HiperLan 2 for FWA Below 11 GHz

IEEE 802.16 Presentation Submission Template (Rev. 8)

Document Number:
IEEE 802.16.3p-00/09

Date Submitted:
2000-07-11

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Venue:
802.16.3 Session #8, La Jolla, CA

Base Document:
N/A

Purpose:
Information

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HiperLAN Type 2:
A Candidate for Fixed Wireless Access Systems Below 11 GHz & Wireless HUMAN

A Presentation to
IEEE 802.16 BWA.3 Task Group & BWA HUMAN Group
July 11, 2000, San Diego

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Ericsson Eurolab Deutschland - Nürnberg
Agenda

• Wireless “Data” Solutions
• HiperLAN/2
  – Requirements
  – Spectrum Allocation
  – Operation Modes
  – Application Scenarios
  – Protocol Architecture
    • Convergence Layer
    • DLC
    • PHY
  – Security
• Conclusions
Wireless “Data” Solutions

- Wide Area Network (WAN)
  - Large coverage
  - High cost
- Personal Area Network (PAN)
  - Connectivity
  - Cable replacement
  - Low cost
- Local Area Network/Access
  - Hot Spots
  - High speed
  - Moderate cost

User Bitrates

- Bluetooth
- HiperLAN/2 IEEE802.11a
- 3G cellular
- 2G cellular
- LAN

Mobility

- Outdoor
  - Vehicle
  - Walk
  - Stationary
- Indoor
  - Walk
  - Stationary/Desktop

Mbps

0,1 1 10 100
Requirements - 1

• Core network independent with QoS support for real time services (VoIP, Video)
  – Support of IP transporting networks, ATM networks, 3rd Generation, Firewire, etc.
  – Packet network based on connection-oriented wireless link

• Radio access network specifications (physical layer, data link control layer and convergence layer)
  – Interoperability standard with conformance test specifications

• No frequency planning
  – Dynamic Frequency Selection

• Capable of handling different interference and propagation situations
  – “Link Adaptation” with multiple modulation and channel coding schemes Supporting asymmetrical traffic load fluctuating in uplink and downlink as well as for different users
Requirements - 2

• A cellular multi-cell radio network capable of offering access, switching and management functions within a large coverage area
  – A point-to-multipoint topology with mandatory centralized mode and optional direct mode
  – Mobility management
  – Power management
    • Uplink power control, downlink power setting, sleep mode
• Usage in indoor and outdoor environments
• Multicast and broadcast
• Scalable security
  – Different key encryption: 56 bit and 168 bit
  – Authentication: Optional pre-shared or public key
Spectrum Allocation at 5 GHz

High Speed Wireless Access
- **Europe**
  - **HiperLAN** 5.15 - 5.35 GHz
- **Japan**
  - **U-NII** 5.15 - 5.25 GHz
- **US**
  - **U-NII** 5.15 - 5.35 GHz, 5.725 - 5.825 GHz

Licensed:
- 455 MHz
Unlicensed:
- 300 MHz

100 MHz
Operation Modes

*Infrastructure based network:*

- Fixed network
  - Access Point (AP)
  - Mobile Terminal (MT)
  - AP - AP Mobility (link level)

*Ad-hoc network:*

- No compromise on QoS in ad-hoc mode!
Application Scenarios

GPRS/UMTS

ISP

On the move

Internet

Home

Office

Ethernet

HIPERLAN/2

HIPERLAN/2

HIPERLAN/2
Protocol Architecture

- Standardization scope: air interface, service interfaces of the radio access system and the convergence layer functions.
Convergence Layer

- Multiple convergence layers
- One single convergence layer active at a time
- Mapping between higher layer connections/priorities and DLC connections/priorities

- Segmentation and re-assembly to/from 48 bytes packets
- Priority mapping from IEEE 802.1p
- Address mapping from IEEE 802
- Multicast & broadcast handling
- Flexible amount of QoS classes

