BWA Standardisation: A European View

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ABSTRACT

Emerging millimeter-wave Broadband Wireless Systems (e.g. MVDS. LMDS. LMCS) are predicted to become world business worth $billions in the next 5-10 years. Open standards in the industry are beneficial to the market development and uptake of new systems. This paper reviews the regulatory and standards situation, and evolution of Broadband Wireless Systems (BWS) from a European perspective.

1. Introduction

1.1 Background

Initial standards and deployments of millimetre-wave broadband wireless systems concentrated on TV distribution and were aimed at assisting in the development of the BWS market [1]. This followed the early pilot testing in both the USA and Europe. This paper reviews how standards are evolving towards interactive Broadband Wireless Systems within Europe.

During 1986 millimetric video broadcasting at 28GHz was proposed in Europe by British Telecom (BT) [2] and successfully tested in technical and commercial trials between 1987 and 1989. Their aim was to provide cable *substitution* in areas of topographical difficulty, cable *supplement* in areas of lower density housing or take-up, and cable *pull-through* enabling the acceleration of programmes. BT were unable to progress BWS as a business option as the UK 1990 Broadcasting Act excluded BT from the new licensing process.

CellularVision in the USA conducted trials at the same time.

Many BWS Interactive Trials have been conducted in Europe over the last few years. These include tests being conducted by two consortia; the `CRABS' project of 11 partners from 9 countries and the `CABSINET' project with 20 partners from 8 countries. Some of the early trial starters are now entering commercial rollout.

1.2 Analogue Standards

The UK Radiocommunications Agency selected the 40,5 to 42,5 GHz ITU broadcasting band for LMDS (known as MVDS in the UK) in 1989. A working group of manufacturers, potential users and the regulator was set up to recommend a strategy. The technical output of the group was embodied in the specification MPT1550 [3], this stipulated channel plans in addition to transmitter and antenna characteristics. A report, taking the form of an applications note included system budget, path loss and rainfall models based on the work of the Rutherford Appleton Laboratory [4]. Since then, the CEPT has adopted the 42 GHz band for use across Europe (but note that this does not preclude local administrations from licensing additional bands).

MPT 1550 provides for a four frequency set: two true frequency blocks together with the use of interleaving vertical and horizontal polarisation. This conservative planning approach should result in wanted to unwanted signal ratios between the four blocks much in excess of which can provide suitable interference rejection using FM Modulation

Systems conforming to MPT1550 have been deployed in a number of countries, most notably in Switzerland, and Eastern Europe where the design has been verified

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through both winter snow and summer thunderstorms.

1.3 Digital Standards

DVB has formulated the technical specifications for digital TV delivery by all transmission methods and adopts MPEG-2 coding.

DVB has recommended that wireless systems below 10 GHz should broadly follow the 64QAM cable specification and that wireless systems above 10 GHz should follow QPSK DTH. These recommendations have been adopted by ETSI.

The UK have issued specification MPT1560, which includes the DVB/ETSI parameters, and also specifies the other microwave parameters necessary to plan a cellular system in the 42 GHz band - e.g. power, frequency stability and antenna masks. Again mirroring satellite, 24 transponder channels are provided per cell/subscriber at 39 MHz spacing, with a four frequency/polarisation set cellular plan.

The MPT 1550 and MPT1560 together with the amount of allocated spectrum are at present under review by the UK Radio Communications Agency. The 40.5 GHz to 42.5 GHz band may be extended to 43.5 GHz and is subject to a discussion document due to be released from the UK Radio Agency later this year. A technical working group within the Broadband Wireless Association[2] will respond in order to help establish the way forward.

2. BROADBAND ACCESS

2.1. Spectrum Licensing

One of the first major steps in moving to commercial application of BWS is the allocation of spectrum. Many countries in the world have allocated spectrum for Broadband Wireless Systems , however a number of these are still debating how to issue operational licenses. In Europe the 40.5 to 42.5 GHz frequency allocation has been widely accepted following an ERC decision (ERC/DEC/(96)05) designating this band to mulitpoint video distribution systems (MVDS) on a primary basis. This includes the CEPT designation of multimedia wireless systems (MWS) [7]. Despite this there is still some uncertainty with regulators whether to auction licenses or give them away. In addition there is not yet a consensus on how many operators should share the spectrum e.g.. should 4 users have a contiguous 500MHz each? Other conditions which may be attached to the operational licenses are being reviewed, these include digital operation only, predefined channel frequencies and service provisions. It is not yet decided whether Europe will change its current approach and adopt a similar one to the FCC in the USA, where spectrum is allocated without predefined channel plans and modulation requirements.

