Using the TG1 MAC for TG3 purposes

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Base Document:

Using the TG1 MAC for TG3 purposes

An input for 802.16 for a decision on the road map of TG3 MAC development

Using the TG1 MAC for TG3 purposes

Report of the TG3 MAC Ad Hoc Group

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The Goal

- Move to One MAC-Several PHYs Air Interface Document
- Features Specific for TG3 Applications to be Added
  - Features Related to the Expected Differences in PHY and Channel Quality
  - Features Related to Specific Traffic Demand Statistics

Sources and References

- Vladimir Yanover “Some Issues of Accommodation of TG1 MAC at TG3” **802161c-00_10, 802161p-00_10,** “MAC to PLCP sublayers interface for 802.16” **802161c-00_09**
- Subir Varma “Comments on the use of the TG1 MAC for TG3 Purposes” **802161c-00_11, 802161p-00_11**
- Huanchun Ye "TG1-Comments-for-TG3-Purpose” **802161c-00_13**

The Problems

- Problems with Employment of a new PHY:
  - Explicit usage of PHY parameters in the numerous locations in text of MAC (like explicit mentioning of the Burst PHY parameters)
  - Usage of PHY dependent parameters in numerous locations in the MAC text (like time units)
  - Absence of the generic MAC-PHY interface definition (SAP + interface primitives)

The Problems

- TG3 Systems will function in a more hostile channel environment as compared to TG1:
  - Co- channel interference
  - Multipath
- Implication: The protocol should be robust enough to recover from transient error conditions, as well as flexible enough to control a variety of link parameters in response to longer term channel variations

The Problems

- TG3 Systems will see a different mix of traffic types as compared to TG1
  - TCP traffic will dominate, as opposed to TDM
  - Support large number of relatively low bit rate bursty sources
- Implication: The protocol should be able to efficiently handle a wide mix of packet sizes. It should have the ability to efficiently allocate BW to short bursts of data, in addition to longer term flows

MAC-PHY Separation

Parameters and Constants

Remove PHY Parameters from 2.3 "*Encodings for Configuration and MAC–Layer Messaging*" used in the configuration file, in SS registration requests and in Dynamic Service Messages e.g.

- **2.3.1.4 "*Downstream Modulation Configuration Setting*"**
- **2.3.3.1.4 "*SS Modulator Types*"**

Instead, we need a definition of generic information element that carry PHY specific information (Rate, coding, modulation, …) These elements will be then defined differently at the PHY Convergence

MAC-PHY Separation

PHY Frame Structures

- Redefine the PHY frame structures, see e.g. 2.6.1.3 "*Time Division Duplexing (TDD)*" in clearly MAC terms. This includes a replacement for the specification of involved PHY parameters.
- Example: bursts with different types of ***QAM modulation*** at Figure 51 should be changed to bursts with different ***PHY parameters***.

MAC-PHY Separation
PHY Frame Structures

- Remove the definition of the Physical Layer Burst Profile Parameters (e.g. Table 9, Table 12, in 2.5.2.2) to the PHY sections of the standard

MAC-PHY Separation
PHY Frame Structures

- Definition of the Uplink Physical Channel Attributes (Table 7 in 2.5.2.1) should be removed to the PHY sections of the standard
- The same should be done for Downlink Physical Channel Attributes
- Redefine correspondently the PHY Control portion of the downlink subframe at 2.6.4.1