![Diagram of Convergence Layer]

- **ATM**
- **CP**
- **Cell based**

<table>
<thead>
<tr>
<th>UMTS</th>
<th>PPP</th>
<th>Firewire</th>
<th>Ethernet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Part (CP)</td>
<td>Packet based</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Mapping higher layer packets onto layers of HiperLAN/2**

- **Higher layer packet (e.g. Ethernet packet)**
  - Flags, 12 bits
  - Payload, 384 bits

- **DLC:**
  - Header
  - DLC SDU, 396 bits
  - CRC

- **PHY:**
  - Preamble
  - SCH
  - SCH
  - LCH
  - LCH

- **PHY burst**
  - DLC LCH PDU, 432 bits
DLC: Medium Access Control - 1

- TDMA/TDD with a fixed frame duration of 2 ms
- 3 transmission possibilities: AP to MT (Downlink), MT to AP (Uplink) and MT to MT (Direct Link)
- Centralized scheduling (not specified)
  - Air interface frame creation in the AP
  - Resource allocation by the AP
  - Resource requests from MTs
  - Dynamic assignment of capacity in uplink and downlink - no fixed slot structure is mandatory, but possible for CBR type services
  - Could consider QoS and link adaptation modes
  - Transmission of Data PDU and ARQ PDU without collisions
- Peer-to-peer and multicast support
DLC: Medium Access Control - 2

- Random access scheme
  - Association and resource request transmissions from MTs
  - Random access in mobile stations: slotted ALOHA with exponential increase of contention window
  - Processing random access in the AP: acknowledgements of random access in the next frame
- Sector antenna support
Logical and Transport channels are used to construct MAC frame

- **Logical Channel:**
  - A generic term for any distinct data path which describes a specific data transfer service offered by the MAC entity
  - Defined by the type of information it carries and the interpretation of the value in the corresponding messages

- **Some important Logical Channels**
  - **BCCH (Broadcast Control CHannel):** used in downlink conveying the necessary broadcast information concerning the whole radio cell e.g. scrambler seed, access point ID, network ID, etc.
  - **FCCH (Frame Control CHannel):** used in downlink conveying information describing the structure of the MAC frame visible at the air interface (resource grant announcement)
  - **RACH (Random Access CHannel):** used by MTs in uplink to send signalling data (resource request, association request) for DLC or RLC.
MAC Frame Channels: Logical Channel - 2

• Some important Logical Channels: Contd
  – **RFCH (Random access Feedback CHannel):** used in downlink to inform the MTs that have used the RACH in the previous MAC frame about the result of their access attempts.
  – **RBCH (RLC Broadcast CHannel):** used in downlink (when necessary) conveying broadcast CONTROL information concerning the whole radio cell, e.g. broadcast RLC message, MAC ID in the association process, encryption seed, etc.
  – **DCCH (Dedicated Control Channel):** used in downlink, direct link and uplink conveying RLC messages
  – **LCCH (Link Control CHannel):** used bi-directional to transmit ARQ and discard messages between peer error control functions
  – **UDCH (User Data CHannel):** used bi-directional to transmit user data
MAC Frame Channels: Transport Channel

- Logical channels are mapped onto different transport channels which describe the basic message format and are the basic elements for constructing message sequence of each user
  - **BCH (Broadcast Channel)**: carries BCCH transmitted once per MAC frame per sector antenna
  - **FCH (Frame Channel)**: used in downlink for carrying FCCH with variable amount of data
  - **ACH (Access feedback Channel)**: used in downlink for transporting RFCH
  - **LCH (Long Transport Channel)**: used for transporting user data and control information
  - **SCH (Short Channel)**: used for transporting short control information
  - **RCH (Random Channel)**: used in uplink for transmitting resource request or association request
Mapping between Logical and Transport Channels

