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SoftSSD: enabling rapid flash firmware prototyping for solid-state drives

Key words: Solid-state drives; Storage system; Software hardware co-design

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Motivation

1. The research of flash firmware has been mostly based on simulations due to the lack of a realistic and extensible solid-state drive (SSD) development platform.
2. Hardware-based SSD development platforms are not user-friendly to firmware developers who are more familiar with software design.
3. A novel software-oriented and flexible SSD development platform is proposed and implemented for rapid flash firmware prototyping.

Design

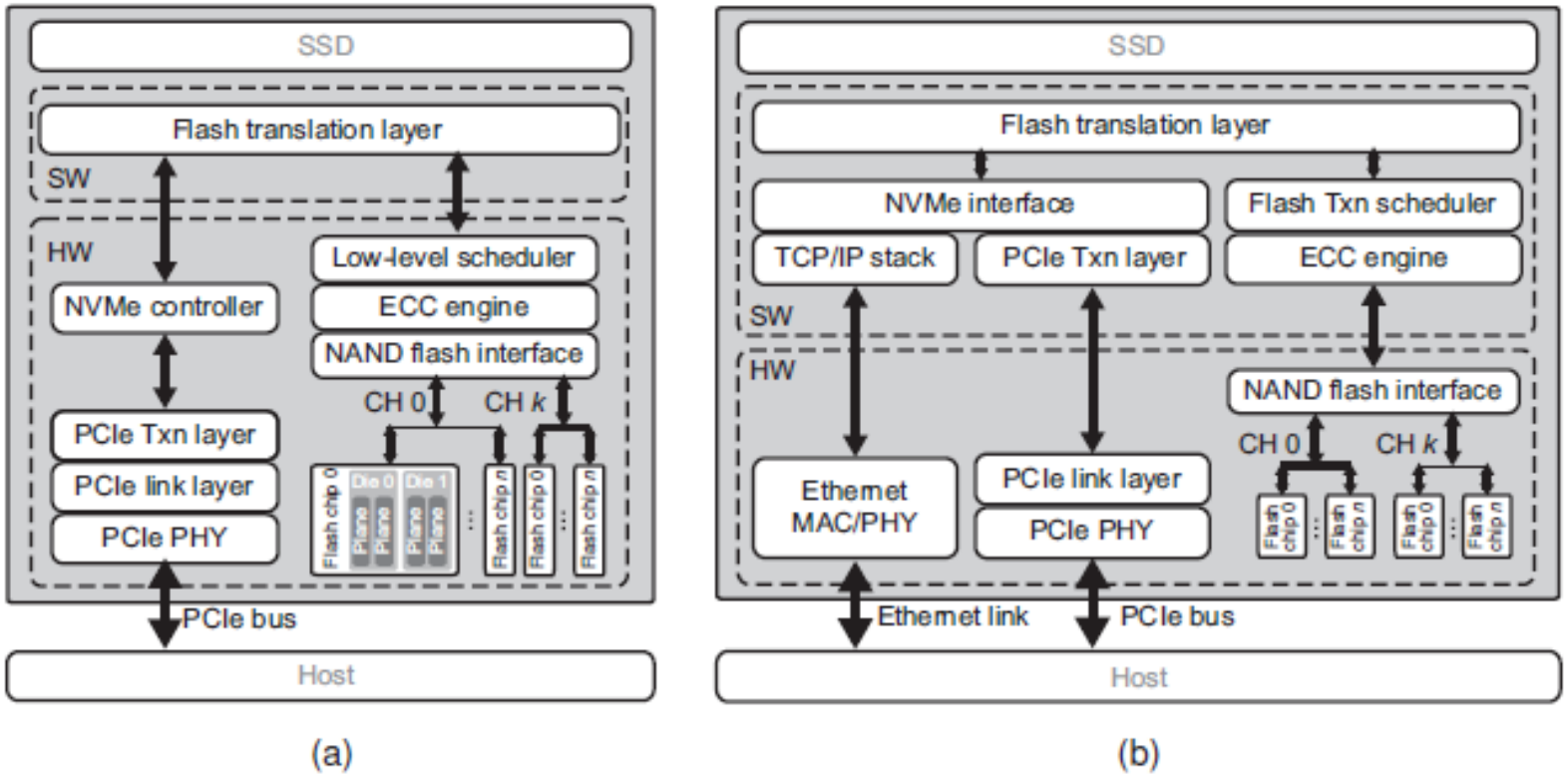

Fig. 1 Comparison of existing hardware-oriented platforms (a) and SoftSSD (b)

Design (Cont'd)

