Gen-Z Operation Classes (OpClass)
October 2017

This presentation covers Gen-Z Operation Classes, also referred to as OpClasses.

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OpClass

- Each OpClass supports 32 OpCodes
  - Some OpClasses support the same OpCodes, e.g., Read and Write operations
    - This enables applications to operate over a variety of topologies or solution stacks while enabling protocol optimizations or support for additional capabilities, e.g., Access Keys
- Gen-Z supports a total of 35 OpClasses
  - Three implicit OpClasses—OpClass Label field is not present in the packet
    - P2P-Core
    - P2P-Coherency
    - P2P-Vendor-defind
  - Thirty-two explicit OpClasses—OpClass Label field is present in the packet
- P2P-Core and P2P-Coherency also support a SubOp OpCode that enables each to support up to 128 additional sub-operations, e.g., in-band management, atomics, etc.
- In theory, a single component could support 1000+ distinct operation types
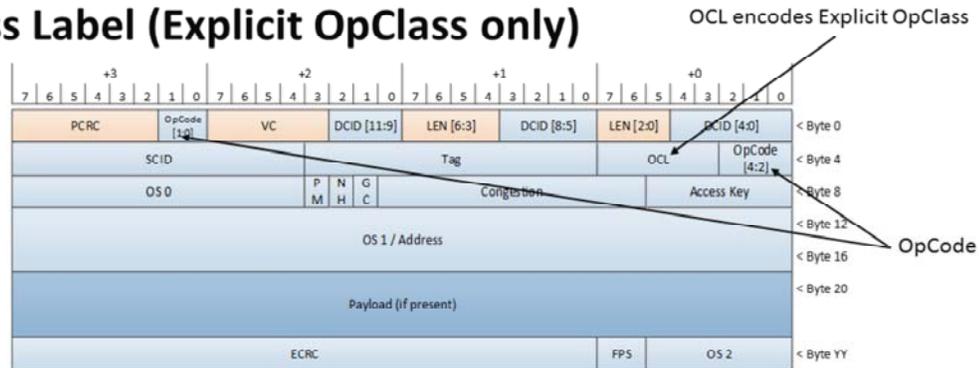
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Gen-Z organizes operations into OpClasses. Each OpClass contains 32 OpCodes, where each OpCode represents a unique operation, e.g., a Read or Write operation.

Gen-Z supports a total of 35 OpClasses. Three implicit OpClasses and 32 explicit OpClasses.

Implicit OpClasses are configured on a per component interface basis and are intended for use in point-to-point, mesh, and daisy-chain topologies. Implicit OpClass packets do not contain an OpClass Label field.

Explicit OpClasses are intended for use in point-to-point and switch-based topologies. Explicit OpClass packets contain an OpClass Label field that explicitly identifies the OpClass.

This slide illustrates a generic explicit OpClass packet. There are two fields of interest: the OpCode field identifies the specific operation type and the OpClass Label (OCL) field identifies the specific OpClass. Each is a 5-bit field respectively providing 32 OpCodes and 32 Explicit OpClasses.

Supported OpClasses

- The following implicit OpClasses are specified:
  - P2P-Core—point-to-point / daisy-chain optimized memory communications
  - P2P-Coherency—point-to-point optimized coherency communications
  - P2P-Vendor-defined—point-to-point optimized vendor-defined
- The following Explicit OpClasses are specified:
  - Core 64—Single or multi-subnet with 64-bit effective addressing
  - Control—In-band management operations, event notification, etc.
  - Atomic 1—Atomic operations
  - Large Data Move 1—Buffer operations and large Read operations
  - Advanced 1—Pattern operations and Lightweight Notification operations
  - Advanced 2—Precision Time, Unicast Packet Encapsulation, etc.
  - Context ID—used for operations that target a Responder context identifier (handle)
  - Multicast—Unreliable and Reliable Multicast operations
  - Strong Ordered Domain (SOD)—strong ordering operations
  - 8 Vendor Defined OpClasses—Vendor specified or de facto operations

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The following three implicit OpClasses are specified: P2P-Core, P2P-Coherency, and P2P-Vendor-defined.

- The P2P- Core OpClass is optimized for point-to-point and daisy-chain topologies used to connect processors with memory modules.
- The P2P-Coherency OpClass is optimized for point-to-point and mesh topologies used to connect coherent components, e.g., a processor and an accelerator.
- The P2P-Vendor-defined OpClass is optimized for point-to-point solutions using a vendor-defined protocol.