- Downlink

- Uplink
Basic MAC Frame Structure

- A single sector system

- A multiple sectors system
DLC: Error Control

• Scaleable Error Control: three EC modes
  – Acknowledged mode for reliable transmission by using ARQ
  – Repetition mode for reliable transmission by repeating LCHs
  – Unacknowledged mode for transmissions with low latency

• SR-ARQ with partial bitmap
  – retransmission efficiency as conventional SR
  – Optimized overhead and delay for acknowledgements
    • acknowledgements are sent not for every erroneous packet but a bitmap for several ones
    • Dynamical management of bitmap packets
    • Cumulative Acknowledgement and Flow Control possible
  – Discarding capability
    • efficient for real time applications

• Short MAC frame (2 ms) allows re-transmission even for voice
Partial Bitmap Basics

- Numbering of PDU from 0 to 1023 (Sequence Number)
- Grouping 8 PDUs into 1 Block, totally 127 Blocks
- ACK of a PDU: BitMap Block (BMB) & BitMap Number (BMN)
- In the ARQ C-PDU: 3 BMBs & 3 BMNs
- BMN1=Block_Id1, BMN2=Block_Id1 - Block_Id2, BMN3=Block_Id3 - Block_Id2

<table>
<thead>
<tr>
<th>ARQ Message Format (Uplink)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Octet 1</td>
</tr>
<tr>
<td>PDU Type</td>
</tr>
<tr>
<td>OCTET 9</td>
</tr>
</tbody>
</table>
Dynamic Acknowledgement

- Problems with fixed ACK
  - low utilisation of channel capacity
  - bottleneck of feedback channel
  - deferring retransmissions

- Dynamic ACK
  - # of ARQ PDUs based on receiver status
  - ABIR-bit used by receiver in MT
  - high utilisation of channel capacity
Link Adaptation

• Link Adaptation
  – Code rate and modulation alphabet (7 modes) adaptive to current propagation and interference environments

• Link throughput versus C/I
  – Link quality measurements (C/I) in access point and mobile terminal
  – rms delay spread 100 ns
  – Selective-repeat ARQ,
  – ideal link adaptation
DLC: Radio Link Control

- **Connection handling**
  - Setup / release of DLC connections
  - Peer-to-peer (ad-hoc)
  - Multicast
- **Security**
  - Authentication
  - Encryption key distribution
  - Alternative security negotiation

- **Management functions**
  - Mobility
    - Association / de-association
    - Handover
    - Location update
  - Radio resource management
    - Dynamic frequency selection
  - Power management
    - Sleep mode
    - Uplink and downlink power control
HIPERLAN2 & 802.11a PHY - Key Parameters

- Multi-carrier modulation by **OFDM**

![Flowchart](image)

- A length-127 scrambler with generator polynomial \( S(x) = x^7 + x^4 + 1 \)
- Punctured convolutional code, based on rate-1/2 code, constraint length 7
- Intra-symbol bit interleaving
- Block size depends on the sub-carrier modulation
- 48 (data) + 4 (pilot) sub-carriers
- PSK/QAM (coherent)

- Channel spacing 20 MHz
- Cyclic prefix 800 ns (optional 400 ns only in HIPERLAN/2)
- Possible delay spread (at least) 250 ns
Physical Layer Modes

• Main difference between 802.11a and HIPERLAN/2: Preamble due to different multiple access scheme
• Several physical layer modes are provided
  – Link adaptation selects the “most appropriate” mode.
• Physical layer modes of HIPERLAN/2 & IEEE 802.11a:

