Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	**Physical Layer Proposal based on a Time Division Duplex / Time Division Multiple Access (TDD / TDMA) Frame Structure**
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Re:	This contribution is in response to the 802.16 Physical Layer Task Group CALL FOR CONTRIBUTIONS - Session #4 published 1999-09-22 (Document # 80216p-99_01).
Abstract	This contribution describes a Time Division Duplex (TDD) based PHY layer.
Purpose	The proposal will allow the 802.16 working group to consider all or part of the contribution for inclusion in the 802.16.1 standard.
Notice	
Release	
IEEE Patent Policy	

Physical Layer Proposal based on a Time Division Duplex / Time Division Multiple Access (TDD / TDMA) Frame Structure

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Overview

Include an overview and a reference model that describes functions, including interfaces to other layers.

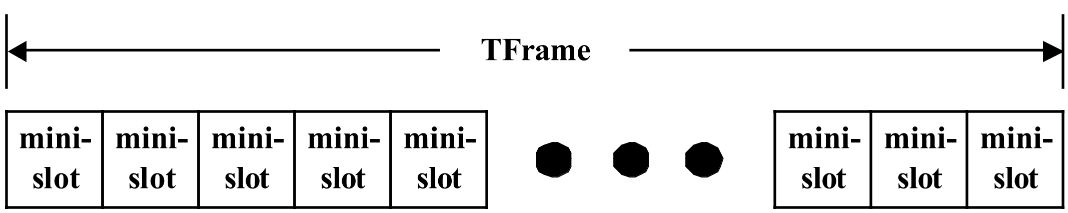
This contribution provides a high level overview of a physical layer protocol based on a Time Division Duplex / Time Division Multiple Access (TDD / TDMA) frame structure. The focus of this contribution is primarily on a frame structure that exploits the benefits of TDD. Specifically TDD can adapt to traffic asymmetry that varies with time (on virtually any scale). The proposed frame structure is capable of supporting voice, data, and video services in a Point-to-Multipoint communication system between a fixed hub and multiple subscriber terminals.

The proposed modulation format is multi-index QAM, although the basic frame structure is capable of supporting other modulation formats. With the proposed modulation format, the PHY is capable of transporting payload data in QPSK, 16QAM, and 64QAM modes.

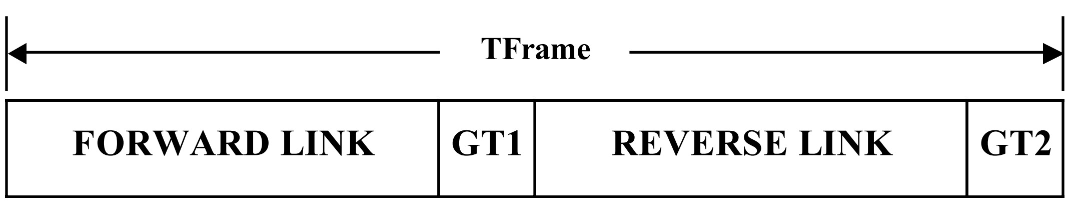
The basic frame structure easily scales to support a range of baud rates and hence RF channel plans. Definition of a finite number of baud rates (approximately in the range of 5 - 60 MBaud) is expected to adequately meet the diversity of global spectrum allocations.

Basic Frame Structure

The basic frame is shown in the figure below and is comprised of an integer number of minislots. The proposed frame duration, Tframe, is 2000 usec enabling the PHY to support the latency requirements of the 802.16.1 system while minimizing overhead associated with TDD guard times.



The frame is divided into four distinct entities as shown in the following figure. Duration of the forward-link (downstream) and reverse-link (upstream) are dynamically variable under MAC control. The guard-times (GT1 and GT2) are fixed in duration for a given baud rate. Each of the four distinct entities shown are comprised of an integer number of minislots.



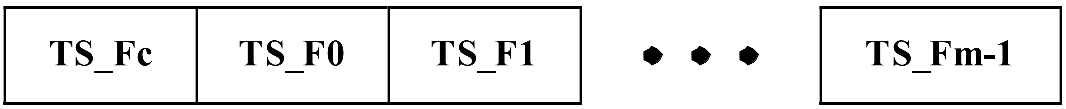
Structure of Forward Link

The basic structure of the forward link is shown in the figure below.

Employment of a modified "broadcast structure" minimizes overhead.

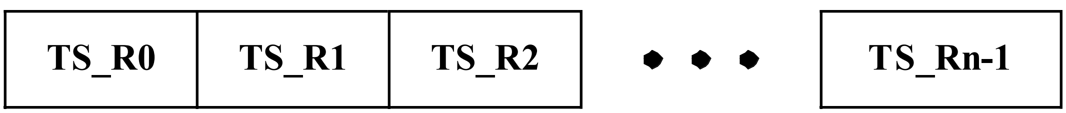
Timeslot TS_Fc, the forward-link control timeslot, is always located at the beginning of the forward-link. It transports synchronization and Airlink Control Channel data only and hence is a non-payload timeslot. Within the framework of the proposed modulation format, TS_Fc operates in QPSK mode only. The MAC layer utilizes this channel to convey changes in the frame structure.

TS_F0 through TS_Fm-1 are defined as payload-timeslots. With the proposed modulation format, three payload timeslots would be employed each supporting operation at a different modulation index. Each payload timeslot transports payload data only and can support multiple subscriber terminals.



