Ordinary Clock (OC) Application Service Interface

802.1as Precision Timing & Synchronization
Jan 24 2007

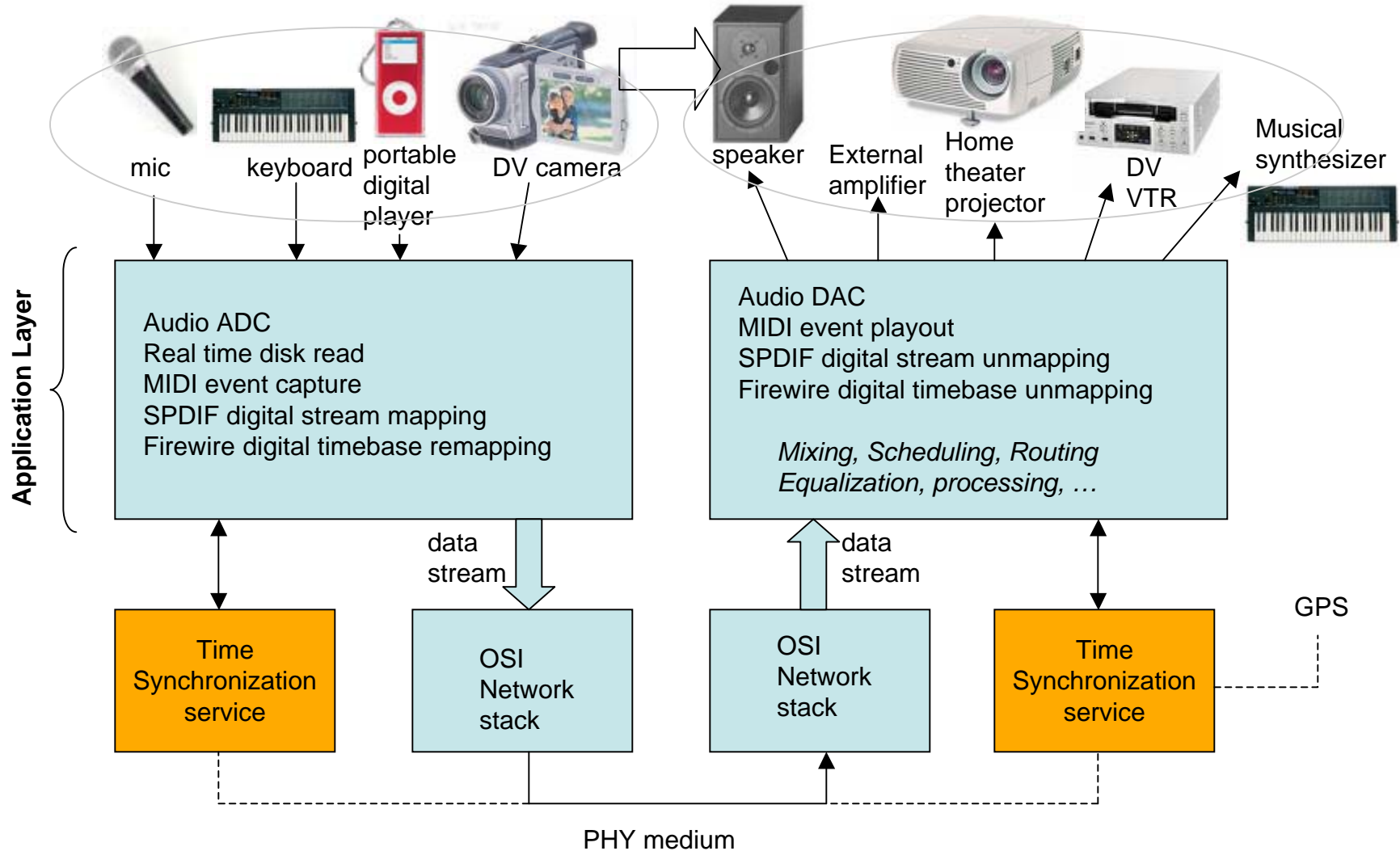Chuck Harrison, Far Field Associates

cfharr@erols.com

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
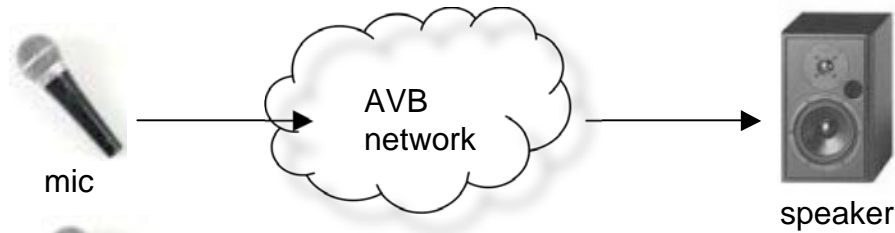
Overview

- 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
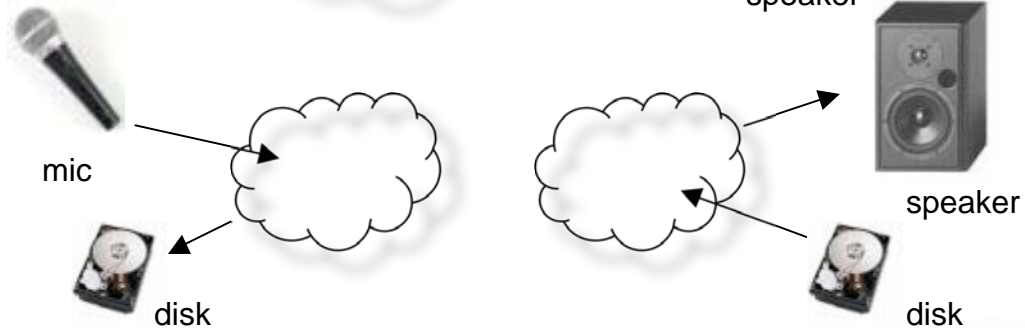
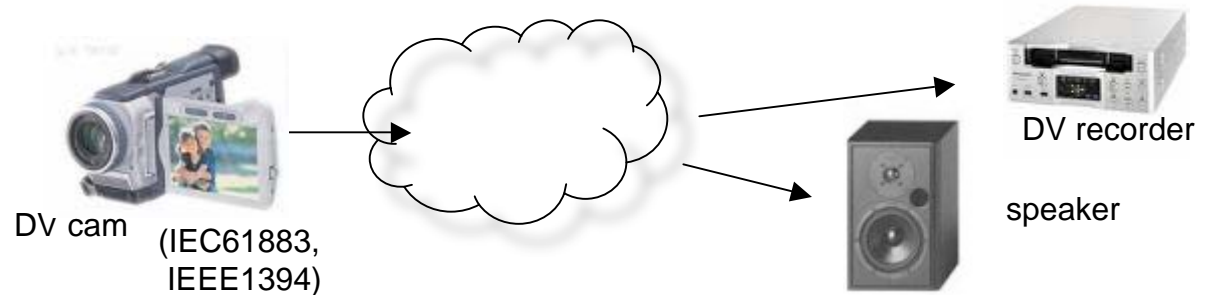# Application layer *vs* Time Synchronization layer

Application Layer

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, …

mic   keyboard   portable digital player   DV camera   speaker   External amplifier   Home theater projector   DV VTR   Musical synthesizer

data stream

data stream

Time Synchronization service

OSI Network stack

OSI Network stack

Time Synchronization service

GPS

PHY medium

Time Requirements at the Media Application Layer

Fixed Latency

mic | AVB network | speaker

Uniform Sampling

mic | disk | speaker | disk

Mapping/wrapping
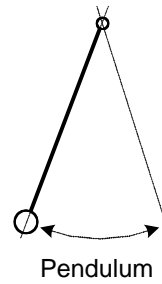
DV cam (IEC61883, IEEE1394) | DV recorder | speaker

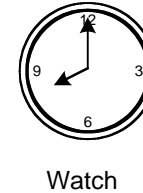Media sample clock *may* come from an external asynchronous source

What is a clock?

