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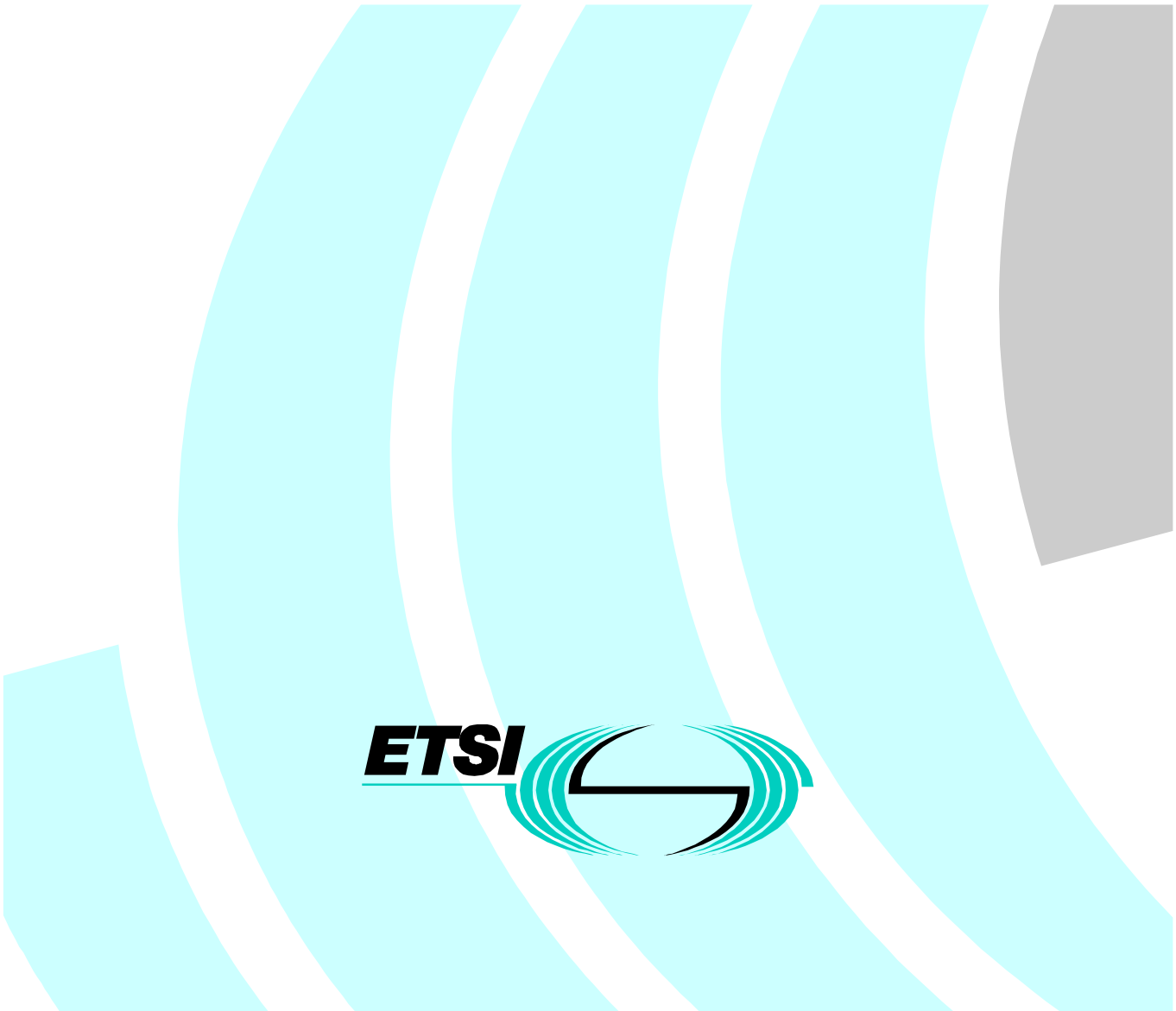
Technical Report

Broadband Radio Access Networks (BRAN); Common ETSI - ATM Forum reference model for Wireless ATM Access Systems (WACS)



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Foreword

This Technical Report (TR) has been produced by ETSI Project Broadband Radio Access Networks (BRAN).

Introduction

The present document describes a Common Reference Model for Broadband Radio Access Networks (BRAN) supporting ATM. The main requirements for this system can be found in [2]. Its purpose is to document a common understanding between ETSI and the ATM Forum concerning reference models, services, features and interface specifications. This understanding will be the basis for the development by ETSI of a set of standards for Broadband Radio Access Networks intended for interworking with ATM transport networks.

ETSI is developing specifications for broadband wireless access systems that support at least two different applications. The primary focus of the first of these, called HIPERLAN/2, is to provide local access with controlled quality of service to broadband applications and services as well as to telecommunications services, e.g. Internet and video conferencing. The main application of HIPERLAN/2 devices is wireless terminals, including portable computers for use within buildings and on-campus using unlicensed radio spectrum in the 5 GHz band [1].

The second application is called HIPERACCESS which will primarily be used as a broadband remote access network using radio transmission, and also supporting a range of data communications services. The radio spectrum for this application may be assumed to come from almost anywhere in the 2 GHz to 60 GHz region. These networks normally will conform to [10] which places limitations on what may be done within the access network itself and marks an important difference between HIPERACCESS and HIPERLAN/2.

The third ETSI BRAN application is called HIPERLINK, which is primarily a network-to-network radio interconnect which will support ATM and possibly other protocols.

Each of the above BRAN Family members will support ATM transport and signalling protocols. However, support for other protocols, e.g. Internet Protocol, is not precluded. The common reference model described here is a more detailed instantiation of the overall (general) BRAN reference model and covers the ATM compliant versions of each of the above BRAN Family members. It is intended to meet the requirements of both the ATM Forum and the ETSI BRAN Project with regard to the specification of the functions, interfaces and interworking aspects of wireless ATM systems. These specifications will be complimentary and together specify complete systems.

