1722A Global System Clock Streams (aka Media Clock Streams)

Principles and Suggestions

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The purpose of Media Clock Streams is to distribute a <u>common timing grid</u> to multiple nodes on a common AVB network, such that all nodes can use this same grid to operate on sampled media data with <u>synchronicity in both frequency and phase</u>.

- A generalized AVB domain must concurrently support multiple, independent media clock frequencies (also known as media clock domains). Therefore, the gPTP clock cannot directly serve as the common timing grid for media. Rather, the gPTP clock is used by the various nodes, as a *measuring stick,* to derive media clock(s) based on information received in network PDUs.
- A well established (and uncontested) model to follow is "standard synchronous digital logic design," such as a digital logic board, a VLSI chip, or an FPGA. In this model, a global clock is provided from a single point in the system, and distributed to a large number of flip-flops across the system. (In an AVB network, each node is analogous to a different group of flip-flops, and the whole LAN is analogous to the digital system). For digital systems that have multiple clock domains (a very common occurrence), multiple GCLK signals are received and then distributed throughout the system.
    - See diagrams for illustration of the key concepts.
    - The network delay in AVB is analogous to the "setup time" in a digital logic circuit. We might also say that the packet transmit time is subject to variability, analogous to the "clock-to-output" time of a flip flop.
    - Presentation Time is analogous to the clock arrival time at a "listener flip flop," and matches our 1722-2011 model in that this is the time when the data present on the input pin of the flip flop is "handed off" to the circuit inside the flip flop. Note that the data must arrive at the "input pin" before the clock event occurs. Same is true for each and every stream PDU: It must arrive before its corresponding presentation time.
    - ***<u>This principle is fully consistent with best practices in professional digital audio systems, as standardized in AES11-2009 (Clause 5.3 "Equipment Timing Relationships")</u>***
- This "common timing grid" (CTG) is ultimately 1x the sampling rate of the media, but the mechanism used to distribute the "grid parameters" can operate at a much lower rate.
    - For audio, the CTG is the audio sampling clock
    - For video, the CTG may be the video frame clock or the line clock. If it is the line clock, we need a mechanism to demark ticks on the grid that correspond to frame start (first line in a video frame).

    - For Digital Control Systems, the CTG is most likely the system sampling clock
- "Operate on sampled media" (from the first paragraph of this doc) can mean anything from ingest (e.g. acquire from signal input chain), to "outgest" (deliver to signal output chain), to process via DSP, or other usage. The point is that all such operations are synchronized to a "global clock."
- The timing grid must be expected to be subject to some error (jitter and/or phase skew) between different nodes. (In the digital logic design model, this is exactly analogous to clock tree skew, which even exists inside VLSI or FPGA chips).

We would like to minimize the network bandwidth used by MCS, and therefore define a solution that does not require "high" packet rates.

- We assume that media time is independent of network (802.1AS) time. We do NOT want to restrict a media source (or MCS source) to have a fixed and constant relationship to network time. Therefore we need to distribute clock timing information across the network (rather than relying on nodes to be locked to some universal clock like GPS/TAI).
    - Note this assumption is counter to the assumption made by SMPTE, wherein all nodes are assumed to have TAI time "built in." But our MCS solution will not preclude application of the SMPTE solution; both could co-exist on the same LAN.
- A single master MCS source is required to generate this global clock. We should strictly object to the concept of plural nodes generating plural versions of a MCS that is intended to be "common".
    - The exception to this rule is an important one: How do we support redundant MCS? For example, do listeners all have to use the primary MCS (if present) and only fall back to secondary MCS when primary goes away? Or can they use either one at will?
    - In the model proposed by SMPTE, the "single master MCS source" is GPS, or other mechanism which delivers a universal clock to all network nodes. It is the same concept that we propose here; but instead of using the network itself to deliver time sync, it relies on an external system for this task (thus it is arguably more complex).
- The MCS does not need to (and probably should not) deliver every tick mark on the timing grid. Instead, it should deliver a sufficient supply of tick marks to allow listener to interpolate tick marks to re-construct the local timing grid, and to respond/adapt to changes in the global clock frequency reasonably quickly.

