Concepts for IP-based Radio Interface in the BRAIN Framework

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ABSTRACT

Considering that mobile communications systems and the Internet are key technologies for the development of the information society, one objective of the European IST project BRAIN is the design of a mobile broadband IP radio interface. This radio interface is based on the ETSI HIPERLAN Type 2 standard with some enhancements necessary to optimise the system for the delivery of IP broadband services with high QoS and Mobility requirements. The project is working on optimising layer 2 algorithms and protocols for IP mobile services such as adapted schedulers, optimised handover procedures, handling of a standby mode and specifying a dedicated IP Convergence Layer able to transport efficiently IP version 4 as well as version 6 packets over the air and interworking with IP Mobility and QoS functions.

INTRODUCTION

The European project BRAIN (Broadband Radio Access for IP-based Networks), is working on a broadband extension for Third Generation mobile systems [1][5]. The access network is fully based on IP whereas the radio interface is derived from the ETSI Hiperlan Type 2 standard. However, as described on Figure 1, the project considers also the integration of other access technologies such as GSM and UMTS on the open IP platform.

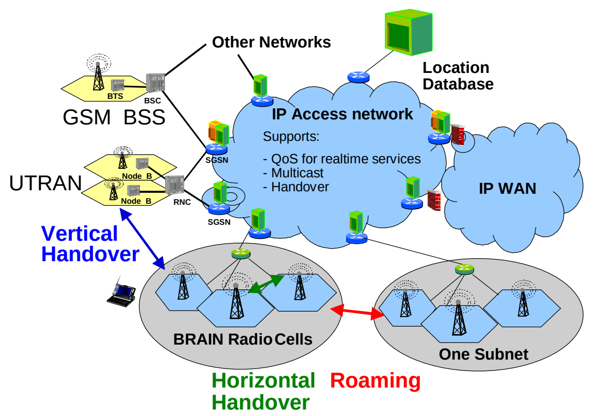

Figure 1 : BRAIN network architecture

The project adopts a top-down approach starting with service and application requirements and mapping them to access network and radio interface requirements in order to focus on the crucial points in developing the BRAIN technology. In this paper, we consider the design of the broadband IP based radio interface able to provide QoS and Mobility functions required by BRAIN IP services [6].

Section 1 addresses BRAIN air interface focusing on features supporting IP traffic. Section 2 focuses on Data Link Control algorithms for IP QoS. Section 3 describes BRAIN enhancements on mobility. Section 4 considers means to deliver IP packets over the air.

1 - OVERALL DESCRIPTION OF THE BRAIN RADIO INTERFACE

The BRAIN air interface provides broadband air interface for IP-based networks as a complement to $2^{nd}/3^{rd}$ generation systems. HIPERLAN Type 2 (H2) [2][3][4] specifies PHY layer, Layer 2 protocols and a generic Convergence Layer concept. BRAIN adapts these and focuses on delivering IP QoS in cellular environment. This is achieved by designing layer 2 algorithms, enhancing physical layer and designing Convergence Layer protocol. The BRAIN air interface provides wireless access with wireline quality for a wide range of broadband services such as video-telephony in different environments such as offices and hot spots (e.g. airports) [6]. Therefore security, roaming and handover features play an essential role in BRAIN air interface. BRAIN protocol stack is adapted from H2, see Figure 2. Therefore, it operates at 5 GHz unlicensed band and automatic and dynamic frequency planning, including the sharing of frequencies between different systems and transmission power control are included to enable global deployment.

On Physical layer BRAIN uses H2 OFDM modulation [4]: on the OFDM subcarriers there are three mandatory (BPSK, QPSK and 16-QAM) and one optional (64-QAM) modulation techniques, two code rates are mandatory for each subcarrier modulation; this results in 36 Mb/s and optionally 54 Mb/s on the top of physical layer. Furthermore, for the BRAIN Physical layer, also turbo coding schemes, adaptive modulation techniques and diversity techniques are considered to increase system efficiency and provide bit rates required for delay sensitive multimedia applications. All BRAIN terminals are able to measure RSSI of the serving and neighboring access points. Also access point and network identification of a neighboring access point can be provided to the DLC layer. These PHY features build a solid foundation for reliable and efficient radio transmission as well as intelligent handover strategies on the upper layers.

