AV bridging: 
Time-synchronization interfaces

David V James & Chuck Harrison
Time-sync entity overview
Time-sync clock interfaces

- ClockSource
  - TIME_SOURCE.request
  - lower levels
- ClockMaster
- GrandSync
- ClockSlave
- ClockSink
  - TIME_SINK.request
- TIME_SINK.indication
- ~localTime~
- MAC relay
- ISS 802.n MAC
- PHY
- LAN
- ISS 802.n MAC
- PHY
- LAN

IEEE AVB
Face-to-face
Clock-sink interfaces
ClockSink interface options

- Option 1: strobe w/o count protection
- Option 2: strobe with count protection
- Option 3: periodic transmissions
Option 1: Strobe w/o protection
Option 2: Strobe with protection

TIME_SINK.request

TIME_SINK.indication

? 

7654680.238402 sec

TIME_SINK.request

globalTime

eventCount

185

TIME_SINK.indication

(185)

7654680.238402 sec

186
Option 3: Periodic clocking

Option 3: Periodic clocking

ClockSink

TIME_SINK.indication

ClockSlave

TIME_SINK.indication

7654680.228399 s

185

eventCount

globalTime

7654680.238402 s

186

Service primitive parameters

TIME_SYNC.request ( )  no parameters in this primitive
TIME_SYNC.indication ( 
  event_count,  index of AS_CLKEVENT.request for this timestamp
  global_time,  802.1AS timestamp value
  stabilization_time  time since most recent 802.1AS timescale discontinuity
  stabilization_count  incremented on each 802.1AS timescale discontinuity
)

• Abstract Interface
  – Manufacturers free to implement the functionality by any method
  – Need not be an “exposed” interface
• Mandatory for any 802.1AS device claiming to provide clock service
Abstract and mandatory (!?)

2. Media Access Control (MAC) service specification

2.1 Scope and field of application

This clause specifies the services provided by the Media Access Control (MAC) sublayer and the optional MAC Control sublayer to the client of the MAC (see Figure 1–1). MAC clients may include the Logical Link Control (LLC) sublayer, Bridge Relay Entity, or other users of ISO/IEC LAN International Standard MAC services (see Figure 2–1). The services are described in an abstract way and do not imply any particular implementation or any exposed interface. There is not necessarily a one-to-one correspondence between the primitives and the formal procedures and interfaces described in Clause 4 and Clause 31.

![Diagram showing MAC client and service primitives]

2.2.4 Basic services and options

The \texttt{MA\_DATA.request} and \texttt{MA\_DATA.indication} service primitives described in this subclause are mandatory. The \texttt{MA\_CONTROL.request} and \texttt{MA\_CONTROL.indication} service primitives are mandatory if the optional MAC Control sublayer is implemented.
Hypothetical compliant implementations of clock slave
# PICS entries

## A.5 Major Capabilities

<table>
<thead>
<tr>
<th>Item</th>
<th>Feature</th>
<th>Status</th>
<th>References</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCLK</td>
<td>Is a slave clock service supported?</td>
<td>O</td>
<td>A.6</td>
<td>Yes[ ] No[ ]</td>
</tr>
<tr>
<td>MCLK</td>
<td>Is a master clock service supported?</td>
<td>O</td>
<td></td>
<td>Yes[ ] No[ ]</td>
</tr>
</tbody>
</table>

## A.6 Slave Clock Service

<table>
<thead>
<tr>
<th>Item</th>
<th>Feature</th>
<th>Status</th>
<th>References</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCLK-1</td>
<td>Are AS_CLK_EVENT.request and AS_CLK_TIMESTAMP.indication primitives implemented?</td>
<td>SCLK:M</td>
<td></td>
<td>Yes[ ]</td>
</tr>
<tr>
<td>SCLK-2</td>
<td></td>
<td>SCLK:M</td>
<td></td>
<td>Yes[ ]</td>
</tr>
</tbody>
</table>
## A.7 Implementation Parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Feature</th>
<th>Status</th>
<th>References</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMP-1</td>
<td>State the maximum value for event_count</td>
<td>SCLK:M</td>
<td></td>
<td>________</td>
</tr>
</tbody>
</table>

## A.8 Performance

<table>
<thead>
<tr>
<th>Item</th>
<th>Feature</th>
<th>Status</th>
<th>References</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERF-1</td>
<td>State the maximum delay from presentation of AS_CLK_EVENT.request to availability of corresponding AS_CLK_TIMESTAMP.indication</td>
<td>SCLK:M</td>
<td></td>
<td>_____ microsec</td>
</tr>
</tbody>
</table>
**MAC sidecar**

- **PHY** → **MAC** → **STA**

**PTP engine & precision clock**
- Proprietary interface
- Event input
- I²C
- Timestamp readout and configuration
- Frequency or triggered event out (not described by 802.1AS)
Enhanced MAC

MMD registers assigned for `event_count`, `global_time`, and `stabilization_time`
Integrated MAC/clock in micro-controller

PERIPHERAL MEMORY MAP:

Reading `global_time` (hi) memory address causes snapshot of all parameter values to be latched into readout register bank.

Writing to a particular reserved address constitutes a CPU-generated event.

<table>
<thead>
<tr>
<th>Offset</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><code>global_time</code> (low)</td>
</tr>
<tr>
<td>4</td>
<td><code>event_count</code></td>
</tr>
<tr>
<td>8</td>
<td><code>stabilization_time</code></td>
</tr>
</tbody>
</table>

Writing to a particular reserved address constitutes a CPU-generated event.
Other slides

(TBDs)
802.1as basic requirements

- Media friendly
  - Link-dependent time-sync intervals
  - Clock-master or clock-slave initiated
- Accurate
  - Errors limited by snapshot accuracies
  - Eliminate: gain peaking
  - Incorporate: per-stage low-pass filtering
- Responsive
  - RX: linkDelay—neighbor local-clock syntonization
  - TX: Minimal grandTime syntonization
- Simple
  - Minimal residence-time constraints
Cascaded TOD synchronization

(a nonscalable approach)
Reclocked TOD synchronization

(a scalable approach)

10 ms interval

0.0-10.0 ms phase offsets

sustained intervals

7.5 – 12.5 ms intervals
Slave-triggered synchronization

(a more heterogeneous cascade)

10 ms interval

0.0-10.0 ms phase offsets

clock-slave triggered

7.5 – 12.5 ms intervals

37.5 – 40.5 ms intervals
Rate conversion overview

(decoupled processes)

(GM selection)

\{txGrandTime0, rxTime\} \rightarrow \text{rxAdjust} \rightarrow \text{txResample} \rightarrow \{rxGrandTime0, rxTime\}

\{txGrandTime0, txTime\} \rightarrow \{txGrandTime1, txTime\}
Gain-peaking suppression

(distinct calibration & deviation indications)
Time formats

grandTime (NTP RFC-1305, SNTP RFC-2030)

seconds

fractions

>34,000 years

< 1 ps

extraTime
Interpolation concepts

(Interpolation range)

```
tx[m]       rx[n]       rx[n-N]
```

**safe interpolation range**
Interpolation intervals

rateInterval

backInterval

interpolation range
Interpolation adjustments

safe interpolation range

↑compTime = backTime

rx[n-N]  tb[m]  rx[n]  tx[m]

←backTime
Interpolation errors

(extraTime supplement)

[Diagram showing interpolation range, extraTime, and grandTime with labels rx[n-N], tb[m], rx[n], tx[m]]