Because clocking can be tricky and confusing to a large portion of our user base (both product makers and product users), and because it is critically important for proper system operation (just like in a digital hardware design), some "governing body" should be explicit about recommending best practices.

- We expect that AVnu will fill this role, since IEEE does not generally govern "best practices"
- IEEE needs to give AVnu the "hooks" in the standards that can be used to specify best practices in a clear and objective way

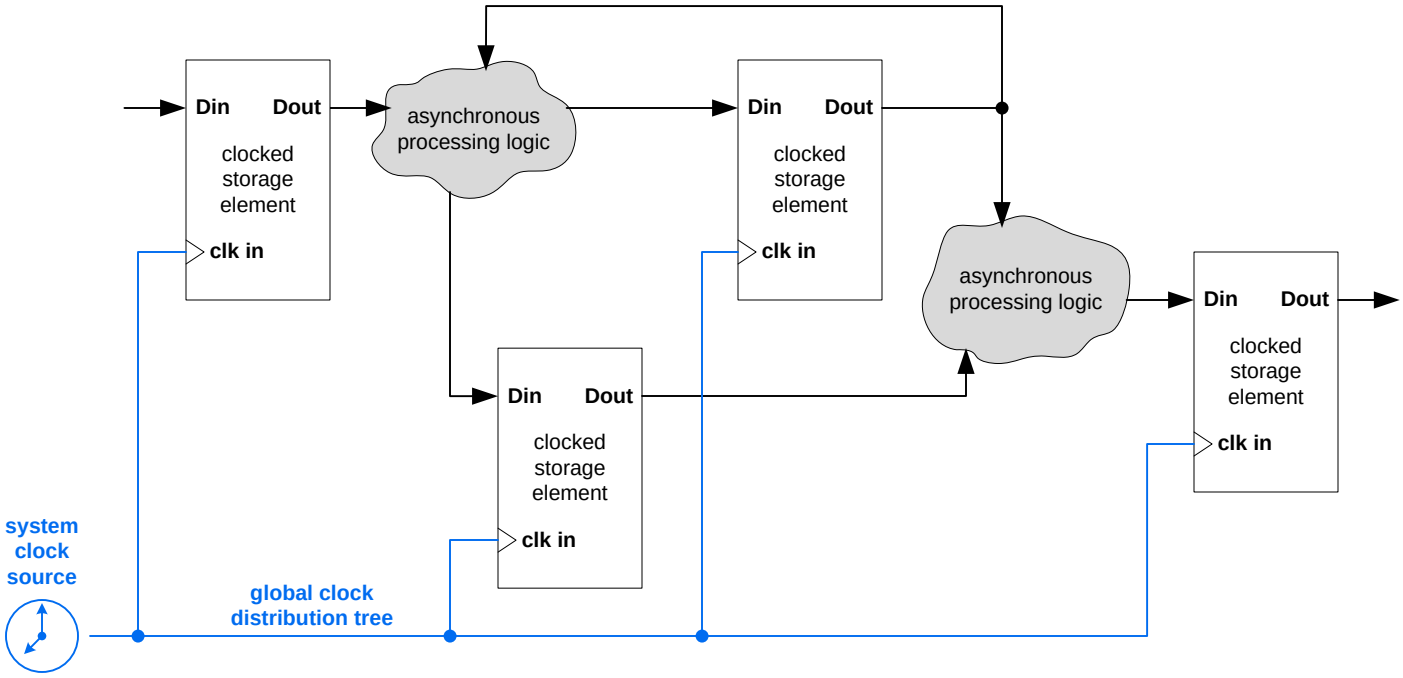
- One example of a best practice is to distribute a master MCS to all devices (who operate on that particular media clock domain) directly. We should discourage the (worse) practice of cascading media clock streams through endpoints. (it seems there is no good reason for this, since all nodes on a LAN are reachable by the node talking the MCS).

I propose that we consider changing the name of MCS to "Global System Clock" (GSC) streams."