In order to accomplish this goal, a clear division of responsibilities has to be established and a means put in place to ensure that the work as divided maintains the appropriate coherence. From ETSI’s point of view, the present document will guide how the specifications it will develop relate to specifications to be produced by the ATM Forum and other bodies. For example, ETSI will be producing radio PHY and DLC layer specifications that have to interface with the ATM layer of a full system protocol stack. The ATM Forum is assumed to provide the other standards, including those required for the extended signalling between a End-user Mobility-supporting ATM Switch and the wireless subsystem.

1 Scope

The present document describes a Common Reference Model for Broadband Radio Access Networks (BRAN) supporting ATM, also know as Wireless ATM Access Systems (WACS). WACS provide wireless local and remote access to ATM networks. In the ETSI BRAN Project, the scope of the standards for such specific systems is limited to the air interface, the service interfaces of the wireless subsystem, interworking functions for specified user and network interfaces, and supporting capabilities required to realize these services. The air interface and the interworking functions for HIPERLAN/2 provide multi-vendor interoperation capabilities at the air interface and at those supported network interfaces.

Interfaces and protocols between the signalling functions in ATM terminal devices and the signalling functions in the ATM switch are outside the scope of BRAN, but may be in the scope of the present document where they relate to radio mobility.

The following describes a reference model to be used as basis for the development of a set of functional standards for WACS. It should be noted that for many purposes, there is no need to distinguish between WACS compliant systems serving mobile user nodes and those serving stationary access nodes. In the latter case, the same node may be visible to more than one access point and the radio link conditions may require a "handover" in order to maintain communications in changing radio environments.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] CEPT Recommendation T/R 22-06: "Harmonised radio frequency bands for High Performance Radio Local Area Networks (HIPERLANs) in the 5 GHz and 17 GHz frequency range".

[2] TR 101 031: "Radio Equipment and Systems (RES); HIgh PErformance Radio Local Area Network (HIPERLAN); Requirements and architectures for Wireless ATM Access and Interconnection".

[3] ITU-T Recommendation Q.2931 (1995): "Digital Subscriber Signalling System No. 2 (DSS 2) – User-Network Interface (UNI) layer 3 specification for basic call/connection control".

[4] ITU-T Recommendation I.356 (1996): "B-ISDN ATM layer cell transfer performance".

[5] ATM Forum (April 1996): "Traffic Management Specification Version 4.0".

[6] ATM Forum (July 1996): "ATM User-Network Interface (UNI) Signalling Specification Version 4.0".

[7] ATM Forum (September 1996): "Integrated Local Management Interface (ILMI) Specification Version 4.0".

[8] ATM Forum (March 1996): "Private Network-Network Interface (PNNI) Specification Version 1.0".

[9] ATM Forum (1994): "ATM User-Network Interface (UNI) Specification Version 3.1".

[10] ITU-T Recommendation G.902 (1995): "Framework Recommendation on functional access networks (AN) - Architecture and functions, access types, management and service node aspects".

[11] TR 101 054 (V1.1): "Security Algorithms Group of Experts (SAGE); Rules for the management of the HIPERLAN Standard Encryption Algorithm (HSEA)".

[12] ISO/IEC 7498-1: "Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".

[13] ISO/IEC DIS 8802-11: "Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications".

[14] ISO/IEC 15802-1: "Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Common specifications - Part 1: Medium Access Control (MAC) service definition ".

[15] ISO/IEC 8802-2: "Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 2: Logical link control".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

[Local] access: this term is used in the telecommunications sense: short-range (less than 100 m) wireless access to other, possibly wired, networks.

[Remote] access: this terms is used in the telecommunications sense: long-range (up to 10 km) wireless access to other, possibly wired, networks. Remote access networks are also referred to as "local loop networks," although the use of this term is deprecated by ITU.

[WACS] access point: a device controlling a single wireless subnetwork.

association: a radio sub-system binding between a WACS Node and a WACS AP.

BRAN family: this currently comprises the HIPERLAN/2, HIPERACCESS and HIPERLINK systems.

data confidentiality: provisions for the protection of transmitted data from observation by unauthorized stations or other monitoring means. One measure for doing that is to implement encryption.

Data Link Control (DLC): layer 2 of the ISO/OSI reference model [12]. The DLC layer consists of the medium access control (MAC) and logical link control (LLC) sublayers.

downlink: the incoming data direction from a WACS Terminal Adapter perspective.

end-user Mobility-supporting ATM Switch (EMAS): ATM switch enhanced to support mobile users.

encryption: a means of obtaining data confidentiality (see also data confidentiality).

handover: the changing of the path over which information flows within or across the wireless ATM subsystem, without releasing the connection.

HIPERACCESS: HIgh PErformance Radio ACCESS network.

HIPERLAN/2: HIgh PErformance Radio Local Access Network.

HIPERLINK: HIgh PErformance Radio network LINK.

interworking: interaction between dissimilar subnetworks, end systems, or parts thereof, providing a Functional Element capable of supporting end-to-end communications.

Local Area Network (LAN): a group of user stations each of which can communicate with at least one other using a common transmission medium commonly managed.

Logical Link Control (LLC): ISO/IEC 8802-2 layer [15] between the network layer and the MAC layer of the ISO/IEC DIS 8802-11 reference model [13]. The LLC sublayer maintains the quality of service on a virtual circuit basis. Depending on the type of service provided and channel quality, capacity and utilisation, the LLC layer may implement a variety of means including FEC, ARQ and flow pacing to optimise the service provided to the (DLC) user.

MAC Service Data Unit (MSDU): the fundamental unit of data delivery between MAC entities.
See Service Data Unit (SDU).

Medium Access Control (MAC): ISO/IEC 15802-1 layer [14] of the ISO/IEC DIS 8802-11 reference model [13] between the PHY and the LLC. The MAC sublayer implements a service policy, i.e. allocation of resources to virtual circuits and terminals, that takes into account such factors as channel quality, number of terminal devices and medium sharing with other wireless subnetworks.

[WACS] node: a grouping comprizing a WACS Terminal and a WACS Terminal Adaptor.

Protocol Data Unit (PDU): data unit exchanged between entities at the same ISO layer.

Physical Layer (PHY): layer 1 of the ISO/OSI reference model [12]. The mechanism for transfer of symbols between HIPERLAN/2 nodes.

registration: a binding between a WACS Node and the external network which enables that network to route connections to the WACS Node.

