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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 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, and preservation of the applied security levels. Recent agreements between ETSI, IEEE and MMAC may now take this work forward to produce a generic WLAN to 3G and external networks interworking standard. Indeed such work may also form the precursor for post 3G systems.

Keywords: ETSI, BRAN, Hiperlan/2, 3G, interworking, public access, WIG

1. Introduction

This paper presents a technical overview of the Hiperlan/2–3G interworking concept. It does not attempt to provide any business justification or plan for Public Access operation. After a brief resume of public access operation below, section 2 then introduces an overview of the technologies concerned. Section 3 describes the system approach and presents the current reference architecture used within the BRAN standardisation activity. Section 4 then goes on to cover in more detail the primary functions of the system such as authentication, mobility, quality of service (QoS) and subscription.

It is worth noting that since the Japanese WLAN standard HiSWANa is very similar to Hiperlan/2, much of the technical information within this paper is directly applicable to this system, albeit with some minor changes to the authentication scheme. Additionally the high level 3G and external network interworking reference architecture is also applicable to IEEE 802.11.

Finally, section 5 briefly introduces the standardisation relationships between ETSI BRAN, WIG, 3GPP, IETF, IEEE 802.11 and MMAC HSWA.

1.1. Public access operation

Recently, mobile business professionals have been looking for a more 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. Indeed certain hot spots, like hotels, airports and railway stations are a natural place to use such services. However, in these places the time available for information download typically is fairly limited.

In light of this, 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 to meet the mechanisms that are available in the 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.

2. Technology overview

This section briefly introduces the technologies that are addressed within this paper.

2.1. Hiperlan/2 summary

Hiperlan/2 is intended to provide local wireless access to IP, Ethernet, IEEE 1394, ATM and 3G infrastructure by both stationary and moving terminals that interact with access points. The intention is that access points are connected to an IP, Ethernet, IEEE 1394, ATM or 3G backbone network. A number of these access points are required to service all but the small-

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est networks of this kind, and therefore the wireless network as a whole supports handovers of connections between access points.

2.2. Similar WLAN interworking schemes

It should be noted that the interworking model presented in this paper is also applicable to the other WLAN systems, i.e. IEEE 802.11a/b and MMAC HiSWANa (High Speed Wireless Access Network), albeit with some minor modifications to the authentications schemes. It has been the intention of BRAN to produce a model which not only fits the requirements of Hiperlan/2–3G interworking, but also to try and meet those of the sister WLAN systems operating in the same market. A working agreement has been underway between ETSI BRAN and MMAC HSWA for over 1 year, and with the recent creation of WIG (see section 5), IEEE 802.11 is also working on a similar model.

2.3. 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 the Universal Mobile Telecommunications System (UMTS) which is one of the major third generation mobile systems. Additionally the 3rd Generation Partnership Project 2 (3GPP2) is also developing another 3G system, Code Division Multiple Access 2000 (CDMA-2000). Most of the work within BRAN has concentrated on UMTS, although most of the architectural aspects are equally applicable to Hiperlan/2 interworking with CDMA-2000 and indeed pre-3G systems such as General Packet Radio Services (GPRS).

The current working UMTS standard, Release 4, of UMTS was finalised in December 2000 with ongoing development work contributing to Release 5, due to be completed by the end of 2002. A future release 6 is currently planned for the autumn of 2003, with worldwide deployment expected by 2005.

3. System approach

This section describes the current interworking models being worked upon within BRAN at the current time. The BRAN Network Reference Architecture, shown in figure 1, identifies the functions and interfaces that are required within a Hiperlan/2 network in order to support inter-operation with 3G systems.

The focus of current work is the interface between the Access Point (AP) and the Service provider network (SPN) which is encapsulated by the L*x* interface. The aim of the Hiperlan/2–3G interworking work item is to standardise these interfaces, initially focusing on AAA (Authentication, Authorisation and Accounting) functionality.

A secondary aim is to create a model suitable for all the 5 GHz WLAN systems (e.g., Hiperlan/2, HiSWANa, IEEE 802.11a) and all 3G systems (e.g., CDMA-2000, UMTS), thus creating a world wide standard for interworking as mentioned in section 5.