At WRC-97 agenda item 1.9.6 considered the High Density Fixed Service within bands from 31 to 71 GHz. The WRC high density fixed service designation is synonymous with the CEPT's multimedia wireless systems. A primary fixed service was inserted into the 40.5 to 42.5 GHz band to strengthen the position of MVDS. Along with the 42.5 to 43.5 GHz band there is now a 3 GHz block of spectrum for fixed services within Europe.

WRC-97 also added new primary fixed service allocations in the band 31.8 to 33.4 GHz in all three regions except the USA. The band was identified as being suitable for high density fixed service applications. This band continues to be shared with other services and reports on sharing studies will be considered at WRC-99 before the band comes into use in 2001. Several bands from 51 to 66 GHz were also allocated as primary fixed service in all three regions and also identified as being suitable for high density fixed service applications.

Hong Kong, Hungary and Russia have announced the phasing out of the bands below 28 GHz, and are awarding millimetric licenses.

2.2 Trials

Over the past 3 years an increasing number of trials have been started to address some of the issues that may arise within the application of BWS. Most countries within Europe are now working and trialing one way and interactive systems. The majority of the systems are working in the 40.5 to 42.5 GHz frequency band, although anticipating country specific frequency allocations, there are also trials being conducted at 2GHz. specific 28 GHz licenses being given.

One of the main European trial activities or set of activities is being conducted within the EU ACTS (Advanced Communication Technologies & Services) research programme. The ACTS framework of programmes is a European initiative in the field of research and technological development and demonstration. Its aim is to pool knowledge and resources of companies, institutions and organisations in pursuit of specific objectives. Under the ACTS task 116a 11 partners from 9 countries are conducting a number of activities as the `CRABS' consortium (formed 1996), these focused on the development and demonstration of

[2] The Broadband Wireless association is a group of European Manufacturers, operators and regulators.

cellular broadband interactive digital services. The consortium consists of Telenor (Norway), Philips (UK & Italy), RAI(+Politecnico Di Torino)(Italy), Testcom (Czech), Demokritos (Greece), RAL (UK), Eurobell (UK), Thompson (France) IAS (Austria),Detecon (Germany) and Podlipki (Russia). Initial trials within the CRABS consortium delivering fast internet, educational services [8], and digital video at 42GHz were conducted in Norway, UK, Czech, Greece and Italy. These early trials helped establish equipment interoperability, customer reactions and propagation characteristics. The final year of trials are being conducted in Norway, Italy, UK and Moscow, these are now primarily focused on the delivery of services via ATM and evaluating user reactions. In parallel with the trials, the CRABS consortium are conducting research that should feed recommendations for standards, architectures and planning rules for interactive MVDS/LMDS to the EU at the end of 1998. Another group operating under the ACTS program and complementary to the CRABS is CABSINET. The CABSINET project[9] aims to define and demonstrate a wireless broadband access network for the coverage of the "last mile" in both urban and rural environments. The target is to serve customers with either fixed, or semi-portable terminal equipment eg. STBs, PCs.

The CABSINET consortium is made up of twenty companies spead throughout eight countries in Europe and includes: Bosch, Deutsche Telekom, Thomson Multimedia, France Telecom and Thomcast.

The system uses MPEG2 and IP and is compliant with DVB-T and DVB-MS standards for framing and modulation techniques. The return channel also follows DAVIC wherever possible. The project is also providing a major contribution to the forthcoming DVB-MT specification which uses DVB-T COFDM mdulation over microwave frequencies.

3. Standards Activities

There are three bodies active in producing standards relating to broadband fixed wireless access within Europe; DVB, DAVIC and BRAN. DVB and DAVIC have built on a broadcast video platform to introduce interactive services. Although there are strong similarities between their approaches there are significant differences. Both specifications define an IF interface, without referring to the RF air interface to allow for regional variations. DVB has adopted the cable modem specification defined in ETS 300800, with the exception the the in-band down stream channel is based on the satellite specification ETS 400 721 Modifications (delta's) are incorporated to enable adaptation to the wireless environment. This is due to be passed by ETSI in November 1998.