Service Data Unit (SDU): data unit exchanged between adjacent ISO layers.

[WACS] terminal: the functional components of a WACS Node that contains the end-user application.

[WACS] terminal adapter: the functional components of a WACS Node that provide the wireless communications services and the related control functions.

Wireless ATM Access System (WACS): ATM specific wireless access subsystem.

uplink: the outgoing data direction from WACS Terminal Adapter perspective.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ACF	Association Control Function
AP	Access Point
APC	Access Point Controller (equivalent to the ATMF AP)
APCF	Access Point Control Function
APT	Access Point Transceiver (equivalent to the ATMF Radio Port)
ARQ	Automatic Repeat reQuest
ATM	Asynchronous Transfer Mode
ATMC	ATM Connection
BRAN	Broadband Radio Access Network
CAC	Connection Admission Control
CAP	Combined EMAS/AP
CBR	Constant Bit Rate
CC	Connection Control
CCF	Call control and Connection control Function
CDVT	Cell Delay Variation Tolerance
CEPT	European Conference of Postal and Telecommunications Administrations
DLC	Data Link Control (layer)

EMAS	End-user Mobility-supporting ATM Switch
ETSI	European Telecommunications Standards Institute
FE	Functional Element
FEC	Forward Error Correction
IEC	International Electrotechnical Committee
ILMI	Integrated Local Management Interface
IMF	Identification Management Function
ISO	International Standards Organisation
ITU-T	International Telecommunications Union (Telecommunications Division)
LAN	Local Area Network
LLC	Logical Link Control (layer)
LME	Layer Management Entity
MAC	Medium Access Control (layer)
MMF	Mobility Management Function
MSDU	MAC Service Data Unit
M-NNI	Mobility-enhanced NNI
M-UNI	Mobility-enhanced UNI
NNI	Network-to-Network Interface
OSI	Open Systems Interconnection
QoS	Quality of Service
PHY	Physical (layer)
PDU	Protocol Data Unit
RF	Radio Frequency
RRC	Radio Resource Control
RTR	Radio Transmission and Reception
SCF	Service Control Function
SDU	Service Data Unit
SMF	Security Management Function
TA	Terminal Adaptor
TR	Technical Report
UBR	Unspecified Bit Rate
UNI	User-Network Interface
VBR	Variable Bit Rate
VBR-RT	Real-Time Variable Bit Rate
VBR-NRT	Non-Real-Time Variable Bit Rate
VCI	Virtual Channel Identifier
VPC	Virtual Path Connection
VPI	Virtual Path Identifier
WACS	Wireless ATM Access System
WCS	Wireless Convergence Sublayer

4 Wireless ATM Access Systems (WACS)

4.1 Services

WACS shall provide the following services:

- connection set-up in accordance with ATM signalling specifications. These are [3], UNI3.1 [9], UNI4.0 [6], or evolved equivalents. Outgoing and incoming connections shall be supported. Device addressing shall be consistent with world-wide roaming;
- releasing incoming connections and outgoing connections;
- unit data transfer;
- indication of changing capacities due to changes in the radio environment. Note that this does not and should not imply resource re-negotiation at the ATM or higher levels.

4.2 Supporting capabilities

WACS shall provide the following capabilities in support of the above services:

- traffic management to maximize adherence to QoS parameters established at connection set-up;
- association of WACS nodes to WACS Access Points;
- informing the ATM switch of the changes in the population of associated nodes;
- monitoring of radio conditions;
- support for power conservation (sleep mode);
- dynamic allocation of radio link capacity to ensure adherence to the negotiated traffic contract [4], [5];
- radio link encryption (optional).

4.2.1 Security

Users of WACS systems may require protection of their transmissions from being listened to by other users operating possibly co-located wireless subnetworks. This requires the implementation of a data confidentiality service. The level of protection provided should be consistent with the protection provided by wired systems that do not implement a data confidentiality service. Further, the cryptographic algorithm shall not be subject to export controls and therefore allow world-wide use.

The WACS standard shall include optional functions for the selective use of encryption and for the synchronization of the use of cryptographic keys between nodes of a WACS.

NOTE: ETSI has developed a cryptographic algorithm for HIPERLANs, the HIPERLAN Standard Encryption Algorithm. For obtaining this algorithm, see [11]. This algorithm is designed to operate at 20 Mbit/s or greater and is available to ETSI members under a Confidentiality Agreement.

The negotiation of cryptographic algorithms, and key exchanges take place either during the association phase or in a second phase (optimally directly following association).

5 WACS reference model

5.1 Reference models for HIPERLAN/2

Specifications for two Reference Models, termed the Distributed and the Unified Control Model respectively will be developed. The radio interface as specified by BRAN should be the same for both models. The WACS Reference Models identify the main groups of functional elements and their reference points. These groups are further decomposed in figures 1 and 2. The functional elements are:

- the WACS Node which consists of the WACS Terminal and WACS Terminal Adapter (WACS-TA);
- the WACS Access Point (WACS-AP), which can be decomposed into an Access Point Controller (APC) controlling one or multiple Access Point Transceivers (APT); and
- the End-user Mobility-supporting ATM Switch (EMAS).

NOTE 1: In the case of the Unified Control Model, the Access Point and the End-user Mobility-supporting ATM Switch are combined into a single Combined EMAS/AP (the CAP) with an internal interface.

The BRAN specifications will describe by default the Distributed Control Model, since the Unified Control Model is a simplification of the Distributed Control Model. In fact, the Unified Control Model can be derived from the Distributed Control Model by making interface W.2 an internal interface (WI.3). The Distributed Control Model additionally provides methods to facilitate intra-AP handover.

NOTE 2: These two reference models not necessarily means physical implementation, but the specification of reference points and the respective protocols make a physical realization possible.

