ETSI Project - Broadband Radio Access Networks (BRAN) - HIPERACCESS

Cover Sheet for Presentation to IEEE 802.16 Broadband Wireless Access Working Group (Rev. 1)

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Purpose:
Describe the ETSI BRAN HIPERACCESS scope, status and activities. As the scope is very similar to that within 802.16, further co-operation between the parties involved may be usefully investigated and encouraged.

Slide 2

ETSI Project

Broadband Radio Access Networks (BRAN)

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This presentation sums up the basic motivation behind and deliverables of the ETSI Project Broadband Radio Access Networks, with particular reference to the HiperAccess network type.

The Broadband Radio Access Networks project was established in April 1997 in response to the opportunity presented by the combination of broadband radio LAN technology an fixed access radio to meet the need of future multi-media applications and services.

This presentation is concerned with the vision behind the project's goals, areas of application, the planning of the work and deliverables as well as the liaison with other bodies working in this field.

Note: This material is for use within and outside ETSI as an introduction to the BRAN Project. In case of differences between this and the Terms of Reference and the workplan, the latter have precedence.

Slide 3

VISION

Broadband Access Technology
at commodity prices
by 2002

IEEE 802.16, Albuquerque, NM, March, 2000 — Andrea Nascimbene

By the year 2002, broadband service will be available on a variety of media, including upgraded TV cable plant, upgraded telephony plant using ADSL, satellites and terrestrial broadband radio. Because of this competition, the price of subscriber units will have to be very competitive - it has to come down to commodity level.

Slide 4

ETSI Project BRAN

- **HIPERLAN/2**
  - *operating at 25 Mbit/s*
  - *providing short range, wireless access and WLAN applications*
  - *indoor and campus-wide usage with a typical indoor coverage of 50 m and outdoor 150 m*
  - *license-exempt in 5 GHz band*
  - *supporting user mobility within local service area*
- **HIPERACCESS**
  - *operating at 25 Mbit/s*
  - *providing long range and fixed radio connections to customer premises*
  - *outdoor usage for residential and small to medium-sized business applications with a coverage of up to 5 km*
  - *wireless access to private networks and public operators (urban and rural)*
  - *licensed*
- **HIPERLINK**
  - *interconnect HIPERACCESS & HIPERLAN (license-exempt)*

ETSI has defined three types of broadband radio networks:

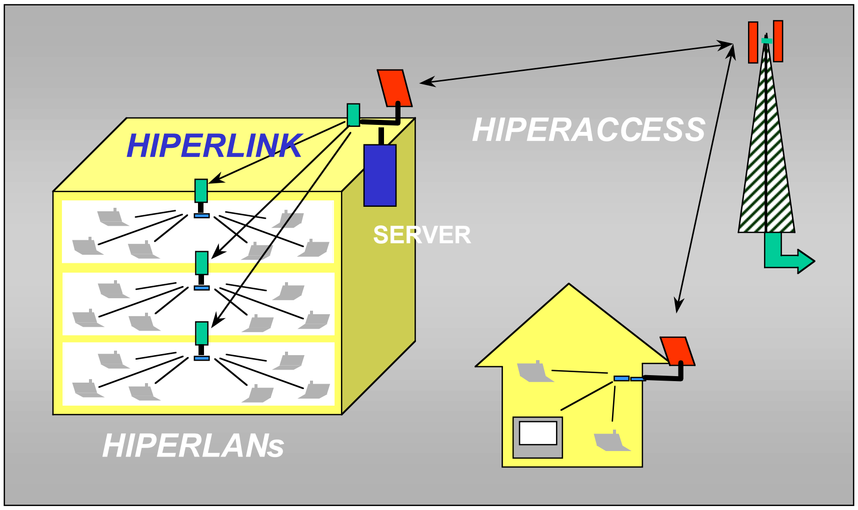
HIPERLAN/2, a complement to HIPERLAN/1, ETSI's high speed wireless LAN, is a local access network, providing communication between portable computing devices and broadband core networks, aimed at telecommunications access and capable of supporting the multimedia applications of the future. User mobility is supported, but only within the local service area.

