Gb Interfaces”. Since then, these specifications, also known as TS 43.318, have been approved and incorporated in 3GPP Release 6 documentation. Consequently, the UMA initiators have decided to disband the independent working group and to continue their effort under the umbrella of the 3GPP organization. Since its adoption by the 3GPP, the UMA name has been changed to Generic Access Network (GAN). However, the old name is still used in technical and marketing circles, so for this reason, we will continue to use it in this book.

UMA specifications allow development of high performance voice, data, and multimedia services over WLANs that are located in homes, offices, hot-spots, or metropolitan areas. UMA uses dual-mode, tri-mode, or multi-mode mobile phones for communications over unlicensed spectrum technologies such as IEEE 802.11x WLANs, Bluetooth WPANs, and WiMAX.

15.2 UMA-based Network Architecture

Unlicensed Mobile Access Networks (UMANs) are parallel radio access architectures that interface with the existing terrestrial mobile public network components. UMAN
allows transparent handover to and from **GSM/GPRS/EDGE** Radio Access Networks (GERAN) and **Wireless Local/Personal Area Networks** (WLANs and WPANs). A specialized **UMA Network Controller** (UNC) or **Generic Access Network Controller** (GANC) is needed. This controller has similar functionality and connectivity as the Base Station Controllers (BSCs) in core mobile networks. Since the land-based mobile core network remains unchanged, it is possible to deliver full service and operational transparency across fixed-mobile networks. Standard Access Points and broadband IP-based networks are used for communications. The high-level UMA-based network architecture is shown in Figure 15.1.

Two components make up the new UMAN network: the dual mode **Mobile Stations** (MS), generally in the form of mobile handsets and portable terminals, and the **UMA Network Controller** (UNC). UNCs are collocated with mobile core network components and their coverage depends on the area designated to support WLAN/GSM convergent services. UNCs support discovery, registration, intra-system handover to other UNCs and inter-system handover between WLANs/WPANs and the **GSM/GPRS EDGE** Radio Access Network (GERAN).

In this diagram, the public land-based Mobile Core Network (MCN) is represented by the Mobile Switching Center (MSC), Home/Visiting Location Registers (HLR/VLR), and the Authentication, Authorization and Accounting (AAA) server. All these components provide well-known roaming and security features in traditional cellular mobile networks. Voice services are provided through the “**A**” **interface** while data services are provided through the “**Gb**” **interface**, via the SGSN.

### 15.3 UMA/GAN-based Networking Overview

UMA/GAN is a fixed-mobile convergent network and a technology that allows transparent access and roaming between cellular mobile wide area networks and fixed wireless local and personal area networks. This is accomplished by using dual-mode or...
multi-mode mobile phones. The use of a single handset and a single phone number are key features of UMA/GAN technology. This convergence is applicable to those second and third generations of mobile networks that are based on GSM/GPRS and UMTS. These architectures were shown in figures in the previous sections. The change in name of Unlicensed Mobile Access to Generic Access Network is very much related to the ambiguous connotation of the word “unlicensed” which has sometimes been construed as illegal. In any event, all the technical considerations regarding UMA remain the same with the GAN.

The landscape of fixed-mobile convergence, using dual-mode or multi-mode handsets, is by far more fragmented than the one suggested in the introduction to this chapter. In addition to UMA/GAN, there are three other proposals and implementations: MobileIGNITE Alliance (Integrated Go-to-Market Network IP Telephony Experience), SCCAN (Seamless Converged Communications Across Networks), and GSM Interworking Profile (GIP).

MobileIGNITE is a SIP-based signaling and convergence technology promoted by BridgePort Networks. Collaborating with them are: Kyocera Wireless, Bingo Wireless, and several SIP and wireless infrastructure vendors. So far, however, there has been no support from the larger mobile carriers. This technology uses the VeriSign software, a pilot implementation that has Net2Phone as an operator. More details are provided in Section 16.14.