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Code rate</th>
<th>Net bit rate</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPSK</td>
<td>1/2</td>
<td>6 Mbps</td>
<td>H/2 and IEEE</td>
</tr>
<tr>
<td>BPSK</td>
<td>3/4</td>
<td>9 Mbps</td>
<td>H/2 and IEEE</td>
</tr>
<tr>
<td>QPSK</td>
<td>1/2</td>
<td>12 Mbps</td>
<td>H/2 and IEEE</td>
</tr>
<tr>
<td>QPSK</td>
<td>3/4</td>
<td>18 Mbps</td>
<td>H/2 and IEEE</td>
</tr>
<tr>
<td>16QAM</td>
<td>1/2</td>
<td>24 Mbps</td>
<td>IEEE</td>
</tr>
<tr>
<td>16QAM</td>
<td>9/16</td>
<td>27 Mbps</td>
<td>H/2</td>
</tr>
<tr>
<td>16QAM</td>
<td>3/4</td>
<td>36 Mbps</td>
<td>H/2 and IEEE</td>
</tr>
<tr>
<td>64QAM</td>
<td>2/3</td>
<td>48 Mbps</td>
<td>IEEE</td>
</tr>
<tr>
<td>64QAM</td>
<td>3/4</td>
<td>54 Mbps</td>
<td>H/2 and IEEE</td>
</tr>
</tbody>
</table>
OFDM Modulation

{d} \rightarrow \{D_{q,l}\} \rightarrow \text{Mapping} \rightarrow \{D_{q,o}\} \rightarrow \text{Serial to parallel converter} \rightarrow \{D_{q,N-1}\} \rightarrow \text{Multiplex} \rightarrow x(t)

\begin{align*}
\{D_{q,o}\} & \rightarrow e^{j2\pi f_{20} t} \\
\{D_{q,l}\} & \rightarrow e^{j2\pi f_{4} t} \\
\{D_{q,N-1}\} & \rightarrow e^{j2\pi f_{N-1} t}
\end{align*}

4 pilot carriers

\text{20 MHz}
Preamble: HIPERLAN2 Downlink

• Preamble for Broadcast Control Channel
  – A and B part could be used e.g. for AGC setting, coarse frequency/time synchronization as well as fine frequency/time synchronization
  – C part could be used e.g. for channel estimation

• Preamble for other downlink channels
  – C part could be used e.g. for update of channel estimation or a new one
Preamble: IEEE / HIPERLAN2 Uplink and Direct Mode

- HIPERLAN2 Short Preamble (only uplink)

- HIPERLAN2 Long Preamble (very similar to 802.11a PLCP preamble)

- IEEE802.11 Preamble
Security Overview

- Wired equivalency
- Sufficient in business, residential and public access environments
- Supports negotiation of different security levels including:
  - encryption (data confidentiality) and authentication (user confidentiality)
- Supports mobility (HO)
- Low/moderate processing overhead
- Exportable
Security Features

• Mobile identity protection
• Restricted to the radio access system
  – High level security not provided, e.g. user authentication through the Internet to corporate network Link level encryption
  – unicast, multicast, broadcast
  – for both user data and signaling
  – 56 bit and 168 bit key encryption based on DES
• Mutual authentication based on challenge/response
  – Optional pre-shared key or public key
• Token based handover authentication
• Key generation based on Diffie-Hellman exchange
• Regular key refresh
Conclusions: Adoption of HiperLAN2 to FWA 802.16.3

• DLC/MAC layer
  – TDD vs. FDD?
  – Deletion of management functions regarding mobility and radio resource (DFS)?
  – Is peer-to-peer communications between wireless terminals needed?
  – Security aspects?
  – ...?

• Physical layer
  – The same channel spacing (20 MHz)?
  – The same delay spread and as a result the same OFDM guard time?
  – Higher distances of terminals to access points (central stations) result in larger guard times for “PHY burst”? 
  – ...?
BRAN Information

- **HiperLAN/2 Technical Specifications**
  - Free of charge @ http://www.etsi.org/bran (Click on Work Items)
    - PHY: ts_101475v010101
    - DLC (basic functions): ts_10176101v010101
    - RLC: ts_10176102v010101
    - Packet based CL Common Part: ts_10149301v010101
    - Packet based CL Ethernet part: ts_10149302v010101
    - Cell based CL Common Part: ts_10176301v010101
    - Cell based CL UNI Part: ts_10176302v010101

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