DAVIC specifies a different standard for hybrid fibre-coax (HFC) and LMDS. Aside from the MAC protocol, the principle differences are the downstream framing structures, mandatory IF interface, In-band and out-of-band signalling approaches. Physical layers are very similar as is the upstream TDMA structure.
The ETSI BRAN Project was established in 1996 and combined the wireless LAN activities of RES10 with those of the radio local loop group. RES10 had begun to define a wireless ATM LAN standard and there was interest from the radio local loop group for a broadband radio access standard that can interwork with an ATM core network. It was decided that there was sufficient commonality in the technical requirement for these two applications to share part if not all of a common standard. In contrast to DAVIC and DVB, BRAN does not attempt to build on a broadcast video platform.

The objective of the BRAN project is to define the technical standard for the PHY and DLC layers of the air interface. BRAN will also define the interworking functions between the DLC and the core access network. BRAN has extended the scope of the technical requirement to included both IP and UMTS core networks as well as ATM.

BRAN will define three technical standards, Hiperlan2, Hiperaccess and Hiperlink of which Hiperaccess is relevant in this paper.
A brief summary of the key features of each of the standards follows.

DAVIC LMDS Specification

3.1 Introduction

This information is derived from DAVIC 1.3 Part 08 Passband PHY on LMDS.

The DAVIC Physical layer interface supports bi-directional transmission using millimetre-wave frequencies. The air interface is point to multipoint using time division multiplex (TDM) from the air interface unit(AIU) at the head-end to the subscriber's network interface unit(NIU) and time division multiple access (TDMA) to share resource between subscribers. The upstream and downstream frame times are equal in duration. Downstream and upstream signals are separated in the frequency domain at the IF.

DAVIC only specifies the radio parameters at the interface between the indoor (UPI/STB) to outdoor (RFU) subscriber units. Spectrum plans are not defined so that national variations can be taken into account. The millimetre-wave transmission parameters can be derived from the physical (IF) interface details.

3.2 Downstream

The downstream can carry either ATM cells or an MPEG2 TS. The data packet size is 188 bytes (MPEG2 packet.) DAVIC shows how 7 ATM cells can be carried

within 2 packets, i.e. 2 x 188 bytes = 7 x 53 bytes plus 3 control bytes. The transmission format is the same asthe QPSK based scheme described in the DVB-S and DVB-MS standards, ETS 300 421 and ETS 300 748 respectively and that adopted by the DVB specification. 16QAM is proposed as a means of increasing the capacity over the radio channel.
Channel bandwidths may range between 20 and 40MHz and frame times between 3 and 6ms. These will support symbols rates between 16.7 and 33.3 Mbaud/s respectively using QPSK. This gives useful bit rates of 26.9 and 53.8 Mbit/s at a code rate of 7/8 and a roll-off factor of 0.2.

The AIU shall not send more than 7% of a frame containing MAC PDUs to any one NIU to limit processing requirements with in the NIU/STB.

The downstream frame consist of a frame start slot followed by random access slots. The latter may contain organisation and maintenance messages or service data units, SDUs (AAL5 for example.)

3.3 Upstream

The upstream transport is structured on ATM cells. An upstream slot consists of a 4 byte pre-amble, 53 byte ATM cell, 10 bytes forward error correction (RS(63,53)) and a 1 byte guard. Differential QPSK modulation is used in channel bandwidths in 2 options; A: 1-2.5MHz and B: 1-20MHz.

With an excess bandwidth of 1.3 symbol rates between 0.77 and 15Ms/s are accomodated.

There are three types of upstream slot, polling response, contention and reserved. They are deifned as follows.

Polling

A slot allocated to one or many subscriber's NIUs consisting of a single cell SDU whose payload is MAC messages only.

Contention

A slot allocated to more than one subscriber's NIU, hence contention resolution must take place. The payload is either a single cell AAL5 SDU whose PDU may be MAC messages or a single cell AAL5 SDU of higher layer data or a multi-cell AAL5 SDU of higher layer data.

Reserved

A slot allocated to one subscriber's NIU whose payload is OAM cells. These may be part of an adaptation layer SDU (AAL5 or AAL1).

The up and downstream frame durations are made equal, typically between 3 to 6 ms and are balanced such that:

(Nd x 204 x 8)/(Rd x 2) = (Nu x 68 x 8)/(Ru x 2)

where N is the number of slot, R is the data rate and d and u refer to the down and upstreams respectively.