SCCAN was initially promoted by Avaya, Proxim, and Motorola, later joined by Chantry Networks (now Siemens), Colubris Networks, Meru Networks, and 2Wire. SCCAN extends PBX functionality to mobile employees in and out of the enterprise. It is focused on Voice over WLAN and mobility management between WLANs and cellular networks. It was tested as part of the Syracuse University Real-World Laboratory.

GSM Interworking Profile (GIP) or simple Interworking Profile (IWP) is a follow-up on the attempt to converge DECT cordless phones with GSM mobile phones. It is based on DECT standards, implementing DECT/GIP. It requires an infrastructure to connect DECT base-stations supporting DECT/GIP to GSM networks.

### 15.4 UMA-based WLAN and GSM/CDMA Convergent Networking Solution

A good example of the convergence of networks having the UMA Network Controller (UNC) component as the core, and based on the UMA architecture and specifications, is that between WLANs and mobile GSM/CDMA. This is shown in Figure 15.2.

The core mobile network provides interconnectivity within the mobile world and connectivity to the wired world PSTN and to the Internet through a GSM/GPRS data-oriented network. The mobile agents/clients are UMA-enabled handsets or terminals that support both WLANs (802.11x or HiperLAN2) and WPANs (Bluetooth or ZigBee).
15.5 Advantages and Disadvantages of the UMA/GAN Technology

The advantages of implementing UMA/GAN derive from the following aspects:

- Use of unlicensed portions of the frequency spectrum for convergent fixed wireless networks, such as those used in WLANs (IEEE 802.11x) and WPANs (IEEE 802.15x);
- Use of existent GSM/GPRS and EDGE/UMTS network infrastructure with no essential changes; only the addition, for convergence, of the UNC/GANC component to support the UMA/GAN architecture;
- Leveraging on existent cellular mobile voice, data, and multimedia services and applications;
- Extension of cellular mobile physical coverage by adding cheap arrays of WLAN access points and Bluetooth-enabled masters;
- Providing high transmission bandwidth at lower cost, usually a fraction of the cost of pure mobile networks; this will serve to reduce loads on congested mobile networks;
- Use of common, dual-mode or multi-mode GSM/CDMA handsets instead of two different phones: a Wi-Fi phone and a regular cellular mobile phone;
- Bundling mobile services with WLAN services in traditional hot-spots (such as the case with T-Mobile);
- Use of VoIP services and Internet network and service infrastructure, both at no cost or lower costs, in comparison with traditional mobile networks data services.

There are some disadvantages that come with the implementation of UMA/GAN:

- Use of more expensive, complex, heavier handsets;
- The relatively high power requirements for WLANs may drain batteries faster, a critical feature for mobile users;
- The current UMA/GAN implementations are focused on 2G and 2.5G mobile networks convergence, so future generations of mobile networks will require enhancements, yet to be standardized;
- It is not clear yet what the charges, and resulting impact on the mobile service revenues, will be for UMA/GAN types of services.

### 15.6 UMA/GAN Standard Specifications

UMA/GAN specifications, prior to their adoption by 3GPP in June 2005, were developed by the [Unlicensed Mobile Access Consortium](http://www.umatechnology.org) (UMAC). The UMA/GAN 3GPP specifications are contained in the [TS 43.318](http://www.3gpp.org) and [TS 44.318](http://www.3gpp.org) technical standards. These specifications, known as Release R1.0x UMA, consist of the following distinct parts:

- UMA Stage 1 Specification (*User Perspective*), last update September 2004;
- UMA Stage 2 Specification (*Architecture*), last update May 2005;
- UMA Stage 3 Specification (*Protocols*), last update May 2005;

There are other standard activities that contribute to the development and implementation of FMC such as:

- ETSI TISPAN, ([www.etsi.org](http://www.etsi.org));
- 3GPP2 IMS Consortium, ([www.3gpp.org](http://www.3gpp.org));
- IETF SIP Working Group, ([www.ietf.org](http://www.ietf.org)); and
- CTIA & Wi-Fi Alliance, common dual-mode handsets testing, ([www.ctia.org](http://www.ctia.org)), ([www.wi-fi.org](http://www.wi-fi.org)).

