HiperLAN/2 Public Access Interworking with 3G Cellular Systems

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ABSTRACT

This paper discusses some of the recent work within the Broadband Radio Access Network (BRAN) project of ETSI (European Telecommunications Standards Institute), regarding the issue of establishing an interworking solution between HiperLAN/2 and 3rd Generation (3G) cellular systems and introduces the concept of HiperLAN/2 Public Access.

So far the BRAN project has identified several fundamentally different types of possible solutions whose differences lie within the level of integration. The most essential requirements identified were authentication, mobility between HiperLAN/2 and 3G, service continuity, Quality of Service (QoS) and preservation of the applied security levels.

Such an interworking system may form the precursor for post 3G systems.

1. INTRODUCTION

This paper presents a technical overview of the HiperLAN/2 – 3G interworking concept [1]. After a brief resume of public access operation and quick overview of the technologies concerned, it then describes separate system approaches (*loose coupling flavours*), addressing issues such as mobility, QoS, subscription, security, together with further standardisation requirements within the 3G bodies and the Internet Engineering Task Force (IETF).

1.1. Public Access Scenario

Recently, business professionals have been looking for an efficient way to access corporate information systems and databases remotely through the Internet backbone. However, the high bandwidth demand of the typical office applications, such as large email attachment downloading, often calls for very fast transmission capacity. Further, certain hot spots, like airports and railway stations are a natural place to use these services, and typically the time available for information download is fairly limited.

In the light of above there clearly is a need for a public wireless access solution that could cover the demand for data intensive applications and enable smooth on-line access to corporate data services in hot spots, and would allow a user to roam from a private, micro cell network (e.g. a HiperLAN/2 network) to a wide area cellular network or more specifically a 3G network.

Together with high data rate cellular access, HiperLAN/2 has the potential to fulfil end user demands in hot spot environments. HiperLAN/2 offers a possibility for cellular operators to offer additional capacity and higher bandwidths for end users without sacrificing the capacity of the cellular users, as Hiperlans operate on unlicensed or licensed exempt frequency bands. Also, HiperLAN/2 has the QoS mechanisms that are capable of meeting the levels of service available in 3G systems. Furthermore, interworking solutions enable operators to utilise the existing cellular infrastructure investments and well established roaming agreements for HiperLAN/2 network subscriber management and billing.

1.2. The Market for Interworking between Public Access and 3G

The early adopters of the Public Access solution will therefore be businessmen that often work outside the office. The interworking with 3G will benefit the customer as they can access their information, wherever they are, inside or outside a hotspot area. Thereby, the authors believe that an interworking might expand the market for wireless communication. As the market grows, it will be expanding to meet a consumer market as well. The services, terminals, usage and demand on the system will change with time, placing further requirements on the system and on the terminals.

The wireless network architecture is predicted to be in the homes in the future. One reason for having the radio interface on the devices at home is to have interconnection between audio/video appliances such as Digital Versatile Disc (DVD) players, TV screens, and video cameras, whilst also removing the cumbersome cables. HiperLAN/2 will be able, through its specified IEEE 1394 convergence layer interface, to provide a wireless connection with the high data speed that is required for such communication.

Another reason is to support connectivity to wide area networks and services, based on any of the network access technologies such as cable, Digital Subscriber Line (xDSL), fibre, satellite, etc. An interworking with 3G will then make the user completely mobile, at home, in the office and on the move.

2. TECHNOLOGICAL OVERVIEW

This section briefly introduces the HiperLAN/2 wireless LAN system, together with a brief resume of 3G systems.

2.1. HiperLAN/2 Summary

HiperLAN/2 is intended to provide local wireless access to IP, Ethernet, IEEE 1394, Asynchronous Transfer Mode (ATM) and 3G systems by both stationary and moving terminals that interact with access points. The intention is that system access points are connected to

all these technologies. A number of these access points are required to service all but the smallest networks of this kind, and therefore the wireless network as a whole supports handovers of connections between access points.

2.2. 3G Summary

Within the framework of International Mobile Telecommunications 2000 (IMT-2000), defined by the International Telecommunications Union (ITU), the 3rd Generation Partnership Project (3GPP) are developing Universal Mobile Telecommunications Service (UMTS) which is one of the major third generation mobile systems. Additionally the 3rd Generation Partnership Project II (3GPP2) is also developing another 3G system, CDMA-2000. Most of the work within ETSI BRAN has concentrated on UMTS, although most of the architectural aspects are equally applicable to HiperLAN/2 interworking CDMA-2000 and indeed pre-3G systems such as General Packet Radio System (GPRS).