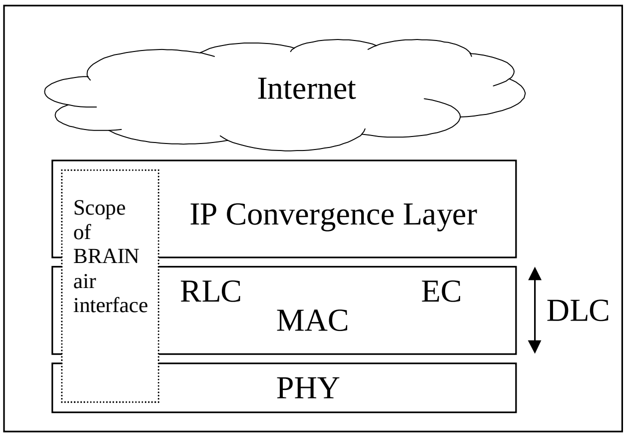

Figure 2 : BRAIN protocol stack.

On Data Link Control layer, BRAIN operates using the H2 centrally controlled TDMA/TDD scheme [2]: the Medium Access Protocol (MAC) enables full rescheduling in every 2 ms and dynamic adjustment of uplink and downlink capacity. Thus, MAC protocol provides excellent means to construct wireless links for bursty IP traffic without increased delay and unnecessary reservation of bandwidth. The radio link control provides establishment of connection oriented secured links service to the convergence layer. Up to 63 unicast data connections per terminal are supported with various QoS parameters. Error control protocol provides selective repeat ARQ (Automatic Repeat reQuest) mode for each connection. Alternatively, e.g. for delay intolerant services and multicast services a repetition mode can be used. Hence, DLC provides means for executing several IP QoS techniques such as prioritization, on-demand based bandwidth reservation and delay guarantee. DLC also provides protocols for dynamic frequency selection (DFS), link adaptation (LA), power control and power saving. In the vast majority of BRAIN target environments [6], it is investigated how the combination of dynamic scheduling, admission control, ARQ/repetition, DFS and LA could reduce IP packet loss rate to the level of wireline networks without significant increase of IP level delay. In other words, BRAIN air interface has potential to provide efficient short-range radio for the TCP protocol. To minimize power consumption and unnecessary signaling in stand-by mode, a location area concept similar to GSM is investigated in BRAIN air interface which allows terminals to move in their location area without maintaining a dedicated signaling link as long as no data session is established. Lastly, the BRAIN air interface also introduces a paging service used by the network to notify terminals when they need to set-up a dedicated signaling link.

In case of decreased link quality or periodically, BRAIN Mobile Terminals (MTs) can request absence and start handover measurements. BRAIN DLC protocol enables signaling of the new Access Point (AP) identity and handover time in advance to the network via old AP. This enables smooth rerouting of IP traffic to new APs.

Convergence layer (CL) provides service interface to BRAIN radio link for upper layers. CL implements the IP/BRAIN specific functions:

- mapping of IP QoS to BRAIN DLC QoS;
- the segmentation and re-assembly of IP packets to BRAIN DLC Service Data Units;
- handover support;
- stand-by mode management together with DLC.

CL offers a QoS interface that can support different IP QoS schemes. The QoS mapping requires that CL is aware of the underlying DLC implementation capabilities, such as amount of supported priority classes. By using IP QoS parameters CL establishes DLC connection where IP QoS parameters are mapped into DLC connection priority, radio bandwidth reservation, appropriate ARQ scheme and handover strategy. Convergence layer also segments IP packets to 48 bytes long payload DLC packets. The segmentation and re-assembly causes extra complexity in convergence layer but may enable better bandwidth reservation policy. It also allows retransmissions of smaller units than whole IP packets, which enables the maintaining of the agreed bit rates with less bandwidth. The stand-by mode management permits to handle terminals states adequate for IP sessions and mobility. Moreover, issues such as header compression and address management are under discussion within BRAIN.

