Initial PHY Layer System Proposal for Sub 11 GHz BWA

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Base Document: 802.16.3c-00/40 This document provides an initial PHY system proposal of a low frequency (Sub 11 GHz) wireless access PHY for point-to-multipoint voice,video and data applications. The submission is for consideration of the Task Group to develop a PHY standard for BWA system.

Purpose:

This presentation is in response to "Call for Contributions: Session #10" by 802.16.3 Task Group chair on Sept. 15th, 2000 for submission of "Initial PHY Proposals" for Sub 11 GHz BWA.

Initial PHY Layer System Proposal for Sub 11 GHz BWA

A Presentation to

IEEE 802.16.3 Task Group

November 08, 2000, Tampa

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Objectives

- This Proposal provides an initial PHY system proposal of a low frequency (Sub 11 GHz) wireless access for point-to-multipoint data, voice, and video applications.

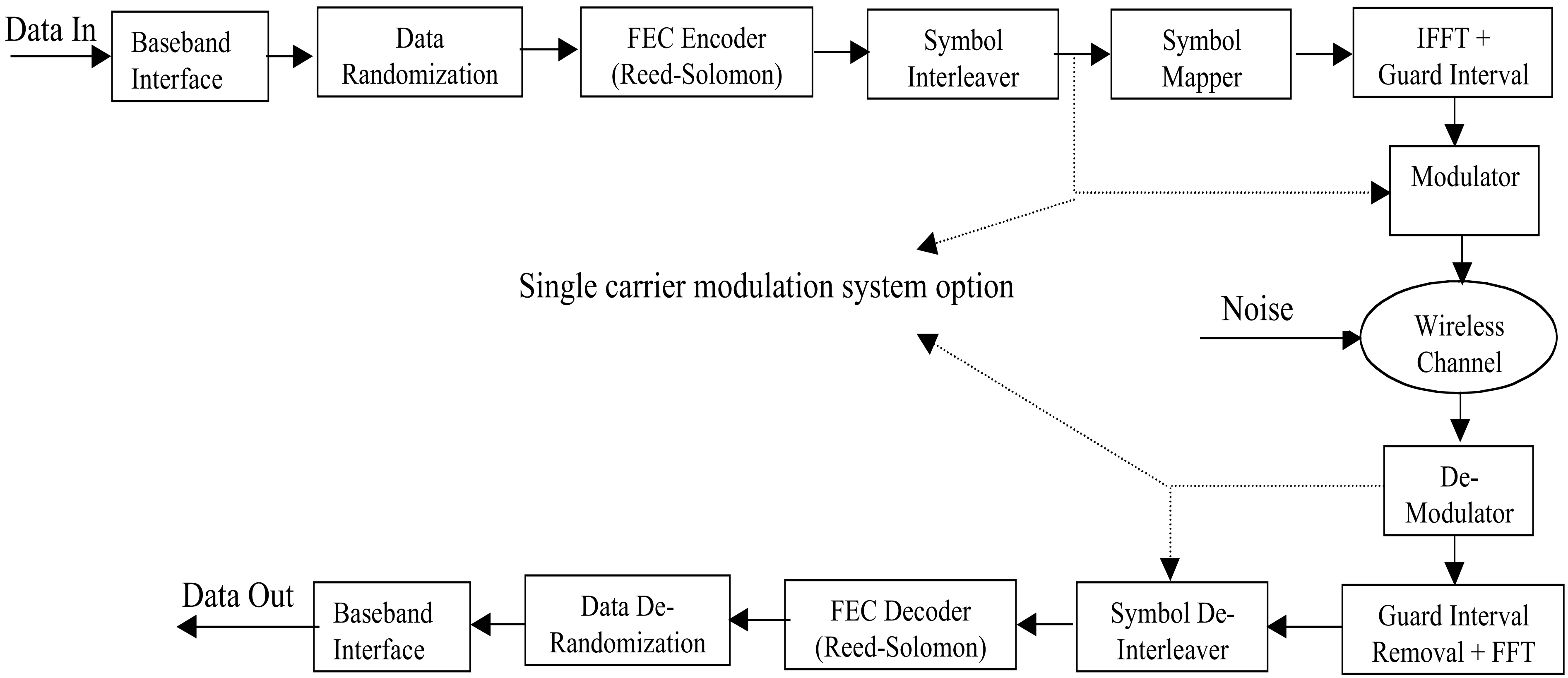
- The submission is for possible adoption as baseline for a PHY standard for BWA systems.

