

WiMAX-PHY 4: Further developments (802.20)

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overview

- The purpose of the IEEE 802.20 work group
- Characteristics of the solution
- Characteristics of the Air Interface (AI)
- PHY and MAC layers in the initial draft
- Comparison to 802.16e and 3G
- Comparison to LTE
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- References

The purpose of the IEEE 802.20 (MBWA) work group

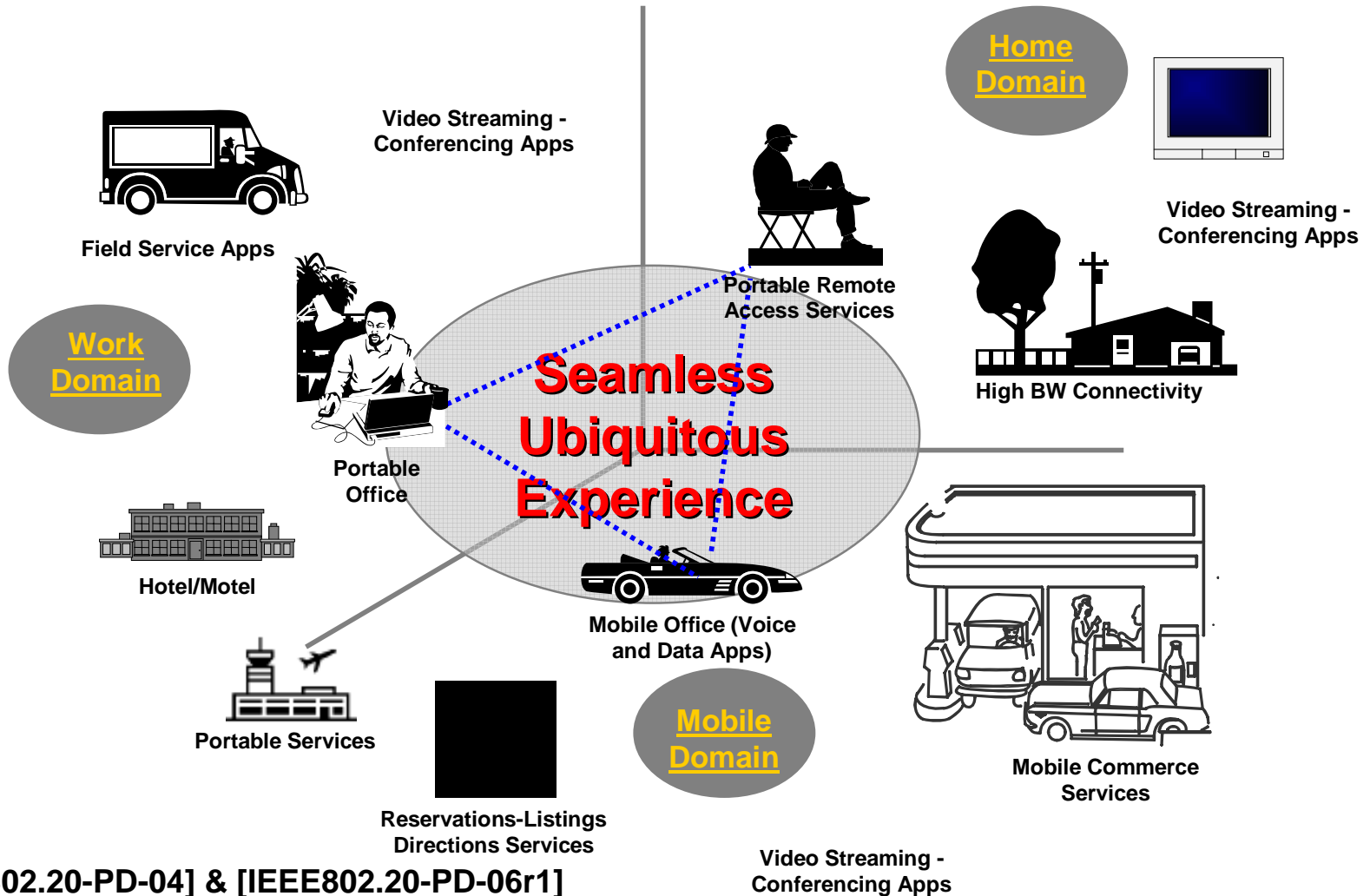
- To develop specification of PHY and MAC layers of an Air Interface (AI) for globally interoperable, Mobile Broadband Wireless Access system (MBWA) which:
 - Operates in licensed bands <3.5GHz
 - Is optimized for packet-data transports (IP)
 - Supports vehicular mobility up to 250 Km/h
 - Targets spectral efficiencies, sustained user data rates and number of active users significantly higher than any existing mobile system.

