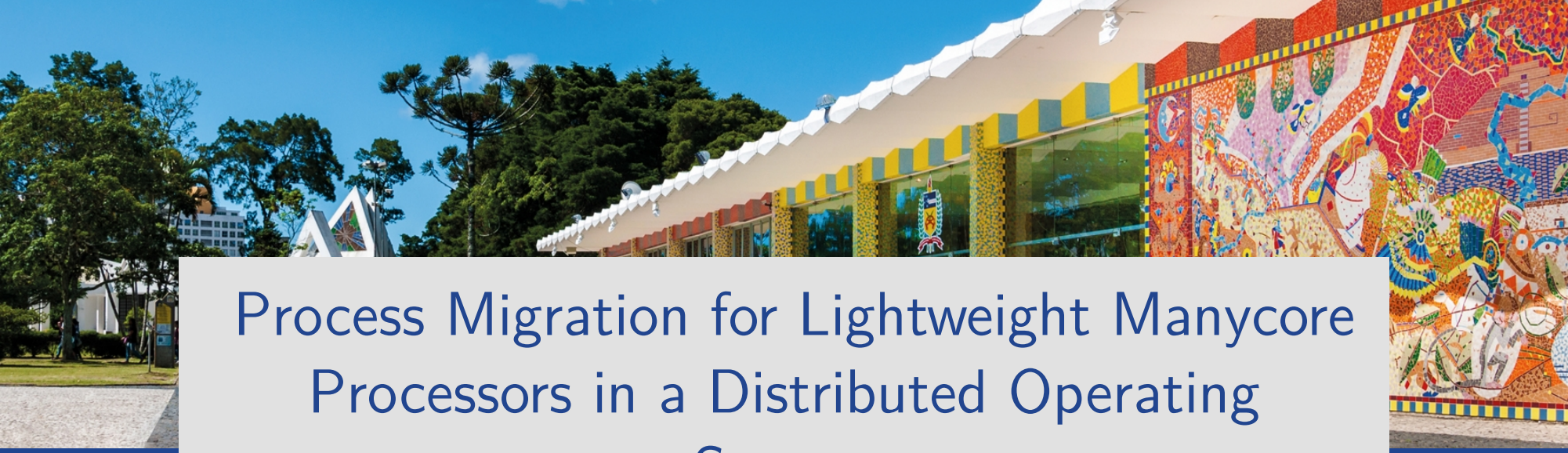

Process Migration for Lightweight Manycore Processors in a Distributed Operating System

João Vicente Souto

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Parallel Computing - Computer Science
INE/UFSC, Florianópolis

September 28, 2020

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Presentation Outline

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Virtualization
Migration
Pre-Copy Migration
Post-Copy Migration
Metrics
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Kalray MPPA-256
Motivation And Justify

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Motivation And Justify

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

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  - MOSIX (1985)
  - V (1988)
  - OSF/1 AD TNC (1995)
- **Transferring a process between machines**
- Proposed for:
  - Dynamic load distribution
  - Fault resilience
  - Improved system administration
  - Data access locality

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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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Process Migration

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Motivation And Justify

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  - Shared resources
  - Internal kernel state.
- Solution: **Virtualization**

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Virtualization

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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

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  - Containers

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Virtual Machines (VM)