Structure of Reverse Link

The basic structure of the reverse link is shown in the figure below. The reverse link is comprised of n time slots with n corresponding to the number of active subscriber terminals on the carrier.



Timeslot Structures - Field Descriptions

The following sections of this document provide an overview of the forward-link and reverse-link timeslot structures employed in the PHY proposal.

R – Ramp

The ramp allows the carrier to smoothly ramp at turn-on and turn-off.

PRE – Preamble

The preamble enhances carrier and baud acquisition. Operation is in QPSK for all payload modes and duration is fixed for a given timeslot type.

UW - Unique Word

The Unique Word provides a mechanism for frame synchronization. Operation is in QPSK for all payload modes and duration is fixed for a given timeslot type.

TFN - Timeslot & Frame Number

The TFN provides a mechanism for timeslot and superframe synchronization. Operation is in QPSK for all payload modes and duration is fixed for a given timeslot type.

ACCH – Airlink Control Channel

The ACCH provides a bi-directional control channel between the hub and subscriber. Operation is in QPSK for all payload modes and duration is fixed for a given timeslot type. The ACCH is used to support NMS and MAC layer messaging.

PAYLOAD

This field contains payload data. Operation is in QPSK, 16QAM, or 64QAM. The duration of this field is dynamically variable under control of the MAC.

GT – Guard Time

These fields provide a buffer between adjacent sections and/or timeslots in the frame. Duration is fixed for a given timeslot type.

Structure of Forward-Link Timeslot

The structure of the forward-link timeslot is shown below. The total duration of the timeslot consists of an integer number of minislots.

R	PRE	UW	TFN	ACCH or PAYLOAD	R

Structure of Reverse-Link Timeslot

The structure of the reverse-link timeslot is shown below. The total duration of the timeslot consists of an integer number of minislots. A lengthened guard-time is utilized during initial acquisition of a subscriber terminal. During acquisition, the remote terminal's transmit timing will be advanced by an amount equal to the round trip propagation time of the link. This permits the use of a short guard time during normal operation.

R	**PRE**	**UW**	**ACCH**	**PAYLOAD**	**R**	**GTr**

Structure of Protocol Data Unit

The payload fields in both the forward and reverse timeslots will consist of an integer number of Protocol Data Units (PDU) as shown in the figure below. The PDU will utilize an outer Reed-Solomon block code and optionally an inner convolutional or TCM code. The PDU will be sized to efficiently transport legacy TDM, ATM , and IP traffic.

HEADER	**DATA**	**FEC**

Generic Description of Operation

The frame structure described facilitates rate-adaptive duplex connections utilizing pairs of timeslots (dynamic in duration and location) operating on a common RF carrier. Specifically the following parameters are dynamically adjustable utilizing a suitable MAC.

Instantaneous data rate in the forward-link (downstream) for each subscriber terminal.
Instantaneous data rate in the reverse-link (upstream) for each subscriber terminal.
Modulation index for each subscriber independently on the forward-link and reverse-link.

Additionally, the structure permits constant bit rate services to be set-up on a permanent or semi-permanent basis (by allocating a fixed number of PDU's / frame or superframe to a given timeslot). This minimizes MAC layer messaging.

Benefits

Describe the benefits of the proposed PHY, including any unique features.

The TDD frame structure can adapt to varying traffic asymmetry on any time scale. This maximizes the efficient use of the available spectrum.

The ability to support variable modulation index enables an efficient trade-off between spectral efficiency, link distance, and interference management.

TDD systems eliminate the need for duplex filtering, thus lowering the cost of CPE equipment.

TDD systems can be deployed in virtually any paired or unpaired spectrum allocation.

The structure can support the services outlined in the 802.16.1 System Requirements Document.

Drawbacks

Describe any drawbacks of the proposed PHY.

Frequency planning for TDD systems must inherently consider additional interference coupling mechanisms as compared to FDD systems. Contributions by Jack Garrison to the coexistence task group have demonstrated these are manageable.

Guard Times required in TDD frame structure cause a loss of efficiency. This loss is expected to be minimal given a reasonable frame size and anticipated cell sizes for BWA systems.

Relationship to Existing Standards

Explain how the submitted PHY relates to existing standards, such as ITU-R JRG 8A-9B, DAVIC, DVB, AF-WATM or others. If it is based on an existing standard, what differences occur due to BWA characteristics?

The proposed PHY bears no direct relationship to any existing standards. It has been developed to address the specific characteristics of BWA systems.

Scalability

Emphasize the scalability of the proposed PHY to deal efficiently with various data types (as IP, ATM, MPEG).

The proposed PHY enables efficient implementation of legacy TDM (T1/E1), ATM, and IP protocols.

Intellectual Property

Include a statement on intellectual property rights and how 802.16 may utilize the proposed PHY in a standard.

Intellectual Property owned by Wavtrace, Inc. may be required to implement the proposed protocol. The author is not aware of any conditions under which Wavtrace, Inc. would be unwilling to license Intellectual Property as outlined by the IEEE-SA Standards Board Bylaws. However, the author lacks the necessary authority to provide the specific assurance required by the IEEE-SA Standards Board Bylaws on behalf of Wavtrace, Inc.