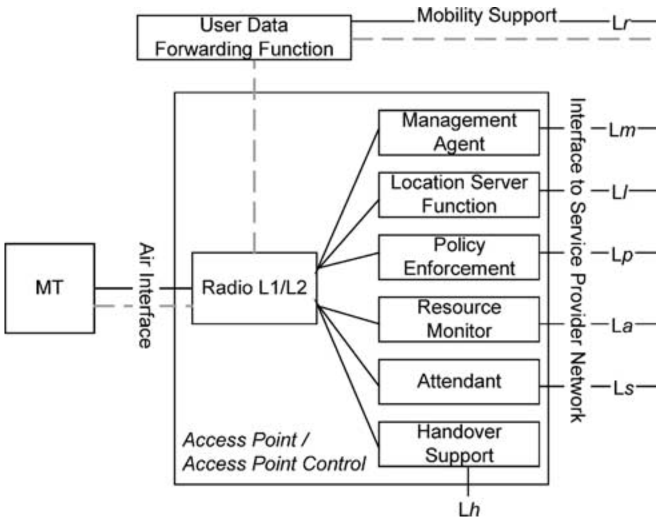

Figure 1. Reference architecture.

Other interfaces between the AP and external networks and interfaces within the AP are outside the scope of this current work.

Figure 1 shows the reference architecture of the interworking model. It presents logical entities within which the following functions are supported:

- *Authentication*: supports both SIM-based and SIM-less authentication. The mobile terminal (MT) communicates via the Attendant with an authentication server in the visited network, for example a local AAA server, across the L*s* interface.
- *Authorisation and User Policy*: the SPN retrieves authorisation and user subscription information from the home network when the user attaches to it. Authorisation information is stored within a policy decision function in the SPN. Interfaces used for this are L*p* and L*s*.
- *Accounting*: the resources used by a MT and the QoS provided to a user are both monitored by the Resource Monitor. Accounting records are sent to accounting functions in the visited network via the L*a* interface.
- *Network Management*: the Management Agent provides basic network and performance monitoring, and allows the configuration of the AP via the L*m* interface.
- *Admission Control and QoS*: a policy decision function in the SPN decides whether a new session with a requested QoS can be admitted based on network load and user subscription information. The decision is passed to the Policy Enforcement function via the L*p* interface.
- *Inter-AP Context Transfer*: the Handover Support function allows the transfer of context information concerning a user/mobile node, e.g., QoS state, across the L*h* interface from the old to the new AP between which the mobile is handing over.

- *Mobility*: mobility is a user plane function that performs re-routing of data across the network. The re-routing may simply be satisfied by layer 2 switching or may require support for a mobility protocol such as Mobile IP depending on the technology used within the SPN. Mobility is an attribute of the L*r* interface.
- *Location Services*: the Location Server function provides positioning information to support location services. Information is passed to SPN location functions via the L*l* interface.

4. Primary functions

This section describes the primary functions of this model (refer to figure 1) in further detail, specifically: authentication and accounting, mobility and QoS.

4.1. Authentication and authorisation

A key element to the integration of disparate systems is the ability of the SPN to extract both authentication and subscription information from the mobile users' home networks when an initial association is requested. Many users want to make use of their existing data devices (e.g., Laptop, Palmtop) without additional hardware/software requirements. Conversely 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 MT and network (indeed SPN) development it is important to be able to have a single set of AAA protocols which supports all the cases.

4.1.1. Loose coupling

The rest of this paper concentrates on loose coupling 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 in figure 1. Within the UMTS context, this scheme avoids any impact on the SGSN and GGSN nodes. Security, mobility and QoS issues are addressed using Internet Engineering Task Force (IETF) schemes.

Other schemes which essentially replace the User Terminal Radio Access Network (UTRAN) of UMTS with a HIRAN (Hiperlan Radio Access Network) are referred to as "Tight Coupling", but are not currently being considered within the work of BRAN.

4.1.2. Authentication flavours

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

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 UMTS term for a combined AAA home server (AAAH)/Home Location Register (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 through the use of separate Interworking Units (IWU) and allow loose coupling to existing and future cellular mobile networks. These alternatives are presented in figure 2.

IETF flavour. The IETF flavour outlined in figure 2 is driven by the requirement to add only 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) compared to that required by broadband wireless data access in the corporate or home scenarios. Within a multi-provider network, the WLAN operator (who also could be a normal ISP) does not necessary need to be the 3G operator as well, but there could still be an interworking between the networks.

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 MT and AP development it is important to be able to have a single set of AAA protocols which supports all the cases.