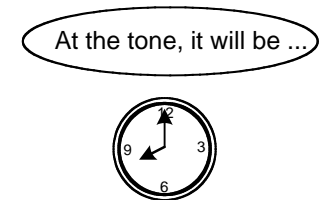- *Constructive* definition: (SMPTE S22) "periodic events + accumulation of time + phasing to common reference"

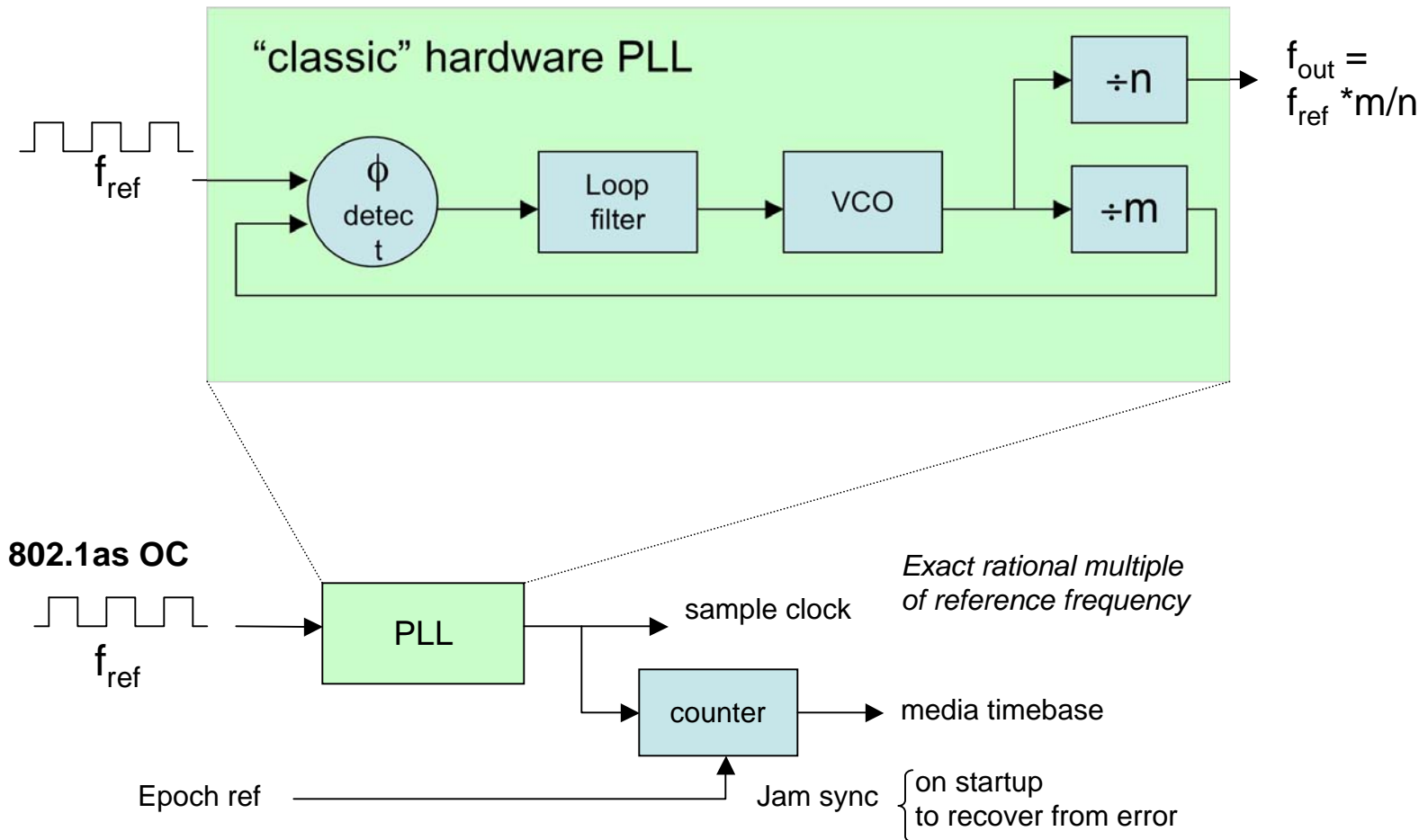1 - Equally-spaced Periodic Events

Pendulum

2 - Accumulation of Time

Watch

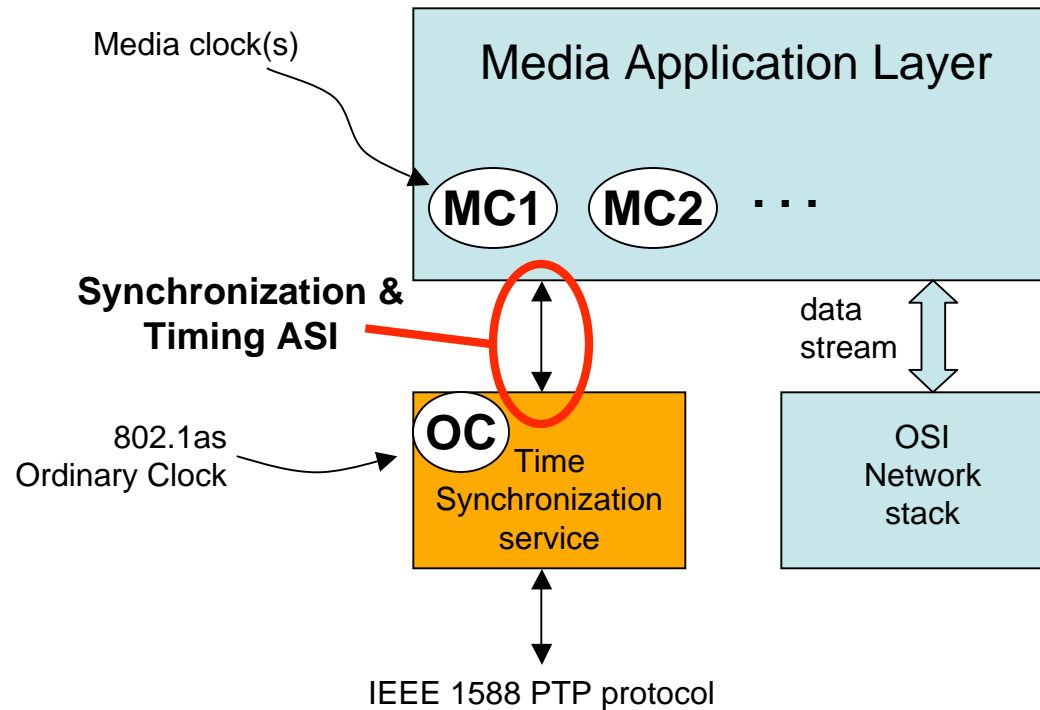3 - Clock Phasing to a Common Reference

At the tone, it will be ...

- *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

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Media clock implementations I

"classic" hardware PLL

f_{ref}

φ detect

Loop filter

VCO

÷n

÷m

$f_{out} = f_{ref} * m/n$

802.1as OC

f_{ref}

PLL

sample clock

Exact rational multiple of reference frequency

counter

media timebase

Epoch ref

Jam sync { on startup, to recover from error

Application service interface I

Media clock(s) → Media Application Layer

MC1   MC2   . . .