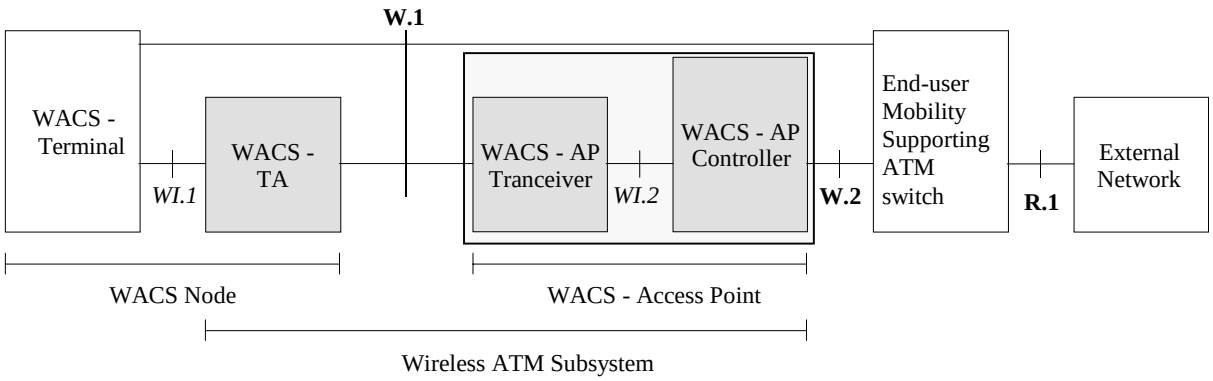

Figure 1: Distributed Control Model

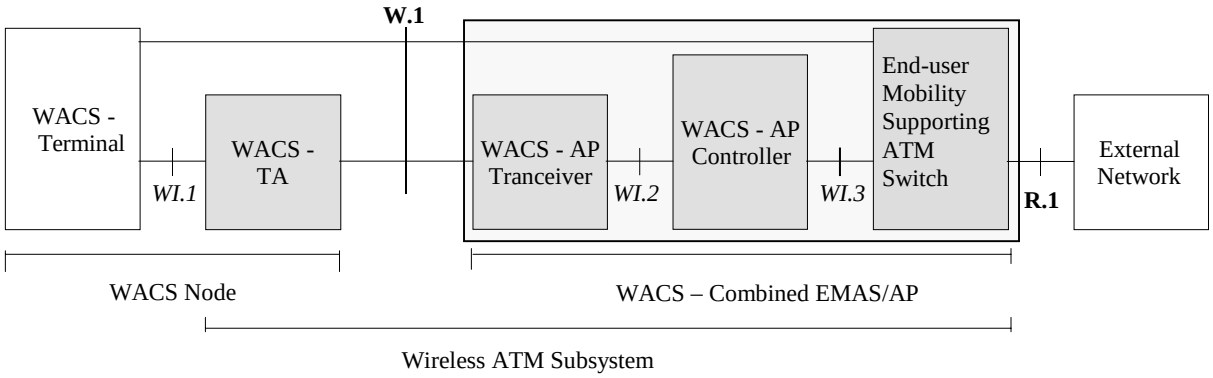

Figure 2: Unified Control Model

5.2 Reference model for HIPERACCESS

In both cases above, the WACS Node is shown as an integrated unit with an internal interface (WI.1). This may not always be the case, for example, in HIPERACCESS systems, the WACS Terminal Adapter typically is provided with a physical interface for a user to attach a terminal or network. This interface is identified in table 1, subclause 5.3 as W.3. In this case the WACS Terminal Adapter terminates WACS specific protocols; it presents a user-network interface to the WACS user via an interworking function.

In this application, the use of switching in the combined EMAS/AP is in contravention to the requirements of [10]. Amongst other reasons, the need in a telecommunications access network to allow for reliable billing to the customer for services used, motivates this requirement. Therefore the reference model for HIPERACCESS systems should normally be based on the Distributed Control variant of the WACS Reference Model.

For the purpose of achieving a high degree of radio coverage a repeater may be present at the W.1 reference point.

5.3 Reference points

The WACS Reference Model includes following reference points, some of which are subject to standardization (see table 1).

Table 1: Reference points

Reference point	Description	Details and/or Comments
W.1	The radio interface.	This reference point comprises: - The WACS DLC protocol supporting transparent ATM transport (User, Control and Management plane traffic) as well as mobility and security support functions such as access point acquisition and association and establishment of security contexts to facilitate radio link encryption; - the UNI protocol - with mobility enhancements according to ATMF implementation agreements; and - optionally the ILMI protocol [7].
W.2	Interface between the Access Point and the End-user Mobility-supporting ATM Switch and its management and control functions.	The reference point comprises: - The WACS Access Point Control Protocol that carries the interactions between the AP and the End-user Mobility-supporting ATM Switch for the establishment and releasing of connections, for connection handover between APs and related purposes. The specification of this protocol depends on the function distribution between Access Point and End-user Mobility-supporting ATM Switch.
W.3	Interface between terminal equipment and WACS Terminal Adapter for HIPERACCESS.	This interface is a standard UNI interface and it is outside the scope of the present document. Note that this interface is not shown in any diagram in the present document.
R.1	Standard Interface between the EMAS and the external network, e.g., (M-)UNI or (M-)NNI.	This interface is a standard interface and it is outside the scope of the present document. Enhancements to support terminal mobility may be included into this interface.
WI.1	Internal interface of the WACS Node.	This interface is not described in the present document. It is a proprietary interface.
WI.2	Internal interface of the WACS Access Point.	This interface is not described in the present document. It is a proprietary interface.
WI.3	Internal interface of the Combined EMAS/AP.	This interface is not described in the present document. It is a proprietary interface.

A complete description of the distribution of functions across the elements of the model is needed to assure alignment with other standards, e.g. those developed by the ATM Forum for signalling and management enhancements to the basic ATM interface specifications. This description is given in the following sections.

6 Functional architecture and elements

6.1 Functional architecture

The main objective of the functional architecture is to define a flexible system with a wireless specific elements separated from the standard wireline specific connection control elements. The separation should allow standard Connection Control (CC) functions, such as [3] or UNI3.1/4.0, to exist as such in the higher protocol layers while they only have a clearly defined interface for the wireless sub-system. It should be noted that some mobility and authentication related functions and information, is also present in the higher protocol layers, e.g. ILMI, that describe the terminal / switch interaction.