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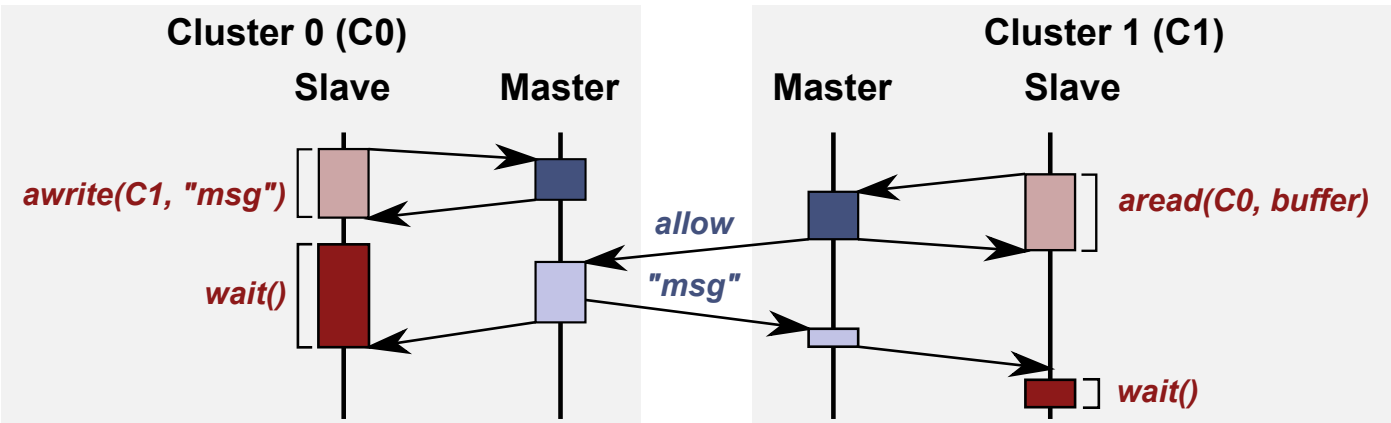
Motivation And Justify

- 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 Justify

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

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Migration of VMs

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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

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Containers

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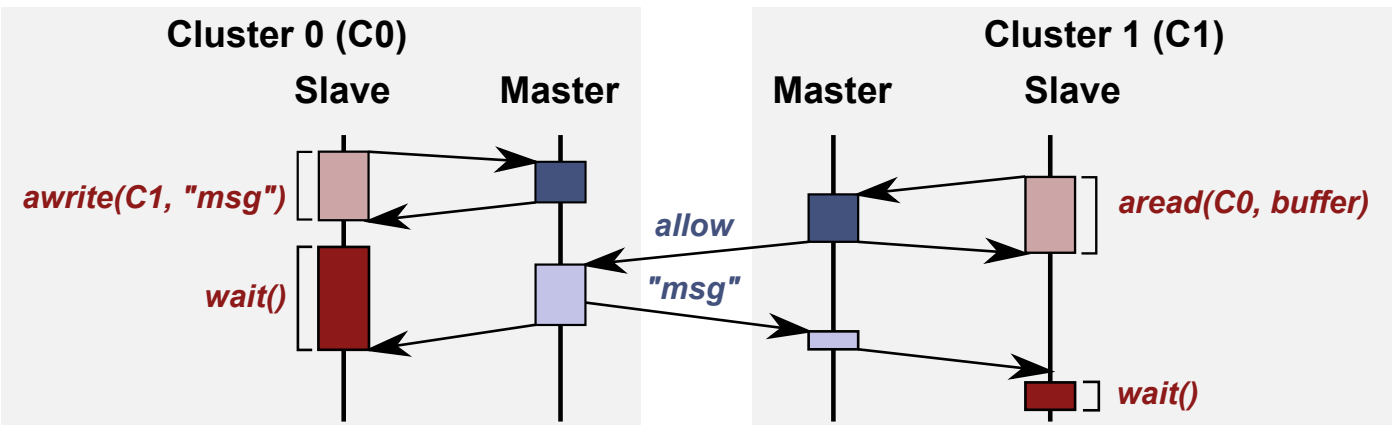
Motivation And Justify

- OS-level virtualization
- Multiple isolated user space instances (Shared OS)
- Lightweight compared to VMs
  - Linux Containers
  - Docker
- Example: Use *cgroups* and *chroot* to isolate a group of process and restrict their resource access.



