Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	**Proposed Capabilities for IEEE802.16 PHY Layer**
Date Submitted	**1999-10-29**
Source	Kamran Etemad Wireless Facilities Inc. 1840 Michael Faraday Drive Reston, VA 20190 Voice: (703) 375-7732 Fax: (703) 904-7455 E-mail: kamran@wfinet.com
Re:	This contribution is submitted in response to call for contributions from the IEEE 802.16 chair on Sept. 22, 1999 for submission of PHY proposals for BWA.
Abstract	A flexible and yet very powerful set of capabilities are suggested to be optionally supported in PHY layer. The optional support of these features allows phased development of products with different capabilities and complexities all interoperable and complying with IEEE802.16.
Purpose	The proposed capabilities be added as mandatory or optional feature in PHY design.
Notice	
Release	
IEEE Patent Policy	

Proposed Capabilities for IEEE802.16 PHY Layer

Kamran Etemad
WFI

Introduction:

Being a telecom consulting firm, WFI provides non-biased recommendation to any standard body including IEEE802.16, purely based on technical merits of features and capabilities. Based on experience in the deployment and standardization of wireless communication systems we recommend a flexible approach BWA standard development to allow efficient radio resource management. Also considering these features as options one can develop different generations of STS and BTS equipment all interoperable based on the same standard but with different capabilities, complexities and costs.

It is always challenging to develop a flexible standard with a tight development time schedule. Also, despite the fact that all participating operator and vendor companies are advocating a single standard for BWA systems, not every company trades off performance vs. cost the same ways. Even for a company looking for the least expensive and fastest solution, the possibility of capacity expansion and feature enhancement becomes more important as the system becomes more mature and more congested. The solution for that is defining a basic configuration with a number of options for upgrades to be introduced at different phases. So , an IEEE802.16 based network can be deployed with minimal number of options in short time and at low cost. However, exponential growth in demand and system congestion motivates operators to look for higher efficiency solutions, and competition among vendors ensures the usage of enhanced optional resource control schemes.

Recommended Features:

We recommend the following capabilities to be defined at least as optional capabilities for PHY. While the BTS capability generation is indicated in a broadcast channel as part of base station parameters, the STS capabilities can be stored upon its registration with the system.

- ***Support for Both TDD and FDD***

Due to variability of spectrum allocations in different countries, we recommend that IEEE802.16 define both TDD and FDD modes of operation. Same frame sizes, multiplexing, coding and modulation can be used in both modes. By increasing the commonalty between the FDD and TDD equipment, development time can be reduced. However, since the network is based on fixed STS's there is not need to design dual mode STS/BTS's.

- ***Variable Rate Channel Coding with Hybrid ARQ***

Transport blocks for to/from different subscribers connected to the same CPE are multiplexed into physical layer frames and a Cyclic Redundancy Check (CRC) is attached to each frame. Frames are then passed to FEC section. A variable rate channel coding based on a single or two basic encoders with different level of puncturing is recommended. For example a 1/4 rate coder which can be punctured to provide 1/2, 3/4 or 5/6 rates.
To achieve good performance at very low target bit error rates a systematic block turbo encoding with iterative decoding is suggested.
Also a hybrid ARQ is recommended where, the information bit are initially coded with a high rate (e.g. 3/4) code and if the first frame is not decoded corrected in the next retransmission a net set of parity bit is sent. The receiver uses the combination of old and new parity bits to effectively form a stronger (lower rate) code for decoding. Using a base low rate encoder and puncturing the parity bits at the output can be nicely combined with the idea of hybrid and adaptive ARQ.
Note that using this scheme the system starts with a higher rate code to maximize the throughput and it lowers the coding rate only if channel suffers from fading. If fade condition is sustained a lower rate coding can be used after

- ***Multiple Order Modulation (MoM) Support.***

Both CPE and Hub need to support QPSK, 16QAM and 64QAM. This would let the system to trade off power vs. spectral efficiencies in different deployment scenarios. Thus 64QAM is used for nearby CPE's where as QPSK is used for far CPE's in large cells.

- ***Modulation Control (MC)***

The Hub should be able to use different modulations on different time slots of the same radio. For example a radio which has 16 time slots and use QPSK on the first 8 time slots and 16QAM on the second 8 slots. All traffic channels to/from a CPE multiplexed together and modulated the same way, unless the CPE is using more than one radio in which case the different modulations may be used on different radios.

- ***Adaptive Power Control***

Both open and closed loop power control are effective in improving the link reliability and reducing interference. Fast periodic power control should be based on Bit Error Rate (BER) at the physical layer and slow message based power control may be based on Frame Erasure Rate (FER) at the MAC layer.
In the reverse link all CPE's are power controlled by the hub periodically, e.g. on a time slot to time slot basis. We also recommend a slow open loop power control mechanism where the CPE autonomously increases/decreases power as it receives a weaker/stronger signal from the hub's broadcast control channel.
In the forward link a slot by slot power control is highly recommended as an option. This feature is specially useful when the same radio is used to serve a number of CPE's at different distances or channel conditions. So that on higher power in used on time slots allocated to far CPE's and lower power for those allocated to CPE's in hub vicinity.
Forward link power control not only improves link reliability and reduces interference, it also improves the forward link capacity and throughput by allowing flexible power resource management at the hub.

Evaluation Notes:

For reviewers convenience, the following table summarizes the evaluation criteria for PHY and indicated those that are not applicable to this contributions.

Meets System Requirement.

	Criterion	Compliance	Explanation
1	Meets System Requirement	Meets	
2	Spectrum Efficiency	Highly Meets	Multi-Order Modulation, Modulation Control and Adaptive Coding/ARQ have a great impact on spectrum efficiency.
3	Simplicity of Implementation	Highly Meets	Since the features are optional it would also allow development of simple low cost STS and BTS.
4	CPE Cost Optimization	Highly Meets	Options provide ease of trade off between cost/complexity and performance.
5	Spectrum Resource Flexibility	Highly Meets	This is one of the main point of focus in this contribution.
6	System Diversity Flexibility	Meets	The proposed features allow phased deployment of capabilities.
7	Protocol Interface Complexity	N/A	Please rate this contribution against this criterion.
8	Implications on other network interfaces	N/A	Please rate this contribution against this criterion.
9	Reference System Gain	N/A	Please rate this contribution against this criterion.
10	Robustness to Interference	Highly Meets	Because of Power Control and Variable Rate Coding
11	Robustness to Channel Impairment	Highly Meets	Because of Power Control and Variable Rate Coding