UMTS-HSS flavour. Alternatively the UMTS flavour (also described within figure 1) allows a mobile subscriber using a Hiperlan/2 mobile access network for broadband wireless data access to appear as a normal cellular user employing standard procedures and interfaces for authentication purposes. It is important to notice that for this scenario functionality normally provided through a user services identity module (USIM) is required in the user equipment. The 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 (3G Partnership Program).

The UMTS-HSS definitely requires that a user is a native cellular subscriber while – in addition and distinctly from the IETF flavoured approach – standard cellular procedures and parameters for authentication are used (e.g., 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 functionality is required in the user equipment.

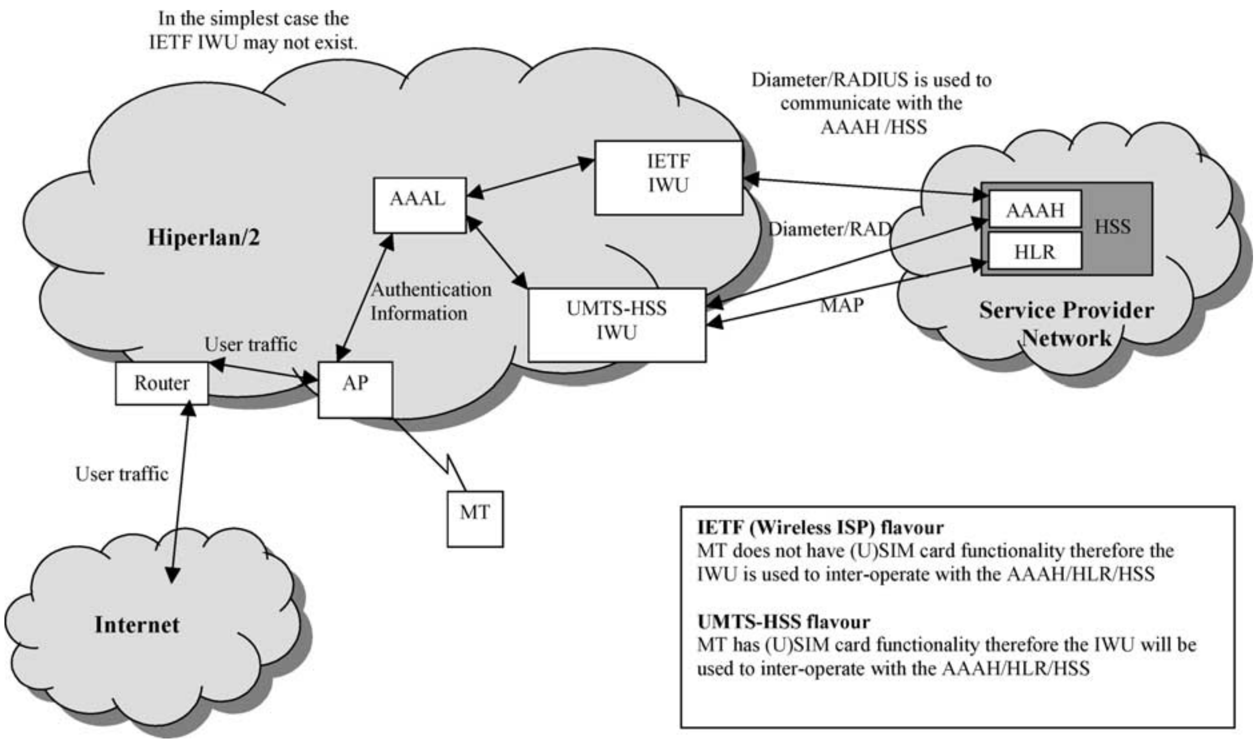

Figure 2. Loose coupling authentication flavours.

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 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.

4.1.3. EAPOH

For either flavour authentication is carried out using a mechanism based on EAP (Extensible Authentication Protocol) [3]. This mechanism is called EAPOH (EAP over Hiperlan/2) and is analogous to the EAPOL (EAP over LANs) mechanism as defined in IEEE 802.1X. On the network side, Diameter [4] is used to relay EAP packets between the AP and AAAH. Between the AP and MT, EAP packets and additional Hiperlan/2 specific control packets (termed pseudo-EAP packets) are transferred over the radio interface. This scheme directly supports IETF flavour authentication, and by use of the proposed EAP AKA (Authentication and Key Agreement) mechanism would also directly support the UMTS flavour authentication.