Migration of Containers

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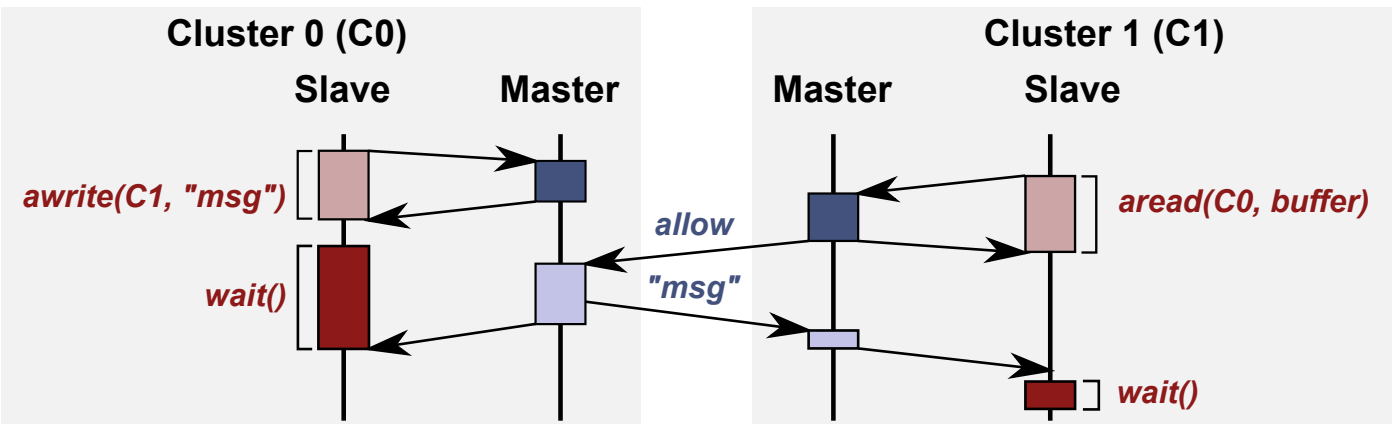
Motivation And Justify

- 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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Migration

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

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Process Migration

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Motivation And Justify

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  - Push Copy (iteration copy) stage
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  - Pull Copy (On-demand copy) stage
- **Migration techniques**:
  - Stop-and-copy
  - *Pre-Copy*
  - *Post-Copy*
  - Hybrid

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Pre-Copy Migration

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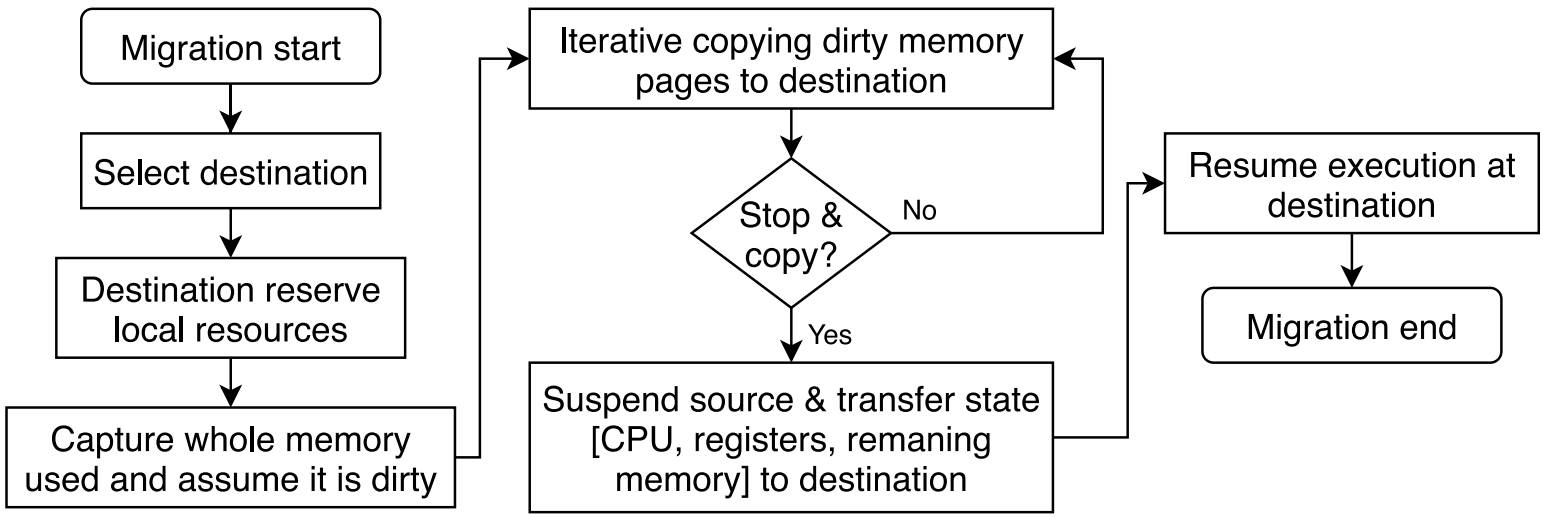
Motivation And Justify



