Enhancing SBP-2 Performance

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Problem

• SBP-2 works well with large transfers and large task sets
• But small tasks, executed serially, suffer from high start-up latency

• Focus of this proposal:
  Disk drives and other fast storage devices
SBP-2 Review

- Initiator - for example, a computer
- Target - for example, a disk drive
- 1394 allows the target to directly access memory in the Initiator without interrupts or software overhead
Operation Request Block

- Initiator assembles ORB(s) in system memory, each with:
  - A command (approximately 12 bytes)
  - A data buffer for I/O (usually)
  - A next_ORB pointer (may be null)
  - Various transfer parameters (direction, length, etc.)
- A typical ORB is 32 bytes (may vary)
- ORB Pointer is 64-bit 1394 address of ORB structure
**SBP-2 Operation**  
*(first time)*

- Initiator writes Target's ORB Pointer register
- Target sees write (1394 8-byte block write) and:
  - Reads ORB from Initiator memory
  - Executes ORB
  - Transfers data to or from buffer in 1394 memory
  - May send status to Initiator upon ORB completion
  - Executes additional ORBs linked to first ORB (if any)
  - Enters Suspended (idle) state when final ORB complete
**SBP-2 Operation**
(after first time - normal)

- Initiator writes new ORB Pointer into final ORB's next_ORB field (in Initiator memory)
  - Target may or may not have reached final ORB
- Initiator writes Target's Doorbell register
  - If Target is Suspended (idle), Target will re-examine next_ORB field in final ORB
  - If Target is not Suspended, Doorbell has no effect
- Either way, the new ORB will be executed as soon as possible
SBP-2 Operation
(after first time - special)

- Initiator knows Target is in Suspended (idle) state
  - Possible if all previous ORBs have completed
- Initiator may write a new ORB Pointer directly to the Target's ORB Pointer register
- Target will fetch the new ORB immediately
- Indirection of re-fetching the previous ORB is avoided
- This optimization is allowed by SBP-2 today
SBP-2 Start-up Latency

- To execute an ORB, the Target must know
  - The ORB Pointer
  - The ORB contents (command, buffer, etc.)
  - Page Tables (for some transfers)
- Target needs three transactions on 1394 to learn each of these three items
  - Each is a small packet on 1394, so arbitration (5-6 times) and overhead (headers and CRC) dominate
  - Between each packet, other nodes may use the bus
SBP-2 Start-up Latency

Initiator

- ORB Pointer (8 byte block write)
- ORB fetch (32 byte block read)
- ORB (32 byte block read response)
- PTE fetch (8+ byte block read)
- PTE (8+ byte block read response)
- First payload transfer (read or write)

Target
Does Latency Matter?

- If Target device is kept busy with multiple requests, Target can fetch ORBs in advance (in parallel with ORB execution)
- If transfers are large, payload I/O dominates bus usage, and 1394 efficiency is high
- But this usage is not typical on most computers
When Latency Matters

• Small transfers, such as VM paging
  – Just 4K per I/O; only on demand; random addresses

• Serial transfers
  – Each I/O must complete before next can be requested
  – Example: Directory scan (transfers are small too)
Proposal: Fast-start Packet

- Initiator sends ORB pointer, ORB contents, and page table together in one 1394 packet
- "Fast-start" packet is larger, so more efficient
- Several 1394 arbitration cycles are avoided
- Only used when Initiator knows Target is Suspended (idle)
  - Otherwise, use traditional ORB append (Doorbell)
Fast-start Packet Format

- ORB_Pointer (8 bytes)
- ORB (32 bytes is typical)
- PTE(s) (8 bytes or more)
Implementing Fast-start

• Few new demands on Target
  – Target already stores ORB Pointer, ORB contents, and page table entries (at least one)
  – Target must indicate fast-start capability
  – Target must recognize fast-start packet

• Few new demands on Initiator
  – Initiator must assemble Fast-start packet
  – Initiator must identify fast-start packet as such
  – Initiator "good behavior" reduces Target complexity
Indicating Fast-start Capability

- New Key in Target's 1394 Config ROM
  - Root, Unit, or LUN directory
- Or, indicate in SBP-2 Login response
- Proposal: New key in Unit or LUN directory
  - Not all LUNs (or Units) created equal
  - New key ignored by legacy software
- Cost: 4 bytes in Config ROM
Identifying a Fast-start Packet

• ORB_Pointer register is 8 bytes
  – Too small to absorb Fast-Start packet
• Proposal: Define a new register address based on Fetch Agent address
  – SBP-2 already allows vendor / protocol-specific registers in this area
  – So, allow the Target to indicate an offset in the new key
## Fetch Agent Registers

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Agent_State</td>
<td>Agent_Reset</td>
<td>ORB_Pointer</td>
<td>Doorbell</td>
</tr>
<tr>
<td>Unsolicited_Status_Enable</td>
<td>reserved</td>
<td>reserved</td>
<td></td>
</tr>
</tbody>
</table>
SBP-2 Features Key

- 4-byte key in 1394 Config ROM indicates:
  - Capability for Fast-start
  - Maximum PTE count in Fast-start packet
  - Address of Fast-start register
- Key has room for additional SBP-2 features
### SBP-2 Features Key

<table>
<thead>
<tr>
<th></th>
<th>3E&lt;sub&gt;16&lt;/sub&gt;</th>
<th>reserved</th>
<th>fs</th>
<th>offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>8</td>
<td>13</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

- **3E<sub>16</sub>:** proposed Key_Type / Key_Value pair
- **fs:** fast_start_feature
  - Zero if not supported
  - Encodes max PTE count in Fast_start packet \((2^{n-1})\)
- **offset:** location of Fast_start register
  - Relative to Fetch agent base location (in quadlets)
Summary of Fast-start Advantages

- Reduced latency for small and/or serialized I/O
- More efficient use of 1394 bus
- No performance loss in any scenario
- Full backwards compatibility
- Completely optional
- Low cost in ROM and Target firmware
Contact Information

Questions, suggestions, and discussion are welcome:

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