HIPERACCESS is an outdoor, high speed radio access network, providing fixed radio connections to customer premises (other technologies such as HIPERLAN2 might be used for distribution within the premises). HIPERACCESS will allow an operator to rapidly roll out a wide area broadband access network to provide connections to residential households and small businesses. It will be an attractive alternative to wired access technologies such as digital subscriber loop or cable modems, especially in the competitive market of the future where no one operator will have the certainty of monopoly.

The third category is **HIPERLINK**: a very high speed radio network for infrastructure - like applications; a typical use is the interconnection of HIPERACCESS networks and/or HIPERLAN Access Points into a fully wireless network.

Slide 5

Broadband Radio Networks



IEEE 802.16, Albuquerque, NM, March, 2000

Andrea Nascimbene

The figure shows an example of how the three network categories might be deployed in a business and domestic environment. In both cases, HIPERACCESS provides the means to reach the premises of the customer.

HIPERLINK is used internally in the building, HIPERLAN is used to as basic local area network giving to the employees or to the single residential user (in block of flat environment) access to the server. HIPERLINKs are used to complete the wireless infrastructure and link the HIPERLAN access point to the server and to HIPERACCESS.

In the single house residential example, HIPERLAN is coupled directly to HIPERACCESS.

In both cases, variants with different mixtures of wired and wireless networks are possible.

The Scope&Requirement

- **EU Operators and Manufacturers co-operate in order to define requirement and applicability of a Broadband Radio Access Networks standard**
    - ***address residential and business markets***
    - ***support different applications***
    - ***service different core networks***
  - **But all variations**
    - ***must be low cost***
    - ***must offer high bit rates***
    - ***must be interoperable***
    - ***must provide managed QoS***

The technologies for achieving what above are becoming available and the Broadband Radio Access Networks project aims to develop specifications that allow maximum functionality to be achieved at minimum cost. Thanks to the presence of service providers as well as manufacturers, we expect to be able to achieve a useful compromise between the opposing objectives of functionality and cost.

The EU standardisation tradition

- **CEPT SE/FM**
  - ***SE drafts recommendations on technical conditions under which a band can be used for particular services (e.g. channel arrangement, like T/R 13-02) and provides spectrum sharing requirements and guide lines***
  - ***FM takes decisions on whether a service can operate in a given band, according to SE studies and existing CEPT recommendations or decisions***
- **ETSI TM4**
  - ***develop radio co-existence standard for digital radio relay systems (DRSS) operating in accordance with bands allocated by CEPT recommendations (e.g. EN 301 213)***

The BRAN background

The specification of the co-existence standard is being done by TM4

A co-existence specification will be defined for HIPERACCESS systems, which specifies those parameters necessary for frequency management with other HIPERACCESS systems in adjacent frequency block in the same area and the same frequency block in adjacent areas.

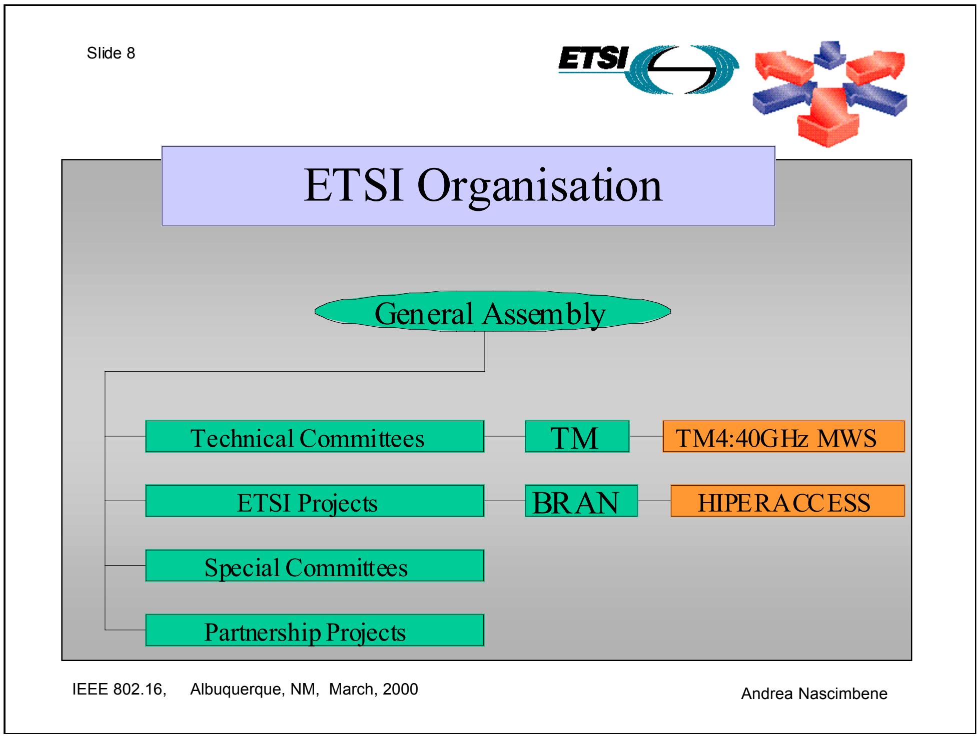
The specification will give the conditions for Fully interoperable systems to coexist (defined by BRAN)

