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| Project | **IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>** |
| Title | **Proposal to Add Point-to-Point Option to IEEE 802.16™ MAC** |
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| Re: | "Proposed New Concepts"forum at Session #26 |
| Abstract | This is a basic proposal to add a point-to-point option to the IEEE 802.16 MAC. This would expand and enhance the application of IEEE 802.16 technology. Though the existing point-to-multipoint IEEE 802.16 MAC can operate in point-to-point mode, a customized point-to-point option would operate more efficiently in that special case. |
| Purpose | To stimulate Working Group thinking on this topic, and to prepare the groundwork for developing a point-to-point option at the next opportunity, such as during the next Revision of IEEE Standard 802.16. |
| Notice |  |
| Release |  |
| Patent Policy and Procedures |  |

# Proposal to Add Point-to-Point Option to IEEE 802.16 MAC

*Ken Stanwood and Roger Marks*


## Abstract

This is a basic proposal to add a point-to-point option to the IEEE 802.16 MAC. This would expand and enhance the application of IEEE 802.16 technology. Though the existing point-to-multipoint IEEE 802.16 MAC can operate in point-to-point mode, a customized point-to-point option would operate more efficiently in that special case.


## Introduction

The basic IEEE 802.16 MAC functions in point-to-multipoint (PmP) configuration, with a base station (BS) communicating with multiple subscriber stations (SSs). Some applications, however, could be supported more effectively with a point-to-point (PtP) link. In particular, a PtP link could support the backhaul requirements of a PmP BS. Clearly, the IEEE 802.16 MAC reduces to PtP when only a single SS is present. However, the MAC is designed for the more complex case. A custom PtP option could operate more efficiently.

## Overview of Point-to-Point Opportunities for IEEE 802.16

Many microwave and millimeter-wave communication deployments are in PtP configuration. These typically use narrow radio beams and therefore transmit high data rates with good frequency reuse opportunities. Obviously, PtP communications are beneficial in many situations. One particular evolving need is to backhaul IEEE 802.16 base stations. A wireless backhaul allows flexibility in BS placement. If the backhaul protocol is compatible with the 802.16 PmP protocol, additional efficiencies may result.

In spite of the popularity of PtP radios, the PtP industry makes little use of air interface standards. This is often attributed to the fact that PtP radios are sold in matching pairs, so interoperability issues do not arise. However, some of the evolving applications indicate the need to differentiate the two radios in a PtP link. For example, in the 802.16 backhaul application, the radio at the BS might take advantage of BS facilities and therefore look different from the SS radio. Traditionally, PtP radios use continuous-mode FDD, with a fixed bandwidth allocation in each direction. This prohibits the use of many 802.16 features based on 802.16's burst design. For applications in which the data flow requirements are not continuous but bursty, the 802.16 MAC can provide much better service. For instance, the 802.16 MAC provides continuously variable bandwidth asymmetry, adaptive link control, payload efficiency features, and support for multiple connections with varying QoS requirements. Therefore, it is likely that PtP radios based on IEEE 802.16 would offer better performance than existing PtP radio systems in many common scenarios. Even for radios sold in pairs, standardization would bring the benefit of efficiencies of scale, particularly in the components. Furthermore, standardization would bring interoperability, which would provide new flexibility in the purchase of replacement units and in single-unit requirements such as backhaul applications.

## Comparison of Conventional PtP Technology to IEEE 802.16 PmP MAC

Current PtP links typically use FDD, with static asymmetry. Varying physical layer choices are available, but PHY options are set at installation to provide sufficient margin to handle worst-case environmental conditions while providing fixed bandwidth. However, PtP links must be sized, in both directions, to accommodate peak demand, thereby limiting the chance to improve efficiency through statistical multiplexing. These systems provide low delay and low management overhead that works well for symmetric TDM voice services, but they are not optimal for asymmetric IP or Ethernet traffic. Because of their fixed nature, these PtP links cannot offer true differentiated QoS; QoS is provided merely by ensuring that peak demand is less than the available bandwidth. Conventional PtP links must also be designed at the physical layer for the worst-case environmental conditions of the location of installation (though adaptive power control may be provided). This means that the link must be robust enough to meet the availability requirements (typically 99.999% for carrier class equipment) during inclement weather even though 99.99 % of the time it could operate with more efficient PHY parameters.

In contrast, IEEE 802.16 specifies a PmP system with more capabilities. Duplexing is either FDD or TDD. TDD allows statistical multiplexing of the uplink and downlink. In TDD, and in FDD (because 802.16 uses a burst FDD), the dynamic PHY parameter adaptivity allows real-time tradeoff of robustness versus capacity. The delay and overhead are larger than with PtP systems, but service is provided to multiple user terminals and multiple connections simultaneously. Quality of Service (QoS) and flexible bandwidth allocation allow the efficient simultaneous transport of a multitude of service types.

Broadband access requirements are heading towards bandwidth-on-demand services that burst and subside and may be highly asymmetric. These services have a range of QoS needs, such as CBR, rt-VBR, nrt-VBR, and UBR. The 802.16 MAC can accommodate these services well. However, for backhaul of PmP, or where the demand at an individual location is large, PtP if often called for. Even when only one terminal is supported, that terminal may need to support multiple connections with varying QoS needs. The design of the 802.16 MAC addresses this problem.

A trivial 802.16 PmP link with a single user may serve as a PtP link, but the design for PmP inherently causes a trivial PmP link to have more delay, less range, and lower efficiency than an equivalent PtP link with the same PHY. Two interesting questions arise: (1) If used in PtP mode, are there cases in which the benefits of the 802.16 MAC outweigh the overhead penalties imposed? (2) Can the 802.16 MAC be made more efficient in the PtP case?

## Potential Efficiencies in an IEEE 802.16 Point-to-Point Option

Although IEEE 802.16 can be applied effectively in the PtP case, the result would be less than optimally efficient. A few simple changes would allow a more efficient PtP option that would be compatible with the existing PmP MAC.

In the PtP configuration, the BS could also be viewed as the "master" of the PtP pair, with the SS serving as the "slave." The master would allocate uplink bandwidth to the slave in accordance with the bandwidth requests made by the slave connections. Note that, in accordance with 802.16's "grants per SS" operation, grants are awarded to the slave SS rather than to the connection. The slave SS will then play a significant role in QoS management by scheduling uplink transmissions in accordance with the need of the uplink connections.

The changes to the 802.16 MAC required for efficient PtP operation are:

1. Add a bit in the DL MAP, possibly in the PHY synchronization field, indicating whether the particular channel is operating in PmP or PtP mode.
2. When in PtP mode, the BS simply allocates the entire uplink subframe to the lone SS.
3. When in PtP mode, the SS refrains from issuing bandwidth requests.
4. For asymmetric TDD operation, allow the BS to determine the TDD split without knowledge of the instantaneous uplink demand. For example, the BS may choose the split based on past utilization. This is a scheduling issue that is outside the scope of the standard.

## Emphasizing Commonality with Existing PmP Technology

Without sacrificing efficient PtP operational efficiency, an enhanced IEEE 802.16 standard could accommodate a PtP topology that emphasizes commonality with the existing PmP MAC. QoS and queuing should work as it does in the PmP System over the airlink since the total user data capacity may exceed the airlink capacity. The standard should de designed such that a manufacturer could:

1. build a slave end of the PtP link that differs from a PmP SS only in software and firmware;
2. build a master end of the PtP link that differs from a PmP BS channel only in software, firmware, and antenna.

Note also that, in the TDD case, the PtP link can be implemented in the same frequency band as an associated PmP deployment while maintaining synchronization with the PmP system.