- This might help to encourage the best practice described above and avoid cascading of clock streams (because once a clock is cascaded it is, hopefully, no longer seen as "global")
- One important reason for a new name is because the term "media clock stream" is already being used in reference to systems following the 1722-2011 standard. It may be very difficult to deprecate that term, and not worth trying to do so.
- We might use the term "master" rather than "global." One possible problem with this is that "master" and "media" both begin with M.
- The term "global" means that this stream is available everywhere on the network. It does not imply that this is the only clock stream that is available everywhere. As noted above, a digital logic design commonly has several global clocks feeding different clock domains.

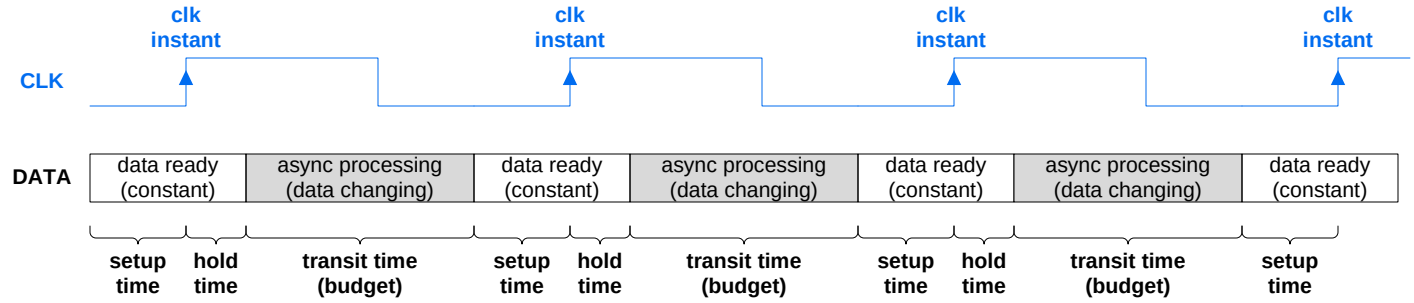
Digital Logic (System) Design : Standard “Best Practice”

Schematic

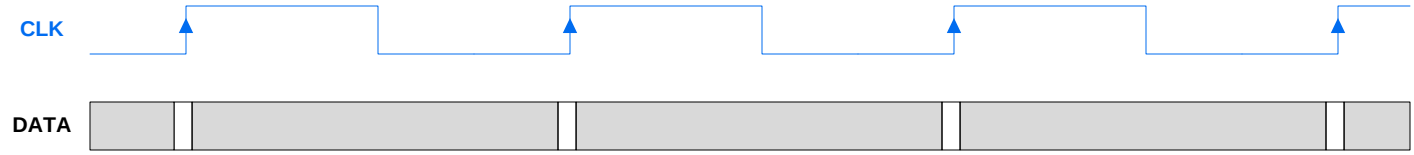


Timing Diagram

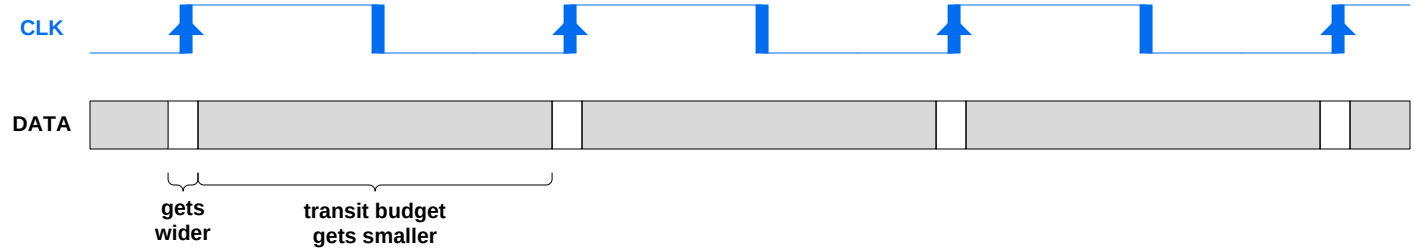
For illustration (scale exaggerated)