Synchronization & Timing ASI

data stream

802.1as Ordinary Clock →

OC Time Synchronization service

OSI Network stack

IEEE 1588 PTP protocol

Media clock implementations II

Application service interface II

TIMESTAMP.indication

EVENT.request   STATUS.indication

Time synchronization service
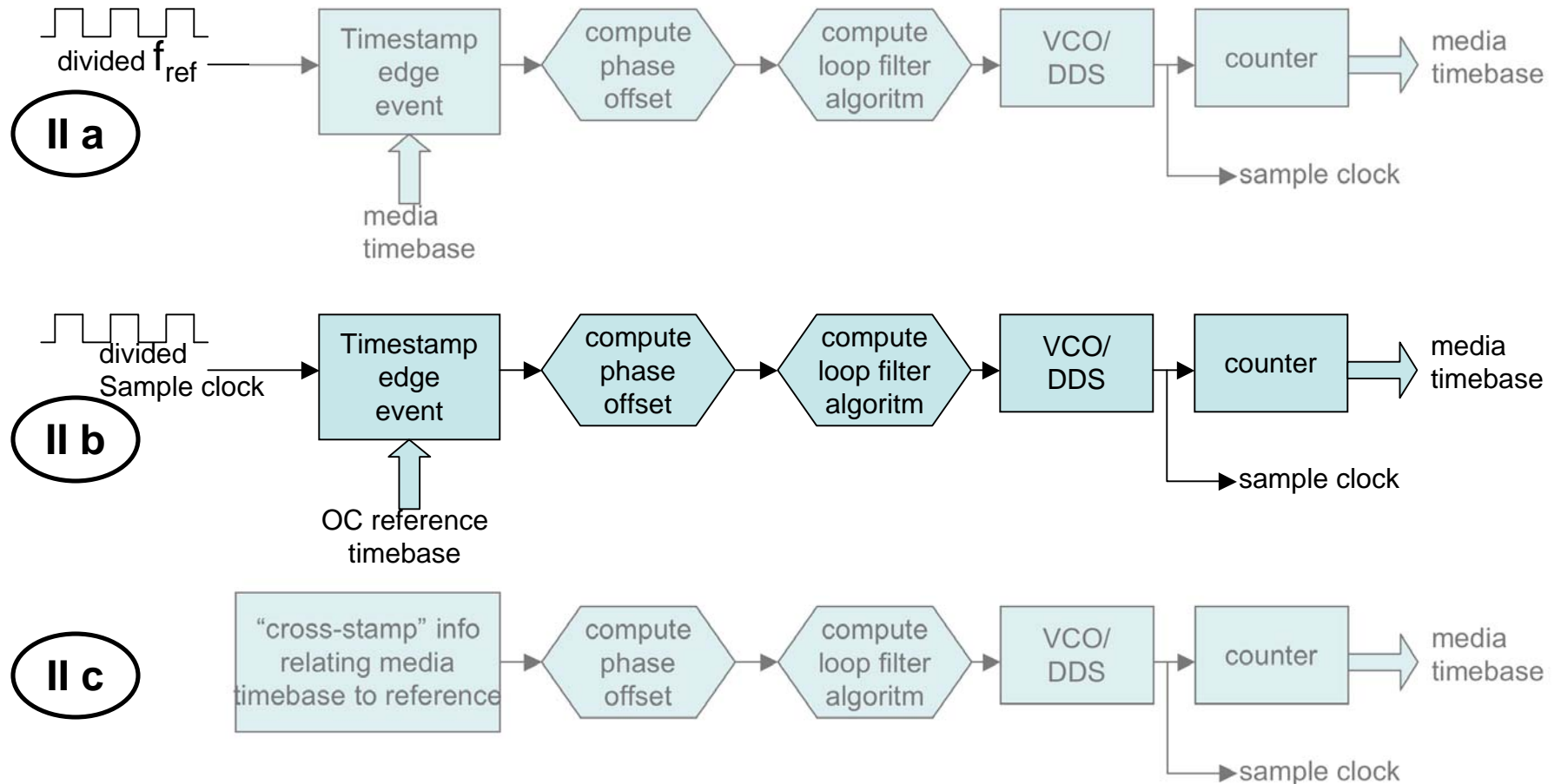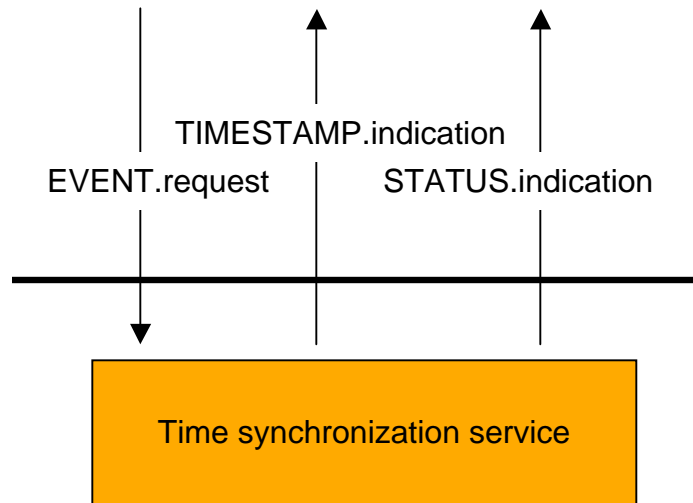
CSMA/CD
IEEE
Std 802.3-2005