Once an association has been established, authorisation information (based on authentication and subscription) stored within a Policy Decision Function within the SPN itself can be transmitted to the AP. This unit is then able to regulate services such as time-based billing and allocation of network and radio resources to the required user service. Mobile users with different levels of subscription (e.g., “bronze, silver, gold”) can be supported via this mechanism, with different services being configured via the policy interface. A change in authentication credentials can also be managed at this point.

4.1.4. 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 should be reused within the Hiperlan/2 when interworking with a 3G SPN (i.e. core network). This will also increase the applied level of security.

The Diffie-Hellman encryption key agreement procedure, as used by the Hiperlan/2 air interface, could be used to improve user identity confidentiality. By initiating encryption before UMTS 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.

4.1.5. Subscriber data

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 (U)SIM 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 (U)SIM card), and
- IMSI encapsulated within a NAI (requires a (U)SIM card).

4.1.6. Pre-paid SIM cards

As far as the HLR within the SPN is concerned, it cannot tell the difference between a customer who is pre-paid 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 2G network are handled via an Intelligent Network (IN) probably 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 SPN 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.

This may be undesirable in a Hiperlan/2–3G network, so that a more graceful solution is required. A suitable solution is to add pre-paid SIM operation to our system together with hot billing (i.e. bill upon demand) or triggered session termination. This could be achieved either by the AAAL polling the SPN utilising RADIUS [5] to determine whether the customer is still in credit, or by using a more feature rich protocol such as Diameter [4] which allows network signalling directly to the MT.

The benefit of the AAA 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 SPN subscriber management system. Further additional services such as Customized Applications for Mobile Network Enhanced Logic (CAMEL) may also allow roaming with pre-paid SIM cards.

4.2. Accounting

In the reference architecture of figure 2, the accounting function monitors the resource usage of a user in order to allow cost allocation, auditing and billing. The charging/accounting is carried out according to a series of accounting and resource monitoring metrics, which are derived from the policy function and network management information.

The types of information needed in order to monitor each user's resource consumption could include parameters such as, for example, volume of traffic, bandwidth consumption, etc. Each of these metrics could have AP specific aspects concerning the resources consumed over the air interface and those consumed across the SPN, respectively. As well as providing data for billing and auditing purposes, this information is exchanged with the Policy Enforcement/Decision functions in order to provide better information on which to base policy decisions.

The accounting function processes the usage related information including summarisation of results and the generation of session records. This information may then be forwarded to other accounting functions within and outside the network, for example a billing function. This information may also be passed to the Policy Decision function in order to improve the quality of policy decisions; vice versa the Policy Decision function can give information about the QoS, which may affect the session record. There are also a number of extensions and enhancements that can be made to the basic interworking functionality such as those for the provision of support for QoS and mobility.

In a multiprovider network, different sorts of inter-relationships between the providers can be established. The inter-relationship will depend upon commercial conditions, which may change over time. Network Operators have exclusive agreements with their customers, including charging and billing, and also for services provided by other Network Operators/Service Providers. Consequently, it must be possible to form different charging and accounting models and this requires correspondent capabilities from the networks.

Charging of user service access is a different issue from the issue of accounting between Network Operators and Service Providers. Although the issues are related, charging and accounting should be considered separately. For the accounting issue it is important for the individual Network Operator or Service Provider to monitor and register access use provided to his customers.

Network operators and service providers that regularly provide services to the same customers could either charge and bill them individually or arrange a common activity. For joint provider charging/billing, the providers need revenue accounting in accordance with the service from each provider. For joint provider charging of users, it becomes necessary to transfer access/session related data from the providers to the charging entity. Mechanisms for revenue accounting are needed, such as technical configuration for revenue accounting. This leads to transfer of related data from the Network

Operator and/or Service Providers to the revenue accounting entity.

The following parameters may be used for charging and revenue accounting:

- basic access/session (pay by subscription),
- toll free (like a 0800 call),
- premium rate access/session,
- access/session duration,
- credit card access/session,
- pre-paid,
- calendar and time related charging,
- priority,
- Quality of Service,
- duration dependent charging,
- flat rate,
- volume of transferred packet traffic,
- rate of transferred packet traffic (Volume/sec),
- multiple rate charge.

4.3. Mobility

Mobility can be handled by a number of different approaches. Indeed many mobility schemes have been developed in the IETF that could well be considered along with the work of the MIND (Mobile IP based Network Developments) project that has considered mobility in evolved IP networks with WLAN technologies. Mobility support is desirable as this functionality would be able to provide support for roaming with an active connection between the interworked networks, for example, to support roaming from UMTS to WLAN in a hotspot for the downloading of large data.