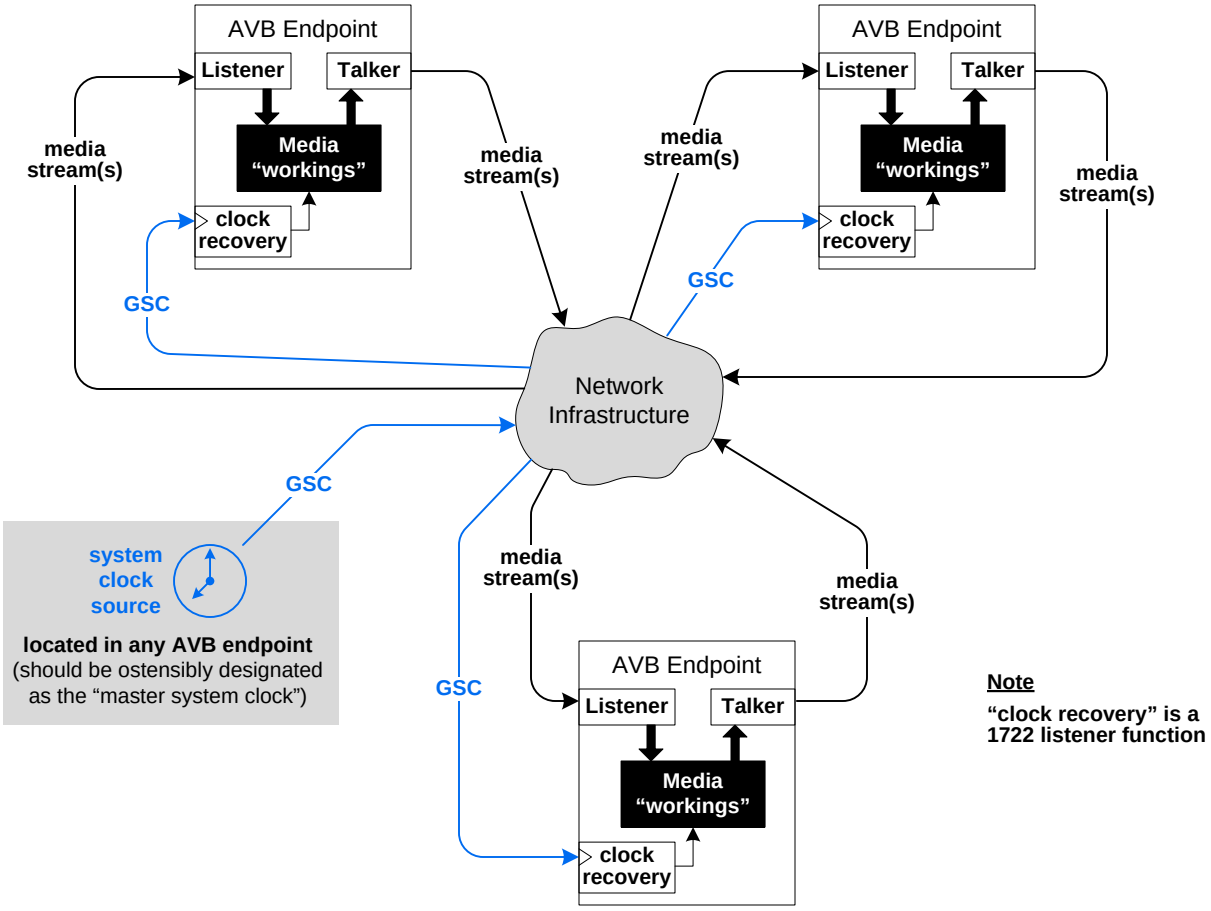
Now with clock period >> setup/hold times



Now with clock skew / jitter



AVB Network with Global System Clock (GCS) streams



Conceptual Timing Diagram for AVB Media Synchronization and Delivery

Corresponds to <u>one</u> Media Clock domain on an AVB network. For illustration purposes, not to scale