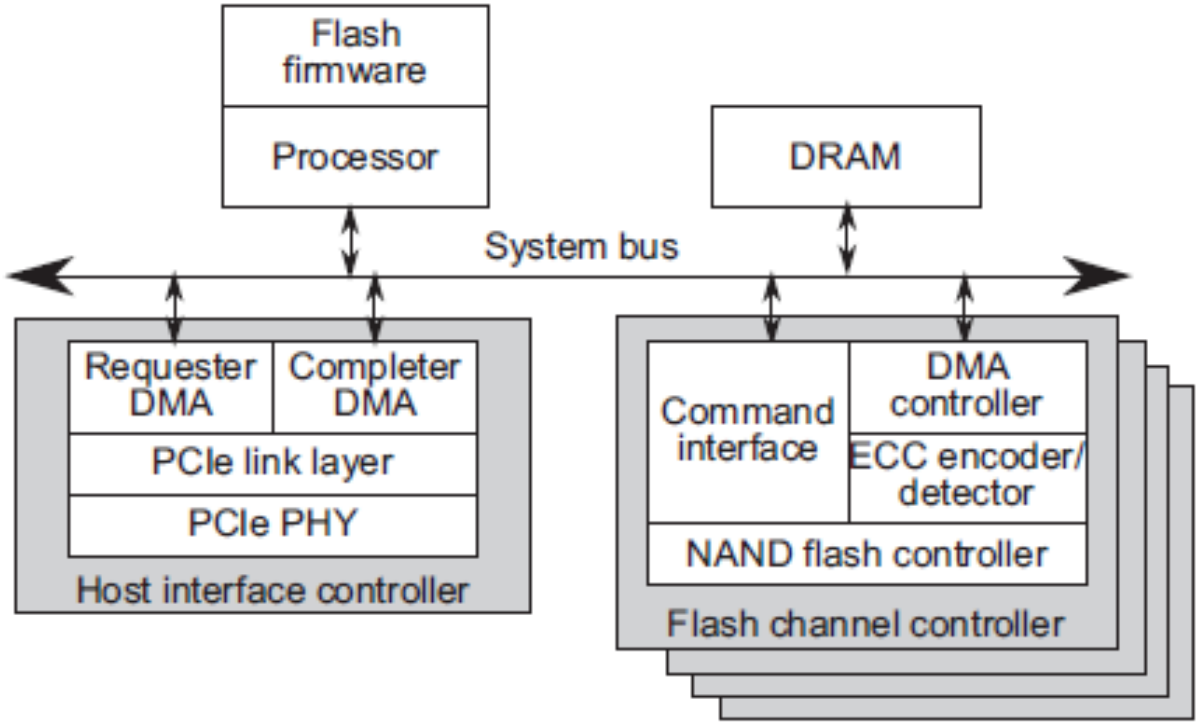

Fig. 2 Overall architecture of the SoftSSD hardware components

Design (Cont'd)

An easy-to-use application programming interface for flash firmware to interact with the host is proposed.

```
void pcie_mem_read_callback(int bar_nr,
    unsigned long addr, u16 requester_id, u8
     tag, size_t len);
void pcie_mem_write_callback(int bar_nr,
    unsigned long addr, const u8* buf,
    size_t len);
int pcie_send_completion(unsigned long addr,
     u16 requester_id, u8 tag, const u8*
    buffer, size_t count);
int pcie_dma_read(unsigned long host_addr,
    u8* buffer, size_t count);
int pcie_dma_write(unsigned long host_addr,
    const u8* buffer, size_t count);
void pcie_send_msi(u16 vector).
```

Design (Cont'd)

Requests are scheduled with a coroutine framework to overlap computation and input/output operations.

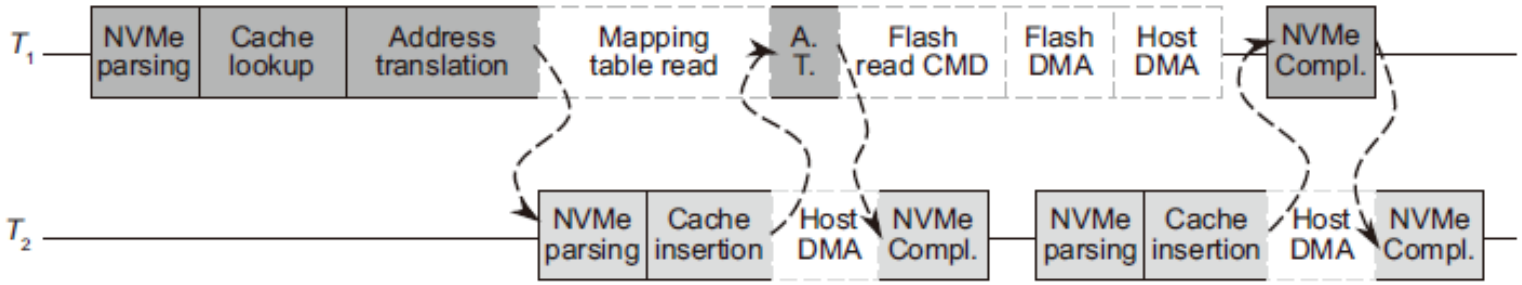

Fig. 5 An example of request processing under the proposed programming model with two threads