2 - SUPPORT OF IP BASED QOS

IP QoS focuses on end-to-end QoS, whereby the network elements have to serve the respective requirements on a per hop basis, see Figure 3. Wireless access networks may provide only one or two hops of an end-to-end traffic flow, i. e., in case of wireless access networks on one or both sides of the IP network.

A H2 wireless LAN is able to support QoS on a per connection basis. The BRAIN IP Convergence Layer (CL) will provide the functions needed for mapping IP different QoS schemes to the Data Link Control (DLC) connections. Furthermore, the IP CL has to support segmentation and re-assembly to adapt variable length IP packets to fixed length H2 Protocol Data Units (PDU).

Mechanisms like error control by means of an ARQ protocol and dynamic link adaptation aim to reduce the radio specifics on the packet loss rate but introduce additional overhead and delay to the radio access system decreasing the capacity. To realize the QoS requested by an IP application at the radio interface algorithms, the DLC layer must decide how to schedule the related data. In the following we firstly introduce considered IP QoS schemes, then describe how to determine the quality of the radio link. Lastly, with respects to those schemes and quality metrics, we discuss scheduling and link adaptation strategies.

2.1 Considered IP QoS schemes

A service model describes a set of end-to-end QoS capabilities defining the ability of the network to deliver data packets according to the service required by the specific traffic from one end of the network to another. For IP traffic the following service models have been defined: Best Effort Service, Differentiated Services and Integrated Services.

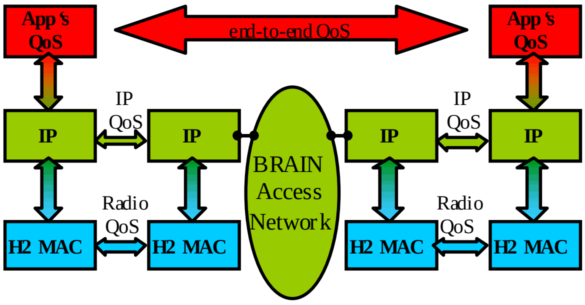

Figure 3 : BRAIN QoS Architecture

Best Effort Service
Best Effort Service is basic connectivity with no guarantees, so it is also known as lack of QoS. Best Effort is a single service model where an application sends data whenever it has to and in any quantity. This is done without requesting permission or informing the network. For Best Effort Service, the network delivers the data as best as it can without any assurance of delay bounds, throughput and reliability.

Differentiated Services
In this service model traffic [18] is grouped in service classes that are served differently by the network, whereby one class may be treated better than another, i. e., with higher bandwidth or lower loss rate. This results in a statistical preference and not in a hard guarantee, so that Differentiated Services are also called Soft QoS. For the Differentiated Services, the network tries to deliver the IP packets according to the QoS assigned to a specific service class indicated by each individual packet.

Integrated Services
This model represents an absolute reservation of network resources for specific traffic. It is also Hard-QoS. Integrated Services is a multiple service model that can accommodate multiple QoS requirements. In this model the application requests a specific kind of service from the network before sending data. The request is made by explicit signaling. This means, that the application informs the network nodes of its traffic profile and requests a particular kind of service that can encompass its bandwidth and delay requirements. Integrated Services support both Controlled Load Service [19] and Guaranteed Service [19]. The Controlled Load Service guarantees to provide a level of service equivalent to best effort service in a lightly loaded network, regardless of the actual network load. This service class is designed for adaptive real-time applications. These applications work well on low loaded networks but their performance degrade quickly under overloaded conditions. Guaranteed Service guarantees a maximum end-to-end delay and bandwidth. It is intended for audio and video applications with strict delay requirements.

