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Access to GSM and GPRS mobile services over unlicensed spectrum technologies through UMA

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Abstract. -UMA is a technology helping cellular operators to retain control over subscribers in the era of converging radio access technologies. By supporting handovers to and from Wi-Fi networks. This research paper discusses the technical implications of UMA based on measurement results for GSM to Wi-Fi handovers. The measurements show that UMA works well, and voice handover breaks are similar or lower than those experienced in traditional GSM systems. In addition, UMA provides a considerably higher throughput than GSM systems. The challenges are introduction to Unlicensed Mobile Access (UMA) Evolution of telecom network from early analogue networks to digital circuit switched network has already taken place. The next major trend in network evolution will be the change from circuit switched networks with centralized control towards packet switched next generation network with distributed control separated from media connectivity is UMA.

Keywords: UMA, GSM, WI-FI, WLAN

INTRODUCTION

Unlicensed Mobile Access a new technology that complements an operators' network coverage with unlicensed wireless technologies, such as WLAN or Bluetooth. UMA opens a new range of opportunities for both consumers and operators. It allows consumers to enjoy the benefits of better indoor coverage using WLAN radio access. UMA serves to give operators the ability to fully leverage their cellular assets via alternative radio access methods. UMA is a cost-effective way to expand cellular coverage for voice and data services to homes and enterprises where it might be too difficult or expensive to build cellular coverage indoors. In more technical terms, UMA technology creates a secure tunnel from a multiradio terminal, such as the Nokia 6086, to an operator's UMA Network Controller (UNC). This UNC is the link between the UMA call and the cellular core network. With a highly flexible UNC implementation, Nokia provides operators the possibility to deploy a UMA network in a very cost efficient way. WLAN and Bluetooth Wireless Technology can both be used for UMA, which is one way of using the Internet Protocol for voice services (Voice over IP, or VoIP).The UMA (unlicensed mobile access) technology provides a way to access the core GSM network through WiFi. This sounds attractive from the point of view of cellular network operators, who could thus extend their network coverage through WiFi hotspots with minimal additional investment.

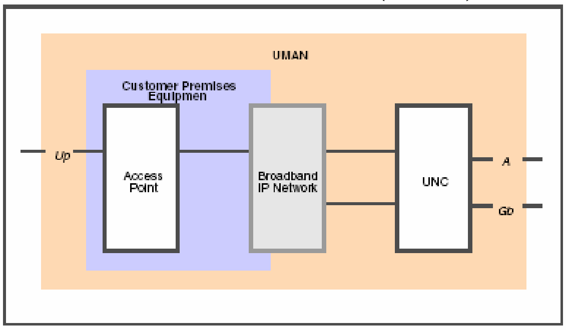
Improving coverage (especially indoors) is of great importance in some countries where adequate GSM coverage indoors and throughout some other areas in the country is not yet available. This research paper discusses the UMA technology in detail, after which technical performance measures of the technology are considered. The paper sets out to technically address whether UMA could work in real life situations. Focus is put on the handover and packet data performance of UMA compared to current cellular networks. Based on the measurement results conclusions are presented.

UMAN (UMA NETWORK)

The core idea of UMA is to provide an access to the operator's network through not only cellular, but also through unlicensed radio access technologies such as WiFi. Originally, UMA was developed to provide an access to GSM/EDGE networks through unlicensed radio access points. The technology, however, is nowadays developed in the 3GPP consortium under the name GAN (generic access network), which also considers the link to WCDMA[3]. Despite the official Second name being changed to GAN, UMA is used quite a lot as it was the name with which the idea became public and familiar in the industry. The principle for UMA is the possibility to tunnel connections over unlicensed radio access technologies back to the operator's network. UMA also supports seamless handovers between cellular and WiFi. This new technology provides a means to extend coverage through e.g. cheap WiFi access points instead of expensive cellular base stations. UMA could thus decrease the load of legacy GSM access networks. At the same time the operator still holds control over the connection, and therefore can charge upon that. The possibility to use e.g. WiFi could, however, also reflect in connection prices, as WiFi hotspots are much cheaper to deploy than GSM base stations. The key question is naturally whether the same or different operator owns the WiFi access network than cellular network.