MAC-PHY Separation
MAC Frame Structures

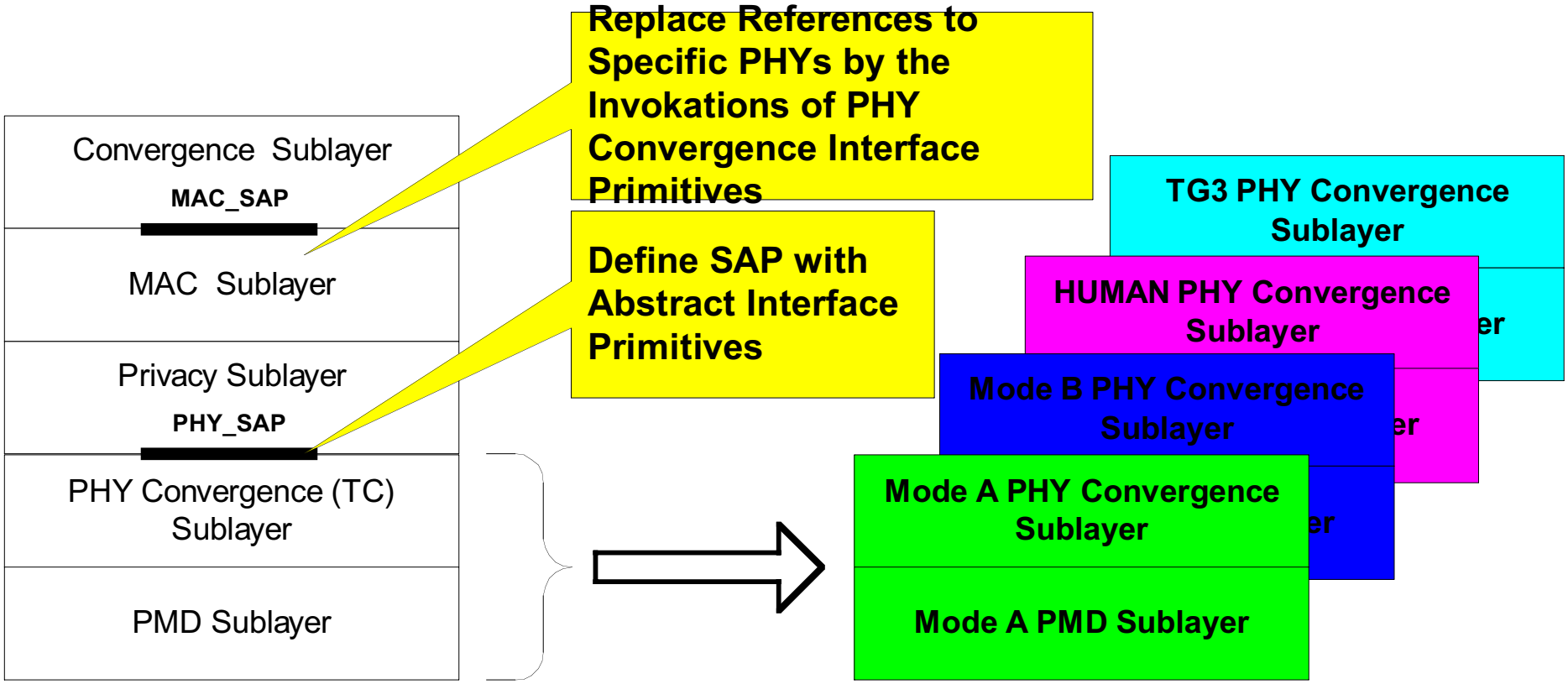
- Reconsider the definition of the time unit (PS = Physical Slot) in the MAC Control portion of the downlink subframe (2.6.4.1). The time unit has to provide sufficient granularity in bandwidth allocation for all PHYs

Proposed Solution
Sources: 802.11, 802.16.1

- MAC-PHY Separation and Definition of a Generic MAC-PHY Interface:
  - PHY Convergence Sublayer and the corresponding SAP should be defined
  - References to the specific PHYs should be replaced with the references to generic PHY interface

Proposed Solution

Define PHY Convergence Sublayer



Proposed Solution

PHY_SAP Primitives

- **Functions** of the PLCP sublayer and **PHY_SAP Primitives** should be defined for communication MAC ⇔ PHY, MAC ⇔ peer MAC etc.
- Example:
  - **PHY-TXSTART.request (TXTIME)** requires from PHY starting transmission at the given time, assuming the PHY parameters (like rate) have already been configured

TG3 Specific Features to be Added

- Features Related to the Expected PHY Specifics
- Features Related to Lower Channel Quality
- Features Related to Efficient Support of Bursty Data Traffic
  - Encapsulation
  - Request/Grant Mechanism
  - Fast Discovering of Bursty Uplink Demand

TG3 Specific Features to be Added

Features Related to the Expected Differences in PHY

- MAC Control portion of the DL subframe in 2.6.4.1.