The specification will give the conditions for Non interoperable systems to coexist

The amount of co-ordination required by the HIPERACCESS operators in the core band should be minimal

BRAN cannot allocate frequency bands, that is made by regulatory bodies and particularly by CEPT SE19.

However, BRAN has noted that the 40.5-43.5 GHz band will almost certainly be allocated to MWS (HIPERACCESS is a MWS system according to the CEPT definition).



The TM4 40GHz MWS :

Two TM4 work items, standardising:

- Equipment parameters relevant to co-existence of systems.
- Antennas for 40GHz MWS

MWS = Multimedia Wireless Systems

- Convergence of telecommunications and broadcasting
- Voice, data, entertainment services
- Multipoint architecture (P-MP and MP-MP)
- 40.5GHz to 43.5Ghz

The BRAN HIPERACCESS standard is one form of MWS

- TM4 will provide the coexistence part of the specification for HA
- If other frequency bands are required, further TM4 work items can be opened

The ETSI BRAN work and decision process

- **Item by item discussion**
    - ***decision list updated at every meeting***
- **Unanimous consensus policy**
    - ***voting avoided as far as possible***

– ***advantages:***
- ***easy comparisons***
- ***deep discussion***
- ***well defined and understood solution***

– ***critical aspects:***
- ***slow***

The HIPERACCESS strategy&architecture

- **Standardization strategy:**
  - ***"wireless optimized" air interface with no reference to any existing standard***
    - ***priority 1: high frequencies,*** *42GHz (-32GHz-28GHz-26GHz)*
    - ***priority 2: low frequencies,*** *derived from 1*
- **Topology scheme:**
  - ***Point-to-Multipoint***
- **Multiple Access scheme:**
  - **TDM/TDMA**
    - ***load leveling functionality***
- **Duplex scheme:**
  - ***FDD and H-FDD***
    - ***TDD for unpaired spectrum***

Decision 1: BRAN will specify a full interoperable HIPERACCESS standard

Decision 2: The HIPERACCESS PHY layer will be based on a FDD duplex scheme. Full and half-duplex terminal operation will be included in the standard.

For spectrum allocation not suitable for FDD, TDD operation based on the technology specified for FDD HA system will be included in the standard

Decision 3: HIPERACCESS will have a Point to MultiPoint (PMP) topology

Decision 4: TDMA is selected as multiple access method. Load leveling, i. e. the possibility to switch to another frequency channel shall be supported. In the case of load leveling, both the downlink and uplink channels are changed.

Decision 5: Priority 1: One standard for an interoperable broadband radio access network working at high frequencies. The top priority for the BRAN HIPERACCESS group is to write a standard for one broadband radio system, as defined in TR101177, at mm-wave frequencies (20-50 GHz).

The main frequency band for HIPERACCESS is 40.5-43.5 GHz.