The current working UMTS standard, Release 4, of UMTS was finalised in December 2000 with work continuing in Release 5. This further developed standard will be available by beginning of 2002 with full service deployment expected between 2002 and 2005.

3. TIGHT COUPLING SOLUTION

Tight Coupling is a direct integration of the HiperLAN/2 radio access network into a 3G network. The term 'tight' refers to the alignment of the Hiperlan/2 interfaces with the access interfaces of the 3G network. In this respect tightly coupled solutions become highly specific to the 3G technology used and indeed specific to a release variant (i.e. UMTS R5).

To continue with UMTS as an example 3G system for tight coupling, the HiperLAN/2 network is connected to the rest of the core network in the same manner as other UMTS radio access technologies (UMTS Terrestrial Radio Access Network - UTRAN, GPRS/EDGE Radio Access Network - GERAN), using a new Iuhl2 interface, which is very similar to the existing UMTS Iu interface. This resulting radio network has been termed a HIRAN (HiperLAN/2 Radio Access Network).

The principle advantage of this solution is that mechanisms for mobility, QoS and security of the UMTS core network can be directly reused.

However, other interfaces in addition to the than Iuhl2 mentioned above also have to be re-defined and hence standardised (e.g. Iubhl2 and Uuhl2).

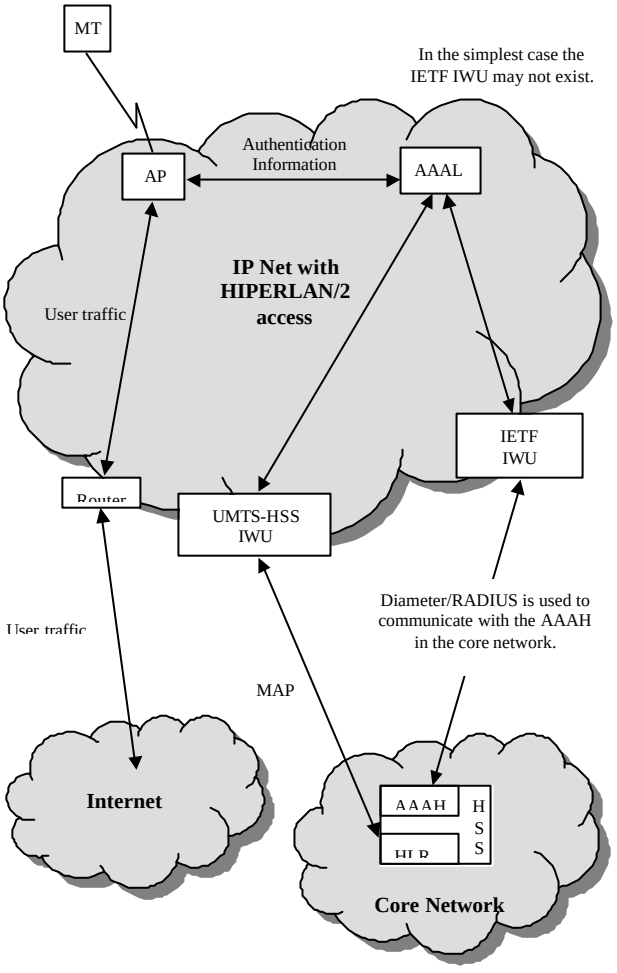
The BRAN project, after initial investigation, decided in the summer of 2001, that this solution would be very complex to analyse, define and standardise and is now considered not to be a priority for HiperLAN/2 – 3G Interworking and is not currently working in this area.

This solution is not considered further within this paper.

4. LOOSE COUPLING SOLUTION

The remainder of this paper concentrates on what is termed as loosely coupled solutions. "Loose coupling", is generally defined as the utilisation of HiperLAN/2 as a packet based access network complementary to current 3G networks, utilising the 3G subscriber databases but without any user plane Iu type interface, as shown below. Within the UMTS context, this scheme avoids any impact on the Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN) nodes. Security, mobility and QoS issues are addressed using IETF schemes.