3.4 MAC Protocol

The MAC protocol is based on centralised control. It allows adaptable sharing between NIUs of both the up and downstream capacities on a demand request and reservation basis.

The head-end AIU polls every subscriber's NIU periodically (< 2s.) The response from the NIUs is used for signal calibration (frequency, timing and power) and to facilitate network entry. When an NIU wishes to enter the network it acquires a downstream channel by acquiring the frame start slot and synchronising to it. The NIU then listens for a poll directed at it. If it does not find a poll it moves to the next downstream frequency.

The AIU decides which uplink frequency channels and time slots should be allocated to each NIU as contention and polled slots. After the NIU has "signed on," a process of NIU calibration then takes place so the transmit power, frequency and timing "offsets" are corrected. Correction to the upstream frame synchronisation performed by the Access Node.

An NIU can request reserved time slots and must transmit on every reserved time slot even if it has no data when it then transmits an idle cell.

The AIU can tell the NIU to move to a new downstream channel so that improved performance or capacity can be obtained. Parameters such as symbol rate, modulation type (QPSK or 16QAM), roll off factor and error correction rate can be changed.

DAVIC gives a full description of the signalling messages

3.5 IF Interface

DAVIC recommends that the downstream channels are positioned from 950 to 2050 MHz on the radio frequency unit to indoor unit IF interface. This is consistent with existing schemes for DBS and broadcast only LMDS. The upstream channels should be positioned from 400 to 700 MHz. DAVIC also specifies DC levels.

3.6 Network Layer Issues

DAVIC provides support for broadband core networks such as PDH, SDH and SONET and narrowband core networks such as PSTN, ISDN and PLMN.

4. DVB LMDS Interaction Channel Specification

4.1 Introduction

This information is derived from the ETSI standard for DVB interaction channel for LMDS distribution system, ETS 300 800 (LMDS) (draft) dated 28 July 1998. The interactive channel provides an upstream return path for LMDS broadcast systems (DVB-MC) as defined in ETS 300 748. Commonality between this specification and that for cable networks (ETS 300 800) is also a feature.

The specification describes both an in-band (IB) interaction channel whereby the downstream or forward interaction path is embedded into the broadcast channel data stream and an out-of-band (OOB) interaction channel where the downstream or forward interaction path is completely separate from the downstream broadcast path. The in-band approach has similarities to the DAVIC Passband PHY on LMDS description. Whereas the out-of-band approach is based on a narrowband symmetric overlay that is completely separate from the broadcast channel.

4.2 Broadcast Channel

In the IB case the downstream broadcast channel uses an MPEG2 transport stream as defined in ISO 13818-2 and radio transmission parameters as defined in ETS 300 421 (also ETS 300 748). The downstream broadcast channelisation is therefore the same as that which is used in the satellite broadcast bands.Unlike DAVIC there is no provision to carry ATM cells directly on the physical media dependant layer. The in-band approach requires ATM to be carried as private data in an MPEG-TS multiplex.
The out-of-band option provides a symmetric capacity based on ATM.

4.3 OOB and IB Physical Parameters

The IB downstream is inserted into the MPEG2-TS and its rate is n x 8 kbit/s. OOB downstream and the IB and OOB upstreams operate at a rate of 3.088 Mbit/s and use QPSK modulation (the OOB downstream uses DQPSK This rate is consistent with the higher rate used in cable networks.These streams are positioned within 2 MHz spaced radio channels.

The OOB downstream is structured into an extended super frame (ESF) consisting of 24 frames each containing a 192 bit payload plus 1 bit overhead. The ETS describes a scheme whereby the payload of the ESF can transport 10 ATM cells plus RS FEC and cell identifiers.

The upstream path (IB and OOB) uses a packet size (slot) of 64 bytes and contains a unique word, an ATM cell, RS FEC and a guard byte. The transmission rate is 6000 slot/s or 3.088 Mbit/s.

Ranging is used to set the power level and timing and frequency offsets of the NIU. The upstream channels are shared between the network interface units (NIU) using TDMA. One downstream channel is used to synchronise a maximum of eight upstream channels. There is no indication of the method of upstream and downstream diplexing on the radio channel (other than frequency division multiplexing on the IF interface.)

