

Process Migration for Lightweight Manycore Processors in a Distributed Operating System

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Presentation Outline

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Virtualization

Migration

Pre-Copy Migration

Post-Copy Migration

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LW Processors

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Motivation And
Justify

- **Transferring a process between machines**
- Proposed for:
 - Load balancing
 - Fault tolerance
 - System administration
 - Data access locality
- Arising of distributed systems
- Solutions established:
 - MOSIX (1985)
 - V (1988)
 - OSF/1 AD TNC (1995)

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Process Migration

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Motivation And
Justify

- Despite the research efforts, **migration has not achieved widespread use**
- Treating residual dependency is a difficult task:
 - Opened files stored in the source node
 - Opened communicators with other processes
 - Shared resources
 - Internal kernel state.
- Solution: Virtualization

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- Solution: **Virtualization**

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Motivation And
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- Create a **Virtual Version** of Computing Resources
 - CPU
 - Memory
 - Storage device
 - Network device
- Features
 - Improved previous features
 - Power management
 - Isolation
 - Security
- Two types
 - Virtual Machines (VM)
 - Containers



Virtualization

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Virtual Machines (VM)

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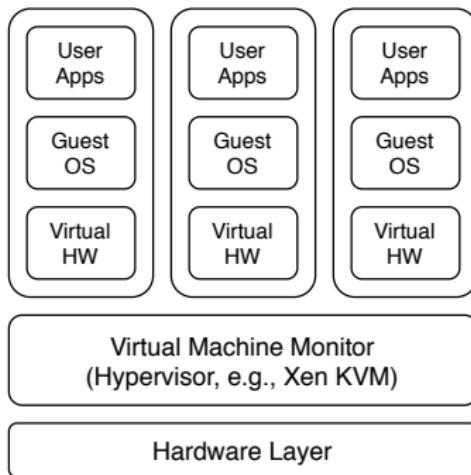
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Motivation And Justify

- Encapsulates a whole operating system
- Depends on a Hypervisor to provide the hardware resources
 - Full virtualization
 - Paravirtualization



Migration of VMs

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Motivation And
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■ Memory content

- Hypervisor allocate memory
- Guest OS allocate memory
- Application requested memory

■ Disk content

- Hypervisor allocate blocks
- Guest OS and Application used blocks



Migration of VMs

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Motivation And
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- **Memory content**
 - Hypervisor allocate memory
 - Guest OS allocate memory
 - Application requested memory
- **Disk content**
 - Hypervisor allocate blocks
 - Guest OS and Application used blocks



Containers

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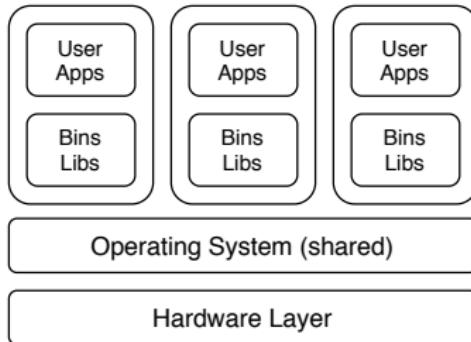
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Motivation And
Justify

- OS-level virtualization
- Multiple isolated user space instances (Shared OS)
- Lightweight compared to VMs
 - Linux Containers
 - Docker



Migration of Containers

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Motivation And
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- Transfer the file system of the container
- Save the state of the container into a file (all processes and their resources)
- Transfer the container file
- Restart the container



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Process Migration

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Motivation And
Justify

- Generally, there are **three stages of memory transfer:**
 - Push Copy (iteration copy) stage
 - Stop-and-Copy stage
 - Pull Copy (On-demand copy) stage
- Migration techniques
 - Stop-and-Copy
 - *Pre-Copy*
 - *Post-Copy*
 - Hybrid

Process Migration

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Motivation And
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- Generally, there are three stages of memory transfer:
 - Push Copy (iteration copy) stage
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- **Migration techniques:**
 - Stop-and-Copy
 - ***Pre-Copy***
 - ***Post-Copy***
 - Hybrid