It is planned to have the UMA network access specifications compatible with the IP-based Multimedia Subsystem (IMS) recommendations developed by the 3G Partnership Project. IMS will provide convergence of GSM/GPRS/UMTS/CDMA networks with any wireless and wired network. UMA is viewed as an FMC access technology where IMS is a long-term service-oriented technology. Additional technical and implementation-based information can be found at the ([http://www.umatechnology.org](http://www.umatechnology.org)) website.

### 15.7 UMAN UNC Design Requirements and Functionalities

UNC is the core component of the UMA network architecture. As noted above, UNC communicates with the mobile core network through the “A” interface for circuit switched voice services, and with SGSN, through the “Gb” interface, for packet data services. Connectivity with multi-mode terminals is through the “up” interface that relays user and signaling information. The primary functions of the UNC are:

- Provides discovery, registration, and redirection of services to allow the mobile stations to connect to the appropriate UNC's (provisioning, default, current);
• Provides secure, private, communications over open IP networks between each mobile station and the service provider core network. UNC contains a security gateway that implements a secure IP interface towards each mobile station, using IPsec tunnels. The tunnel assures data integrity and confidentiality while authentication is provided through the RADIUS interface to an AAA server;
• Relays core network control signaling for higher layer stations and GSM/GPRS;
• Sets up and tears down UMAN bearer connections for circuit and packet services;
• Transcodes the voice bearer from Voice-over-IP transport to voice-over-circuit transport towards the conventional PCM-based A interface;
• Emulates paging, handover, and similar radio access procedures for UMAN mobile access; and
• Provides standards-compliant A and Gb interfaces with appropriate physical, signaling, and bearer interfaces.

15.8 UMAN UNC Discovery and Registration

UMAN discovery and registration allows UMA-enabled mobile stations to access UMA services, assuming there is UMA/UNC support throughout a larger coverage area. The discovery and registration process is depicted in Figure 15.3.

Figure 15.3 Discovery and Registration in UMA Networks

Regular voice services, including roaming, are provided through MSCs that have connectivity to the PSTN network. Regular data services are provided through
GSM/GPRS EDGE networks that contain GGSNs, not shown in the diagram. Inter-
spersed within the global cellular domains, there are islands of WLAN/WPAN Access
Points with direct connectivity to the Internet through a router-based network. Each
UMA/UNC provides data and voice services handoff of UMA-enabled MS between two
domains. One domain is the Unlicensed Mobile Access Network (UMAN), backed by
fixed wireless access points. The other is the GSM/GPRS EDGE Radio Access Network
(GERAN), backed by a GPRS EDGE data network. In this diagram, several combinations
of GERAN and UMAN domains are presented as islands. In reality, mobile cell-based
coverage is quasi-total for a given area. UMA coverage depends on the presence of
UNCs. Although there is one physical UNC, it logically belongs to both the UMAN and
GERAN functional domains.

In the process of registration and discovery, we can distinguish three functional types
of UNCs: provisioning, default, and serving. When subscribing for UMA services,
each MS, based on its original location, is assigned a provisioning UNC. This is one
aspect of registration. The actual discovery process starts when the MS connects to
the provisioning UNC whose IP-address is provided through an Internet Domain Name
System (DNS) lookup.

Based on location information and subscription to UMA services, the provisioning
UNC will assign a default UNC to the MS. This information is stored in the MS for
future use. To obtain the UMA services, the MS registers with the default UNC. Once
the MS is registered, the default UNC will become the serving UNC for that particular
session, assuming that the MS continues to stay in the location covered by the default
UNC.

When a MS moves outside the default UNC coverage area, the UNC will determine
the appropriate serving UNC based on the MS’s location. The MS will once again register
with the new serving UNC and will store this new information for future use, thereby
avoiding the redirection process. So the calls can be sent and received through the mobile
network, the MS information is sent through the UMAN domain to the core network.
Each time the MS connects with a new serving UNC, discovery and registration messages
are protected and authenticated by using an IPsec tunnel.