The following explicit OpClasses are specified:
- Core 64 is optimized for switch-base solutions, e.g., I/O and memory expansion within a single enclosure or rack. It supports 64-bit addressing and can be used in single and multi-subnet topologies.
- The Control OpClass is used by in-band management to access control space.
- The Atomic OpClass is used to support a robust set of atomic operations compatible with multiple processor architectures.
- The Large Data Move OpClass is used to move large quantities of data using Buffer Put and Get semantics as well as large read semantics. In general, large data move operations are executed by data mover logic instead of a processor core.
- The Advanced 1 and Advanced 2 OpClasses are used to support pattern operations, lightweight notification, precision time, unicast packet encapsulation, etc.
- The Context ID OpClass is used to target a Responder Context Identifier (handle). This enables operations to target a specific instance of a service, e.g., to transmit messages used to a specific eNIC (emulated NIC) or to communicate collective operations to a specific application instance.
- The Multicast OpClass is used to transmit unreliable and reliable multicast operations. This enables Requesters, Responders, and switches to easily delineate unicast from multicast operations, simplifying hardware designs.
- The Strong Ordered Domain (aka SOD) is used to exchange strongly ordered operations, i.e., these packets use sequence number based to enable a Responder to detect missing or out-of-order packets.

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- Vendor-defined operations will be covered in the next slide.

Vendor-defined OpClasses and OpCodes

- A component may support up to 8 vendor-defined explicit OpClasses at a given time
    - Each OpClass is associated with a UUID
        - UUID is a 128-bit globally unique identifier
        - UUID enables very wide range of vendor-defined operations
    - UUID is mapped to a given OpClass label
        - Indirection enables vendor-defined operations to be dynamically mapped to a given label
        - Reduces multi-vendor coordination to a single UUID
        - Allows cooperating components to support any mix of vendor-defined OpClasses
    - Vendor-defined OpClasses transparently operate across any Gen-Z topology
        - Cooperating components are the only ones that need to understand the specifics of a given OpClass
        - Switches do not use the OpClass to perform packet relay
- A component may support P2P-Vendor-defined OpClass
    - A point-to-point optimized vendor-defined OpClass
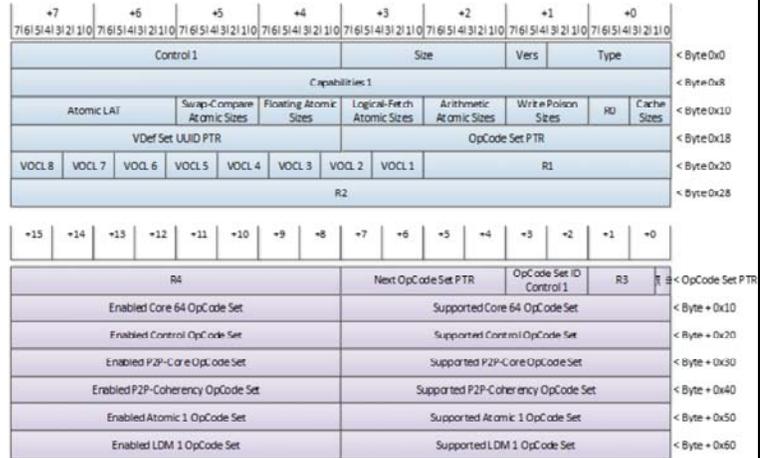- A component may support 16 P2P-Core or P2P-Coherency Vendor-defined OpCodes

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In addition to these standard OpClasses, Gen-Z supports 8 vendor-defined OpClasses. These OpClass may be used to communicate vendor-specific operations or de facto standard operations. A UUID is used to uniquely identify each OpClass. This enables the architecture to support nearly any number of vendor-defined operations and, by using UUIDs, to significantly simplify management and enable vendors to innovate and collaborate without requiring a central management authority.

The UUID is not present on the wire since that would be extremely inefficient. Instead, it is mapped to an OpClass Label field. Hence, any component can support up to 8 different vendor-defined OpClasses at a given time, and these are transparently transported across the Gen-Z topology.

OpClasses are managed through the OpCode Set structure. Two fields are provisioned per OpClass: the supported OpCode set and the enabled OpCode Set. As the names imply, the Supported field indicates which OpCodes are supported and the Enabled field indicates which OpCodes a component may use. Further, each field is composed of sub-fields to indicate each OpCode's role, i.e., whether it supports and is enabled to use an operation as a Requester, as a Responder, or as a Requester-Responder.

A component may support multiple OpCode Set structures to enable interoperability with a variety of disparate component or across multiple technology generations.

This concludes this presentation. Thank you.