Pre-Copy Migration

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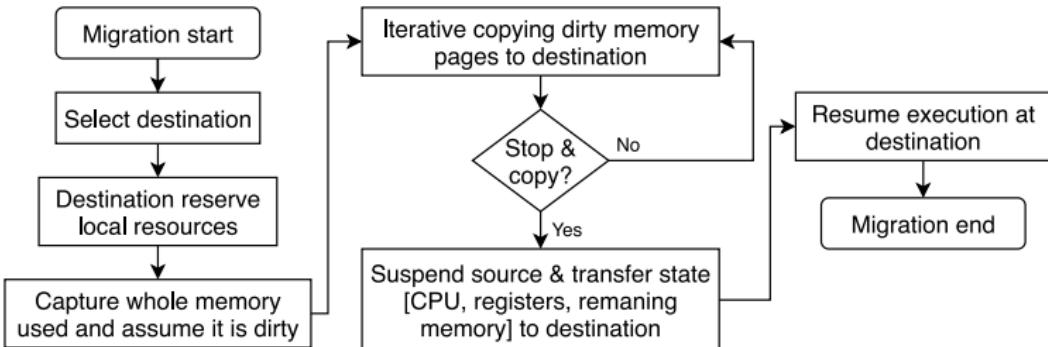
Post-Copy Migration

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Pre-Copy Scenario

Pre-Copy Migration

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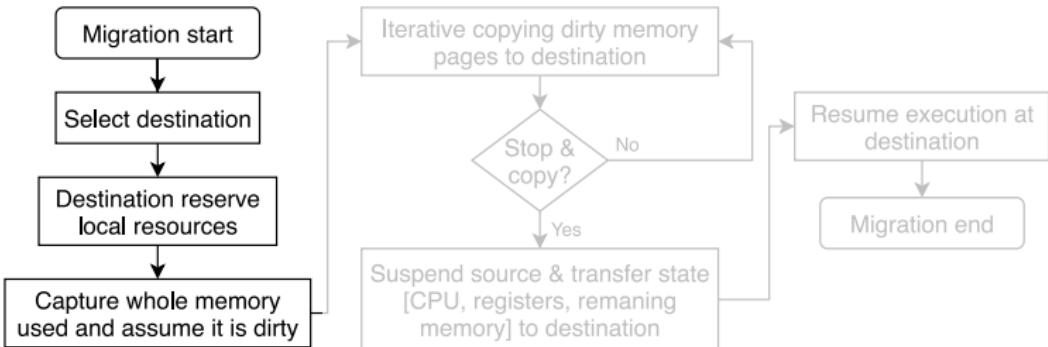
Post-Copy Migration

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Motivation And Justify



Resource reservation and **transfer preparation**

Pre-Copy Migration

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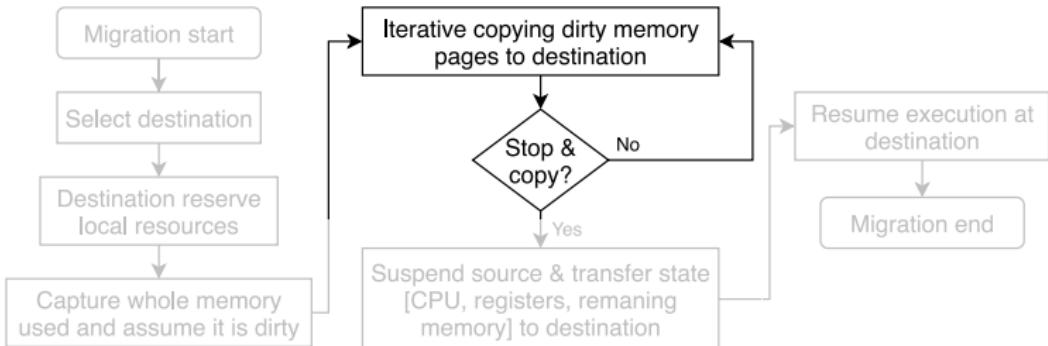
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Motivation And Justify