2.2 Measuring the quality of the radio link

There is a strong interaction between the used PHY mode, retransmission load, utilisation of the radio link, delay and overall throughput. To manage radio link quality, a number of things have to be considered. First of all it has to be decided which values constitute the basis for the choice of PHY mode. Besides the QoS parameters it is important which values can or should be measured. While the received signal strength and the PDU error rate is easily available, it would be helpful to have also information about the C/I ratio. The interference level could e.g. be measured in certain time intervals while a BRAIN MT is not active.
With respect to the measured values it is furthermore important how often and at what times the measurements are performed. If the measurements would always be performed at the same instant, e.g. MTs while BCH reception, this would be disadvantageous. The frames of different radio cells have a fixed offset to each other and thus always the same (respectively a similar) interference situation would be measured meaning that the interference was always caused by another AP (downlink interference) or by other MTs (uplink interference). That's why the measurements should be performed at different instants. Furthermore, a not too small number of measurements should be performed. The scheduling is performed in every new frame which means that MTs are either scheduled at different instants in the frame or that other MTs than in the frame before are scheduled. According to the characteristics of the source and the used scheduling strategy fast changes in the interference situation can happen even if no mobility is present and when omitting other influences on the radio link. The interference situation changes even while reception of one PDU train. This makes it advantageous to perform measurements quite often to get a more reliable picture of the interference situation and to smooth out strong variations.
Having decided about what values are measured and at what times, the question arises how the measured values should be processed. The minimum and maximum value of the measured values will most often be too optimistic or pessimistic. So, some sort of averaging should be used. Since strong variations in the received levels are possible the usage of a mean value is disadvantageous. Some few very low or very high values will change the mean value significantly. That is why the median might be a better choice. It has similar behaviour as the mean value but is not influenced by few very high or very low values. This leads to the next question how big the measurement window, meaning the number of measured values, should be. With a small measurement window the processing of data is easier but high variations might not be smoothed out. A big measurement window means that the processing of data becomes more difficult (processing time) but high variations are better smoothed out. Nevertheless, a too big measurement window leads to a too pessimistic or optimistic view since too many

old and inadequate values are stored. This is a further point to be investigated.

2.3 Scheduling and link adaptation for IP QoS

Scheduling in the H2 DLC layer has to take care of the QoS requirements of a specific IP flow and the capabilities of the H2 radio system, such as the MAC and the ARQ) protocol. Furthermore the physical layer supports a set of modulation schemes with various coding rates that can be adapted dynamically by the DLC scheduling algorithm.

Adaptive scheduling of IP flows requires to prioritize and to guarantee specific DLC services for the various IP connections or groups of connections. Besides this, the DLC scheduling algorithm has to take into account the various properties of the H2 radio access that are mutually dependent:

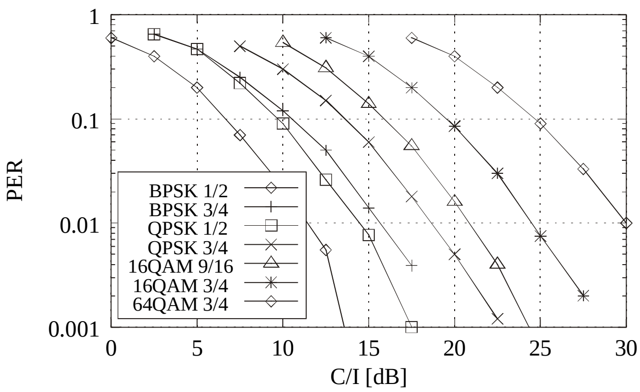

Figure 4 : PER vs C/I

- **ARQ** is used to react on transmission errors by re-transmission. However, in case of a poor radio link the transmission delay increases. Re-transmissions have to be considered as additional DLC signaling overhead, so that the net system capacity will be reduced. Figure 4 shows results from literature [8] giving the Packet Error Ratio (PER) dependence on the Carrier-to-Interference ratio (C/I) for office environment.
- **Discarding of PDUs** allows to skip re-transmission of specific PDUs, e. g., when due dates expire.
- **Link Adaptation:** In case of a poor link quality the PHY mode chosen for LCH PDUs can be adapted to a more robust one. However, PDUs coded with a more robust PHY mode require more capacity in the MAC frame, resulting also in a degradation of system capacity. For more informations on link adaptation, see [11].

