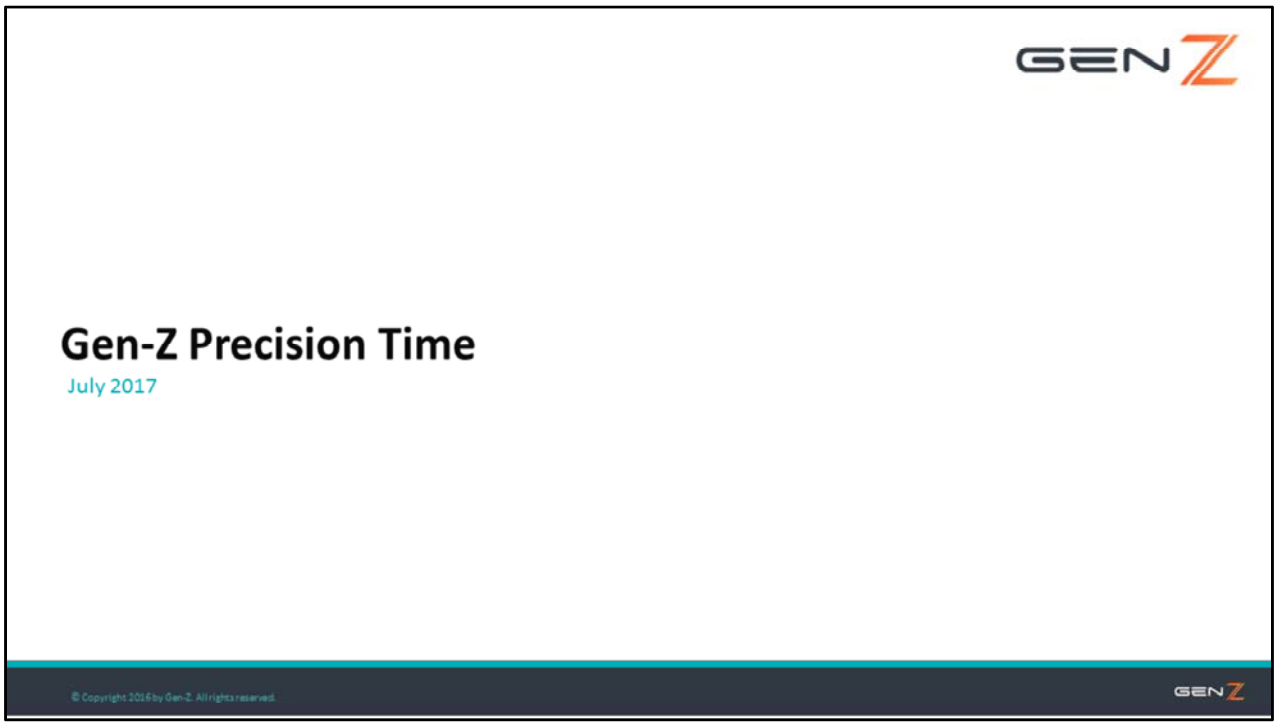

This presentation covers Gen-Z Precision Time. Precision time is used by numerous applications to synchronize time with relatively high precision.