Sending the memory pages before the execution context

Push Copy Stage

Pre-Copy Migration

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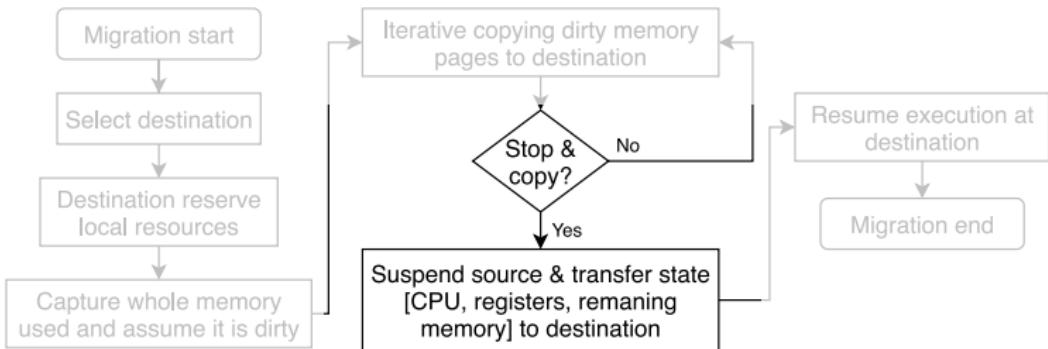
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Motivation And Justify



When enough memory has been transferred, send the execution context
Stop-and-Copy Stage

Pre-Copy Migration

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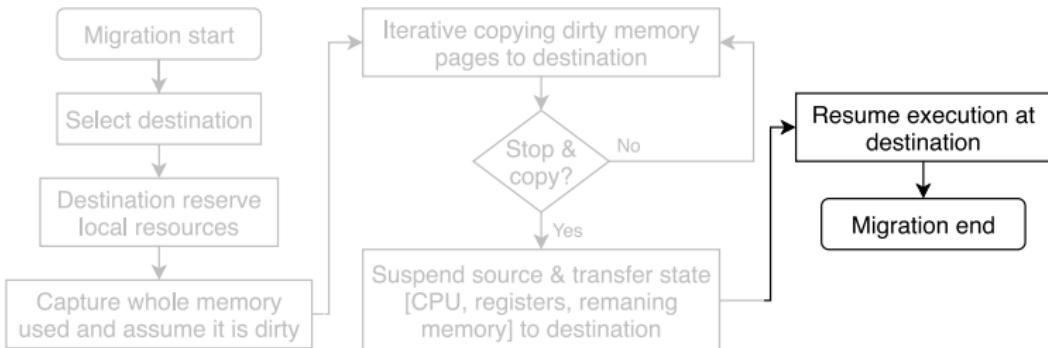
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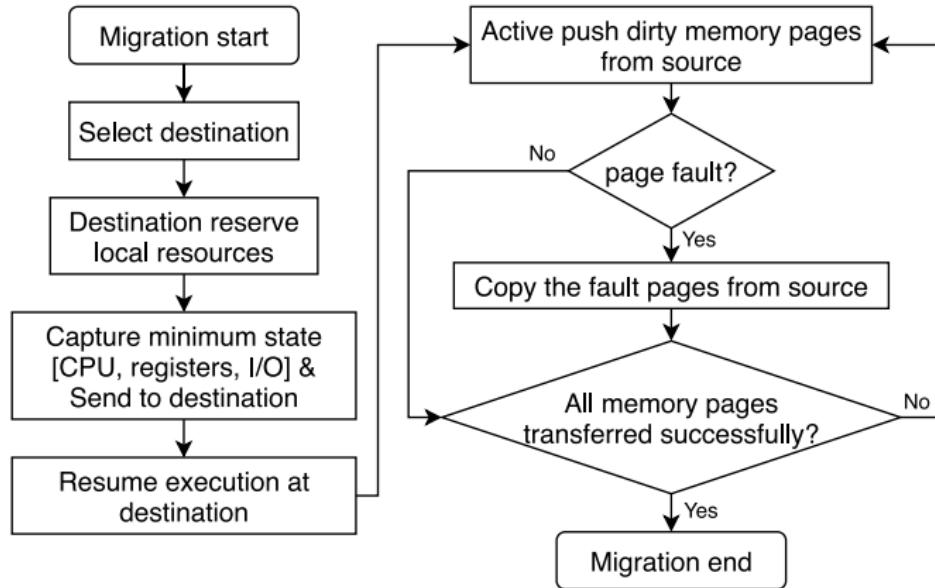
Motivation And Justify