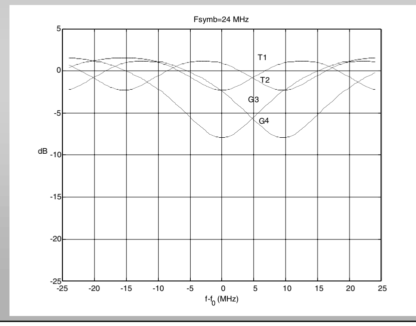
Other interesting bands are 24.5-26.5, 27.5-29.5 and 31.8-33.4 GHz

Decision 6: Priority 2: One standard for an interoperable broadband radio access network working at lower frequencies. The second priority for the BRAN HIPERACCESS group is to write a standard for one broadband radio system, as defined in TR101177, working at frequencies below 20 GHz. This specification should be based on the one for high frequencies. Variations should be made where it is appropriate for the lower frequency.

Slide 11

The HA modulation scheme (1)

- **The channel model analysis**
  - ***The proposed models are as a results of measurements or of ray tracing simulations***
  - ***LOS assumption for above 20GHz***
  - ***the delay spread is up to 40ns***

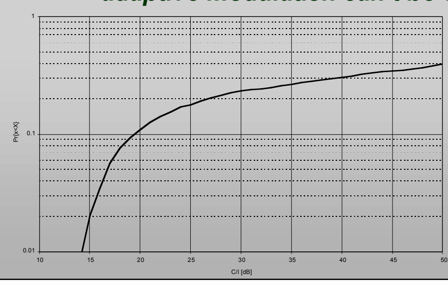


Channel measurements as well as simulations based on channel models and real link measurements all reveal that multipath delay causes irreducible BER if no countermeasure is incorporated. An equaliser is necessary to combat ISI in a single carrier modem if the symbol rate is exceeding an approximate of 10 Mbaud. It should be noted that the problem occurs although narrow beam antennas (i.e. 2-4 degrees) are used at the CPE. By means of a multipath mitigation technique, the area coverage and reliability in typical urban and suburban environments can be improved, and the CPE installation simplified.

Slide 12

The HA modulation scheme (2)

- **The intra-system interference analysis**
  - ***the Downlink direction shows a deterministic "slow variation" behavior***
    - ***adaptive modulation can simultaneously achieve high coverage/high efficiency***
  - ***the Uplink direction shows a statistic "burst" behavior***
    - ***adaptive modulation can't be very helpful***



Modulation	C/I limit [dB]	Allowed area [%]
4QAM	14	100
16QAM	22	87.3
64QAM	28	79.7

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The C/I ratio in the downlink is a function of the position of the AT within the cell (or sector). Considering the reuse scheme with 2 frequencies and 2 polarisation, and a 90° sectored antenna the C/I distribution within a sector is the one reported in the above figure.

Given this distribution it is possible to evaluate the percentage of sector area where it is allowed to use the three modulation schemes considered. A particular modulation scheme can be used everywhere the C/I ratio is greater than the corresponding limit reported in the above table. Obviously, the 4QAM scheme is the one that must ensure the complete (100%) coverage of the cell, but also 16QAM and 64QAM can be used over a great percentage of area thanks to restricted areas with low C/I ratios (because of narrow beam AT antenna). This is also possible, by the C/N ratios point of view, due to the rain margin during clear sky periods (that is about 99.xx% of time).

By defining *Ca* as the overall capacity of a radio frequency channel when all the users employ 4QAM, if an adaptive modulation scheme is provided the overall capacity increases is expected to be approx. 2.5.

The C/I ratio in uplink is a function of the time, depending on frequency reuse, LOS assumption, traffic load, etc. Given this distribution it is possible to evaluate the percentage of time when a time slot is allowed to use the three modulation schemes considered. Also in this case the allowed time for higher order modulation schemes is high, but there is a big difference with respect the downlink. In that case the C/I is deterministic (depending on user position) and, more or less, constant in time. On the uplink the C/I is variable in time on a slot by slot basis. Thus, it is hard to implement an adaptive modulation scheme with a percentage of time slot error of 2% (16QAM) or 8% (64QAM).