The UMA solution does not need much direct investments. The most critical point is a UMA network controller (UNC), which provides authentication and tunneling setup. In the UNC operators can also specify other restrictions for the access, such as access point SSID or MAC specifications. Therefore, the cellular network operator (who also runs the UMA solution) can specify who can use UMA and how they can use it in connecting to the operator's core network. The generic structure of the UMA access system is illustrated in Figure 1.

UMA Network (UMAN)



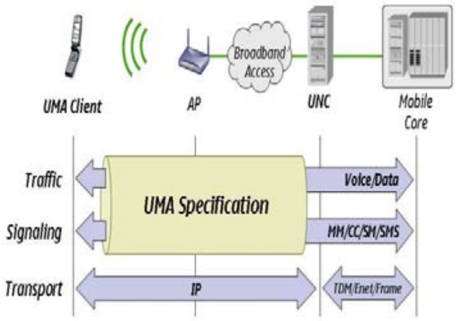


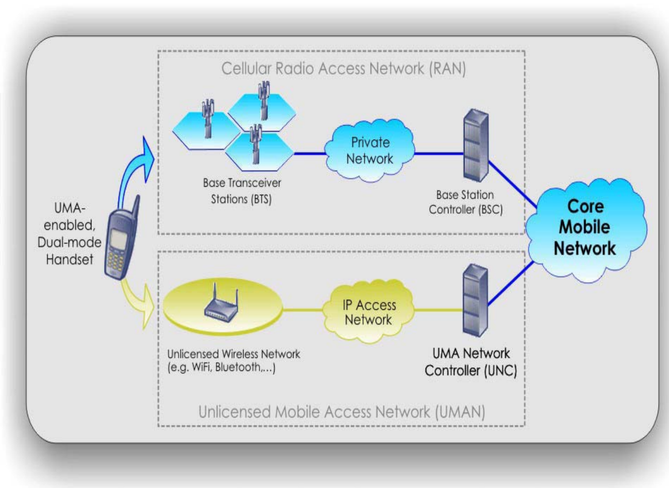
Figure 1. UMA access to cellular network

UMA CONCEPT

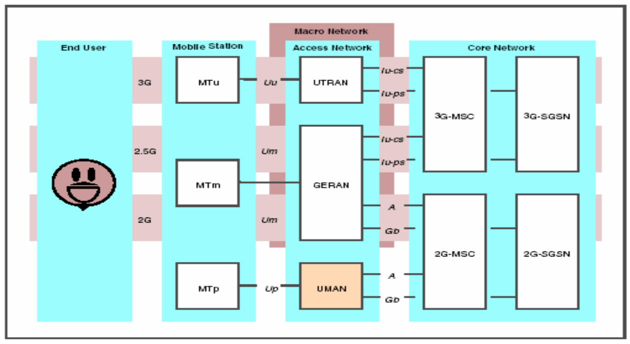
The following functional blocks in the mobile station (MS) support end-user access to telecommunication services:

- An MTu provides access via UTRAN. A mobile station that exclusively contains this mobile termination is also known as a UE.
- An MTm provides access via GERAN.
- An MTp provides access via UMAN. It uses Bluetooth or Wi-Fi.

Note that a physical device may comprise one or more functional blocks, e.g., a physical implementation of a mobile station may contain any combination of the following functional blocks: MTu, MTm, or MTp.



UMA Concept



Why is UMA attached to 2G-MSC and not the 3G-MSC?