Resume stopped execution context in the destination

Post-Copy Migration

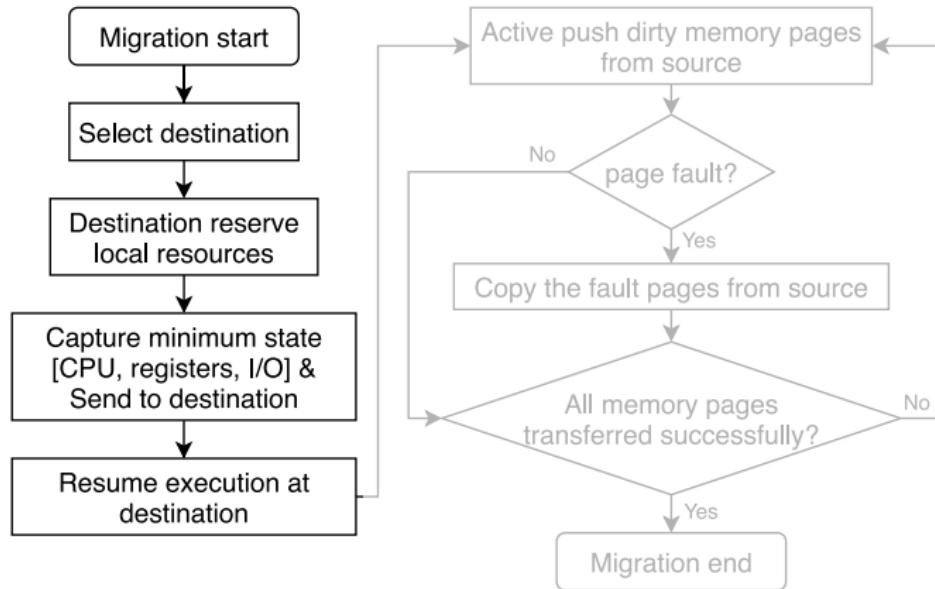
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Post-Copy Scenario

Post-Copy Migration

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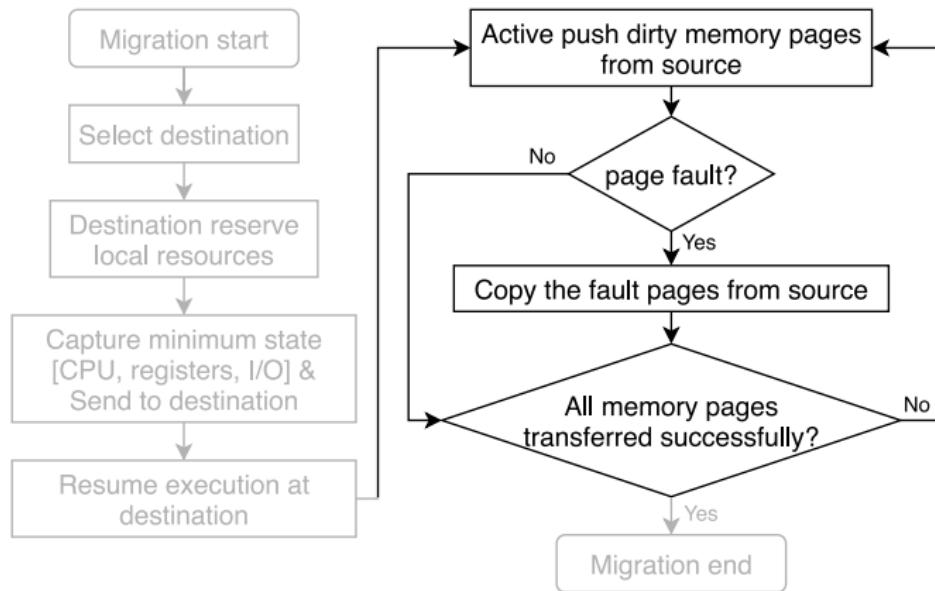