15.9 Securing the UMA “up” Interface

As shown in Figures 15.1 and 15.2, the “up” interface is established between the UMA-
enabled mobile station and the UNC over the air to the AP, over the public IP-based
Internet or private packet switched data network, then to the mobile core network. This
path is not secured. To provide the necessary security (data integrity and confidentiality),
the “up” interface creates an IPSec tunnel between the mobile station and the UNC
[83]. The UNC MS performs authentication and encryption of all communications on
that link. The IPsec tunnel will handle GSM/GPRS signaling and any voice, data, or
multimedia packet flows between the MS and UNC. Initial configuration of the UMA-
enabled handsets includes service set IDs, user names, and security keys, all stored in a
profile on the handsets along with home/hot-spots profiles [84].
Voice traffic is carried over the Voice over IP (VoIP) protocol stack. The User Datagram Protocol (UDP) is used in the Transport Layer in combination with the Real-Time Protocol (RTP). This stack is the same as that used on fixed line networks. Therefore, the VoIP protocol stack can interface with compatible fixed-line media gateways.

15.10 GERAN to UMAN UNC Handover Operation

To understand how UMA provides transparent handoff/handover between GERAN and UMAN, we refer to Figure 15.3. To begin, assume that the MS is in a voice call originated in, and was handled by, a regular GSM network. The voice traffic is carried through a mobile network BTS, and the tandem between BSC/MSC assures mobility, roaming, and connectivity to the PSTN.

When the UMA-enabled dual-mode handsets come into proximity of a UNC, the UNC starts the discovery and registration process described in the previous section. Once registered, the serving UNC will provide system information to the registered MS to allow connectivity to an Access Point of the UMAN (WLAN or WPAN). Based on the MS measurements and its reporting to UNC, GERAN will treat the UMAN access point as a regular cell with adequate signal strength and quality.

If all conditions are met, based on established algorithms, the GERAN will ask the serving UNC to initiate the handover operation using standard GSM signaling procedures. To assure the necessary resources are available, the UNC will inform the core mobile network about the coming change. A Voice over IP path will be established between the MS and the serving UNC and the MS software client will switch from access over GSM to access over WLAN/WPAN. The new connection over the “up interface”, as supported by the UMA-enabled WLAN/WPAN APs, is established before breaking the GSM connection to assure a soft handoff. Any traffic, voice or data, will be channeled over this AP as long as the MS stays in its proximity.

15.11 UMAN to GERAN UNC Handover Operation

To understand the UMAN-to-GERAN UNC handover, consider a mobile station that already has a voice call or data transmission in progress over the UMAN. This means the UMA-based MS has gone through the discovery and registration process and a serving UNC is supervising the ongoing call. Nevertheless, the handover from UMAN to GERAN is always initiated by the multi-mode handset or mobile station. This decision is taken by the MS based on continuous monitoring of WLAN signal strength, characteristics of the voice channel, and status information coming from the serving UNC. When such a decision is taken, the MS sends a “handover required” message to the UNC and indicates the GSM cell to be used for handover.

At this time, the serving UNC, using common signaling, informs the core network about the request for handover, indicating the GSM cell that should be used to take over the call. Using standard GSM handover signaling, the core network will request that the
target GSM cell allocate the resources required for handover. To assure a soft handoff, the call is handled as an inter-BSC operation while the UMA client in the MS switches from the WLAN/WPAN to the GSM network. Subsequent voice calls and data transmitted from the mobile station will be sent over the GERAN.

For new voice calls initiated by the UMA-enabled MS, requests for services will be sent by the MS to the GSM network using standard connection management procedures. Signaling messages using the “up” interface are relayed to the serving UNC and forwarded to the MSC and GWMSC, responsible for preparing the PSTN to take the call if necessary.

When the UMA MS requires a GPRS connection, the MS activates a UMA Radio Link Control (URLC) transport channel to the serving UNC over the “up” interface. This channel will transport packets to the serving UNC that then forwards them to the SGSN over the UMA Gb interface. In a similar fashion, GPRS packets coming from the mobile core network are passed by the SGSN to the serving UNC and from there to the MS over the active URLC transport channel. This channel is established when there is a data flow and terminated when the flow of packets ends.