Pre-Copy Scenario

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Pre-Copy Migration

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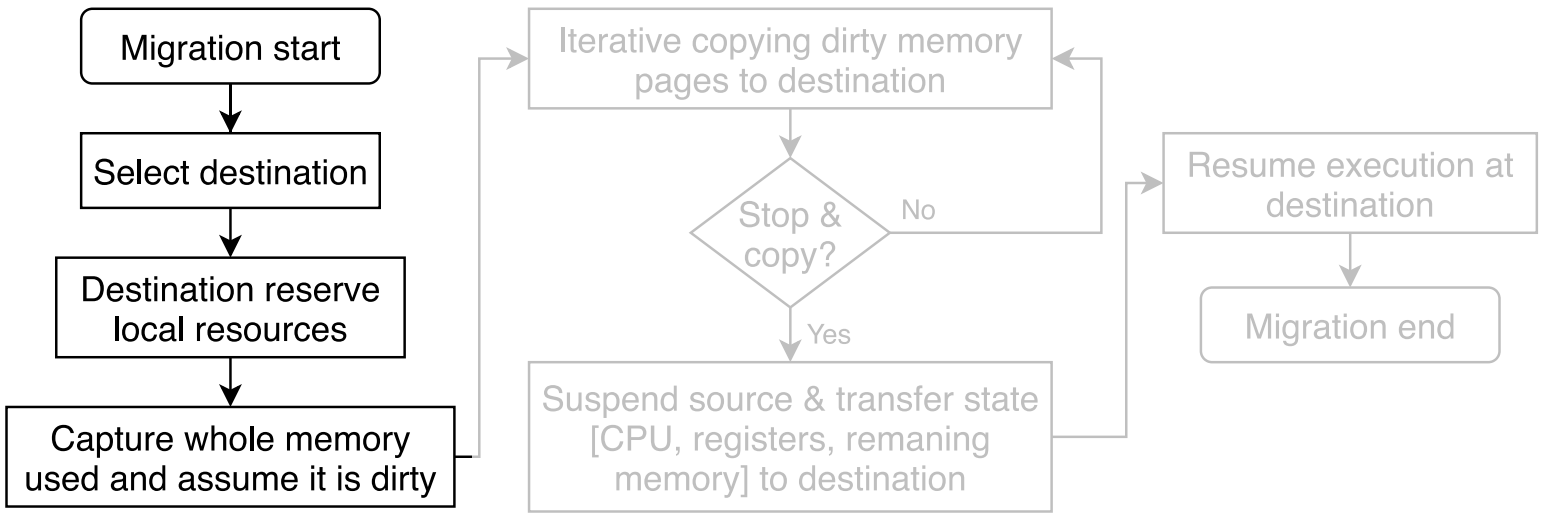
Motivation And Justify