The Distributed reference model defines Connection Control end points in the WACS Node and End-user Mobility-supporting ATM Switch (see figure 3). The AP is transparent to connection control signalling ([3] or UNI3.1/4.0). The AP will behave as an ATM level bridge/multiplexer (VPC cross-connect) with additional functions supporting Connection Admission Control and hand-over decision making by the EMAS. These additional functions require a specific protocol. This approach allows the wireless specific functions to be kept within the radio sub-system while keeping the connection control end point as in the standard ATM switch.

The Unified Reference Model defines Connection Control end points in the WACS Node and Combined EMAS/AP (CAP) (see figure 4). The protocol between WACS Node and CAP will include (M-)UNI and a set of wireless specific messages. The exact content of these wireless specific messages will depend on the level of mobility supported. The interface between WACS combined EMAS/AP and external network may be a standard NNI interface (e.g. PNNI [8]) or M-NNI which supports mobility as will be defined by the ATM Forum.

The functional model here is sufficient for the purposes of the present document. However, it is recognized that functional elements like the MMF may be further decomposed or distributed over other functional elements.

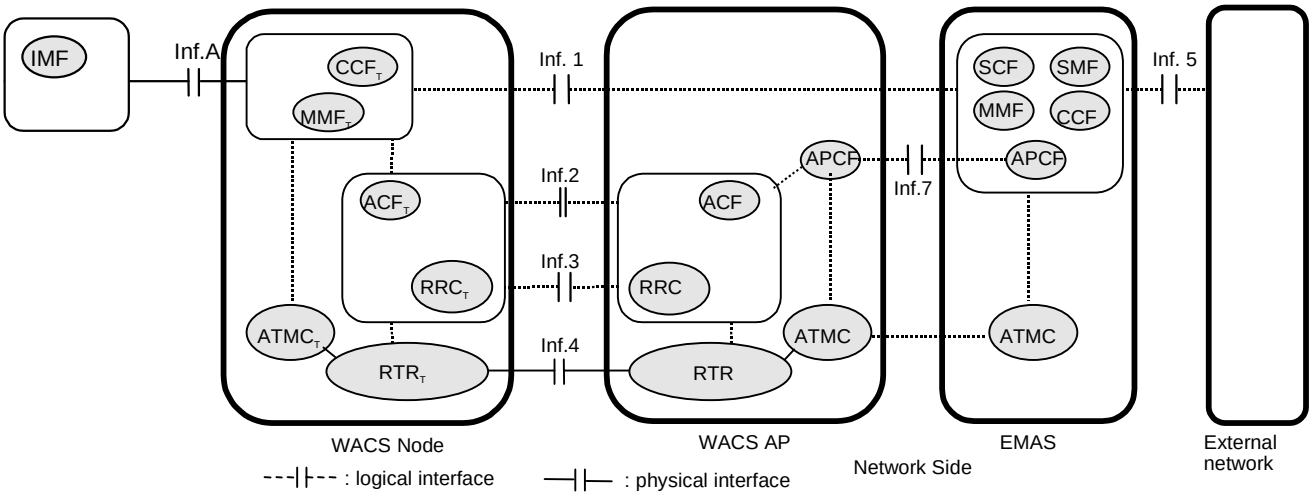

Figure 3: WACS Functional Architecture - Distributed Control

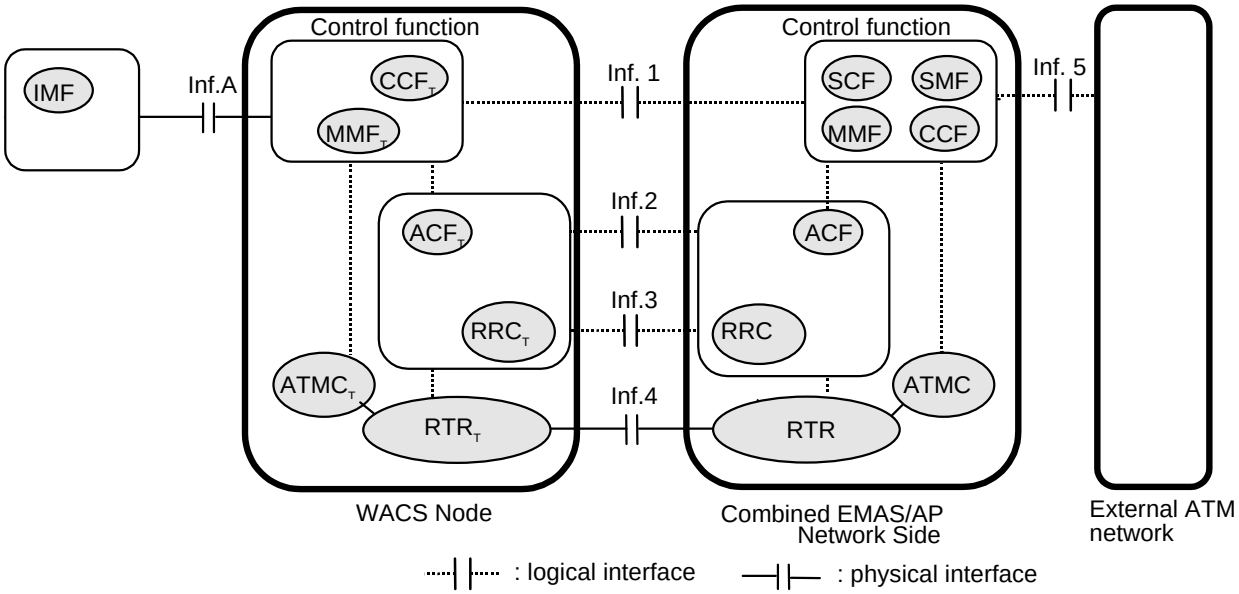

Figure 4: WACS Functional Architecture - Unified Control

6.2 Functional elements

6.2.1 WACS Node side

6.2.1.1 IMF (Identification Management Function)

IMF provides the means to identify the WACS Node. This FE includes functions to:

- store identification information (e.g. subscription, service, identity), location management related information and security related information;
- support authentication on the WACS Node side (e.g. calculation of authentication response); and
- provide service related processing and local service control required on the WACS Node side.