Development board

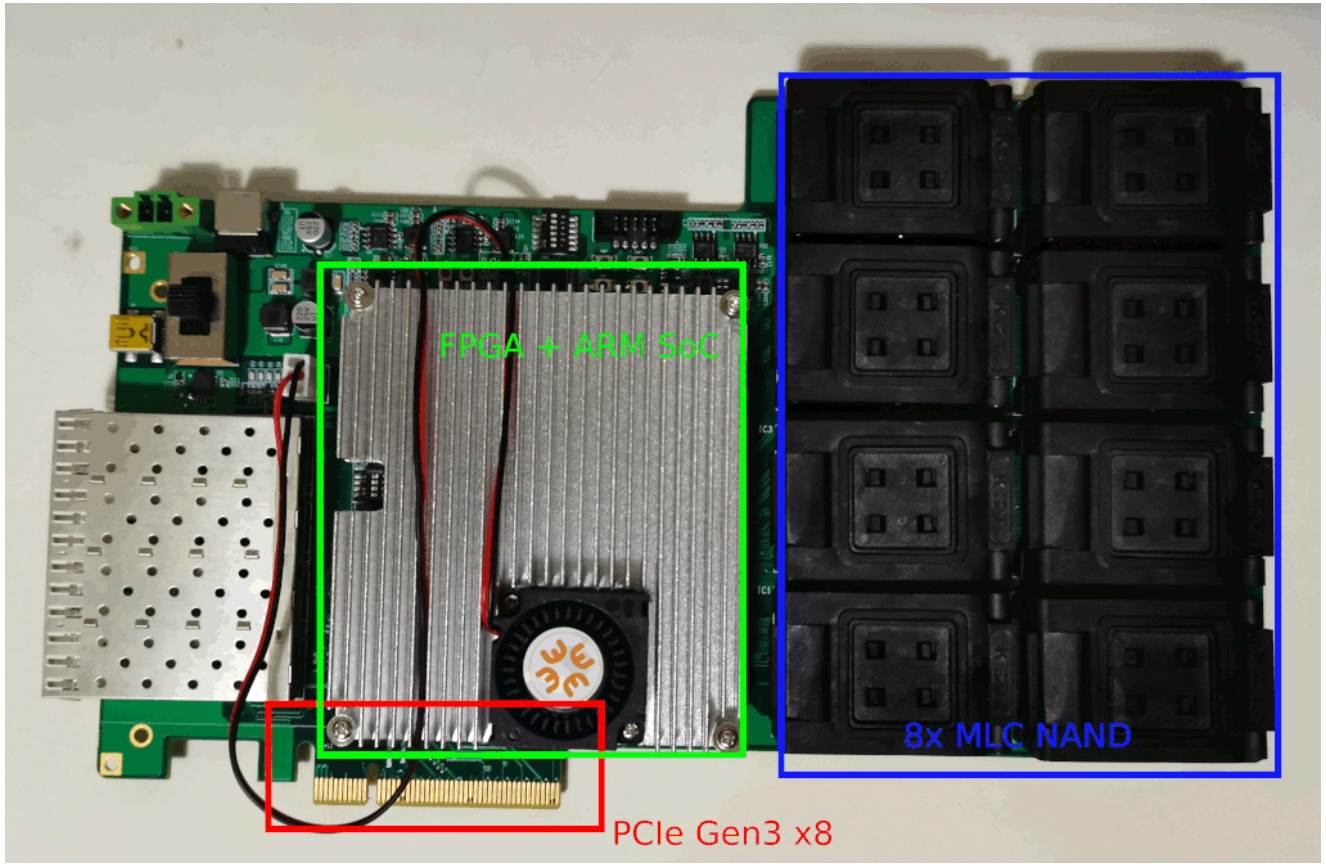

Fig. 7 Hardware development board of SoftSSD prototype

Conclusions

1. We proposed SoftSSD, which enables rapid prototyping of flash firmware on a real hardware platform.
2. We implemented the majority of components in pure software so that SoftSSD can provide better observability of the internal states in the SSD.
3. We conducted experiments with real application workloads to demonstrate the performance of SoftSSD as a standard storage device.