Figure 5 shows the influence of link adaptation and ARQ on the total system throughput [9][11][12]. These figures result from calculations of the H2 MAC, whereby the actual capacity needed to build the MAC frame and the overhead introduced by an ideal ARQ has been considered. First of all, the influence of the H2 MAC on the system throughput can be derived from this figure. Considering a high C/I value (> 30dB) the PER can be neglected (see Figure 4) and ARQ has almost no impact. For example, in case the PHY mode 16QAM3/4 (36 Mbit/s PHY rate) is used for the LCH PDUs the total system throughput achievable is 28 Mbit/s. With decreasing C/I, i. e., increasing PER, the amount of ARQ re-transmissions increases, so that the total system throughput is reduced. From a system throughput perspective link adaptation should switch the PHY mode at C/I = 16 dB to 16QAM9/16. At this point a very high PER has to be served (about 25 % according to Figure 4) and, owing to ARQ re-transmissions, a high transmission delay will be experienced by the respective traffic flow. This high delay may be tolerable for best effort traffic, but not for real time traffic with tight delay requirements. From these estimations scheduling and link adaptation strategies can be derived regarding the IP flow's capacity, loss and delay requirements to choose the appropriate PHY mode. A priority-based scheduling technique seems to be appropriate to serve Differentiated and Best Effort Services connections, whereby a specific amount of system resources have to be reserved for Integrated Services connections. Admission control has to take care about the resources requested by an application and the additional system resources required by link adaptation and ARQ.

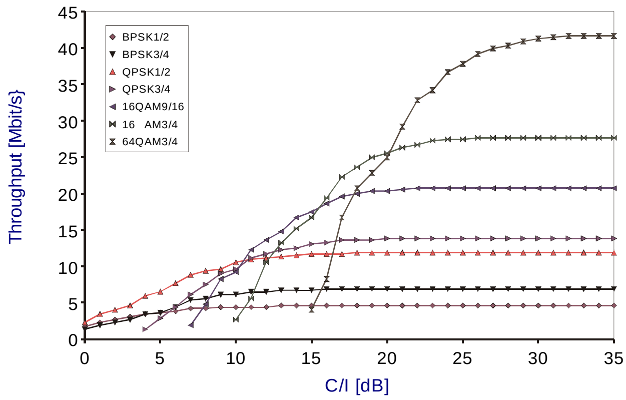

Figure 5 : Total system throughput over C/I with regard to PHY mode and ARQ

A performance evaluation for DLC scheduling considering also link adaptation is currently investigating above topics in detail while considering:

- Realistic SR-ARQ scheme with partial bitmap acknowledgements
- Imperfect performance due to lost acknowledgements
- Scheduling of acknowledgements
- Amount of protocol overhead
- Length and position of interference
- Realistic source models

3 - SUPPORT OF MOBILITY

BRAIN is specifying an IP based access network architecture with support for efficient IP mobility. The following chapters covers stand-by mode and the radio aspects of handover. The IP layer specific mechanisms for performing fast handovers are studied in [7].

3.1 Introduction of a stand-by mode

When a H2 Terminal enters in a network, it starts by associating itself with the Access Point controlling the cell it belongs to. Then, a dedicated control channel is implicitly established in order to allow connections management between the MT and the Access Point (e.g. connection setup, modifications, releases…). Thus, the dedicated channel is maintained even when there is no need to exchange data with the network. While moving from one cell to another (or even from one sector to another), the Mobile Terminal has to manage a handover procedure in order to maintain ongoing connections. The handover procedure implies signalling between the MT and the AP serving the targeted cell and may optionally rely on network protocols between both AP. Even when there is no ongoing user connections, the handover procedure has to be performed and a new dedicated control link is set up in the new cell.

While the H2 standard is designed to be firstly integrated in business and home networks where the expected mobility may be quite limited, in the BRAIN framework it is considered that Mobile Terminals shall support high mobility in large coverage areas. Then, the BRAIN radio interface must optimize the use of radio resources by limiting control information to be exchanged over the air as well as minimizing BRAIN MT battery consumption. It is clear that the existing H2 schemes, which require control messages over the air during movements even while no user data connections is established, does not fulfill those basic BRAIN requirements.

In order to better meet those requirements, it is considered to adopt a scheme similar to $2^{nd}/3^{rd}$ generation systems based on location areas on which a mobile terminal can move without informing the network of its exact location since there is no active data session. The basic idea, adopted from $2^{nd}/3^{rd}$ generation mobile systems, requires:

- to define BRAIN geographic location areas which group a number of BRAIN cells;
- that a MT locates itself in a geographic area when it enters in the network;
- to define a stand-by mode in which the mobile does not exchange neither control nor data packets with the network;
- to let the MT staying in the stand-by mode while it moves inside the same geographic area;
- to specify a fast mechanism to switch into the active mode when the MT has some IP packets to send to the network (e.g. due to movement through a new location area or data session setting).
- to allow the network notifying a stand-by MT when it has to switch in the active mode (e.g. when the network has some control or data packets to deliver to the MT). Such notification mechanism can be supported through broadcasting of paging messages inside the whole location area in order to let the MT triggering when it has to switch into active mode.