Resource reservation and **transfer preparation**

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Pre-Copy Migration

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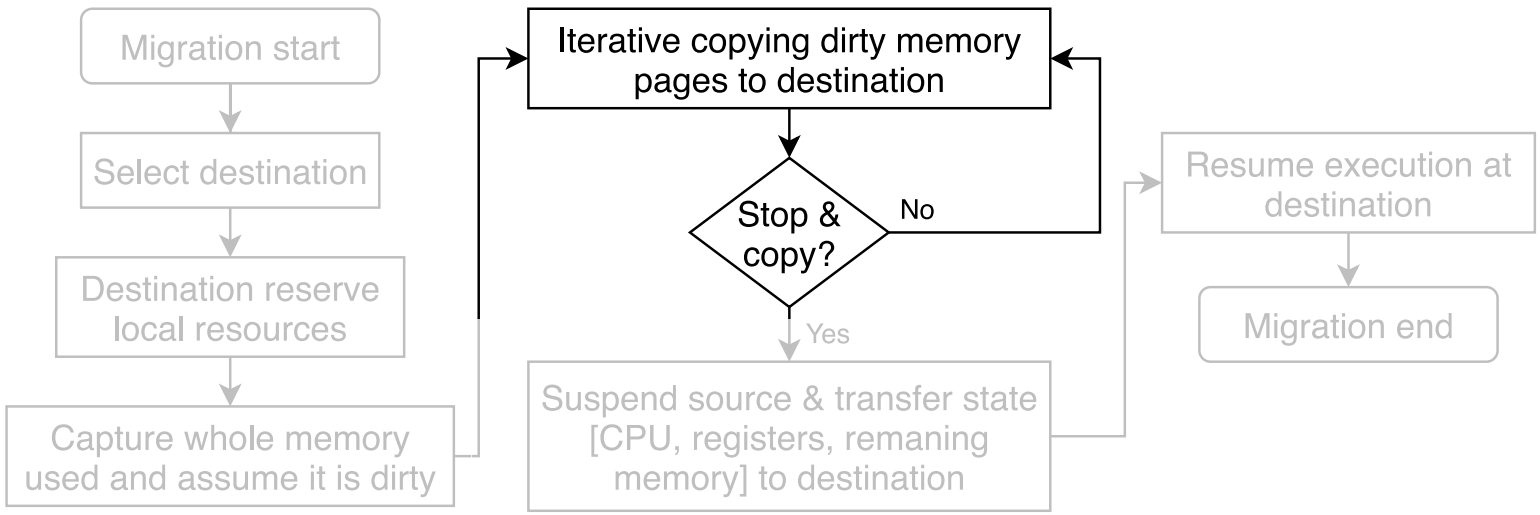
Motivation And Justify



Sending the memory pages before the execution context

Push Copy Stage

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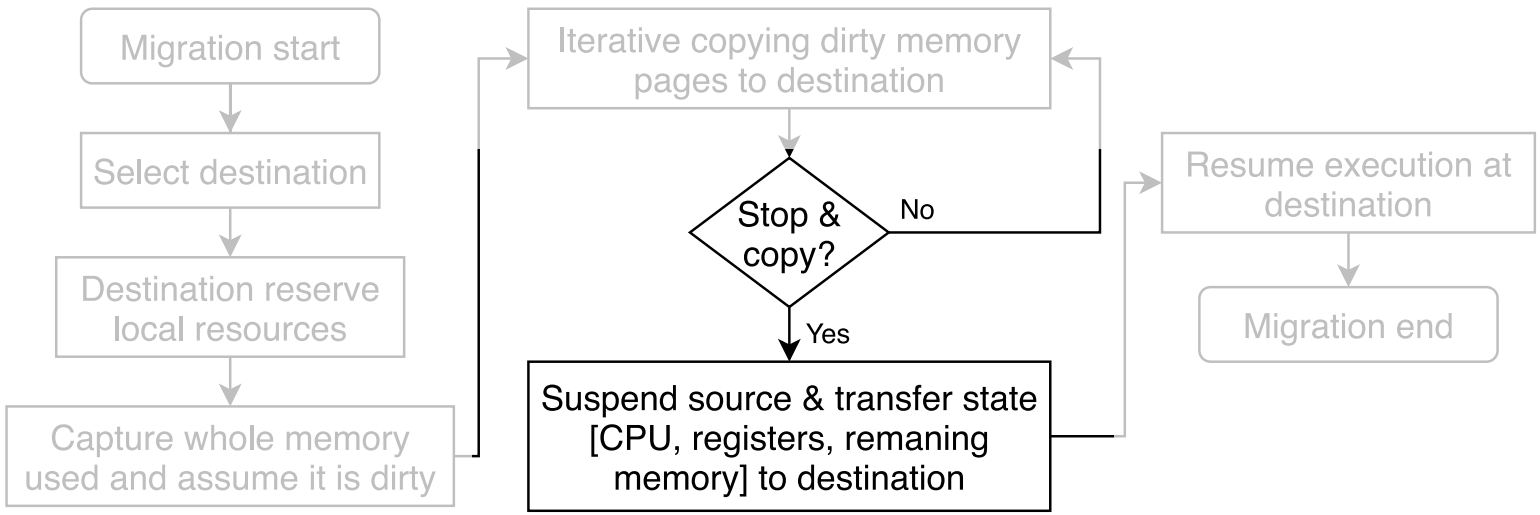
Motivation And Justify