Slide 13

The HA modulation scheme (2)

- **Single Carrier modulation scheme:**
- **Downlink:**
  - ***4-16-64 QAM***
  - ***the modulation schemes must dynamically be adapted to any propagation and/or interference conditions, on burst by burst and/or terminal by terminal basis***
- **Uplink:**
  - ***4 (-16-64) QAM***
    - ***16-64 QAM for best case scenario or technology evolution***
    - ***fast adaptability can't be supported***
  - ***TFM option for residential terminal***
- **Channel size:**
  - ***28MHz for both up/downlink***
    - ***14MHz (and 56MHz) option for suitable bands***

Working assumption for adaptive modulation

We propose:

It will be mandatory to support signalling protocol associated with adaptive modulation. For the downlink, the terminal will assess the downlink condition and will initiate a request to the base station for a specific modulation scheme accordingly. The base station is the one that approves the terminal request. For the uplink, the base station will assess the uplink conditions. If adaptive modulation is disabled on the uplink then the base station will set the modulation scheme to the minimum level supported by the terminal. If adaptive modulation is enabled then the modulation level is set to the one selected by the base station based on terminal capabilities.

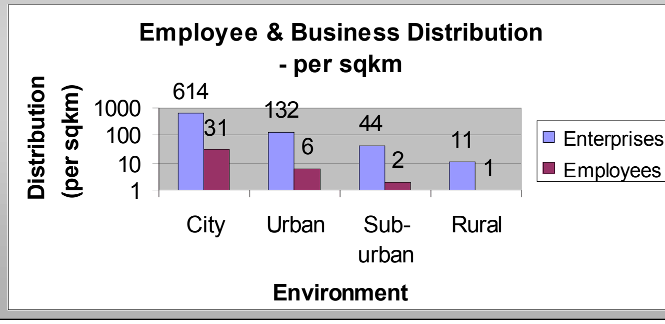
We recommend:

For the base station it will be mandatory to support downlink transmissions of both 4QAM and 16QAM while 64QAM will be optional. It will be mandatory to support base station uplink reception of 4QAM *and/or* TFM (pending final decision of PHY group). 16QAM and 64QAM will be optional for base station uplink reception. For the terminal, it will be mandatory to support downlink reception of 4QAM and 16QAM. It will be mandatory to support uplink transmission of 4QAM *and/or* TFM (pending final decision of PHY group). 64QAM will be optional for terminal downlink reception and 16QAM and 64QAM will be optional for terminal uplink transmission.

Slide 14

The HA traffic model and spectrum requirement the on going discussion (1)

	City	Urban	Sub-urban	Rural
Av. Pop. (sqkm)	14000	3000	1000	250
Av. Businesses (sqkm)	614	132	44	11



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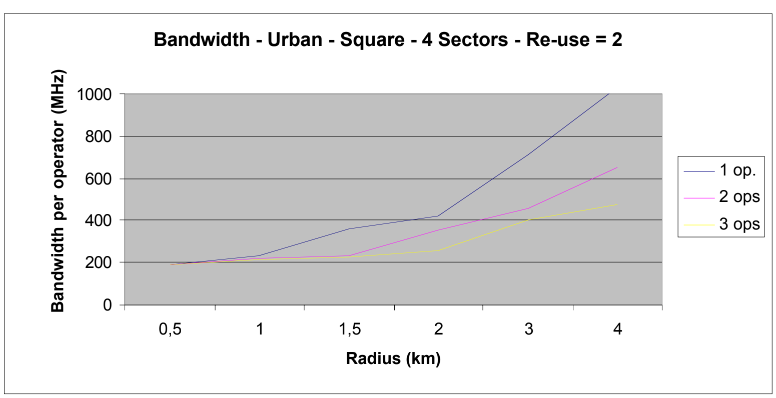
The amount of spectrum needed for HIPERACCESS networks varies with the traffic patterns, the user density, the propagation conditions and the technology used.

Except for the propagation conditions, all will evolve over time. With increasing market penetration both the number of users and the traffic demands will increase as well leading to an increase in the spectrum required. To some extent this increase will be offset by improvements in spectrum re-use resulting from new technologies. Dynamic capacity allocation will not only simplify deployment but also improve spectrum use.

The ideal frequency for a broadband access network varies with user density. At higher frequency, the operating range is lower but the available bandwidth is larger - both factors match the needs of high density deployments. As the market develops, the user density will increase and the high frequency bands (e.g.>20GHz) will provide the necessary larger capacities. This effect will be most notable in urbanized conglomerations.