Different approaches can be developed to support those schemes over the air:

- Only the Layer 2 is concerned by the stand-by and active modes (the air interface network layer is not aware of them). Such an approach is adopted in 2G cellular systems but implies network signalling to centralize localization information for each stand-by mobile. In the BRAIN framework, the network is fully based on IP and then this scheme will limit the availability of location information in the network for adopting relevant IP routing mechanisms. Moreover, Layer 2 is not aware of data sessions initiated above the IP layer and may then decide to switch at non relevant times. However this approach permits to define an efficient layer 2 paging mechanism, which for example may rely on broadcasting paging messages through a dedicated layer 2 logical channel on which each stand-by terminal can listen.
- The stand-by mode is handled at the IP layer which eventually informs Layer 2 when it switches between stand-by and active modes. However, the IP layer has not the knowledge of radio parameters and measurements and may decide to switch in stand-by mode while layer 2 is not ready (e.g. it has to perform and report measurements asked by the Access Point). Moreover, handling paging at the IP layer requires to broadcast paging IP packets to stand-by terminals (through a dedicated channel?) which may be complicated and not efficient because of the need of computation at both layers (Layer 2 shall deliver all paging packets to the IP layer which shall interpret them to know whether they are relevant to the MT or not).
- Considering that both previous approaches are limited because they restrict themselves to information and mechanisms available at one layer only, it could be derived a third L2/L3 Integrated approach. The idea is then to combine Layer 2 and 3 information in order to trigger switching between the active and the stand-by modes. For example, the Layer 2 could make the information available at the IP layer that it is ready to switch and let the network make the decision by considering also information available at L3. Considering paging, it seems to be more efficient to handle it at layer 2 by defining a broadcast paging logical channel on which the Terminal Layer 2 get all distributed paging request and computes them to determine whether they are relevant to the terminal. Then, it would be able to "wake-up" the IP layer through internal mechanisms.

For the design of the BRAIN wireless IP interface, we propose to adopt the last approach which seems to be more efficient as it helps integrating L2 and L3 features in order to avoid creating gaps between the 2 layers. However, this approach will require to design efficiently the interface between both layers as well as the functions to be performed by the IP convergence layer. Then, the introduction of a paging mechanism, e.g. through the specification of a new DLC logical channel used to broadcast paging messages, is under investigations. Moreover, relevant signalling schemes in the RLC shall also be needed to permit a BRAIN MT to inform the network when it switches into stand-by or active mode.

3.2 Handover

The RLC (Radio Link Control) signaling procedures of H2 themselves only have little impact on the transmission delay of user data connections. Resources for RLC message transfer are allocated dynamically when needed. But much more than by the RLC messages alone user data is influenced by certain RLC functions. As a typical example for radio link control the impact of the handover protocol is considered in the following.
In a H2 system the MT is responsible for the evaluation of its own radio link situation. To assure the maintenance of the radio link the MT measures the received signal strength of its own and neighboring channels. The MT uses the AP with the best radio signal performance as measured by RSSI and PER. Thus, as the MT moves it may detect an alternative AP with better radio performance than the current AP. The MT will then initiate a handover to this AP and all its connections will be moved to the new AP. The MT stays associated to the H2 network and can continue its communication.