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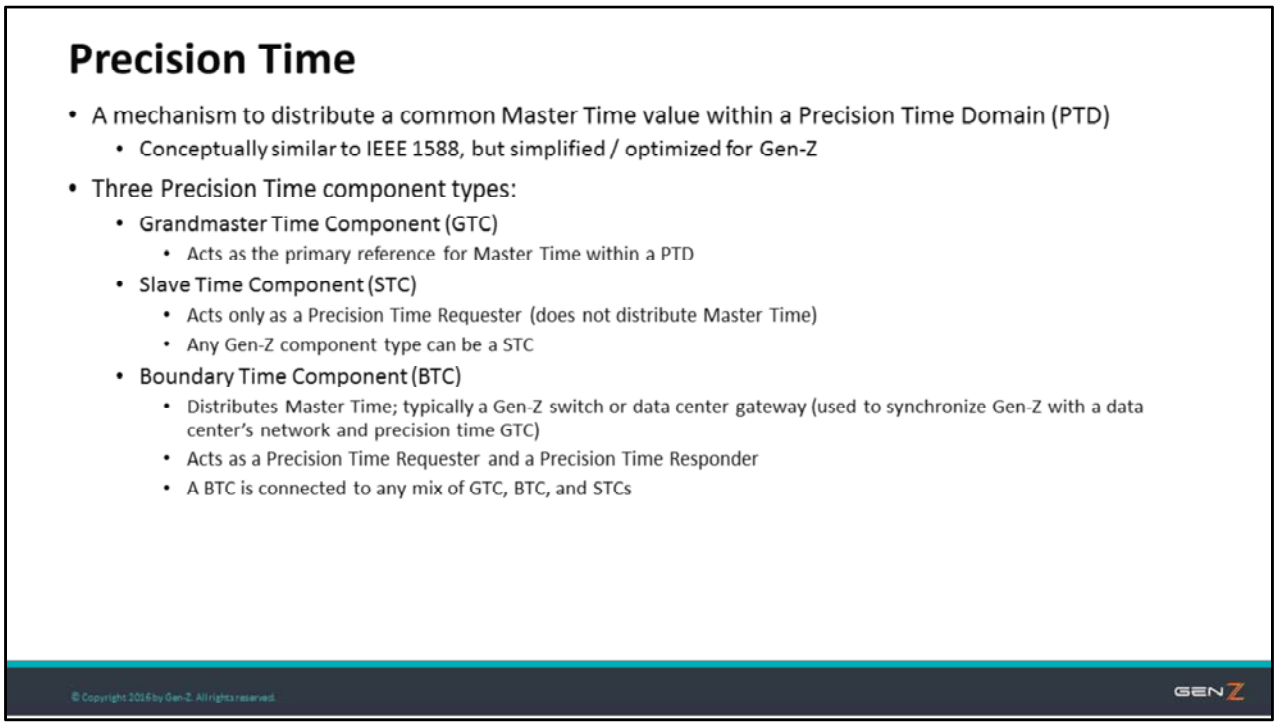


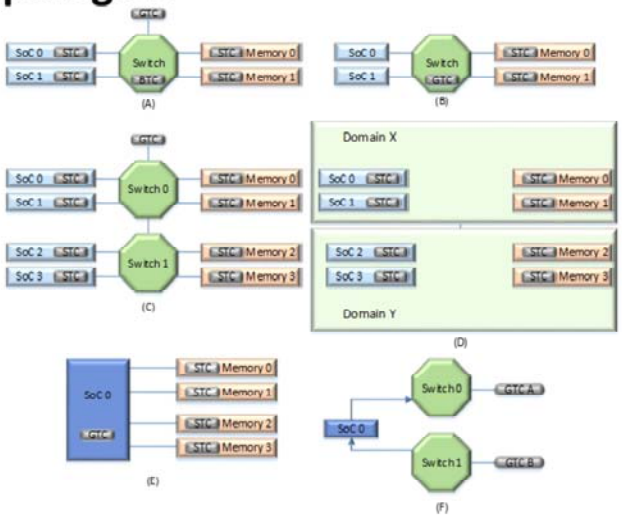
Though IEEE 1588 provides a solid foundation and understanding of precision time within the industry, the specification was designed to accommodate a wide-range of environments, and this can lead to a sub-optimal solution when applied to a Gen-Z topology. As such, Gen-Z leverages concepts from IEEE 1588, but optimizes communication for Gen-Z topologies. Further, this will enable more precise time to be established.

To support precision time, a solution requires multiple component types:

- A GTC is the central Master Time authority within a given precision time domain (PTD). The GTC maintains a clock used for Master Time or synchronizes with a third-party clock source, e.g., in some solutions, a GTC uses an atomic clock.
- A STC is a leaf component that issues precision time requests to synchronize its understanding of Master Time.
- A BTC is communicates with other BTC or GTC to acquire the Master time. A BTC is often implemented within a Gen-Z switch. Switch implementation provides two benefits:
    - Gen-Z topologies are relatively flat, hence, BTC-GTC synchronization is simpler and can be more precise.
    - A STC is often directly attached to a switch (BTC), which simplifies synchronization and improves precision.