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.

MAC client

MA_DATA.indication   MA_CONTROL.indication (optional)

MA_DATA.request   MA_CONTROL.request (optional)

MAC

MAC Control Sublayer (optional)

EVENT.request

TIMESTAMP.indication

7654680.238402 sec
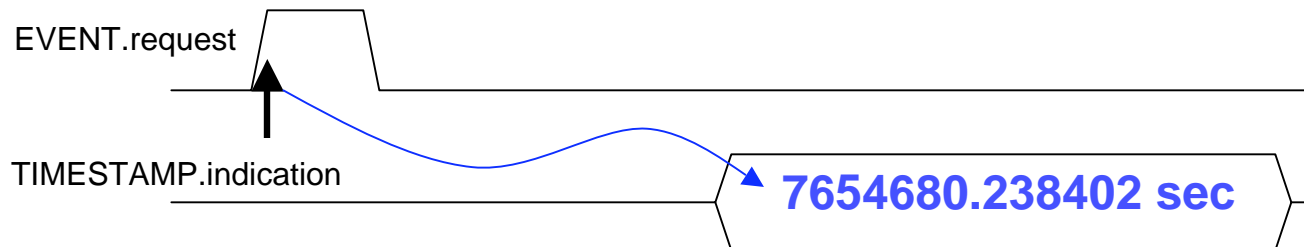
STATUS.indication: <timebase stabilized>, <timestamp valid>, <overrun>, …

Jitter requirements for Media clocks

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

40 ns granularity (for reference)