The PHY Layer Proposal

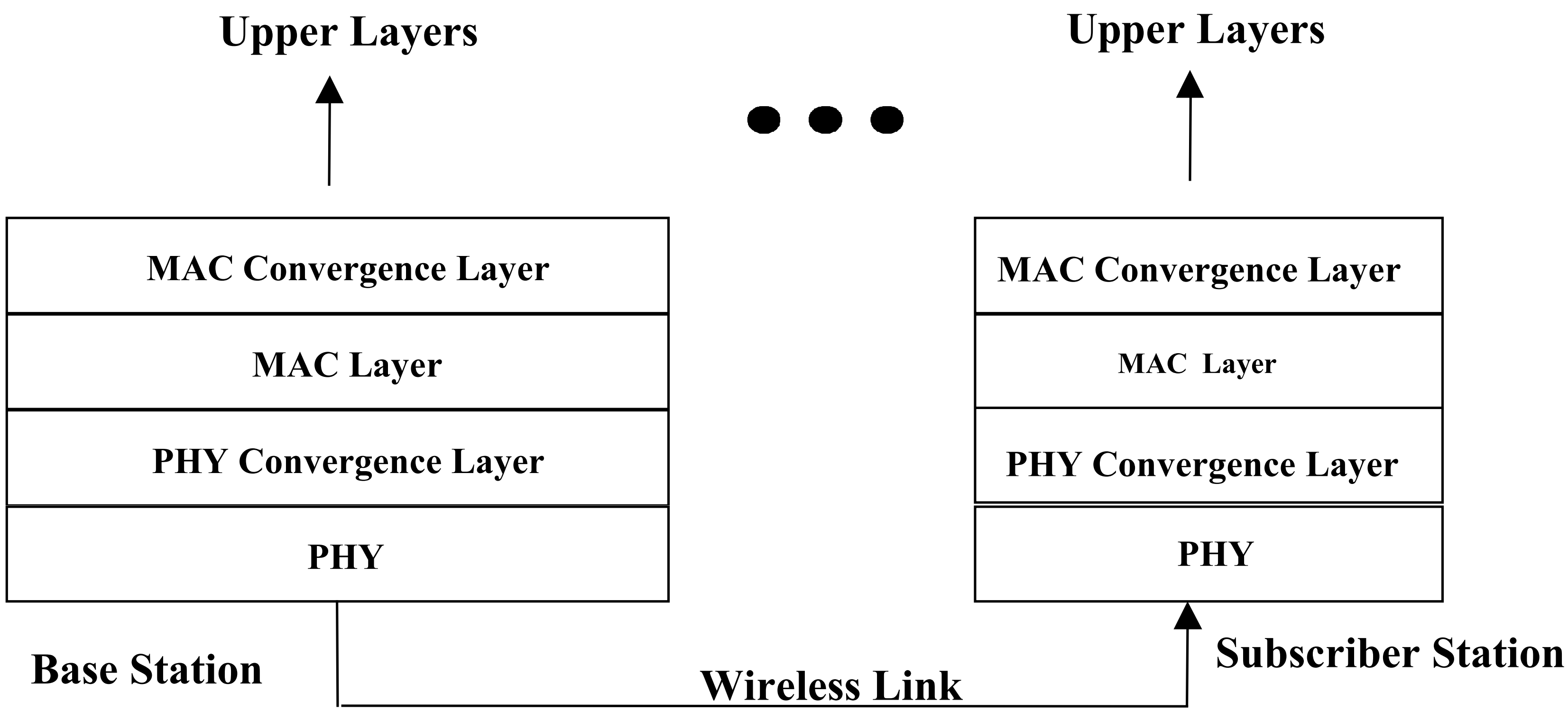
The main features of the proposal are the following:

- Multiple access Scheme is TDMA.
- Duplex schemes are both the TDD and FDD.
- Base Station uses multiple sector antenna.
- Support for future use of smart antenna.
- High capacity single carrier modulation.
- Addition of OFDM for the PHY robustness against various channel impairments.
- A flexible PHY for coverage, in the use of frequency band, and capacity allocation.
- Obtain a low cost Subscriber Station and the Base Station solution.