6.2.1.2 MMF_T (Mobility Management Function - WACS Node side)

MMF_T is used for all mobile terminal related mobility actions. MMF_T supports all mobile specific functions on the WACS Node side, e.g. location update initiation, paging response and network information monitoring and analysis.

6.2.1.3 CCF_T (Call control and Connection control Function - WACS Node side)

CCF_T is used for connection set-up/release as in the standard ATM network. The function is per connection entity and CCF_T uses signalling to setup, control and release connections. Since handover is closely related to CCF_T, the ATM handover control messages could be added into standard UNI signalling. CCF_T handles the WACS Node side of access control and call and connection control (e.g. [3] or UNI 3.1/4.0) and is responsible for initiating functional requests including QoS requests from the user or other functional entities. It includes:

- establish, maintain, modify and release calls and connections;
- call control adaptation between the wireless subnetwork and the external network (if necessary); and
- control functions to establish, maintain, modify and release ATM connections in the $ATMC_T$ (WACS Node ATM Connection) Function Element.

6.2.1.4 ACF_T (Association Control Function - WACS Node side)

ACF_T provides control functions for association of the WACS Node to the WACS AP. This FE includes:

- control functions for establishment and release of the association between the WACS Node and the wireless subnetwork, i.e. association to establish the first wireless link activity as the WACS Node enters the wireless subnetwork;
- support intra-AP handover procedures;
- radio handover execution;
- paging response detection and handling;
- radio access information monitoring and analysis including link maintenance information; and
- power saving/conservation.

6.2.1.5 RRC_T (Radio Resource Control function - WACS Node side)

RRC_T handles the WACS Node side of radio connection including:

- selection, reservation and release of radio resources as required from the communication control plane;
- radio channel supervision;
- local radio environment reporting (if WACS Node-side assisted or WACS Node-side controlled handover);
- handover triggering (if WACS Node-side controlled handover); and
- radio access information monitoring and analysis.

6.2.1.6 RTR_T (Radio Transmission and Reception - WACS Node side)

RTR_T handles the radio transmission and reception at the WACS Node side. It includes Logical Link Control (LLC), Medium Access Control (MAC) and Radio physical layer related (Radio PHY) functions.

DLC functions (LLC and MAC) provide bearer services for ATM connections on U-plane and C-plane and control channels between the WACS Node and the wireless subnetwork. This includes:

- error control functions to improve wireless specific transmission impairment (e.g. ARQ by error detection and re-transmission, and/or forward error correction coding and decoding);
- multiplexing and de-multiplexing of logical channels;
- mechanisms to share radio channels;
- ciphering and deciphering; and
- service requesting and service granting.

Radio PHY function includes:

- RF generation, emission, and reception;
- scramble and descramble;
- baseband channel multiplexing and demultiplexing;
- modulation and demodulation;
- radio channel quality measurement;
- micro diversity relevant functions (e.g. antenna diversity, multipath diversity); and
- RF power setting.

DLC management functions include:

- buffer traffic contracts; and
- buffer link performance data.

6.2.1.7 $ATMC_T$ (ATM Connection function - WACS Node side)

This $ATMC_T$ function connects, maintains, modify and releases ATM connections and provides ATM bearer services for C-plane and U-plane to connect the end user device, i.e., ATM terminal. It may support ATM layer and AAL functions for C-plane and/or U-plane. $ATMC_T$ controls the ATM connection elements to provide ATM services (e.g. CBR, VBR-RT, VBR-NRT, ABR and UBR).

6.2.2 Network side

6.2.2.1 SCF (Service Control Function)

SCF provides service related control functions. SCF handles storage and access to service such as service profile and provides consistency checks on data. SCF contains the service logic and service related processing required on the network side and provides overall service control.

6.2.2.2 MMF (Mobility Management Function)

MMF is used for all network side related mobility actions. MMF contains the control logic for location and mobility management, i.e. location management function to track the mobile user within the customer premizes area, and handover related function, where handover activities could be invoked by CCF through the standard UNI signalling, or via ACF using the Access Point Control Protocol. It also handles storage and access to location data and may store subscriber identity and provide consistency checks on data. This FE also includes:

- paging control (e.g. initiating paging, process paging response);
- location management and routing control;
- location updating;
- store mobility related data; and
- store subscriber identity data, if necessary.

6.2.2.3 SMF (Security Management Function)

SMF contains security related functions, e.g.:

- store authentication data, e.g. security related parameters;
- perform identity, i.e. registered users/terminals management;
- subscriber verification;
- subscriber authentication and authentication processing including ciphering; and
- confidentiality control.

6.2.2.4 ACF (Association Control Function)

ACF provides control functions for association of the WACS Node to the WACS AP. This FE includes:

- control functions for establishment and release of the association between the WACS Node and the wireless subnetwork, i.e. association to establish the first wireless link activity as the WACS Node enters the wireless subnetwork;
- support intra-AP handover procedures;
- radio access information monitoring and analysis including link maintenance functions;
- radio handover execution;
- identify the AP used by a (portable) WACS Node to access the wireless subnetwork;
- identify location area;
- perform system information broadcasting (system access information and service access related information); and
- power saving/conservation support.

6.2.2.5 CCF (Call control and Connection control Function)

CCF establishes a call to the distant end of a network and associates radio and network nodes to the call. It includes:

- establish, maintain, modify and release a call;
- connection admission control for the fixed part of a connection;
- call adaptation between the wireless subnetwork and the external network (if necessary);
- establish a new link under inter-AP and release the old link (if inter-AP handover);
- request for allocation/reservation of network resources and radio resources;
- inter-AP handover initiation except for the cases due to changes in radio environment;
- inter-AP handover execution (inter- and intra-CCF);
- perform charging operation, if necessary;
- control functions to establish, maintain, modify and release ATM connections in the ATMC Functional Element;
- establish, maintain, modify and release ATM connections;
- perform switching for network side ATM connections; and
- provide information relevant to charging.