Sends execution context before memory pages

Stop-and-Copy Stage

Post-Copy Migration

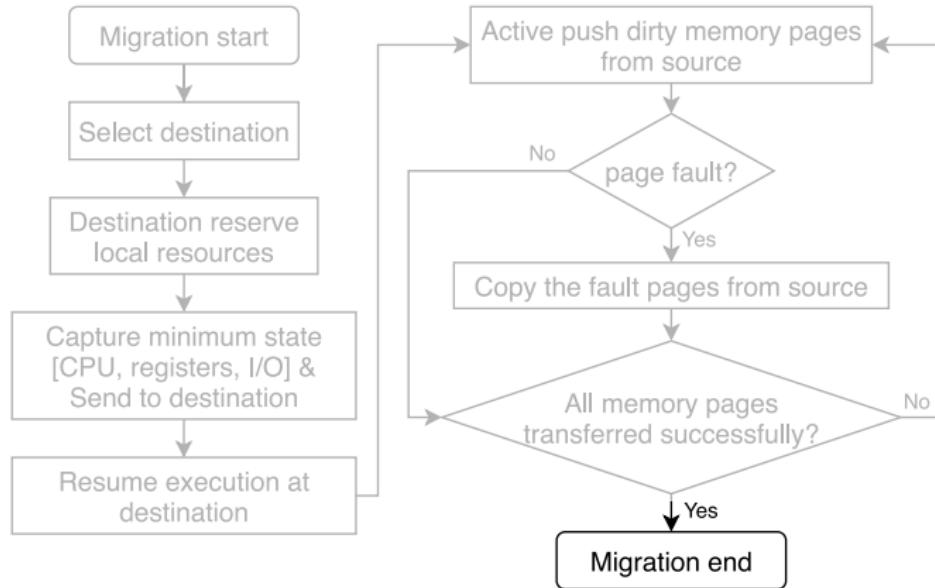
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Merges **pull rest of memory pages** and any page that generate **page faults**
Pull Copy Stage

Post-Copy Migration

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Continues execution normally

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Performance Metrics

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- Total Migration Time
- Downtime
- Pages Transferred
- Page Dirty Rate
- Preparation Time
- Resume Time
- Application Degradation
- Link Degradation



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Lightweight Manycores Processors

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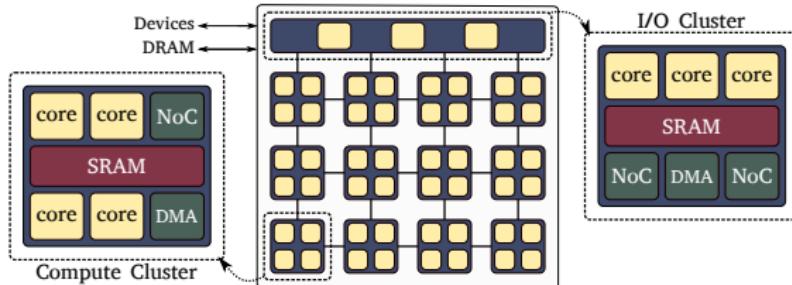
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Motivation And Justify