The HA traffic model and spectrum requirement an evaluation example (2)

RESIDENTIAL Services	% household	% utilisation	Down kbit/s	Up kbit/s	Down Tot kbit/s	Up Tot kbit/s
Voice	80%	7%	64	64	4	4
ISDN	10%	7%	128	128	1	1
V.conf	10%	7%	384	384	3	3
VoD	50%	3,3%	3000	0	50	0
Internet	80%	1%	25000	5000	200	40
Rem. LAN	10%	0,25%	25000	5000	6	1
				Total (kb/s)	**263**	**48**
evening factor=	0,1				**Per business employee**	
BUSINESS Services	**% employees**	**% utilisation**	**Down kbit/s**	**Up kbit/s**	**Down Tot kbit/s**	**Up Tot kbit/s**
Voice	50%	1%	64	64	0	0
ISDN	5%	1%	128	128	0	0
V.conf	5%	1%	384	384	0	0
VoD	0%	0%	3000	3	0	0
Internet	50%	0,1%	25000	5000	13	3
Rem. LAN	5%	0,05%	25000	25000	1	1
				Total (kb/s)	**14**	**4**
Service	**% businesses**	**% utilisation**	**Down kbit/s**	**Up kbit/s**	**Down Tot kbit/s**	**Up Tot kbit/s**
MEs Web serving	75%	80%	5000	25000	3000	15000
SEs Web serving	15%	60%	5000	25000	450	2250
VSEs Web serving	0,010%	40%	5000	25000	0,2	1

URBAN Environement

90¡ square sectors	sector size (sqkm)	Tot. business capacity (Mb/s)	Tot. WEB capacity (Mb/s)	Tot. residential capacity (Mb/s)	total capacity per sector	Spectrum (MHz)	
downlink	4,50	15	24	1065	1104	**689**	4/16/64level
uplink	4,50	4	120	196	320	**581**	4level

Assumptions for the above evaluation example are:

•frequency reuse factor of two (2 frequency+2 polarization)

•coding rate: 80%

•roll off factor: 30% (downlink), 45% (uplink)

•market penetration: 30%

•most busy hour: 9-10pm with 10% business employees activity factor

Slide 16

- **The HA DLC**
  - ***Connection oriented***
  - ***Fixed slot length***

- **Next HA discussions**
  - ***coding schemes***
  - ***frame structure***
  - ***possible ARQ scheme***
  - ***sub-channeling (4x7MHz)***

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Decision 7: The DLC layer is connection oriented. Connection oriented means:

* Guarantee that packets are received in same order as sent

* Checking that there is a path and opening of a connection before they are sent

Decision 8: A fixed slot size was adopted as a working assumption. The size should be suitable for carrying ATM cells and compatible with the decisions taken in the PHY group

Deliverables

- **Specifications for radio subsystems (interoperability / co-existence)**
  - ***Radio Physical layer***
  - ***Radio Data Link Control layer***
  - ***Radio Network Management functions***
- **Specifications for interworking**
  - ***convergence sublayers for core networks***
- **Specifications for regulatory and conformance testing**

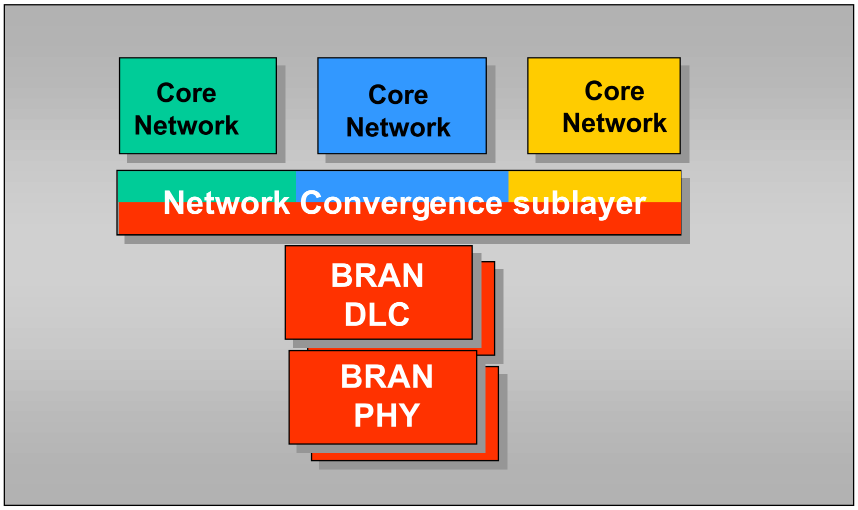
The deliverables of the BRAN project are sets of specifications for PHY, DLC layer and Interworking functions as well as the relevant documents for regulatory compliance and protocol conformance.