This section describes the principle functions of the loose coupling interworking system and explains the different *flavours* that are under investigation. The focus of current work is the interface between the Access Point (AP) and the Core Network (CN). Other interfaces between the AP and external networks and interfaces within the AP are initially considered to be implementation or profile specific.



IETF *flavour*
MT does not have USIM card functionality therefore the Interworking Unit (IWU) is used to inter-operate with the core network AAAH.

UMTS-HSS *flavour*
MT has USIM card functionality therefore the IWU will be used to inter-operate with the core network HLR.

Figure 1: Generic Architecture of Loose Coupling Interworking between Hiperlan/2 and 3G systems

5. SECURITY

Figure 1 shows that there are two alternative coupling approaches or *flavours* that can be supported by one common architecture.

The primary difference between these flavours is in the authentication server itself, and these are referred to as the "IETF flavour" and the "UMTS-HSS flavour", where the Home Subscriber Server (HSS) is a specific 3GPP term for a combined Home Authentication Authorisation Accounting Server and Home Location Register (AAAH/HLR) unit. The motivation for network operators to build up HiperLAN/2 networks based on each flavour may be different for each operator.

However, both flavours offer a maximum of flexibility and allow loose coupling to existing and future cellular mobile networks [2].

5.1. Flavours

For Loose Coupling it is possible to use the security features described in the current HiperLAN/2 standard, with some additions. As mentioned above there are two flavours of security that can be considered: -

5.1.1. IETF flavour

Within this approach HiperLAN/2 users may be either existing 3G subscribers or just HiperLAN/2 network subscribers.

These users want to make use of their existing data devices (e.g. Laptop, Palmtop) without additional hardware/software requirements. For both users and mobile operators it is beneficial to be able to base the user authentication and accounting on existing cellular accounts, as well as to be able to have HiperLAN/2-only operators and users; in any case, for reasons of commonality in Mobile Terminal and AP development it is important to be able to have a single set of AAA protocols which supports all the cases.

This scenario is driven by the requirement to only add minimal software functionality to the terminals (e.g. by downloading java applets), so that the use of a HiperLAN/2 mobile access network does not require a radical change in the functionality (hardware or software) than those required by broadband wireless data access in the corporate, or home scenarios.

5.1.2. UMTS-HSS flavour

The UMTS-HSS definitely requires that a user is a native cellular subscriber while - in addition and distinct from the IETF flavoured approach - standard cellular procedures and parameters for authentication are used (e.g. UMTS Subscriber Identity Module (USIM) quintets). In this way a mobile subscriber using a HiperLAN/2 mobile access network for broadband wireless data access will appear as a normal cellular user employing standard procedures and interfaces for authentication purposes. It is important to notice that for this scenario USIM card functionality is required in the user equipment. USIM provides new and enhanced security features in addition to those provided by 2nd Generation (2G) SIM (e.g. mutual authentication) as defined by 3GPP.

Note that to provide equivalent security functionality within HiperLAN/2 as is required for 3G public operations (e.g. periodic re-authentication) it will be necessary to enhance the base HiperLAN/2 standards specifically the authentication section of the Radio Link Control (RLC).

For the IETF flavoured approach there is no need to integrate the HiperLAN/2 security architecture with the UMTS security architecture [2]. It might not even be necessary to implement all of the HiperLAN/2 security features if security is applied at a higher level, such as using "IP Security" (IPSec) at the IP level.

An additional situation that must be considered is the use of pre-paid SIM cards. This scenario will introduce additional requirements for hot billing and associated functions.

5.2. UMTS Key Exchange

Key agreement for confidentiality and integrity protection is an integral part of the UMTS authentication procedure, and hence the UTRAN confidentiality and integrity mechanisms could be reused within the HiperLAN/2 when interworking with a 3G core network. This will also increase the applied level of security.

The Diffie-Hellman encryption key agreement procedure could be used to improve user identity confidentiality. By initiating encryption before 3G Authentication and Key Agreement Protocol (3G AKA) is performed, the user identity will not have to be transmitted in clear over the radio interface, as is the case in UMTS when the user enters a network for the first time. Thus, this constitutes an improvement compared to UMTS security.

It is also important to have a secure connection between APs within the same network if session keys or other sensitive information are to be transferred between them. A secure connection can either be that they for some reason trust each other and that no one else can intercept the communication between them or that authentication is performed and integrity and confidentiality protection are present.