Overview of a Manycore

■ Hundreds of Lightweight Cores

- Expose Massive thread-level parallelism
- Feature low-power consumption
- Target MIMD workloads
- Distributed Memory Architecture
- On-Chip Heterogeneity

Lightweight Manycores Processors

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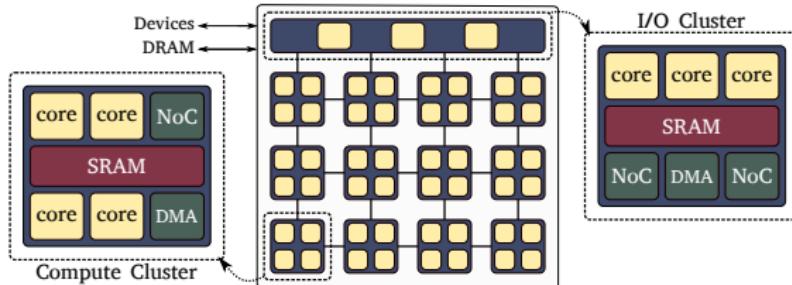
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Motivation And Justify



Overview of a Manycore

- Hundreds of Lightweight Cores
- **Distributed Memory Architecture**
 - Grants scalability
 - Relies on a Network-on-Chip (NoC)
 - Has constrained memory systems
- On-Chip Heterogeneity

Lightweight Manycores Processors

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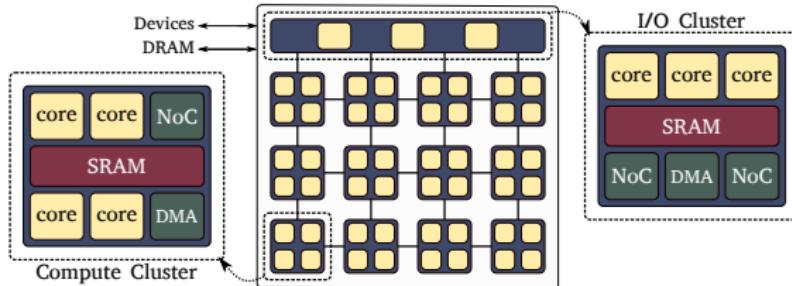
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Motivation And Justify



Overview of a Manycore

- Hundreds of Lightweight Cores
- Distributed Memory Architecture
- **On-Chip Heterogeneity**
 - Features different components

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A Lightweight Manycore Processor

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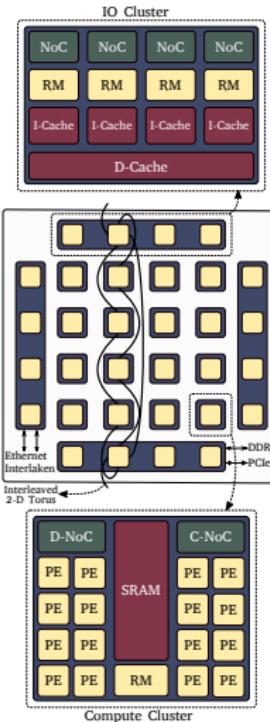
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Motivation And Justify

- **288 processing cores**
 - 16 Compute Cluster (CC)
 - 4 I/O Cluster (IO)

- **Data NoC (D-NoC)**
 - 256 RX slots
 - 8 TX channels
 - 8 μ threads for async TX

- **Control NoC (C-NoC)**
 - 128 RX slots
 - 4 TX channels



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Motivation And Justify

■ Motivation

- Historical evolution from single-cores to Lightweight Manycores

■ Contribution

- A Inter-Cluster Communication Facility for LW Processors

■ Results

- **Optimal sizes** for large data transfers
- Well-known **distributed algorithms can be efficiently supported** by Nanvix OS

■ Future Works on Nanvix OS

- Remove limitation on asynchronous send
- MPI port (BSc dissertation)
- Shared Memory Service (MSc dissertation)
- **Distributed Process Scheduling (MSc dissertation)**



Thank you!
Questions?

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