In case of the PHY layer, the project will develop co-existence specifications and interoperability specifications. For the DLC layer and for the convergence sublayers, co-existence is not an issue and only interoperability will be specified. The specifications for network management functions will include the managed objects needed to perform remote management of equipment develop by different suppliers.

For each type of access network will develop a set of specifications comprised of the components listed here. These specifications will be developed on a set by set basis with significant degree of overlap. This allows re-use of work between to sets. For example: the first set of specifications to be developed is for HIPERLAN/2. The DLC layer specification as well as the ATM and IP convergence sublayers may be fully re-usable for HIPERACCESS. If that is the case, a lot of work can be saved.

Slide 18

Basic Interworking Approach



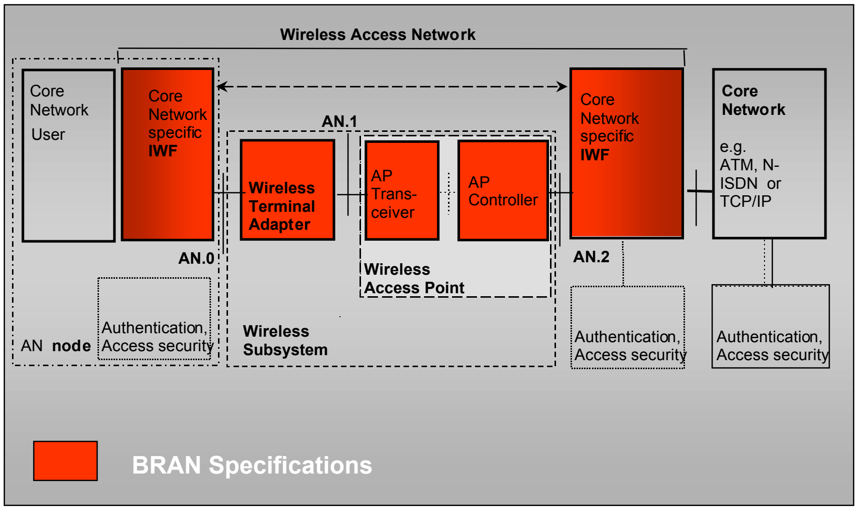
The basic approach to core network independence is the introduction of a Core Network Convergence sublayer where the differences between the different core networks are removed and a common BRAN interface can be used. The difference between the core networks occur in three main areas: call set-up and clearing, changing connections within the network and management of the quality of service provided to the network user. Mapping the different mechanisms or filling in for the absence of certain mechanisms will be performed with the convergence sublayer. The specification of these sublayers will be done in cooperation with the forum that owns the core network standard, e.g. the ATMForum in case of ATM Core networks.

This interface is at the top of the BRAN specific Data Link Control layer. The implication of this approach is that the DLC layer specification must be carefully matched to the superset of the requirements for supporting ATM and IP traffic.

There may be different specifications of the DLC layer - that will be resolved during the actual specification work. However, in view of the various frequency bands in which these networks will operate, a number of different radio physical layers will have to be specified by the project

Slide 19

Reference Model



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The high level reference model used by the project as basis for its cooperation with the ATMForum and ETSI SMG is shown in this picture which also shows the scope of the work of the project.

The figure has in its centre the wireless access subsystem flanked by Core Network specific **I**nter**W**orking **F**unctions. Together, these make up the wireless access network functionality.

The IWFs support all core network specifics. Examples is not only call set-up between access points but also security functions such as user authentication and data confidentiality.

The BRAN project is responsible for the wireless subsystem specifications and, together with the appropriate owner forum, it will develop the IWF specifications or provide the BRAN side of such a specification and leave it to the other fora to fill in the core network specific part.