The Proposed PHY Layer Block Diagram



The proposed PHY Layer with upper layers protocol stack



WHY TDMA?

- CDMA is best-suited access scheme for mobile cellular communications where the user behavior will change dynamically. CDMA systems simplify frequency planning and hand-over in mobile environments, but it places demands on the frequency bandwidth. CDMA is well suitable in unregulated ISM band.
- But for Fixed wireless application, where it is expected to deliver high data rates (tenths of Mb/s) within a limited bandwidth allocation, the benefit of CDMA becomes minimal mainly due to too much bandwidth requirements.

WHY TDMA? (Cont…/)

- FDMA systems are best suited for fixed capacity allocation, and therefore, FDMA is not optimal solution for bursty type traffic. Today, FDMA systems may require expensive Base Stations with multiple number of modem banks.

- TDMA systems can be designed to handle very fast, dynamic-capacity allocation, which is the requirement for statistical multiplexing of bursty traffic sources. As packet–switched traffic is becoming more predominant in the small and medium-sized business sector, which will benefit from the advantages of statistical multiplexing of TDMA system

Why TDD or FDD?

TDD:

- TDD performs better for asymmetric traffic scenario and it can be implementation with less complexity.
- In BWA system, where the delay between transmission and reception can consist of a few time slots, a guard time between the downlink and uplink sections of the frames has to be introduced in order to avoid collision between time slots. The guard time reduces system throughput, especially if the system is designed for low latency.

Why TDD or FDD? (Cont…/)

FDD:

- On the other hand, allocate a fixed proportion between uplink and downlink capacity. Residential users are likely to request asymmetrical uplink and downlink capacity, while in a business-user scenario, more symmetrical traffic behavior is likely to be the rule.
- The current Harris BWA system is designed as an FDD system with full flexibility for instantaneous capacity allocation in the uplink and downlink for each access terminal and connection and is primarily addressing the business market segment.

Why TDD or FDD? (Cont…/)

- We propose the support of TDD and FDD systems and leave the selection of each system to the vendors /operators decision on implementation complexity, traffic scenario and cost objectives.

Modulation

- The proposed BWA system shall use 16QAM or 64 QAM modulation for the downstream transmission and
- QPSK or 16 QAM modulation for the upstream transmission.

Why OFDM?

- It is proven OFDM to be superior in performance than single carrier modulation techniques when the channels of communication suffer from deep multi-path fading in addition to AWGN noise.

- Though OFDM out performs single carrier modulation systems, but OFDM imposes stricter constraints due to:
  - its large Peak-to-Average power (PAP) ratio characteristics,
  - its sensitivity to carrier frequency offset and phase noise.
- To alleviate the frequency offsets must use an accurate AFC circuitry, otherwise the sub-carriers will no longer be **orthogonal**.

Why OFDM? (Cont…/)

- Synchronisation of multi-carrier scheme is much more difficult than single carrier.
- OFDM with large number of sub-carriers, the combined signal has a very large PAP and to maintain linearity over the range, the power amplifier will require back-off as much as 10 dB.

- Harris supports the application of Single carrier modulation and OFDM technologies.

System Capacity

- The aggregate transmission bit rate shaom in Table is optimised based on several constraints. These are:
  - The allocated channel bandwidth;
  - The modulation level;
  - The spectrum shaping filter bandwidth with roll factor of _ = %0.15 to %0.25;
  - The FEC coding scheme (Reed-Solomon (n, k) over GF(2^8));
  - The requirement of upstream time tick for the Mini-slots burst duration; and
  - Processing power limitation of available chips to be used.

System Capacity (cont…/)

Table 1: An example of System Capacity Objectives.