The actions resulting to a handover can be assigned to the following phases:

Scanning neighboring channels: The whole scanning cycle that will be performed every time the MT wants to take measurements from surrounding channels can be divided into three parts (see Figure 6). At first, the MT will inform the AP about its intention to switch temporarily to another frequency. That means, that the MT will execute an RLC procedure. This functions assures that the AP will stop transmitting downlink data. Thus, the scanning of other channels will not provoke any data loss. The second part, is the actual phase for measuring. A time $t_{change\ frequency}$ for changing from one frequency to another has to be taken into account as well. This time is in the order of magnitude of 1 ms.
Handover decision: Based on the measurements carried out the MT's decision to perform a handover is based on an algorithm specific for each MT. Typically the received field strength and the packet error ratio is taken into account. A hysteresis is considered to avoid ping-pong effects.
Handover execution: Three types of handover are distinguished: sector handover, radio handover and network handover. During sector and radio handover the handover execution can be performed within the DLC layer, so that communication can proceed after handover without major interruption, since all relevant information about on-going connections, security parameters, etc., are available in the AP. During network handover the MT associates to a new AP, so that re-negotiation is required. The IP-based core network will be involved.

3.2.1 Influence of the Radio Link Control Protocol

Considering these phases leading to a handover the impact on user data connections can be analyzed. The RLC procedures for frequency scanning and handover execution described above provoke a temporary absence of the MT, so that data has to be buffered resulting in an increasing transmission delay. The procedures for handover execution provoke only a single MT absence period during the actual handover execution, whereby the periodic measurements performed by the MT lead to a significant higher effect on the overall transmission delay. During the present period a minimum transmission delay is in the range of 2 – 4 ms at the H2 radio interface can be achieved, as shown in [8]. Considering also the absence periods, this mean transmission delay increases with the periodicity of the measurements performed.
The duration of the absence period can be expected to be in the range of 3-5 ms at minimum. The periodicity of the measurements performed may be determined by the MT´s mobility and the actual environment conditions. That means, that a highly mobile MT in an environment with fast changing radio conditions (owing to obstacles) will measure neighboring frequencies more often than in an large open space environment. Of course stationary MTs will not perform measurements at all.
However, the AP is not aware of the MT behavior in H2 systems. There are no means for the AP to take into account the additional buffering delay in the IP QoS scheduling algorithm, since the AP is not informed about this absent periodicity and duration of the MT a-priori when negotiating a specific QoS during connection set-up.

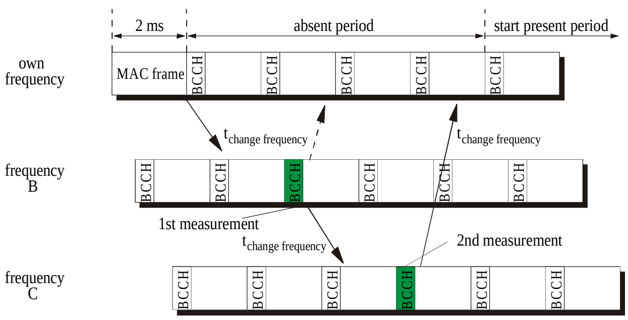

Figure 6 : Frequency Scanning Period

3.2.2 Enhancements for Handover Support

For a cellular system as considered in BRAIN mobility support is one key element. Various kinds of MT mobility and QoS requirements will be served by the BRAIN system, whereby QoS capabilities have to be weighted against mobility. For the BRAIN access system it is therefore essential, that both AP and MT are aware about the protocol influence owing to mobility and QoS parameters negotiated. In the BRAIN project strategies will be investigated to limit the protocol influences on the data transmission to a minimum. The absence procedure triggered for neighbor cell measurements will be adapted dynamically to MT´s mobility. Two environment scenarios will be considered covering

BRAIN´s focus, these are the office scenario taking into account walls and multiple floors and the large open space scenario.
Enhancements to the H2 RLC protocol will be investigated which will allow the AP to obtain sufficient information about MT´s characteristics, so that IP QoS connections can be served also in a mobile environment. Moreover, means to let the Network side controlling Handover execution will be investigated.

4 - EFFICIENT IP TRANSPORT OVER THE AIR

In this section, we describe some main issues to be considered to provide an efficient IP transport over the air interface. However, this section is not willing to be exhaustive but give some important tracks studied for the design of the BRAIN wireless interface.