Transmission parameters such as spectral masks may be inferred from the IF parameters.*4.4 Upstream Access Modes*

There are four types of access mode, contention, fixed rate, reservation and ranging. The first is contention based and the second and third are contention-less. The fourth type may be either.
Contention access allows information to be sent at will though a collision may occur and is useful for burst type traffic. On receipt of an ATM cell the INA will acknowledge the sending NIU. The NIU assumes that a collision has occurred if it does not receive an acknowledgement.

Fixed rate access slots are uniquely assigned to a connection by the INA and cannot be initiated by the NIU.

Reservation access slot are uniquely assigned on a frame to frame basis by the INA at the request of the NIU.

Ranging access is used to allow NIUs to adjust their clocks to that of the INA.

4.4 MAC Protocol

Centralised control resides at the head-end interactive network adapter (INA) and allows the adaptable use of the available channel capacity between the NIUs. The ETS describes the MAC message set for operations from connection initialisation through to termination and also link management.

When a NIU becomes active it must first find the provisioning channel message. This is found on the current provisioning frequency and is also sent aperiodically by the INA on all OOB downstream channels. The NIU then receives the default configuration parameters and other downstream provisioning parameters such as the channel frequency. A procedure for signing on and calibration (ranging) then follows. Once this procedure is completed low bit rate default up and downstream connections are permanently assigned to the NIU.
If the NIU wishes to obtain reservation access slots is must wait for a reservation assignment message from the INA. The NIU can then respond with a request and will then be granted slots by the INA.

4.5 IF Interface

The standard recommends that the downstream broadcast channels are positioned from 950 to 2150 MHz in the IF interface between the radio frequency outdoor unit to the indoor unit. This is consistent with existing schemes for DBS and broadcast only LMDS.

The OOB downstream channels can be positioned in downstream broadcast band (950-2150 MHz) or in the band 70 to 130 MHz. The OOB upstream channels are positioned from 5 to 65 MHz. These two lower frequency bands are consistent with bands that are currently used in cable networks.

The IB upstream channels should be positioned from 5 to 305 MHz to allow backwards compatibility with cable networks. Furthermore the extended bandwidth allows for future service expansion

5. ETSI BRAN Hiperaccess Standardisation Activity

Hiperaccess is a fixed point to mulitpoint radio system that will deliver broadband services to customers premises. The requirements and architectures of Hiperaccess are described in a BRAN technical report [10].

Hiperaccess networks will provide up to 25 Mbit/s to and from user's terminal equipment and it is seen as either a competitor or complementary to wired access technologies such a digital subscriber loop and cable modems. The supported services will include ATM transport, IP, video streams and other broadband services also ISDN and POTS. Target customers are SMEs and residential with an emphasis on the high-end and SOHO users.

A systems overview document is nearing completion. Candidate technologies are described in [11]. BRAN may make use of Hiperlan2 technical work which is progressing more rapidly, for example a physical layer using 64 carrier OFDM alligned with IEEE 802.11a. BRAN views the commonality of technical approach as being important for achieving the rapid progress to the completion of the standards. However, Hiperaccess may be deployed over a diverse range of operating frequencies in which case there may be technical differentiation between standards. At the current time it is not clear whether BRANs Hiperaccess will adopt a standard meeting interoperability of co-existance.

The Hiperlan2 technical standard is expected to be completed by mid 1999 followed by the completion of the conformity testing specification in mid 2000. It is estimated that the Hiperacces work is between 6 to 9 months behind that of Hiperlan2.

6. CONCLUSION

The MVDS/LMDS market is now emerging through the initial trial phases to commercial installation. Frequencies and operating licenses are gradually being auctioned and issued, standards are slowly evolving although they may follow the early adopters of the systems. What must not be underestimated is the need for high volume, cost effective and reliable products to realise these applications. There is no doubt that the technology is capable but few manufacturers have shown the movement of this technology through production engineering and into high volume manufacture at a household consumer price. The differing standards and operational frequencies clearly do not help the achievement of low cost consumer LMDS/MVDS product due to the number of product types. Also, potential operators will require to be convinced that their installations are protected for future migration and upgrade. This requires increased co-operation between standardisation bodies around the world. **Thus , if this market is to be realised the standardisation process should be managed in order that it does not `dampen', `restrict' of even `kill' this business.**

The `business' is one that can produce a `WIN' situation for manufacturers, operators and customers, but the window of opportunity is not unlimited in time.

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