Channel Spacing	**Downstream Transmission Rate (Mb/s)**		**Upstream Transmission Rate (Mb/s)**	
	(16 QAM)	**(64 QAM)**	**(QPSK)**	**(16 QAM)**
3.5 MHz	11.84 Mb/s	17.76 Mb/s	5.12 Mb/s	10.24 Mb/s
5 MHz	16.90 Mb/s	25.34 Mb/s	8.00 Mb/s	16.00 Mb/s
6 MHz	20.22 Mb/s	30.34 Mb/s	9.60 Mb/s	19.20 Mb/s
7 MHz	23.68 Mb/s	35.52 Mb/s	10.24 Mb/s	20.48 Mb/s

The frequency range and the channel bandwidth

Table 2: ....

Frequency Bands	Channel Bandwidth	Reference
a) 2.5 GHz	6 MHz	FCC 47 CFR 21.901 (MDS) FCC 47 CFR 74.902 (ITFS, MMDS) Industry Canada SRSP-302.5 (Fixed Services operating in the 2500 to 2686 MHz band)
b) 3.5 GHz	5, 7 MHz	EN 301 021, CEPT/ERC Rec. 14-03 E, CEPT/ERC Rec. 12-08 E, Others: TBD
c) 10.5 GHz	3.5, 5 and 7 MHz	EN 301 021, CEPT/ERC Rec. 12-05 E

Similarity with other standards

- The proposed PHY is similar to some extend with TG1 PHY (supporting TDMA multiple access, both TDD and FDD, QPSK/m-QAM, and FEC coding), to some degree with DOCSIS (supporting TDMA multiple access, QPSK/m-QAM, and FEC coding), and to some degree with IEEE802.11 (for supporting OFDM).

Compliance with the Evaluation Criteria

Meets system requirements	This proposal is believed to meet the requirements described in the current version of TG3 FRD.
Channel spectrum efficiency	The average of bps /Hz in a typical deployment (TDD or FDD) is about 3 bps/Hz. In FDD mode, the spectrum efficiency of the system ranges from 1.46 for QPSK and to 2.9 bps/Hz for 16 QAM modulation for the Uplink. For the Downlink, 3.38 for 16-QAm and to 5.0 bps/Hz for 64 QAM modulation.
Simplicity of implementation	The major functions of the proposed PHY (i.e., QAM, FEC and OFDM) are well known or they are becoming available technologies and do require complex implementations.
SS cost optimization	Similarity that exists between this proposal with other standards mentioned above, will facilitate the availability of chip-sets to be used for the SS with lower cost.
BS cost optimization	The use of OFDM at the BS can be a drawback from the complexity and PA Back-off requirements, but this feature will be advantageous for future addition of Smart antenna capability to the system.
Spectrum resource flexibility	The proposed PHY can be scaled to any channel spacing. Modem bit rate can be easily modified to support 10 to 40 Mbps.
Channel Rate Flexibility	This data rate scalability can be obtained by changing FEC code rate and modulation scheme. The changes will have to meet the specified QoS in the FRD.

System service flexibility	The proposed PHY in conjunction with MAC layer will support various services defined within FRD that may require variable data rates and with different QoS requirements.
Protocol interfacing complexity	The proposed PHY will efficiently carry variable length packets and will comply with the delay and speed requirements by upper protocol layers.
Reference system gain	The system gain for 16QAM, 3.5GHz band, and 3.5 MHz BW Gain=103.5 and The system gain for 16QAM, 10.5GHz band, and 3.5 MHz BW Gain=96.5.
Robustness to interference	The proposed PHY uses powerful coding scheme with interleaving and good interference rejection capabilities.
Robustness to channel impairments	The multi-path robustness of OFDM an important capability of the system and it reduces (almost removes) the impact of small and large scale fading.
Robustness to radio Impairments	The proposed PHY has the capability to support multiple data rates, modulations, and power control circuitry. When the radio channel attenuation becomes severe, then through the MAC control loop, the PHY system can re-adjust the transmission level to the appropriate level to keep the good quality of service intact.
Support of advanced antenna techniques	The proposal supports the need for advanced antenna techniques such as smart antenna into the standard. This feature, in conjunction with OFDM can be powerful feature for the system.
Compatibility with existing standards and regulations	This proposal is compliant with ETSI, FCC, and other existing standards and regulations as provided in Table 2.