Characteristics of the solution

- Always on and ubiquitous
 - user needs only one connection, and the connection from MT (Mobile Terminal) to BS (Base Station) shall be automatic
- Universal frequency reuse
 - All the users in a cell share the same bandwidth
- Support for inter-technology roaming and handoff
 - E. g. from MBWA to WLAN
- seamless inter-cell and –sector handoff
 - Seamless integration of user domains: home, work and mobile
- Transparent support for IP based services (realtime and non-realtime)
 - VoIP, FTP, Web, video, VPN, etc
- Support for QoS
 - Policy-based, both IPv4 and IPv6
- Security
 - Protect:
 - Against theft of service
 - Privacy of the user
 - Against denial-of-service attacks
 - Mechanism for authenticating MT and BS
 - Digital signature based
 - Data encryption with AES
- User data rate management: automatic selection of optimized data rates consistent with the RF environment constraints

Characteristics of the solution

The Ultimate goal is to fill the gap between high data-rate low mobility (WLAN) solutions and high mobility low data-rate cellular networks (3G) by adopting the best from both worlds. Thus enabling a truly mobile broadband wireless connection for users.



AI interface characteristics

- **Duplexing and Frequency Arrangements Plans:**

| FDD | TDD |
|--------------|---------|
| 2 x 1.25 MHz | 2.5 MHz |
| 2 x 2.5 MHz | 5 MHz |
| 2 x 5 MHz | 10 MHz |
| 2 x 10 MHz | 20 MHz |
| 2 x 15 MHz | 30 MHz |
| 2 x 20 MHz | 40 MHz |

System only needs to support either FDD (paired channel) or TDD (unpaired) duplexing mode.

Also not all block sizes need to be supported (only 1.25 to 5), but the system should be easily extensible if an extra bandwidth is allocated.

- **Spectral efficiency requirements**

- Sustained overall spectral efficiency > 1 b/s/Hz in a cell
- Examples of required values that user is expected to experience:

| Spectral efficiency requirements | | | |
|----------------------------------|---------|--------|---------|
| Downlink | | Uplink | |
| 3 km/h | 120km/h | 3 km/h | 120km/h |
| 2.0 | 1.5 | 1.0 | 0.75 |

At higher velocities the spectral efficiency will degrade gracefully

AI interface characteristics

- **Cell sizes:**

- Appropriate for ubiquitous MANs and capable of using the existing infrastructure, namely the existing cellular masts.

- **Cell sectoring:**

- The system should have the ability to support 6 or more sectors per cell. In addition, the MBWA system should be well-suited for a typical configuration of 3 sectors per cell.

- **Frequency reuse:**

- Frequency reuse factor < 1, so that same frequencies can be used in all cells (or sectors).
- Directed adaptive antennas, could enable the same frequencies to be used more than once in a single cell (or sector)

- **Doppler tolerance:**

- > 400 Hz Doppler tolerance is needed to satisfy the desired vehicular mobility.
- Example:

$$f_d = \frac{V * f_0}{c} \Leftrightarrow V = \frac{f_d * c}{f_0} \approx 230\text{km/h}$$

Where V is velocity of the terminal, f_d is the doppler spread of 400Hz, c is the propagation velocity (3e8) and f_0 is the carrier frequency (1,9GHz)

- **Delay spread tolerance:**

- 10ms the performance should degrade gracefully in the presence of longer multipath components.