UMA Technology

Unlicensed mobile Access (UMA) technology enables access to GSM and GPRS mobile services over unlicensed spectrumusing Bluetooth™and WiFi™. Highlights of the UMA Technology are:

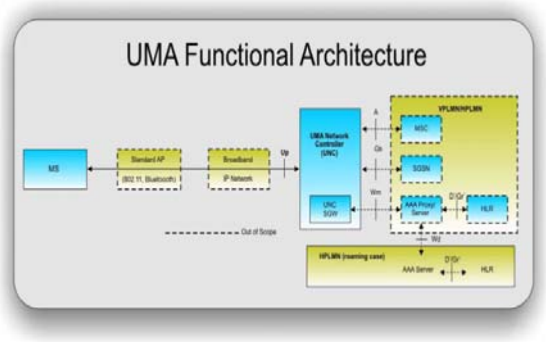
- Seamless delivery of mobile voice and data services over wireless networks using unlicensed spectrum.
- Provides the same mobile identity on Cellular RAN and unlicensedwireless networks.
- Seamless transitions (roaming and handover) between Cellular RANand unlicensed wireless networks.
- Preserves investment in existing/future mobile core network infrastructure.
- Independent of underlying unlicensed spectrum technology (e.g. WiFi™, Bluetooth™).
- Transparent to existing, standard CPE devices (e.g. access points, routers and modems)
- Utilizes standard "always on" broadband IP access networks (e.g. DSL, Cable, T1/E1, Broadband Wireless, FTTH…)
- Security equivalent to current GSM mobile networks
- No impact to operations of Cellular RAN (e.g. spectrum engineering, cell planning,…)

UMA Functional Architecture

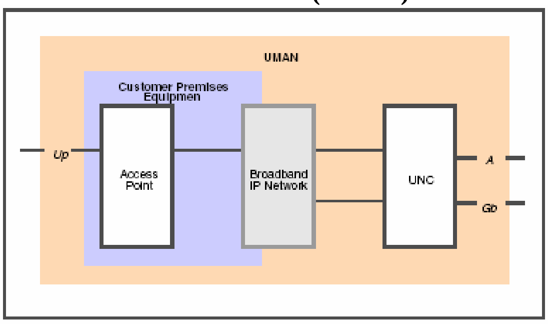
The UMA Network (UMAN) consists of one or more access points (AP) and one or more UMA Network Controllers (UNCs), interconnected through a broadband IP network.

- Mobile Station (MS) versus Mobile Terminal (MT)
- Access Point (AP). The AP provides the radio link to the mobile station using unlicensed spectrum.
- UMA Network Controller (UNC). The UNC appears to the core network as a GERAN base station subsystem (BSS). It includes a Security Gateway (SGW) that terminates secure remote access tunnels from the MS, providing mutual authentication, encryption and data integrity for signaling, voice and data traffic.
- A broadband IP network provides connectivity between the AP and the UNC. The IP transport connection extends all the way from the UNC to the MS, through an AP. A single interface, the Up interface, is defined between the UNC and the MS.

- Co-existence with the GSM/GPRS Radio Access Network (GERAN) and interconnection with the GSM Core.
- Network (CN) via the standardized interfaces defined for GERAN: A-interface for circuit switched services [TS 48.008]
- Gb-interface for packet switched services [TS 48.018]

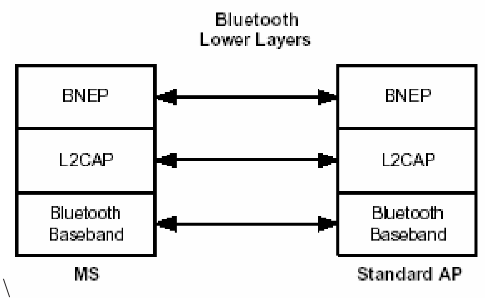


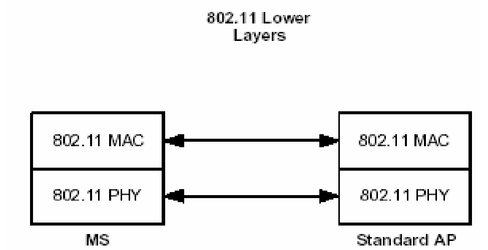
UMA Network (UMAN)



Functional Entities - Mobile Station

- The MS shall include dual mode (GSM and unlicensed) radios and the capability to switch between them. The MS supports either Bluetooth (using the Bluetooth PAN profile) or 802.11
- The MS supports an IP interface to the access point. In other words, the IP connection from the UNC extends all the way to the MS.