6.2.2.6 RRC (Radio Resource Control function)

RRC handles the overall control of the radio resources and radio connections within a given area with typically many WACS Nodes. RRC should have an interface for AP transceiver and may have another interface for the mobility enabled switch. RRC includes:

- sharing of radio resources between APTs;
- radio channel management;
- radio channel supervision including assessment of radio channel measurement results from RTR;
- radio channel power control;
- analysis of mobile radio environment;
- hand-over initiation due to changes in radio environment (inter- and intra-AP); and
- wireless CAC.

6.2.2.7 RTR (Radio Transmission and Reception function)

RTR handles the radio transmission and reception on the network side. It includes Data Link Control (DLC), Medium Access Control (MAC) and radio physical layer related (Radio PHY) functions.

DLC functions (LLC and MAC) provide bearer services for ATM connections on U-plane and C-plane and control channels between the WACS Node and the wireless subnetwork. This includes:

- error control functions to improve wireless specific transmission impairment (e.g. ARQ by error detection and re-transmission, and/or forward error correction coding and decoding);
- multiplexing and de-multiplexing of logical channels;
- mechanisms to share radio channels;
- service requesting and service granting;
- scheduling function to assign the "air time slot" for the ATM cells. The scheduling will be based on the ATM traffic contract and QoS parameters;
- ciphering and deciphering; and
- PDU handling function to manage the MAC data packets to be transmitted over the air interface.

Radio PHY functions include:

- RF generation, emission, and reception;
- scramble and descramble;
- baseband channel multiplexing and demultiplexing;
- modulation and demodulation;
- radio channel quality measurement and reporting;
- RF power setting;
- initial (random) access detection;
- micro diversity relevant functions (e.g. antenna diversity); and
- power control execution.

DLC management functions include:

- buffer traffic contracts; and
- buffer link performance data.

6.2.2.8 ATMC (ATM Connection function)

The ATMC function connects, maintains, modifies and releases ATM connections and provides ATM bearer services for C-plane and U-plane to connect the end user device to the external network (e.g. ATM switch). ATMC controls the ATM connection elements to provide ATM services (e.g. CBR, VBR-RT, VBR-NRT, ABR and UBR). It includes scheduling function to multiplex the ATM cells to be sent to the ATM switch. The scheduling will be based on the ATM traffic contract and QoS parameters.

6.2.2.9 APCF (Access Point Control Function)

APCF includes functions to execute AP specific commands given by the EMAS and functions to relay information between the WACS terminal and the EMAS. These message exchanges take place via the APCP.

6.2.3 Interfaces

Table 2 below describes the interfaces given in figures 3 and 4.

Table 2: Description of interfaces

Interface	Description	Comments
Inf.1: M-UNI	This interface supports all the ATM core network related exchanges required for call set-up, clearing, location management.	
Inf.2: Association Control	This interface supports the exchanges required for radio level association, radio level handover, paging and the radio link management for power conservation purposes.	The activities on this interface must be closely co-ordinated with those on the Inf.1 Interface, the Inf.3 Interface and the Inf.7 Interface.
Inf.3: Radio Resource Control	This interface supports the exchanges required for radio resource monitoring, capacity monitoring, RF channel selection, etc.	Consideration should be given to merging this with the Inf.2 Interface.
Inf.4: Wireless DLC/PHY	This interface supports the exchanges required for the operation of the radio link between the wireless Node and the wireless Access Point.	
Inf.5: (M-)UNI/NNI	Standard interface between ATM switches, possibly enhanced to support mobility.	
Inf.6: UNI	Does not apply to ETSI BRAN.	This interface does not appear in the present document but it does appear in the ATM Forum baseline text.
Inf.7: Access Point Control	This interface supports the exchanges between the elements of the mobility support functions distributed between the Access Point and the End-user Mobility-supporting ATM Switch.	The activities on this interface must be closely co-ordinated with those on the Inf.1 Interface, and the Inf.2 Interface.
Inf.A: Smart Card Access	This is an optional interface to access smart cards, containing, e.g. subscription information.	Optional interface.

6.2.4 Protocols

6.2.4.1 Wireless ATM layer model

The layer architecture presented below replaces the ATM PHY layer with two wireless layers that describe the wireless protocols: the Wireless Data Link Control Layer and the Wireless PHY layer.

The DLC and PHY layers are each provided with Layer Management Elements. These model the functions and interfaces available for non-communications functions such as changing a radio channel.

6.2.4.2 Wireless ATM Convergence Sublayer

The Wireless ATM Convergence Sublayer (WCS) is defined as a sublayer that generates no protocol but that provides the wireless DLC layer with the information it needs to perform its QoS management functions as required (e.g. the DLC Unitdata request could have parameters: VPI/VCI, cell loss priority, user data). Figure 5 shows the WCS in relation to some of the other system elements and protocols. The exact definition of the primitives between the DLC and the WCS is for definition by the BRAN Project. Given the desired behaviour and protocol of the DLC layer, the interface specification can be given and specified sufficiently clearly.

The Layer Management Entity of the DLC layer is used to convey traffic contract information and performance requirements between the DLC layer and the higher, connection control functions.