AI interface characteristics

- Handoff:
 - Soft handoff, the MS should be able to monitor the signal strength.
- Support for advanced antenna technologies:
 - Multi-antenna capabilities at the BS must be supported, optional at the MS
- Average aggregate data throughput when user in motion:

| Mb/s/sector | 3 km/h | 120 km/h |
|--------------|--------|----------|
| DL (1.25MHz) | 2.5 | 1.25 |
| UL (1.25MHz) | 1.25 | 0.94 |
| DL (5 MHz) | 10.0 | 5.0 |
| UL (5 MHz) | 5.0 | 3.75 |

Throughput degrades gracefully with higher velocities

[IEEE-MBWA] & [IEEE802.20-PD-06r1]

- Available bandwidths
 - 2x1.25MHz for FDD and 2.5 MHz for TDD:

| Bandwidth (example) | 1.25MHz | 5 MHz |
|-----------------------------|------------|------------|
| DL peak user data rate | > 1 Mb/s | > 4 Mb/s |
| UL peak user data rate | > 300 kb/s | > 1.2 Mb/s |
| DL peak aggregate data rate | > 4 Mb/s | > 16 Mb/s |
| UL peak aggregate data rate | > 800 kb/s | > 3.2 Mb/s |

Data rates will scale accordingly to the available channel bandwidth

Average data rates delivered to user will be lower, depending on various factors.

Simulations show average of > 512 kb/s for UL for 1.25MHz channel.

PHY and MAC in the initial draft

- Since the standardization process is on going, no detailed technical information is publicly available but the following summarizes the PHY and MAC layer features from the initial draft:

| | |
|------------|--|
| MAC | <p>Includes session, convergence, security and lower level MAC functions.</p> <p>Lower MAC sublayer controls operation of data channels: Forward and Reverse traffic channels. It includes MAC protocol for: control channel, access channel, shared signaling, forward traffic channel, reverse control channel and reverse traffic channel.</p> <p>Forward- and reversed-link transmission are divided into superframes which are then divided into units of PHY layer. FDD and TDD superframe timing are used.</p> <p>The default access channel MAC protocol enables accessing terminal to send an access probe, by the initial access or handoff. Network will reply with Access Grant.</p> |
| PHY | <p>2 different duplexing modes: FDD and TDD</p> <p>2 different forward link hopping modes: Symbol rate Hopping and Block Hopping</p> <p>2 different synchronization modes: Semisynchronous and Asynchronous</p> <p>2 different multicarrier modes: on and off</p> <p>OFDM modulation with QPSK, 8PSK, 16QAM, 64 QAM</p> |

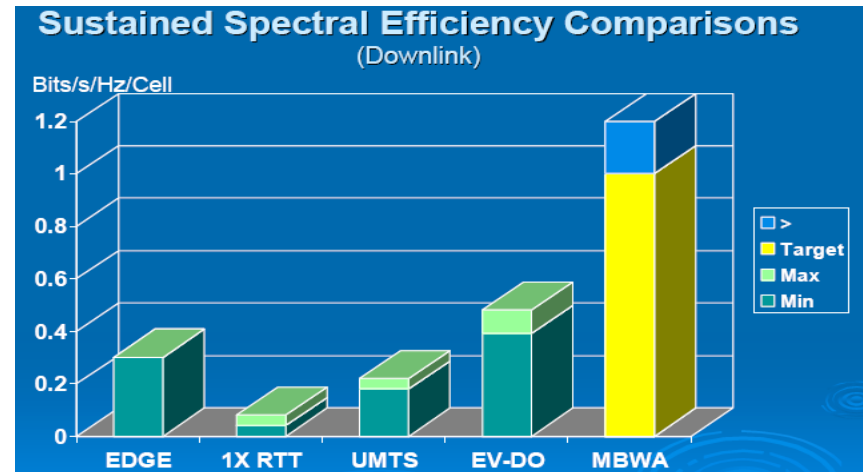
Comparison with 802.16e and 3G

- Distinction to 802.16e and 3G:
 - 3G is fundamentally a voice-based technology and it is not optimized for packet-based services. Deficiencies e. g.:
 - Voice-centric channel parameters, which prevent efficient scheduling and power control
 - Contention-based access, introduces latency and delay variations
 - Insufficient support for QoS due to best-effort
 - 802.16e is backwards compatible with fixed wireless standards and therefore fails to be fully mobile.
- Still the similarities of MBWA and wimax are obvious, and future will tell whether there is room for both standards in the markets
- The next table summarizes the basic characteristics of each system.