4.1 Addressing

In order to deliver IP packets over the air, it has to be discussed how to provide addressing on the wireless interface. Indeed, as Wireless LAN are designed to be deployed in existing LAN infrastructures or as ad-hoc networks, they generally provide an "Ethernet like" service to the IP layer. In the BRAIN concept, the IP protocol is delivered directly without encapsulation of IP packets into Ethernet frames. As the BRAIN air interface is derived from the existing H2 standard, DLC uses a temporary MAC-ID to address a BRAIN MT inside the H2 cell (the MAC-ID is allocated by the Access Point). As the BRAIN Access Point is providing routing functionality, it is necessary to define the mapping between layer 3 and 2 addresses. It is considered such a scheme:

- At layer 2, the used MAC-ID is allocated by the Access Point as specified in the H2 standard;
- Depending on the mobility scheme, the BRAIN MT uses a permanent or temporary IP address (e.g. acquired through autoconfiguration mechanisms);
- The BRAIN MT IP address is given to the Access Point which maintains a routing table providing the correspondence between the IP address and the underlying interface to be used (H2 MAC-ID). It shall be considered if this table has to be maintained by the IP layer or the Convergence Layer.

4.2 Movement detection

In existing cellular networks, as the handover is fully handled at layer 2, the movement detection is based on knowledge of performed handovers. Moreover, as existing Mobile IP schemes are specified to be fully independent of the underlying technology, they do not require to inform Mobile IP about Layer 2 movements [17]. Then, some mechanisms can be used at the IP layer to detect movements, for example by learning new router address and prefix which are broadcast periodically by routers. This kind of movement detection procedure handled at layer 3 may introduce large delays and packet losses not compatibles with applications requiring certain level of QoS. Thus, it is considered how to better integrate layers 2 and 3 mobility features in order to be able to provide real-time movement detection and fast re configuration of layer 3 during movements.

4.3 Support of IP version 4 and version 6

The IP Convergence layer (CL) defined in BRAIN provides an efficient mapping of IP packets onto radio flows. The mapping for IP versions 4 [15] and 6 [16] is necessarily different. This section discusses the additional considerations brought on by IPv6. The main issues include header compression, address management, and new features introduced by IPv6.

The minimum IPv6 header size is 40 octets, twice the size of an IPv4 header, and can contain additional extension headers between the header and the payload. This makes support for efficient IP header compression schemes over the air attractive in the CL.
The basic issues of address management have been discussed in section 4.1. IPv6 addressing, however, brings additional considerations. IPv6 supports address autoconfiguration where an IPv6 address is formed by combining one of a number of prefixes, advertised by an IPv6 router, with a unique interface identifier. The mechanism is quite different from IPv4. IPv6 address autoconfiguration is a process that can take several interactions over the link. Ways of supporting IPv6 address selection efficiently, but without compromising compatibility, will be considered for the BRAIN CL.
Another issue to consider is the special address types defined in IPv6, including anycast addresses, scoped multicast addresses, and predefined multicast groups. BRAIN DLC supports multicast DLC addresses, the mapping rules between IPv6 and DCL multicast addresses will be considered for the BRAIN CL.
Both IPv4 and IPv6 provide a header field for carrying Diffserv QoS information, although the fields are named and located differently. Thus, the QoS mapping can be done in the same manner for IPv4 and IPv6. In addition, an IPv6 header carries a flow label, which could be used to identify a flow even when it is encrypted and assist in mapping it to the corresponding radio flow.

5 - CONCLUSION

In this paper, we described the IP radio interface under development and evaluation in the IST BRAIN project. This interface is mostly based on the HIPERLAN Type 2 protocol stack but introduces some enhancements and new concepts in order to provide efficient IP transport over the radio link with respects to QoS and mobility requirements given by the project technical "Top-Down" approach.
The proposals described in this paper will be evaluated by means of protocol and system simulations. This will permit to validate and refine the air interface design as well as its integration in the BRAIN access network.

Acknowledgements

This work has been performed in the framework of the IST project IST-1999-10050 BRAIN, which is partly funded by the European Union. The authors would like to acknowledge the contributions of his colleagues from Siemens AG, British Telecommunications PLC, Agora Systems S.A., Ericsson

Radio Systems AB, France Télécom R&D, INRIA, King's College London, Nokia Corporation, NTT DoCoMo, Sony International (Europe) GmbH, and T-Nova Deutsche Telekom Innovationsgesellschaft mbH.

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