Ordinary Clock (OC)
Application Service Interface

802.1AS Precision Timing & Synchronization
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Media Timing & Synchronization – more subtle than you think!

- Sync in traditional media production & distribution has relied on monolithic, per-application standards, e.g.
  - NTSC television
  - AES/SPDIF digital audio
  - MIDI
- Different features/behaviors for different media, markets, and tasks
- AVB is creating a *layered* synchronization environment which ideally supports all media, markets, and tasks with a single abstraction
Overview

• Application layer vs time synchronization layer
• Time at the media application layer
• What is a clock? (2 answers)
• Media clock implementations
• Application service interface (inter-layer)
• Performance specification at the ASI
Application layer vs Time Synchronization layer

- Application Layer
  - mic
  - keyboard
  - portable digital player
  - DV camera

- Time Synchronization service
  - Time Synchronization service

- OSI Network stack
  - OSI Network stack

- PHY medium
  - GPS

Audio ADC
Real time disk read
MIDI event capture
SPDIF digital stream mapping
Firewire digital timebase remapping

Audio DAC
MIDI event playout
SPDIF digital stream unmapping
Firewire digital timebase unmapping

Mixing, Scheduling, Routing
Equalization, processing, …
Time Requirements at the Media Application Layer

Fixed Latency

Uniform Sampling

Mapping/wrapping

Media sample clock may come from an external asynchronous source
What is a clock?

- **Constructive** definition: (SMPTE S22) “periodic events + accumulation of time + phasing to common reference”

- **Functional** definition: (IEEE1588) “a node that is capable of providing a measurement of the passage of time since a defined epoch.”
  - Event $E$ happened at time $T$
  - Matches modern physics definition
Media clock implementations I

"classic" hardware PLL

\[ f_{\text{out}} = \frac{m}{n} f_{\text{ref}} \]

802.1AS OC

Note: This is a "strawman": exact freq. ratio to 802.1AS OC is not a general solution
Media clock implementations II

II a

II b
preferred

II c

divided $f_{ref}$

Timestamp edge event

compute phase offset

compute loop filter algorithm

VCO/DDS

counter

media timebase

sample clock

_feedback path

divided Sample clock

Timestamp edge event

compute phase offset

compute loop filter algorithm

VCO/DDS

counter

media timebase

sample clock

_feedback path

"cross-stamp" info relating media timebase to reference

compute phase offset

compute loop filter algorithm

VCO/DDS

counter

media timebase

sample clock
Application service interface I

Media Application Layer

Synchronization & Timing ASI

Media clock(s)

MC1 MC2 . . .

Media Application Layer

OC

Time Synchronization service

802.1AS Ordinary Clock

IEEE 1588 PTP protocol

OSI Network stack

data stream

IEEE 1588 PTP protocol
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.
Jitter requirements for Media clocks

Lower Envelope of Network Interface MTIE Masks for Digital Video and Audio Signals

40 ns granularity (for reference)
Performance specification at the Application Service Interface (ASI)

- Critical jitter requirements (previous slide) apply at media clocks, not necessarily at OC
- Time delivered at ASI can meet looser specs, as application layer will implement filtering (dependent on application requirements)
- Time delivered at “timestamp” ASI has granularity, e.g. 40ns for 25MHz crystal (in simple implementations)
- IEEE1588 “Sync” message timing has granularity from ingress/egress timestamps anyway
- Best to leave ASI jitter spec loose but well defined: this places the bulk of the filtering responsibility on the application layer
Summary

• Media clocks are distinct from – and often asynchronous to – the OC timescale
• The AVB media application layer will use a lower layer “time synchronization service”, i.e. an 802.1AS OC, to support precise media timing
• The “event/timestamp” style Application Service Interface provides
  – A clear and appropriate abstraction
  – A viable implementation option for media clock generation
• Should define timing performance specs:
  – “contract” for network timing accuracy in AVB system
  – Testable compliance spec for 802.1AS devices
extras
Timing performance compliance concept

Ensemble of test sequences

Idealized (but simple) OC

OC Device Under Test

Periodic event stream

EVENT

TIMESTAMP

Compliance tolerance band

“test sequence”:
A sequence of 802.1AS-protocol messages at defined times emulating a certain PTP system environment and behavior
Compliance…

For convenience in modeling, the idealized reference clock is defined in a mathematically simple way which simply interpolates between the adjacent two Sync Event messages. This idealized clock is a model and is not physically realizable. (It is non-causal.)
Hidden agenda advantages to EVENT/TIMESTAMP ASI

- OC doesn’t inherently need a VCO (instead, use a fixed cheap crystal; all software) – “as digital as possible”
- Maps easily into microcontroller implementation (much like capture/compare registers)
- Service extends painlessly to coexisting multiple domain environment or non-1588 timing functions (e.g. cross-stamp a media clock & \( \mu \)proc cycle counter)
- Works compatibly at arbitrarily high resolution (subnanosecond)
- Same multimedia applications could run over an alternative protocol to 1588 in other environments
“dvj” reference model

Adaptation Sublayer

MAC Client
Maintains model of $T_L:T_G$ relationship

PORT
Common local-clock domain

EVENT.request
TIMESTAMP.indication
STATUS.indication

Query: $<\text{local time } T_L>$
Reply: $<\text{global time } T_G>$

Status

Sync msg

Ref: as-dvj-perspective-070124.pdf