| Network | 802.16e | 802.20 | 3G |
|----------------------------|---|--|--|
| Mobility | High-data-rate fixed wireless user, with adjunct mobility service | Fully mobile, high-throughput data user | Voice user, requiring data services |
| Data patterns | symmetric | symmetric | Asymmetric |
| Services | Support fo low-latency data and real-time voice services | Support for low-latency data | No support for low latency data |
| Roaming | Local/Regional mobility and roaming support | Global mobility and roaming support | Global mobility and roaming support |
| MAC/PHY | Extension to 802.16a | New, optimized for packet data and adaptive antennas | W-CDMA, cdma200 |
| Technology | Optimized for and backward compatible with fixed stations | Optimized for full mobility | Evolution of GSM |
| Channelization and control | For multimedia services with QoS | For mobile multimedia services. Mobile-IP | For mobile voice services. MAP/SS7 based |
| Bands | 2-6 GHz | < 3.5 GHz | < 2.7 GHz |
| Typical channel BW | > 5 MHz | < 5 MHz | < 5 MHz |

Comparison with 802.16e and 3G

- Figure on the right side depicts the sustained spectral efficiencies of the existing cellular technologies compared to MBWA
- Spectral efficiency of wimax and MBWA systems pretty much alike due to the similar nature of the systems. (author was unable to find comparable figures)
- Table on the right side compares the range and expected data rates of wimax and MBWA.



| Wimax | MBWA |
|---|--|
| Typical range is likely to be between 1-5km | •Ranges of up to 15 kilometers (km) are likely |
| Data rates are likely to be on the order of up to 15 Mbits/s. | Peak data rates of 1 Mbit/s per user. |

Comparison to LTE

- 3GPP's Long Term Evolution project aims to improve UMTS.
- LTE is not a standardization project in the same sense that IEEE 802. Results of this project will merge in the forthcoming (8) release of the UMTS standard.
- The purposes of LTE and MBWA are very much alike:
 - Flexibility of use of existing and new frequency bands, enable co-deployment with existing cellular networks.
 - Allow for reasonable terminal power consumption
 - IP-based, Increased service provisioning
 - Support for high vehicular mobility
 - Interoperable, global
 - Make use of existing infra
 - Etc.
- Too much overlapping for both to survive?
- The main advantage of LTE is backwards compatibility with 3G

Comparison to LTE (E-UTRA)

| | LTE | MBWA |
|--|---|--|
| Frequency arrangements | 1.25MHz, 5Mhz paired or unpaired channels, support up to 20MHz | 1.25MHz, 5Mhz paired or unpaired channels, support up to 20MHz |
| Support for MIMO | Yes | Yes |
| modulation | (DL) OFDM with QPSK, 16QAM and 64QAM; (UL) SC-FDMA BPSK, QPSK, 8PSK and 16QAM. | OFDM with QPSK, 8PSK, 16QAM, 64 QAM |
| Support for vehicular mobility | Up to 350 km/h | Up to 250 km/ h |
| Target values for link spectral efficiency (DL) | 5 bp/s/Hz | 3.6 bp/s/Hz |
| Example of data rate on 5MHz Channel | 25 Mb/s | 18 Mb/s |

Summary

- Although 802.20 seems to meet the requirements for 4G, it has not been able to gain the upper hand in the battle for the next generation wireless network standard.
- General opinion seems to be that there are only two options for the next generation network: mobile-wimax and LTE.
- It remains to be seen whether or not MBWA plays a role in this 3GPP vs IEEE race towards the next generation wireless standard.

References

- **References to IEEE permanent documents:**

documents are available at <http://grouper.ieee.org/groups/802/20/Documents.htm>

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