Example Precision Time Topologies

- A, B, C, E illustrate single PTD topologies
- D illustrates two PTDs operating over a single physical topology
- E illustrates a single SoC that acts as a GTC for a set of memory components
- F illustrates an SoC attached to two independent PTDs



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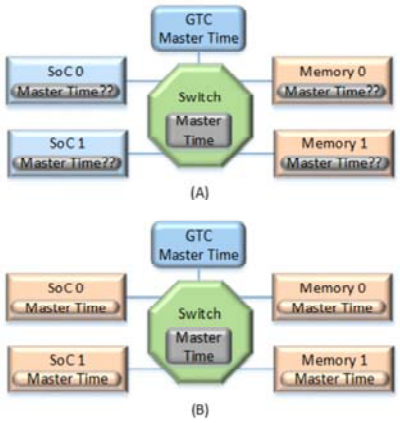
This slide illustrates a series of example topologies that support precision time.

- Topologies A, B, C, and E illustrate single precision time domains, i.e., ones with a single active GTC. Though these topologies are small, the same technique can be used to support precision time across any Gen-Z topology regardless of scale.
- Topology D illustrates two PTDs operating over the same physical topology. Each component is associated with a single GTC for precision time purposes. Precision time request and response packets are self-describing, which enables precision time request and response packets to communicate with the correct GTC even if flowing across the same physical topology.
- Topology E illustrates a very simple precision time topology. In this topology, a single SoC acts as the GTC, and the leaf memory components (STCs) directly synchronize with the GTC.
- Topology F illustrates a STC attached to two switches (BTCs) which are connected to two independent GTCs. If the GTCs are synchronized, then this topology can be used to provide highly-available precision time.

Example Precision Time Distribution

- At time T0, the GTC and BTC established Master time
  - GTC establishes Master Time
    - For example, synchronizing with a known time source
  - The switch acts as a BTC
    - BTC transmits Precision Time requests to the GTC
  - GTC transmits Precision Time responses to the BTC
- At time T1, the BTC and STC establish Master time
  - SoC and memory components act as STCs
    - STC transmits Precision Time requests to the BTC
  - BTC transmits Precision Time responses to the STC



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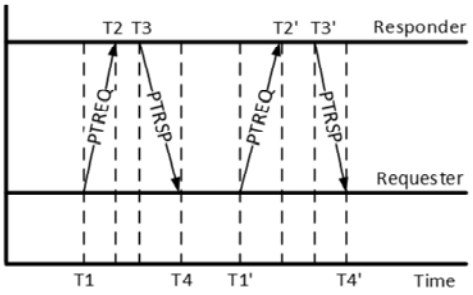
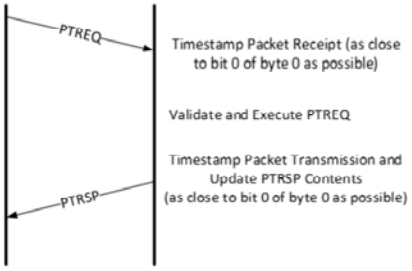
This slide illustrates how Gen-Z uses a stepwise process to distribute precision time across a topology. The process starts with the GTC, and then proceeds to each BTC, and from each BTC to each STC. Using a stepwise approach is simpler, and since synchronization occurs across a single link hop, the precision should be better. Depending upon how precise each component maintains its understanding of Master Time (need to account for any drifts in time), Gen-Z precision time solutions can support sub-microsecond precision time.

Precision Time Request-Response Exchange





- Timestamps T1-T4 and T1' to T4' are captured
- Timestamps [T2, T3, T2', T3'] captured close to transmission of bit 0, byte 0 of Precision Time response
- Timestamps [T1, T4, T1', T4'] captured close to transmission of bit 0, byte 0 of Precision Time request
- Master Time at T1' = T2' – ((T4 – t1) – (T3 – T2)) / 2

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This slide highlights how each component calculates precision time. Precision depends upon how close or how accurate the individual timestamps are captured relative to when the request or response packet is transmitted.