Functional Entities - Access Point

- The Access Point (AP) provides the radio link towards the mobilestation using unlicensed spectrum.
- It connects through the broadband IP network to the UNC. The AP provides Bluetooth (PAN profile) [BTSIG3] or 802.11 access pointfunctionality [802.11].
- The AP does not provide any UMA-specific gateway functions, and any generic AP can be used to interconnect the MS to the UNC viathe broadband IP network.

UMA provides four possibilities to manage/prioritize cellular and unlicensed accessnetworks:

- GSM-only
  - ➢ MS stays in GSM mode; normal GSM Procedures apply.
- GSM-preferred
  - ➢ If no GSM PLMN available, and if UMA coverage detected, MS switches to UMA mode.
  - ➢ When GSM PLMN becomes available, or if UMAN coverage is lost, MS switches back to GSM mode.
- UMA-preferred
  - ➢ When UMA coverage is detected, the MS switches to UMA mode.
  - ➢ When UMA coverage is lost, the MS switches to GSM mode.
- UMAN-only
  - ➢ MS switches to UMA mode after power-up sequence (even before UMA coverage is detected)

From the technical point of view, all in all, UMA is thus effectively an extension of GSM to the unlicensed spectrum, while at the same time, it provides a way to control the customer and direct the traffic back to the operator's own network.
The UMA cell is analogous to a GSM base station controller (BSC). For that reason, it is perceived as such by the cellular network and roaming between UMA and GSM is considered an inter-BSC handover.
From the BSC perspective the UNC is just another BSC. In theory, if the UNC is in the BSC neighbors list, it is possible to perform a handover. However, the individual WiFi cells are independent from the UMA system. Regardless of the similarities between the UNC and the BSC, the cell size does not directly correlate.

GSM-UMA Mobility

Handovers between the GSM and UMA systems are in most of the cases originated by the MS. Depending on the operating mode, the MS will decide how often it will attempt to establish a connection and/or start a handover. The handover triggers are likely to be based on received signal strength measurements. However, the standard also provides the means to originate the handover based on a request from the UNC.

In the case of GSM-to-UMA handovers, the message flow is depicted in Figure 2 [11]. The initial state before the handover requires that the call is active in the GSM system. That is, voice goes through the BSC and then to the core network (CN). Afterwards, while the GSM call is ongoing, four main stages take place. First, when the MS detects WiFi, it will establish a link with the access point and attempt to establish a secure IPsec tunnel with the UNC. The establishment of the secure tunnel requires the mobile station to be
authenticated by the UNC. This procedure is known as UMA registration. Second, the mobile station initiates the handover by reporting a UMA neighbor cell as the highest signal level to the BSC. Assuming that the operator's BSS is configured with the UMA cell as a neighbor, the source BSC decides to start the handover procedure based on the handover report. The handover procedure between the source BSC, core network and UNC follows the same signaling flow as the GSM inter-BSC handover. It is not explicitly visible to the source BSC that the target handover is the UMA access. Once the signaling required for the handover has taken place, a handover command message will be sent to the MS indicating that the handover can take place (messages 1 to 6). Third, the MS will start the actual handover between systems. This procedure involves two main phases, one to setup a voice stream connection (messages 7 to 9), and another phase to transfer the voice stream from the GSM access to the UMA access. The actual voice break resulting from the handover will happen only in this second phase of the handover (messages 10 to 12). Fourth and last, the previous connection is released from the GSM system (messages 13 to 14).