In approaching its scope in this way, the project is probably unique: it implements a modular approach to standardization and it shares its work with other fora. That saves time and effort and allows implementors maximum flexibility.

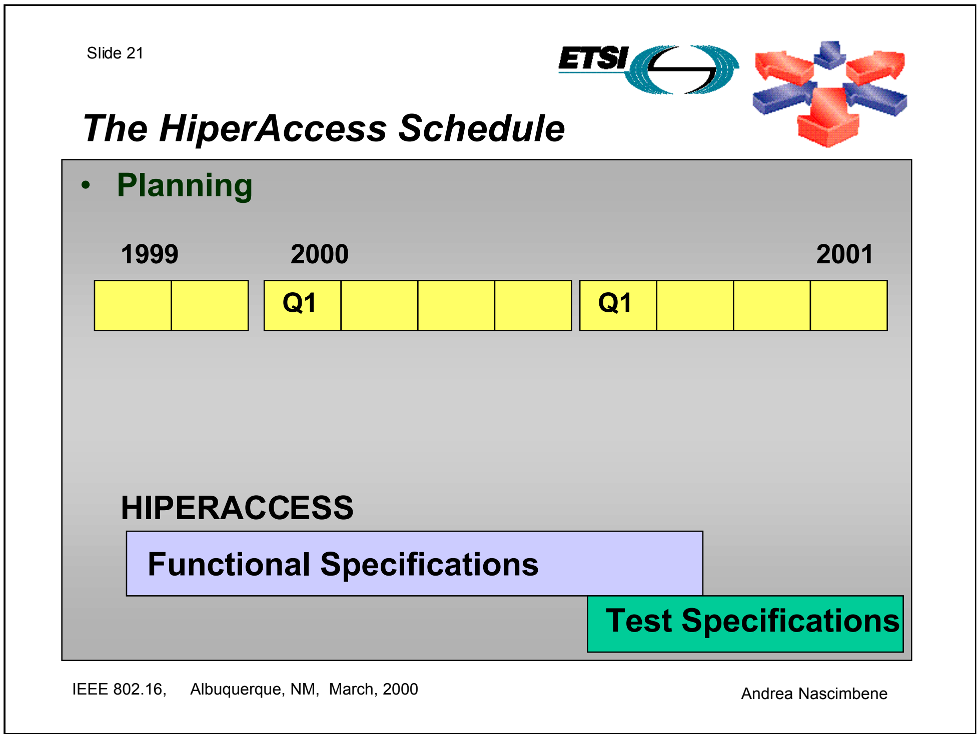
Organization

- **Rapporteur groups for deliverables**
- **Area Co-ordinators for HIPERLAN, HIPERACCES, Regulations and Spectrum**
- **Project Management Committee to assure consistency**

The project is organised along expertise lines - the working groups represent capabilities under the chairmanship of a qualified person. People with various interests and capabilities can contribute to different working groups depending on their interest and the work in progress. As a consequence, WG membership varies with time.

Within each WG there are rapporteur groups that are responsible for a single deliverable. This provides focus and makes for progress. At the same time, by operating within the parent WG expertise area support from and review by peers is facilitated and encouraged.

An organization like this that works on a large number of subjects in parallel always runs the risk of spreading under the natural “group” forces. Therefore the Project Management Committee has been charged with keeping a good eye on the consistency of the work within the Project.



This slide shows in a single picture the rough schedule for the completion of the specifications for HIPERACCESS. The HIPERLAN2 functional specification has been concluded and this opens up the possibility of re-use part of that work for the HIPERACCESS specifications.

The HA/802.16 co-operation issue

- **A high level of standard harmonisation is highly desirable**
  - ***common EU-US market***
  - ***higher economy of scale***
  - ***no regulatory barriers***

- **To be more deepely discussed in a possible HA/802.16 joint interim meeting (May, '00?)**

further information:

http://www.etsi.fr/bran

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The ETSI WEB site provides a home page for the Broadband Project - it contains the terms of reference, the work progamme and the Executive Summaries of past meetings as well as the invitation and agenda for the next meeting.

For ETSI members, the page also provides a path to the document filing system of ETSI.