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 [6], 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 MTs and APs.

Given that Hiperlan/2 network handover is supported, further details for completing the mobility between access points are provided by CL 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.

4.3.1. 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 SPN 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.

Two 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).

4.3.2. 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.

4.4. QoS

QoS support is available within the Hiperlan/2 specification but requires additional functionality in the interworking specifications for the provision of QoS through the CN rather than simply over the air. QoS is a key concept, within UMTS, and together with the additional QoS functionality in Hiperlan/2, a consistent QoS approach can therefore be provided. A number of approaches to QoS currently exist which still need to be considered at this stage.

QoS within the Hiperlan/2 network must be supported between the MT and external networks, such as the Internet. In the loose coupling scenario, the data path is not constrained to travelling across the 3G SPN, 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.

4.4.1. HiperLAN2/Ethernet QoS mapping

Within the Hiperlan/2 specification, radio bearers are referred to as DLC connections. A DLC connection is characterised by offering a specific support for QoS, for instance in terms of bandwidth, delay, jitter and bit error rate. The characteristics of supported QoS classes are implementation specific. A user might request for multiple DLC connections, each transferring a specific traffic type, which indicates that the traffic division is traffic type based and not application based. The DLC connection set-up does not necessarily result in immediate assignment of resources though. If the MT has not negotiated a fixed capacity agreement with the AP, it must request capacity by sending a resource request (RR) to the AP whenever it has data to transmit. The allocation of resources may thereby be very dynamic. The scheduling of the resources is vendor specific and is therefore not included in the Hiperlan/2 standard, which also means that QoS parameters from higher layers are not either.

Hiperlan/2 specific QoS support for the DLC connection comprises centralised resource scheduling through the TDMA-based MAC structure, appropriate error control (acknowledged, unacknowledged or repetition) with associated protocol settings (ARQ window size, number of retransmissions and discarding), and the physical layer QoS support. Another QoS feature included in the Hiperlan/2 specification is a polling mechanism that enables the AP to regularly poll the MT for its traffic status, thus providing rapid access for real-time services. The CL acts as an integrator of Hiperlan/2 into different existing service provider networks, i.e. it connects the SPNs to the Hiperlan/2 data link control (DLC) layer.

IEEE 802.1D specifies an architecture and protocol for MAC bridges interconnecting IEEE 802 LANs by relaying and filtering frames between the separate MACs of the Bridged LAN. The priority mechanism within IEEE 802.1D is handled by IEEE 802.1p, which is incorporated into IEEE 802.1D. All traffic types and their mappings presented in the tables of this section only corresponds to default values specified in the IEEE 802.1p standard, since these parameters are vendor specific.

IEEE 802.1p defines eight different priority levels and describes the traffic expected to be carried within each priority level. Each IEEE 802 LAN frame is marked with a user priority (0–7) corresponding to the traffic type [8].

In order to support appropriate QoS in Hiperlan/2 the queues are mapped to the different QoS specific DLC connections (maximum of eight). The use of only one DLC connection between the AP and the MT results in best effort traffic only, while two to eight DLC connections indicates that the MT wants to apply IEEE 802.1p. A DLC connection ID is only MT unique, not cell unique.

The AP may take the QoS parameters into account in the allocation of radio resources (which is out of the Hiperlan/2 scope). This means that each DLC connection, possibly operating in both directions, can be assigned a specific QoS, for instance in terms of bandwidth, delay, jitter and bit error rate, as well as being assigned a priority level relative to other DLC connections. In other words, 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.

The support for IEEE 802.1p is optional for both the MT and AP.

4.4.2. End-to-end based QoS

Adding QoS, especially end-to-end QoS, to IP based connections raises significant alterations and concerns since it represents a digression from the "best-effort" model, which constitutes the foundation of the great success of Internet. However, the need for IP QoS is increasing and essential work is currently in progress. End-to-end IP QoS requires substantial consideration and further development.

