This presentation covers Gen-Z Address Translation and Page Services. Address Translation is used to improve performance primarily in virtualization solutions. Page services are used to support on-demand paging in order to eliminate the need to pre-pin a page prior to access.
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Address translation services involves two components: a component (e.g., a SoC) that contains memory that is accessed by a second component (e.g., I/O). This figure illustrates two components. The blue component contains some amount of memory and a Translation Agent (TA) that manages a MMU (memory management unit) / ZMMU. The orange component contains one or more contexts and each context may have a context cache that is contains translated addresses. A translated address is obtained by transmitting a Translation Request packet that contains the untranslated address to the TA, to which the TA responds with a Translation Response packet that contains the translated address. A Translation Request packet may also communicate if the untranslated address is associated with a PASID and whether execute or privileged attributes are required.
**TA Invalidate Exchange**

- If a TA needs to invalidate or change the attributes of a translated address, it issues an Invalidate Request packet.
- Once the Responder ensures there are no outstanding request packets with the translated address, it transmits an Invalidate Response packet.
  - Responder evicts translated addresses from its context cache.
  - Each context cache is independently managed. If multiple context caches contain the translated address, then the TA transmits an Invalidate Request packet to each context.
Process Address Space Identifier (PASID)

- PASID is a 20-bit value that uniquely identifies a process address space on an application component, e.g., an application process or a guest virtual machine.
  - Using a PASID enables a single component or component context to be simultaneously shared by multiple processes by logically extending each untranslated address to be [untranslated address, PASID].
- PASID usage can improve solution performance such as in a virtualization environment, by reducing the need for a guest virtual machine to trap to a hypervisor to update address mappings.
  - For example, an untranslated address without a PASID represents a guest physical address (GPA). A hypervisor manages GPA-to-system physical address mappings.
  - In contrast, an untranslated address with a PASID represents a guest virtual address (GVA). A guest virtual machine running on top of a hypervisor directly manages the GVA-to-GPA mappings, i.e., no hypervisor traps.
Translation Request packets can take a non-determinate amount of time to execute, hence, are governed by the Non-deterministic processing requirements.

If the component supports Logical PCI Devices (LPDs), then the REQCTXID contains a 16-bit PCI BDF (Bus Number, Device Number, Function Number).

The above is the CTXID packet format. The P2P 64 packet format is available in the Core Specification.
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Invalidate Request and Translation Response packets from a TA may arrive out of order. Each context’s cache is responsible for detecting if an invalidation range overlaps any translation address range within any outstanding Translation Request packet. If an overlap is detected, then the outstanding Translation Request packet shall be marked as invalid (implementation-specific method) and the context should silently discard the subsequently received Translation Response packet. If the subsequently received Translation Response packet is not silently discarded, then the Translation Field(s) that overlap the invalidation range shall be discarded.

If the context receives the Translation Response packet prior to scheduling Invalidate Response packet transmission, then the context may use the translated addresses in new request packets if these request packets are guaranteed to complete prior to the expiration of the invalidation timer (see above).

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Page Services

- Page services are used by a Requester to request memory pages be made resident upon demand.
- On-demand paging can be used to improve solution performance and alleviate memory pressure due to excessive “pinning” of memory.
- PRG Request packets are used to request a page be made resident, and PRG Response packets indicate success.
• R and W indicate if read and access permission is requested
• EX indicates if execute permission is requested
• PRIV indicates if the page is associated with Privilege Mode operation

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- Indicates success of all PRG Request packets associated with the PRG Index
- Indicates failure for page management issues, e.g., page does not exist, page residence steps failed, etc.
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- Upon being informed to stop using a PASID, a context can transmit a Stop Marker packet to indicate that it has completed all stoppage processing.
  - Context marks all outstanding and queued PRG Request packets for the PASID as stale prior to Stop Marker.
  - Eliminates the need to wait for a PRG Response Notification packet for each outstanding PRG Request packets associated with the PASID.
Thank you

This concludes this presentation. Thank you.