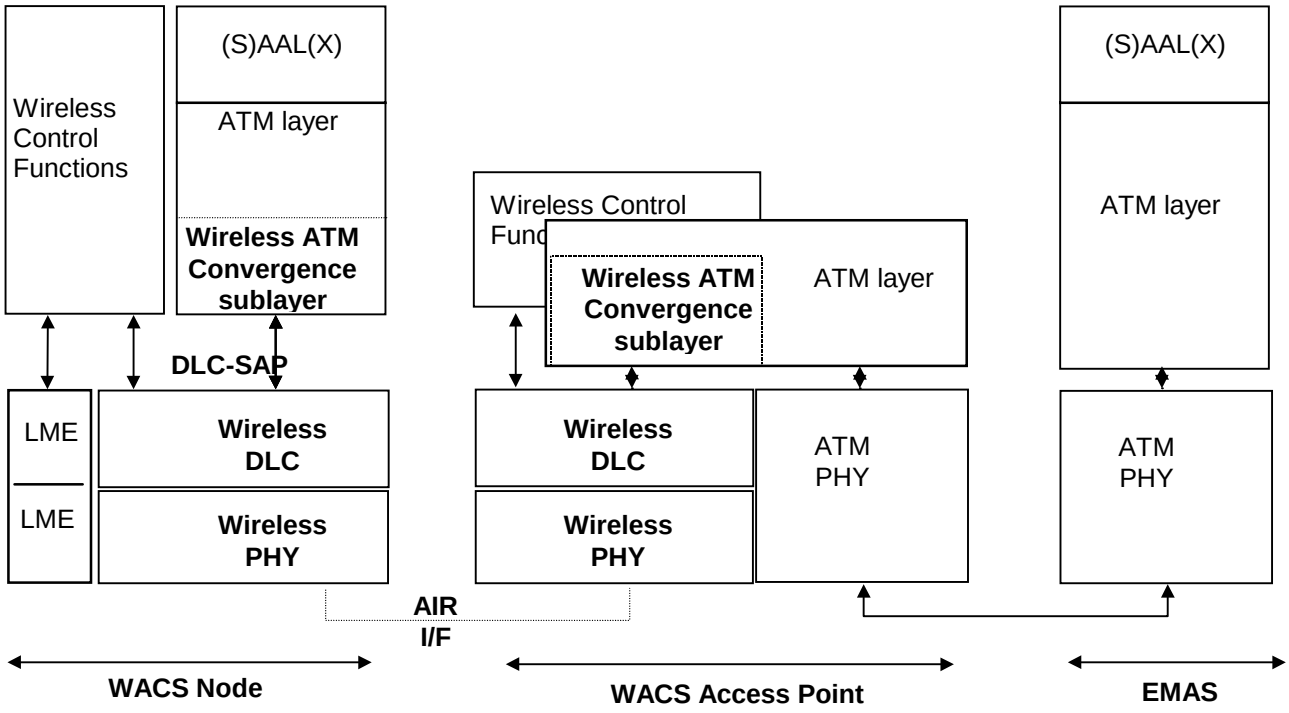

Figure 5: Wireless ATM Protocol Layer architecture based on Wireless Convergence Sublayer (Distributed Control Model)

This model is functionally equivalent to the respective ATMF models. BRAN will specify the interface between the ATM layer and the Wireless Convergence Sublayer.

Some notes on the Layer Model:

NOTE 1: The DLC layer contains two sublayers: a Medium Access Control sublayer (MAC) and a Logical Link Control sublayer (LLC). The MAC sublayer implements a service policy that takes into account such factors as channel quality, number of terminal devices and medium sharing with other wireless subnetworks. The LLC sublayer maintains the quality of service on a virtual circuit basis. Depending on the type of service provided and channel quality, capacity and utilization, the LLC layer may implement a variety of means including FEC, ARQ and flow pacing to optimize the service provided to the (DLC) user.

NOTE 2: Generic Flow Control, once specified - may impact the functionality of the DLC layer and its service definition.

NOTE 3: Usage Parameter Control is an optional capability of ATM systems that may have impact on the specification of the Wireless DLC layer and on the Access Point behaviour.

7 Division of responsibility between ATMF and BRAN

This is the proposed division of responsibility between the ATM Forum and the BRAN Project. Responsibility assigned for a Functional Element or an Interface means that the relevant organization is responsible for producing the specification. However in some cases, it is indicated that specifications should be jointly created. In these cases, the responsibility for producing the specifications remains as designated, but both parties should contribute.

7.1 Responsibility for interfaces

The responsible bodies for specifying Interfaces are listed in table 3 below.

Table 3: Responsibility for Interface specifications

Interface	Responsible	Comments
Inf.1: M-UNI	ATM Forum	
Inf.2: Association Control	ETSI BRAN Project	For joint specification.
Inf.3: Radio Resource Control	ETSI BRAN Project	For joint specification.
Inf.4: Wireless DLC/PHY	ETSI BRAN Project	
Inf.5: (M-)UNI/NNI	ATM Forum	
Inf.6: UNI	ATM Forum	This interface does not appear in the present document but it does appear in the ATM Forum baseline text.
Inf.7: Access Point Control	ATM Forum	For joint specification.
Inf.A: Smart Card access	ATM Forum	Optional interface.

7.2 Interfaces subject to joint specification

7.2.1 Inf.2: Association Control interface

This interface may contain, amongst others, the following elements:

I.2.1 AP Beacon. Signals the presence, network name, current load and other details of AP.

I.2.2 AP Associate - AP Disassociate. These allow a WACS Node to attach itself to an AP so that DLC connections can be established. The AP Disassociate can be send by the AP as well to unilaterally end an association, e.g. in terms of compromized security or failed authentication.

I.2.3 Radio Handover Request/Complete. This is for further study.

I.2.4 Freeze DLC link - Unfreeze DLC link. This supports power conservation modes and listening by the WACS Node on other (RF) channels.

I.2.5 Establish Security Context - This allows the establishment of a security context between the WACS Node and the WACS AP in order to facilitate radio link encryption.

7.2.2 Inf.3: Radio Resource Control interface

This interface may contain, amongst others, the following elements:

I.3.1 Channel Quality Report Request - This allows an Access Point to query its nodes to report local RF channel conditions.

I.3.2 Channel Quality Report - this allows a node to report RF channel conditions. This information may be combined with other interface elements, e.g. an Association Request.

7.2.3 Inf.7: Access Point Control interface

The reason for a joint specification is the close relationship of this interface to interfaces Inf.1 and Inf.2.

7.3 Responsibility for Functional Elements

The responsible bodies for Functional Element specifications are listed in table 4.

Table 4: Responsibility for Functional Element specification

Functional Element	Responsible	Comments
IMF	ATM Forum	The ID of the terminal user should be linked to the MMF and/or the ACF.
CCF	ATM Forum	Should include high-level applications associated with call control, such as OA&M, billing, etc. For joint specification (depending on handover).
MMF	ATM Forum	For joint specification (depending on handover).
ACF	ETSI BRAN Project	For joint specification.
RRC	ETSI BRAN Project	For joint specification.
RTR	ETSI BRAN Project	
ATMC	ATM Forum	
APCF	ATM Forum	For joint specification.
SCF	ATM Forum	
SMF	ATM Forum	

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