6. SUBSCRIBER INFORMATION

There are three basic ways in which the subscriber management for HiperLAN/2 and 3G users can be co-ordinated:

- Have the interworking between the HiperLAN/2 subscriber database and HLR/HSS. This is for the case where the interworking is managed through a partnership or roaming agreement. The administrative domains' AAA servers share security association or use an AAA broker.
- The HiperLAN/2 authentication could be done on the basis of a USIM token.
- The 3G authentication and accounting capabilities could be extended to support access authentication based on IETF protocols. This means either integrating HLR and AAA functions within one unit (e.g. a HSS unit), or by merging native HLR functions of the 3G network with AAA functions required to support IP access.

Based on these different ways for subscriber management, the user authentication identifier can be on three different formats:

- Network Address Identifier (NAI)
- International Mobile Subscriber Identity (IMSI), requires a USIM card
- IMSI in NAI, requires a USIM card

6.1. Pre-Paid SIM cards

As far as the HLR, within the core network, is concerned, it cannot tell the difference between a customer who is pre-pay or not. Hence, this prevents a non-subscriber to this specific 3G network from using the system, if the operator wishes to impose this restriction.

As an example, pre-paid calls within a 3G network are handled via an Intelligent Network (IN) possibly co-located with the HLR. When a call is initiated, the switch can be programmed with a time limit, or if credit runs out the IN can signal termination of the call. This then requires that the core network knows the remaining time available for any given customer. Currently the only signals that originate from the IN are to terminate the call from the network side.

Due to the transfer of data traffic, termination of the call from the network side may be undesirable in a HiperLAN/2 - 3G network, as a transfer may fail in mid connection, so that a more graceful solution is required. A suitable solution is to add pre-paid SIM operation to the system together with hot billing (i.e. bill upon demand) or triggered session termination. This could be achieved either by the Local AAA Server (AAAL) polling the core network utilising RADIUS [4] to determine whether the customer is still in credit, or by using a more complicated protocol such as Diameter [5] which allows network signalling direct to the mobile terminal.

The benefit of this approach is to allow the operator to present the mobile user with a web page (for example), as the pre-paid time period is about to expire, allowing them to purchase more airtime.

All these solutions would require an increased integration effort with the core network subscriber management system. Further additional services such as Customized Applications for Mobile Enhanced Logic (CAMEL) may also allow roaming with pre-paid SIM cards.

7. MOBILITY

In the loose coupling approach, the mobility within the HiperLAN/2 network is provided by native HiperLAN/2 (i.e. RLC layer) facilities, possibly extended by the Convergence Layer (CL) in use (e.g. the current Ethernet CL, or a future IP CL). This functionality should be taken unchanged in the loose coupling approach, i.e. handover between access points of the same HiperLAN/2 network does not need to be considered especially here as network handover capabilities of HiperLAN/2 RLC are supported by both Mobile Terminals (MT)s and APs.

Given that HiperLAN/2 network handover is supported, further details for completing the mobility between access points are provided by convergence layer dependent functionality.

Completion of this functionality to cover interactions between the APs and other parts of the network (excluding the terminal and therefore independent of the air interface) are currently under development outside BRAN. In the special case where the infrastructure of a single HiperLAN/2 network spans more than one IP sub-network, some of the above approaches assume an additional level of mobility support that may involve the terminal.

7.1. Roaming between HiperLAN/2 and 3G

For the case of mobility between HiperLAN/2 and 3G access networks, recall that we have the following basic scenario:-

A MT attaches to a HiperLAN/2 network, authenticates and acquires an IP address. At that stage, it can access IP services using that address while it remains within that HiperLAN/2 network. If the MT moves to a network of a different technology (i.e. UMTS), it can re-authenticate and acquire an IP address in the packet domain of that network, and continue to use IP services there.

We have referred to this basic case as AAA roaming. Note that while it provides mobility for the user between networks, any active sessions (e.g. multimedia calls or TCP connections) will be dropped on the handover between the networks because of the IP address change (e.g. use Dynamic Host Configuration Protocol - DHCP). It is possible to provide enhanced mobility support, including handover between HiperLAN/2 access networks and 3G access networks in this scenario by using servers located outside the access network. Two such examples are: -

- The MT can register the locally acquired IP address with a Mobile IP (MIP) home agent as a co-located care-of address, in which case handover between networks is handled by mobile IP. This applies to MIPv4 and MIPv6 (and is the only mode of operation allowed for MIPv6).
- The MT can register the locally acquired IP address with an application layer server such as a Session Initiation Protocol (SIP) proxy. Handover between two networks can then be handled using SIP (re-invite message).