2.6.7.2. "***One mini–slot contains N PHY slots (PS), where N = 2^m (where m = 0..7). Since each PS***

contains 4 modulation symbols, ..."

4 symbols = up to 108 bytes in 802.11a OFDM

- Time unit(s) should be redefined to serve certain frame size quantization vs. bit rate options. The resolution should be sufficient to avoid serious padding overhead for Ethernet frames

TG3 Specific Features to be Added

Features Related to the Expected Differences in PHY

- 2.5.2.1: “An Uplink Channel Descriptor shall be transmitted by the BS at a periodic interval to define the characteristics of an upstream physical channel. A separate UCD Message shall be transmitted for each active uplink”.
- Because of the potentially more fast (comparatively to the frame length) changes in the propagation conditions (multipath at considerably low Radio frequencies) we need an additional mechanism to support more dynamic, ideally per packet, changes in the bit rate

TG3 Specific Features to be Added

Power and Rate Management

- Dynamic Rate Control (per packet), clearly associated in implementations with ARQ (packet failure requires retransmission at lower rate etc.)
- Transmit Power Control, designed to deal with long no-transmit periods and fast recovery. Possible solution could be, for example, a “RNG-RSP”-like packet sent by a BS as a response to an uplink packet at BS’s discretion.

TG3 Specific Features to be Added

Frame Length

- Frame Length options in PHY Synchronization topic, [1], 2.5.3 are defined as 0.5, 1, 2 milliseconds.
- The TG3 applications require
  - Larger frame
  - More flexible frame size that may change e.g. in busy hours or even from frame to frame, dependently on bit rates and changes in demand granularity

TG3 Specific Features to be Added

Statistics of the Demand

- For the residential and SOHO the **Internet access** is the most important if not a dominant application
- The total demand per Base Station (sector) is an **integration of numerous streams** (tens or even hundreds) passing to/from CPEs

TG3 Specific Features to be Added

Statistics of the Demand

- The total uplink demand is a composition of a **large number of small elementary demands, with low duty cycle**, that appear **randomly** and independently at numerous CPEs
- Therefore strong efforts should be done to **discover and handle fast changes** of the origin and amount of the **demand**

TG3 Specific Features to be Added

Bursty Traffic: Possible Tools

- (If OFDM PHY Selected) Employ "Fast Polling" mechanism: CPE is choosing to transmit a fixed subcarrier so that BS has to encounter only the fact of transmission reducing the following polling to a small subset of the all SSs.
- Contention-based data frame transfers with exponential Backoff (as in 802.11 DCF).
- Slotted Aloha transmission of the data fragments

TG3 Specific Features to be Added

Efficient Concatenation of Small Packets

- Issues with current TG1 design:
  - Does not support concatenation efficiently (essential to the efficient operation of the TCP protocol)
  - Does not have a large enough Piggyback request field to be able to efficiently handle short bursts of data
- Suggestion:
  - A simple encapsulation scheme, that supports both concatenation and fragmentation
  - Increase the Piggyback request field size to 2 bytes

TG3 Specific Features to be Added

MAC Level ARQ

- Additional functions to avoid higher layer retransmissions which impact negatively the TCP applications (sensitive to the delay variations and packet loss)
- **MAC Level ARQ** including
  - Checksum definition for a fragment
  - ARQ Feedback concept (ACK, NACK, ACK timeout, interaction with Convergence Layer entities, …) and the coding of the correspondent messages

TG3 Specific Features to be Added

Fast Communication Channel

- Fast communication channel to report to BS on the channel state and to send BS commands

TG3 Specific Features to be Added

- MAC support for advanced antenna technologies (adaptive multibeam base station)