### 15.12 UMAN Signaling Protocol for Voice Communications

**UMA Network Controllers** (UNCs) communicate with **Mobile Stations** (MSs) through “**user plane**” or “**up**” interfaces. UNC use the IP-based protocol layer architecture over standard Access Points and Broadband IP networks. They maintain communication with MSs and relay signal call control information from **GSM** networks, more precisely from one of the **Mobile Switching Centers**, which are part of the core public mobile land-based network. UMAN signaling for voice communications is shown in Figure 15.4.

The signaling protocol is based on the SS#7 architecture. This consists of Message Transfer Parts 1, 2, and 3 (MTP1, MTP2, and MTP3), for the first three layers of the protocol stack, and the Signaling Connection Control Part (SCCP) for the Transport Layer. Signaling protocols in mobile networks include additional fields for the upper layers that contain information related to the applications and services supported as part of the fixed-mobile convergence. These fields are: Basic Station Subsystem Management Applications Part (BSSMAP), Mobility Management (MM), and Call Control/Short Message Service (CC/SMS).

### 15.13 UMAN Signaling Protocol for Data Communications

When transmitting data across convergent networks, a UNC communicates with one of the **Serving GSM Supporting Nodes** (SGSN) through a “**Gb**” interface over IP-based standard Access Points and Broadband IP networks. UNC maintain communications with MSs by transparently relaying data to/from the **GSM/GPRS** or **GSM EDGE Radio Access Network** (GERAN). These are subnetworks of public land-based mobile
networks that support data services. UMAN signaling for data communications is shown in Figure 15.5.

Transmission of data across fixed-mobile convergent networks is done by encapsulating or tunneling the TCP/IP stack used in APs and broadband IP-based networks into the Data Link Layer of the protocol stack used between the Serving GSM Supporting Node and the Access Point. This allows for seamless integration between fixed and mobile networks, ensuring that data services can be delivered efficiently and effectively.
Node (SGSN) and Mobile Stations. The encapsulated stack includes the Basic Station Subsystem Protocol (BSSP) sublayer, specific to the mobile environments. On the top of the SGSN-MS Data Link Layer is the standard Logical Link Control (LLC) sublayer followed by the network and upper layers of the SGSN protocol stack.

The “up” interface allows transparent communication of GPRS LLC PDUs for signaling and data transmission between a UMA-enabled MS and a SGSN. This means that all GSM/GPRS services available in a GERAN BTS, such as SMS, MMS, WAP, and IN/CAMEL will be available to the MS with no additional modifications required to the core mobile network. Change appears only in the GPRS Radio Link Control (RLC) protocol stack where GPRS RLC is replaced with the UMA-RLC (URLC) protocol. As in a GERAN base station, the UNC, with functions similar to BSC, terminates the UMA-RLC protocol. All the packets are forwarded through the Gb interface to the SGSN using the Basic Station Subsystem Protocol (BSSP) messaging system [84].

15.14 UMAN Mobile Station Lower Layers Protocols

UMA/GAN Mobile Stations (MS) act either as mobile handsets or as terminals that support, in addition to the standard GSM/CDMA protocol stacks, the lower layer protocols for WLANs (IEEE 802.11× and ETSI HiperLAN2) and WPANs (802.15.1 Bluetooth). Hence, the names of dual-mode, tri-mode, or multi-mode handsets. This architecture allows communications with standards based Access Points or Master Bluetooth. The lower layers protocol stack for UMA/GAN mobile stations is shown in Figure 15.6.

