The Virtual Block Interface: A Flexible Alternative to the Conventional Virtual Memory Framework

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Computing Systems Are Diversifying

Application

Virtual Memory
managed by the operating system

Hardware

Cannot adapt efficiently
Motivation, Goal, and Key Idea

• Continually adapting the conventional virtual memory framework is **challenging**

• Prior work for optimizing virtual memory
  - Applicable to only **limited** problems or applications
  - **Not compatible** and can not be implemented in a single system

• **Goal:** Design an alternative virtual memory framework that
  - **Efficiently** and **flexibly** supports increasingly diverse system configurations
  - Provides the **key features** of conventional virtual memory framework while eliminating its **key inefficiencies**

• **Virtual Block Interface (VBI):** A new virtual memory framework
  - **Key Idea:** Delegate physical memory management to dedicated hardware in the memory controller
VBI: Overview

Conventional Virtual Memory

Virtual Address Space (VAS)

Processes

one-to-one mapping (OS)

Page Tables
managed by the OS

Physical Memory

VBI

Virtual Blocks (VB)

Processes

many-to-many mapping (OS)

Memory Translation Layer
in the memory controller

Physical Memory
Key Optimizations and Results

• **Benefits:** Many optimizations not easily attainable before. Examples:
  - Appropriately sized process address space
  - Flexible address translation structures
  - Communicating data semantics to the hardware
  - Inherently virtual caches
  - Eliminating 2D page walks in virtual machines
  - Delayed physical memory allocation
  - Early memory reservation mechanism

Inherent to VBI design

• **Evaluation:** Two example use cases
  - VBI significantly improves performance in both native execution and virtual machines (by 2.4x and 4.3x on average, respectively)
  - Increases the effectiveness of managing heterogeneous memory architectures

Covered in the paper

**VBI is a promising new virtual memory framework**
- Can enable several important optimizations
- Increases design flexibility for virtual memory
- A new direction for future work in novel virtual memory frameworks
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