Note that in both these cases, the fact that upper layer mobility is in use is visible only to the terminal and core network server, and in particular is invisible to the access network. Therefore, it is automatically possible, and can be implemented according to existing standards, without impact on the HiperLAN/2 network itself. We therefore consider this as the basic case for the loose coupling approach.

Another alternative is the use of a Foreign Agent care-of address (MIPv4 only). This requires the integration of Foreign Agent functionality with the HiperLAN/2 network, but has the advantage of decreasing the number of IPv4 addresses that have to be allocated. On the other hand, for MTs that do not wish to invoke global mobility support in this case, a locally assigned IP address is still required, and the access network therefore has to be able to operate in two modes.

Three options for further study are: -

- The option to integrate access authentication (the purpose of this loose coupling standard) with Mobile IP home agent registration (If Diameter is used, it is already present). This would allow faster attach to the network in the case of a MT using MIP, since it only requires one set of authentication exchanges; however, it also requires integration on the control plane between the AAAH and the Mobile IP home agent itself. It is our current assumption that this integration should be carried out in a way that is independent of the particular access network being used, and is therefore out of scope of this activity.
- The implications of using services (e.g. SIP call control) from the UMTS IMS (Internet Multimedia Subsystem), which would provide some global mobility capability. This requires analysis of how the IMS would interface to the HiperLAN/2 access network (if at all).

7.2. Handover

For handovers within the HiperLAN/2 network, the terminal must have enough information to be able to make a handover decision for itself, or be able to react to a network decision to handover. Indeed these decision driven events are referred to as triggers, resulting in Network centric triggers or Terminal centric triggers.
Simple triggers include the following :

- Network Centric: Poor network resources or low bandwidth, resulting in poor or changing QoS. Change of policy based on charging (i.e. end of pre-paid time)
- Terminal Centric: Poor signal strength. Change of QoS.

8. QUALITY OF SERVICE

QoS within the HiperLAN/2 network must be supported between the mobile terminal and external networks, such as the Internet. In the loose coupling scenario, the data path is not constrained to travelling across the 3G core network, e.g. via the SGSN/GGSNs. Therefore no interworking is required between QoS mechanisms used within the 3G and HiperLAN/2 network. There is a possible interaction regarding the interpretation and mapping of UMTS QoS parameters onto the QoS mechanisms used in the HiperLAN/2 network. The actual provisioning of QoS across the HiperLAN/2 network is dependent on the type of the infrastructure technology used, and therefore the capabilities of the CL.
In the HiperLAN/2 standards the CL has two main functions: adapting service requests from higher layers to the service offered by the Data Link Control (DLC) and to convert the higher layer packets (SDUs) with variable or possibly fixed size into a fixed sized that is used within the DLC.
As an example, the Ethernet CL offers two QoS schemes:-

- Best effort: mandatory to support and treats all traffic equally, so that guarantees can be provided.
- IEEE 802.1p: priority schemes, optional and separates traffic in different priority queues as described in IEEE 802.1p

IEEE 802.1p provides priority mechanism to enable QoS in LANs. These mechanisms have been incorporated into IEEE 802.1d [3]. Eight (numbered 0-7) different priority levels are defined. The user priorities are mapped one-to-one or many-to-one to queues, depending on the number of queues supported. In HiperLAN/2 each queue corresponds to one DLC user connection. Parameters provided by the application, including UMTS QoS parameters if desired, are used to determine the most appropriate QoS level to be provided by the network, and the traffic flow is treated accordingly.

9. CONCLUSIONS

This paper has addressed some of the current thinking within ETSI BRAN regarding the interworking of the Hiperlan/2 Wireless LAN system into a 3G Cellular System.
Of the two initial solutions investigated (tight and loose coupling), current work has concentrated on the loose variant, producing viable solutions for security, mobility and QoS.
The standardisation activity thus hopes to ensure that Hiperlan/2 can provide a value added service within hotspot environments for both customers and operators of 3G systems.

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