![Figure 15.6 UMA/GAN Mobile Stations Lower Layers Protocol Stack](https://www.cambridge.org/core/figures/fig15_6a.png)

Dual mode WLAN/GSM mobile stations have four modes of operation:
- GERAN only; The MS is used only as a GSM/CDMA mobile phone;
- UUMAN/GAN only; The MS is used only as a Wi-Fi smart phone;
- GERAN preferred; The MS connects to the GSM/CDMA network, as the first choice, provided signal strength is acceptable; and
- Wi-Fi preferred; The MS connects to the WLAN network, as the first choice, provided the signal strength is acceptable.
Similar modes of operations can be established for convergence between Bluetooth and GSM/CDMA. In that case, the tri-mode MS will interact with the designed Bluetooth master, hosted by a home desktop or laptop computer. The Bluetooth lower layers protocol stack consists of Bluetooth Network Encapsulation Protocol (BNEP) on top of the Logical Link Control and Adaptation Protocol (LLC & AP or L2CAP) on top of the Bluetooth radio baseband Physical Layer. If the underlying network is an Ethernet, the BNEP header replaces the Ethernet header. The Ethernet payload remains the same. The BNEP header and the original payload are encapsulated by the L2CAP header. Maximum BNEP payload is 1691 bytes, where 191 bytes are reserved for the BNEP header [85]. The Ethernet payload can vary from 0 to 1500 bytes.

15.15 UMA-based FMC Solutions, Products, and Services

Incorporation of UMA/GAN specifications into the 3GPP technical standards opened up opportunities for manufacturers and mobile operators alike to provide convergent products and services. By bundling Wi-Fi calls with their mobile networks, carriers can enhance coverage and presence in the relatively under-penetrated residential sector. It is expected to see, in the near future, use of Dual-Mode Handsets (DMH) not only in WLAN hot-spots but in enterprise WLANs as well. Despite the advantages listed earlier, major operators in the USA, with the exception of T-Mobile, still fear they will lose revenue by offering convergent services. The introduction of convergent features in the latest mobile phones models, including the 2007 BlackBerry and iPhone editions, will certainly change this situation.

Companies such as ABI Research predict an increase of DMH to reach 50 million units in 2009, 100 million in 2010, and 256 million in 2012. In-Stat’s forecast calls for 66 million DMHs in operation by 2009. Similar predictions based on VoIP, advancements that go along with FMC, are from Frost & Sullivan. DMHs costing less than $100 are key for this penetration. Lists of current UMA-based products and services follow:

UMA-based chipsets
- Airify Communications Inc and Helic S.A.: Chipset for Cellular-WLAN convergence, (www.airify.com);
- Infineon TechnologiesAG: BlueMoon Unicellular chipset for Bluetooth Cellular FMC, (www.infineon.com);

UMA-based Dual Mode Handsets (DMH)
- Calypso Wireless: DMH C1250i Wi-Fi/GSM-GPRS, (www.calypso.com);
- HP: iPAQ 510 DMH (based on Kineto Wireless technology), (www.hp.com);
- Kyocera: DMH Slider Remix CDMA/Wi-Fi, (www.kyocera-wireless.com);
- LG Electronics: Mobile Communications, UMA-enabled tri-band cellular and Wi-Fi LG CL400 mobile phones, (www.lge.com);
- Motorola Corporation: A910 GSM/Wi-Fi/Bluetooth, (www.motorola.com);
• **Motorola Corporation**: DMH CN650, Avaya Seamless Communication Solutions (Avaya, Motorola, Proxim), (www.motorola.com);

• **NEC**: DMH N900iL 3G/WLAN UNIVERGE, (www.nec.com);

• **Nokia**: Nokia N80 and Nokia 6136, UMA-based Wi-Fi/GSM, (www.nokia.com);

• **Nokia Corporation**: DMH Nokia 9500 Communicator, GSM/GPRS EDGE and Wi-Fi tri-band, DMH, (www.nokia.com);

• **Research in Motion (RIM)**: Blackberry 8220 GSM/CDMA/iDEN and Wi-Fi, (www.rim.com);

• **Samsung Corporation**: P200 SGH-T709, GSM/GPRS, EDGE/Wi-Fi, (www.samsung.com).