avb-garner-requirements-summary-r4-060217.pdf
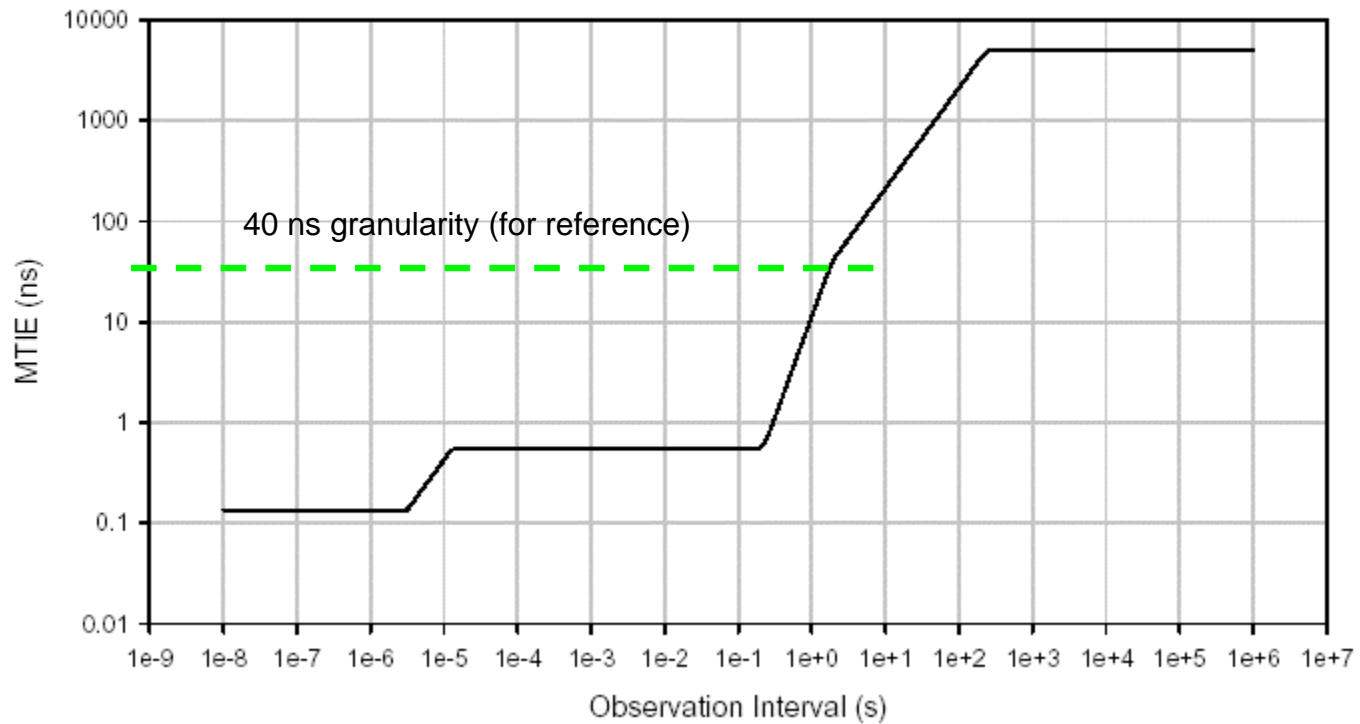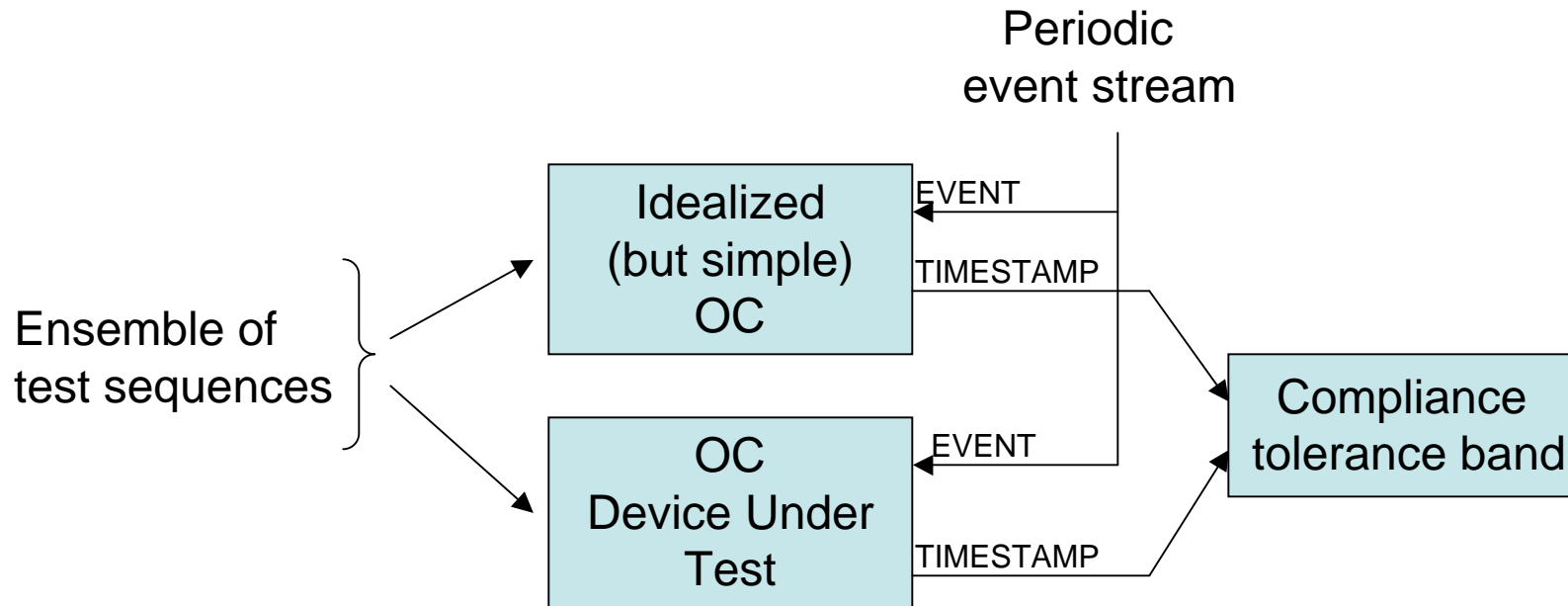
Performance specification at the ASI