To account for variable length physical paths and cables, Gen-Z Link CTL operations can be used to measure the propagation time across a given link. This should improve precision.

Precision Time Management

- Components need to support the Component Precision Time structure
- Component Precision Time structure is used to configure the following:
  - GTC support and configuration
  - Precision Time Requester support and configuration
  - Precision Time Responder support and configuration
  - Precision Time Granularity—ns or ps
  - GTC CID / SID
  - Precision Time Responder CID / SID
  - Alternative GTC and Precision Time Responders
  - Primary and alternative interfaces to use for Precision Time operations

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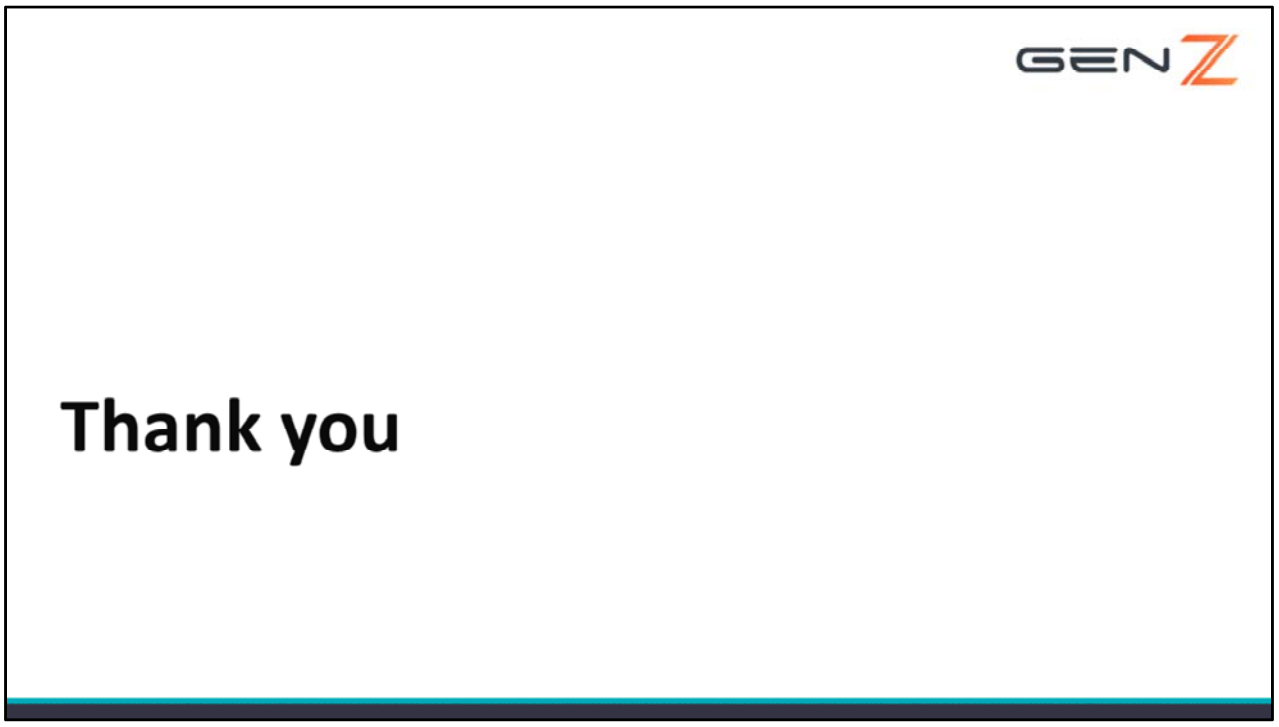
Precision time is managed through the Component Precision Time control structure. This structure contains multiple fields that identify support, the CID / SID of the connected precision time Responder, and the identity of the GTC to use within the component's PTD. Further, precision time packets are exchanged through a single component interface. To ensure availability, the structure enables a primary and alternative interface to be identified.



This concludes this presentation. Thank you.