**UMA/GAN Systems Integrators**

• **Alcatel/Lucent**: NGN-UMA Architecture, Standalone UMA Architecture, Alcatel 1430 Home Subscriber Server, Alcatel 1300 OMC-CN, (www.alcatel-lucent.com);

• **Aruba Wireless Networks**: WLAN AP for FMC using NTT DMH, (www.aruba.com);

• **BridgePort Networks**: NomadicONE Network Convergence Gateway software for wireless carriers and MVNOs, (www.bridgeport-networks.com);

• **Ericsson**: Mobile @Home SupportNode, Mome Base Station Controller, Security Gateway, (www.ericsson.com);

• **Kineto Wireless Inc.**: Mobile over Wireless LAN (UMA-based MoWLAN), UMA-compliant handset client software, UMA development tools, (www.kinetowireless.com);

• **Meru Networks**: Cellular WLAN and Meru System Director Version 3, (www.merunetworks.com);

• **NXP**: Nexperia Wi-Fi Cellular Systems Solution 7210, (www.nxp.com).

**UMA-based Services and Implementations**

• **British Telecom**: Bluephone FMC Project, “BT Fusion”, UMA-based Bluetooth/GSM service and Wi-Fi/GSM service, (www.bt.com);

• **Cincinnati Bell**: CB Home Run, based on tri-mode Nokia 6086 headsets, (www.cincinnatibell.com);

• **Embarq** (Sprint USA), SMART Connect Plus Service using STARCOM PC6200 dual mode handsets (WiFi/CDMA), (www.embarq.com);

• **Korea Telecom**: FMC Service covering Wi-Fi hot-spots and residential WLANs, (www.koreatelecom.com);

• **NTT**: DoCoMo DMH 3G/Wi-Fi, (www.ntt.com);

• **Osaka Gas**: FMC 3G/Wi-Fi using Meru Networks APs and NEC N900iL DMH, (www.osakagas.co.jp);

• **Orange**: “unik/unique”, UMA WLAN/GSM based service, (www.orange.com);

• **Saunalaiti**: (Finland MSP), Kineto Wireless Technologies and Nokia handsets;

• **Telia Sonera**: (Denmark) “Home Free”, UMA-based Wi-Fi/GSM service, (www.teliasonera.com);

• **Telecom Italia**: “Unica”, UMA-based WLAN/GSM service, (www.telecomitalia.com);
T-MobileUS: “HotSpot@Home”, UMA-based Wi-Fi/GSM/GPRS EDGE and WCDMA 3G, 7000 hot-spots USA and Europe, (www.t-mobile.com).

**UMA-based Convergence Testing**
- Agilent Technologies: UMA testing, (www.agilent.com);
- CTIA & Wi-Fi Alliance: DMH testing, (www.ctia.org), (www.wi-fi.org);

**15.16 UMA-based Nokia Dual-mode 6301 Handset**

Wi-Fi Alliance data indicates that almost 90% (82 out of 92) of the Wi-Fi certified phones introduced since 2004 function in dual or multi modes. In addition to Voice over WLANs, these phones will also support one of the cellular mobile access technologies that will be used in standard handsets that operate outside of WLAN coverage. We listed earlier several UMA-based or “UMA-like” dual-mode handsets from major manufacturers such as Nokia, Motorola, Samsung, RIM Blackberry, and Apple Computers. One example of UMA-based handset/cell phones are Nokia’s series 6301. Orange, one of the mobile carriers, is expected to be the first operator to offer these cell phones in Europe for its Unik/Unique service. Nokia has already tested previous UMA-based models 6136 in a well publicized field trial in Oulu, Finland.

The main characteristics of these phones are [86]:

- GSM tri-band support 900/1800/1900 GHz;
- Wi-Fi 802.11 b/g support;
- Form factor (93g weight and 13.1 mm thick);
- 2-inch QVGA 320×240 screen;
- Mini USB/PC synchronization;
- Internal user memory in-box microSD card of 30MB and 128MB, expandable to 4GB;
- Voice dialing, voice commands and voice recording;
- Digital camera, 2 Megapixels;
- MP3 player, FM radio;
- Music and video streaming;
- Bluetooth 2.0-enabled; Headset BH-208 or BH-602;
- Integrated hands-free speaker;
- Push to Talk;
- GPRS class 10, 53.6 Kbps and EGPRS class 10, 236.8 Kbps data services;
- Talk time up to 3.5 hours (UMA up to 3 hours);
- Standby time up to 14 days (UMA up to 100 hours).