- 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 also has granularity from ingress/egress timestamps
- 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 "timestamp" style Application Service Interface provides
  - A clear and appropriate abstraction
  - A viable implementation option for media clock generation
- Should define timing performance spec for 802.1as-compliant devices

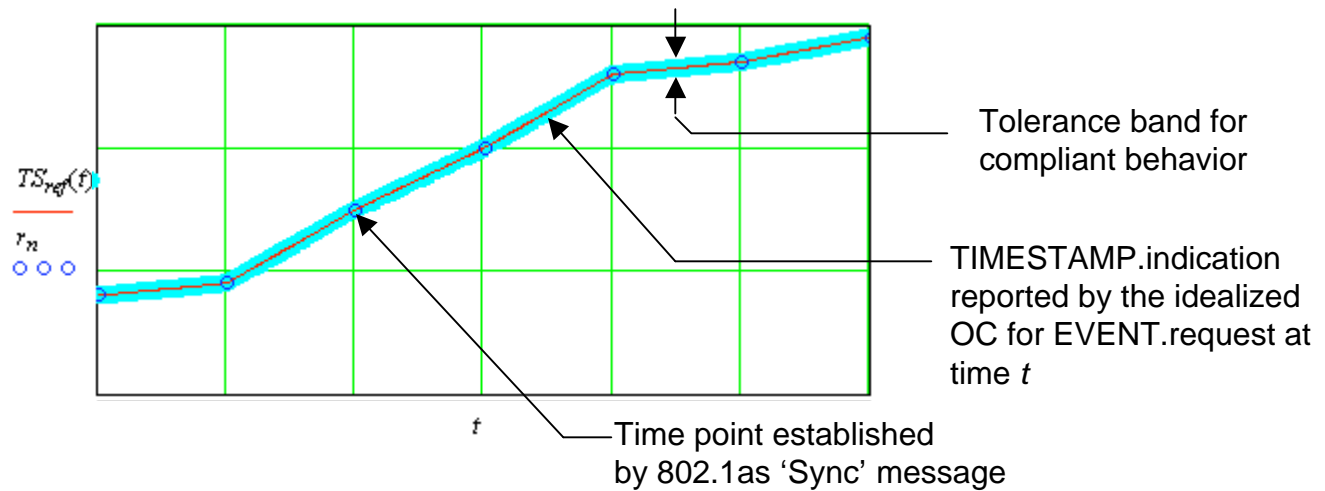# extras

Timing performance compliance concept

Periodic event stream

Ensemble of test sequences

Idealized (but simple) OC

EVENT

TIMESTAMP

OC Device Under Test

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.)

IDEALIZED OC BEHAVIOR

Tolerance band for compliant behavior

TIMESTAMP.indication reported by the idealized OC for EVENT.request at time t

Time point established by 802.1as 'Sync' message

Hidden agenda advantages to EVENT/TIMESTAMP ASI

- OC doesn't inherently need a VCO (fixed cheap crystal; all software) – "as digital as possible"

- Maps easily into microcontroller implementation (much like capture/compare registers)

- Extends painlessly to coexisting multiple domain environment or non-1588 timing functions (e.g. cross-stamp a media clock & μproc cycle counter)

- Works compatibly at arbitrarily high resolution (subnanosecond)