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Source(s)	Stanley Wang Ensemble Communications, Inc. 9890 Towne Centre Drive San Diego, CA 92121 Voice: (858) 526-7265 Fax: (858) 638-7142 mailto: stanley@EnsembleCom.com
Re:	Letter Ballot #3
Abstract	This contribution describes a mechanism that subscriber stations can use to achieve network synchronization. A new MAC management message is proposed to carry the necessary information to achieve this task.
Purpose	To comment on the Letter Ballot #3 on the network synchronization issue, which is currently not addressed by the draft standard.
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Subscriber Station Network Synchronization

Stanley Wang
Ensemble Communications, Inc.

1. Overview

For the transport of existing hierarchical signals (e.g., DS1 and DS3), timing jitter performance is very important. Jitter control of DS1 signal is necessary to ensure proper timing recovery at a DS1 terminal. The control of wander (defined as jitter below 10 Hz) is necessary to reduce the slip-rate when the signal is terminated at a DS0 switch. ITU-T recommendation G.824 on the control of jitter and wander specifies that the end-to-end jitter of a DS1 signal should not be larger than 5 *Unit Intervals* (U.I.) at 10 Hz. Transport of DS1 over a SONET virtual tributary has a tighter requirement of about 1.5 U.I. at 10 Hz. More stringent requirements are stated for higher frequency jitter and G.824 also specifies an 18 msec requirement for wander at very low frequency (i.e., for frequency << 1 Hz). Thus, it is necessary for *Subscriber Stations* (SS) to be synchronized with their *Base Stations* (BS), if the transporting information requires the reconstruction of network clock signals.

This document describes a mechanism that SSs can use to achieve network synchronization. To achieve that, we propose a new MAC management message, which shall be used to carry the necessary information.

2. References

[IEEE00] IEEE 802.16, "Draft Standard for Air Interface for Fixed Broadband Wireless Access Systems," IEEE 802.16.1/D1-2000, December 2000.

Note that only the specific versions of the above referenced documents and the specific versions of the documents referenced within these documents are applicable to this specification.

3. Definitions

Base Station (BS): A generalized equipment set providing connectivity, management, and control of Subscriber Stations.

Subscriber Station (SS): A generalized equipment set providing connectivity between subscriber equipment and a Base Station.

4. Abbreviations and Acronyms

BS Base Station.

CCV Clock Comparison Value.

SS Subscriber Station.

5. The Proposed Mechanism

Synchronization between a BS and its SSs can be communicated from the BS to the SSs via *Clock Comparison Values* (CCV), which encode the difference between the radio symbol clock and the

network clock. In this scheme, the SSs use the CCV to adjust its synthesized local line clocks so that they track the network clock long-term. We propose to create a special MAC management message to carry CCV periodically. The proposed format for the new MAC message is shown as Figure 1 below.

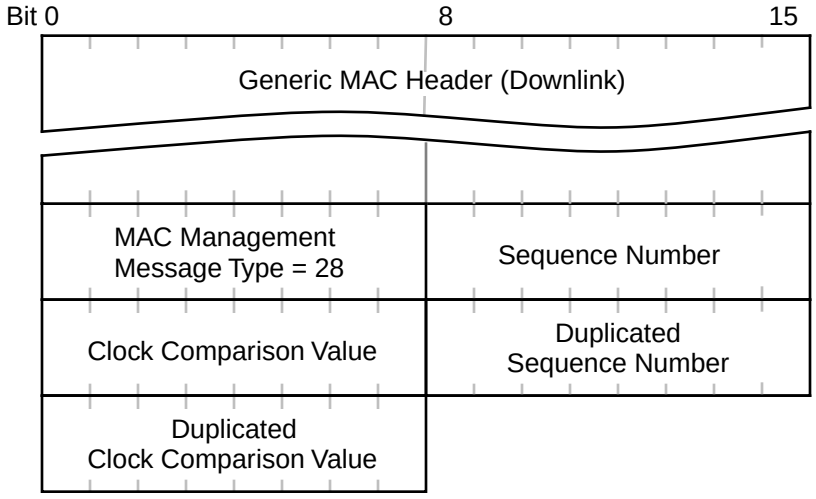

Figure 1—Clock Comparison (CLK-CMP) Message Format

In network systems with service flows carrying information that requires the SSs to reconstruct their network clock signals (e.g., DS1 and DS3), CLK-CMP messages shall be periodically broadcasted by the BS. If provisioned to do so, the BS shall generate one CLK-CMP message at every 50 msec according to the format shown in Figure 1. All CLK-CMP messages shall include the following parameters:

1) 8-bit Sequence Number

   This value shall be incremented by one (modulo the field size, 256) by the BS whenever a new CLK-CMP message is generated. This parameter is used to detect packet losses.

2) 8-bit Clock Comparison Value

   This value shall be the difference (modulo the field size, 256) between the following two reference clock signals: (1) a 10 MHz reference clock locked to the symbol clock of the air link (such as a GPS reference used to generate the symbol clock), and (2) an 8.192 MHz reference clock locked to the network clock.

3) Duplicated Sequence Number

   This value is a duplication of the value in (1) for error detection of undetected and uncorrected bit errors. All CLK-CMP messages received with errors shall be discarded and handled as if the messages were lost.

4) Duplicated Clock Comparison Value

   This value is a duplication of the value in (2) for error detection of undetected and uncorrected bit errors. All CLK-CMP messages received with errors shall be discarded and handled as if the messages were lost.

6. Justification for the Proposed Mechanism

The CCV can be carried via regular DCD messages (*see* Section 6.2.2.2.2 of [IEEE00]) or via a special MAC management message on a broadcasted channel. Currently, DCD messages are broadcasted by a BS every 10 seconds (*see* Table 67 of [IEEE00]). Using DCD messages to carry CCV would required that DCD messages be broadcasted much more frequently (in the interval of tens of mini-seconds instead), which significantly increases the bandwidth consumption.

With the proposed special MAC message, only 11 bytes of information is required for each message, 6 bytes for the MAC header, 1 byte for the message type, 1 byte for the sequence number, 1 byte for the CCV, and 2 bytes for the duplicated payload. The total bandwidth requirement for broadcasting the proposed CLK-CMP messages is only about 5.28 Kbps (assuming 50 msec periodic interval and a strong 1/3 code rate). The 8-bit CCV for the clock difference was chosen such that with a sampling time period of 50 msec, one would be able to deal with relative large initial frequency offsets such as ± 50 ppm.

The proposed 10 MHz reference clock is a commonly used reference frequency, e.g., most GPS units provide this frequency. The 8.192 MHz reference clock proposed above is a commonly available frequency.

Since CRC is optional on a per-connection basis, having a CRC error detection for the CLK-CMP messages would require all broadcast messages (including UCD, DCU, UL-MAP and DL-MAP messages) to have CRC. In stead, duplicated message payload is proposed to further protect the integrity of the payload without adding unnecessary burden to the system.