Since the Hiperlan/2 network supports the IEEE 802.1p priority mechanism and since Differentiated Services (DiffServ) is priority based, the natural solution to the end-to-end QoS problem would be the end-to-end implementation of DiffServ. The QoS model would then appear as follows. QoS from the MT to the AP is supported by the Hiperlan/2 specific QoS mechanisms, where the required QoS for each connection is identified by a unique Data Link Control (DLC) connection ID. In the AP the DLC connection IDs may be mapped onto the IEEE 802.1p priority queues. Using the IEEE 802.1p priority mechanisms in the Ethernet, the transition to a DiffServ network is easily realised by mapping the IEEE 802.1p user priorities into DiffServ based priorities.

Neither the DiffServ nor the IEEE 802.1p specification elaborates how a particular packet stream will be treated based on the Differentiated Services (DS) field and the layer 2 priority level. The mappings between the IEEE 802.1p priority classes and the DiffServ service classes are also unspecified. There is however an Integrated Services over Specific Link Layers (ISSLL) draft mapping for Guaranteed and Controlled Load services to IEEE 802.1p user priority, and a mapping for Guaranteed and Controlled Load services, to DiffServ which together would imply a DiffServ to IEEE 802.1p user priority mapping.

DiffServ provides inferior support of QoS than IntServ, but the mobility of a Hiperlan/2 MT indicates a need to keep the QoS signalling low. IntServ as opposed to DiffServ involves significant QoS signalling.

The DiffServ model provides less stringent support of QoS than the IntServ/RSVP model but it has the advantage over IntServ/RSVP of requiring less protocol signalling, which might be a crucial factor since the mobility of a Hiperlan/2 MT indicates a need to keep the QoS signalling low. Furthermore, the implementation of an end-to-end IntServ/RSVP based QoS architecture is much more complex than the implementation of a DiffServ based one.

Discussions around end-to-end QoS support raise some critical questions that need to be considered and answered before a proper solution can be developed; which performance can we expect from the different end-to-end QoS models, what level of QoS support do we actually need, how much bandwidth and other resources are we willing to sacrifice on QoS, and how much effort do we want to spend on the process of developing well-supported QoS?

5. Relationships with other standardisation bodies

BRAN is continuing to have a close working relationship with the following bodies:

WLAN Interworking Group (WIG)
This group met for the first time in September 2002. Its broad aim is to provide a single point of contact for the three main WLAN standardisation bodies (ETSI BRAN, IEEE 802.11 and MMAC HSWA) and to produce a generic approach to both Cellular and external network interworking of WLAN technology. It has been also decided to work upon, complete and then share a common standard for WLAN – Public Access and Cellular networks.

3rd Generation Partnership Project (3GPP)
The System Architecture working group 1 (SA1) is currently developing a technical report detailed the requirements for a UMTS–WLAN interworking system. They have defined 6 scenarios detailing aspects of differently coupled models, ranging from no coupling, through loose coupling to tight coupling. Group 2 (SA2) is currently investigating reference architecture models, concentrating on the network interfaces towards the WLAN. Group 3 (SA3) has now started work on security and authentication issues with regard to WLAN interworking. ETSI BRAN is currently liasing with the SA2 and SA3 groups.

Internet Engineering Task Force (IETF)
Within the recently created 'eap' working group, extensions are being considered to EAP (mentioned in section 4), which will assist in system interworking.

Institute of Electrical and Electronics Engineers (IEEE) – USA
The 802.11 WLAN technical groups are continuing to progress their family of standards. Many similarities exist between the current 802.11a standard and Hiperlan2/HiSWANa with regard to 3G interworking. ETSI BRAN is currently liasing with the Wireless Next Generation (WNG) group of the IEEE 802.11 project.

Multimedia Mobile Access Communication (MMAC) – Japan
The High Speed Wireless Access (HSWA) group's HiSWANa (High Speed Wireless Access Network system A) is essentially identical to Hiperlan/2, except that it mandates the use of an Ethernet convergence layer within the access point. An agreement between ETSI BRAN and MMAC HSWA has now been in place for some time to share the output of the ETSI BRAN 3G interworking group.

6. Conclusions

This paper has addressed some of the current thinking within ETSI BRAN (and indeed WIG) regarding the interworking of the Hiperlan2 and HiSWANa wireless LAN systems into a 3G Cellular System. Much of this information is now appearing in the technical specification being jointly produced by ETSI and MMAC, expected to be published in the first half of 2003.

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 authentication schemes chosen will assume that EAP is carried over the air interface, thus being compatible, at the interworking level, with IEEE 802.11 and 3GPP.

This standardisation activity thus hopes to ensure that all WLAN technologies can provide a value added service within hotspot environments for both customers and operators of 3G systems.

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