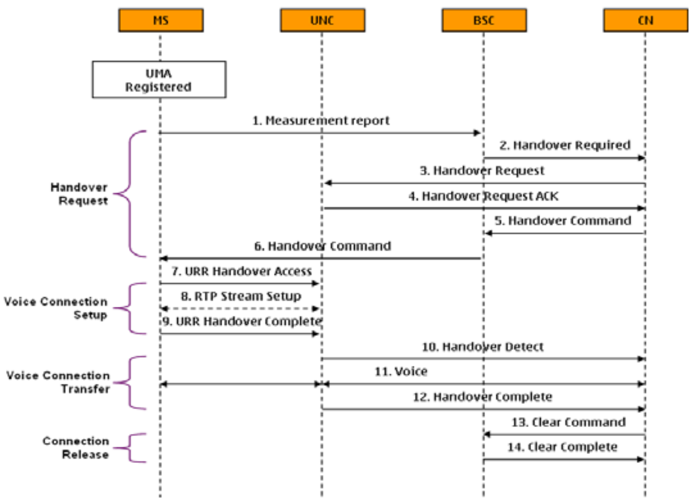
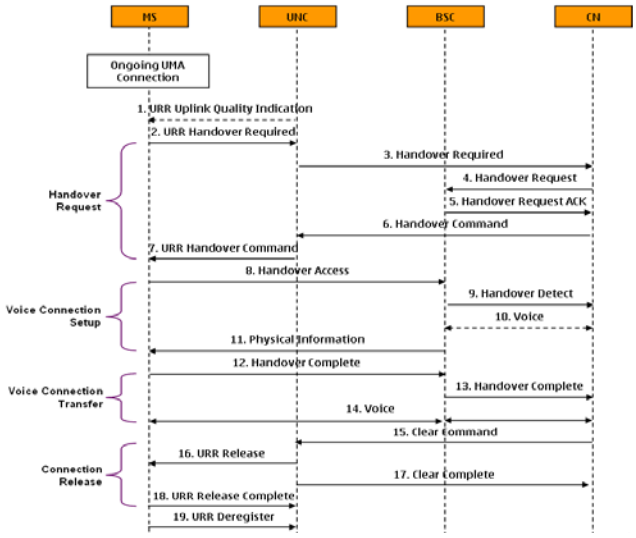


Figure 2. GSM-to-UMA Handover Procedure

The message flow for UMA-to-GSM handovers is
depicted in Figure 3 [11]. The initial state before the handover requires that the call is active in the UMA system. That is, voice goes through the UNC and then to the core network. Whilst the UMA call is ongoing, three main stages take place. First, when the WiFi link is deteriorated up to a predefined threshold, the MS determines that the WiFi link is no longer acceptable for UMA service. However, it is also possible to trigger the handover via an uplink quality indication message from the UNC. At this point, the MS sends a handover required message to the UNC specifying the signal levels of the neighboring GSM cells. Subsequently, the UNC selects one of the target cells and sends a handover request to the core network. The core network then handles the resource allocation procedures with the BSC for the GSM call. Once the resources have been allocated, the MS is notified that the handover is ready to take place (messages 2 to 7). Second, the MS will start the actual handover between systems. This procedure involves two main phases, one to setup a voice stream connection (messages 8 to 11) and another to transfer the voice stream from the UMA access to the GSM access (messages 12 to 14). The actual voice break resulting from the handover will happen only in this second phase of the handover. Third and last, the previous connection is released from
the UMA system (messages 15 to 18).



CONCLUSION

The technical measurements of UMA performance provided evidence that the solution really works. The handover times between UMA and GSM are similar to typical inter-BSC handovers in the GSM system. Therefore, UMA is at its best in extending the cellular network operator's current network coverage in indoor locations. Ceteris paribus, the poorer the initial indoor cellular reception and possibilities to extend GSM coverage, the more attractive it would be business-wise to deploy UMA. Likewise, UMA allows the operator Second Internationalto improve the user experience for data services from GSM to 3G-like kind of services due to the higher throughput available in UMA. The measurements showed that throughput is twice or more than the data rates available in GSM networks. The promising measurement results suggest that there is a lot of potential to extend network coverage and deploy hotspot kind of access points in special circumstances. At the same time, the cellular network operator holds control over subscribers and traffic flows.

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