When enough memory has been transferred, send the execution context

Stop-and-Copy Stage

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Pre-Copy Migration

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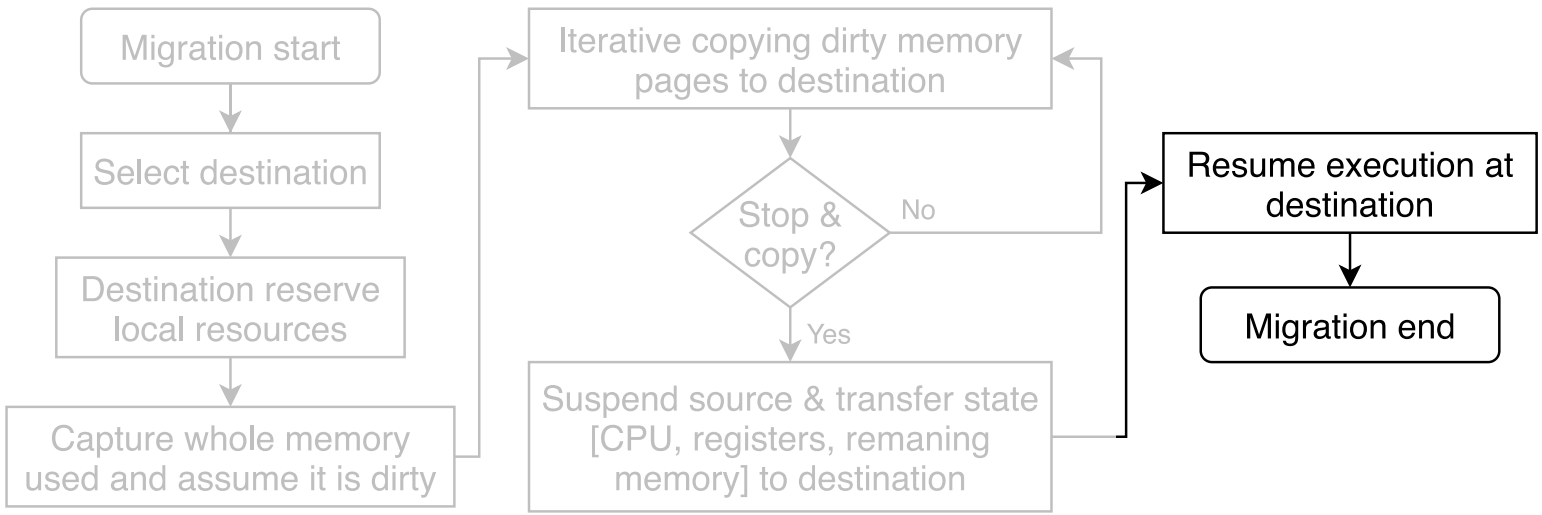

Resume stopped execution context in the destination

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Post-Copy Migration

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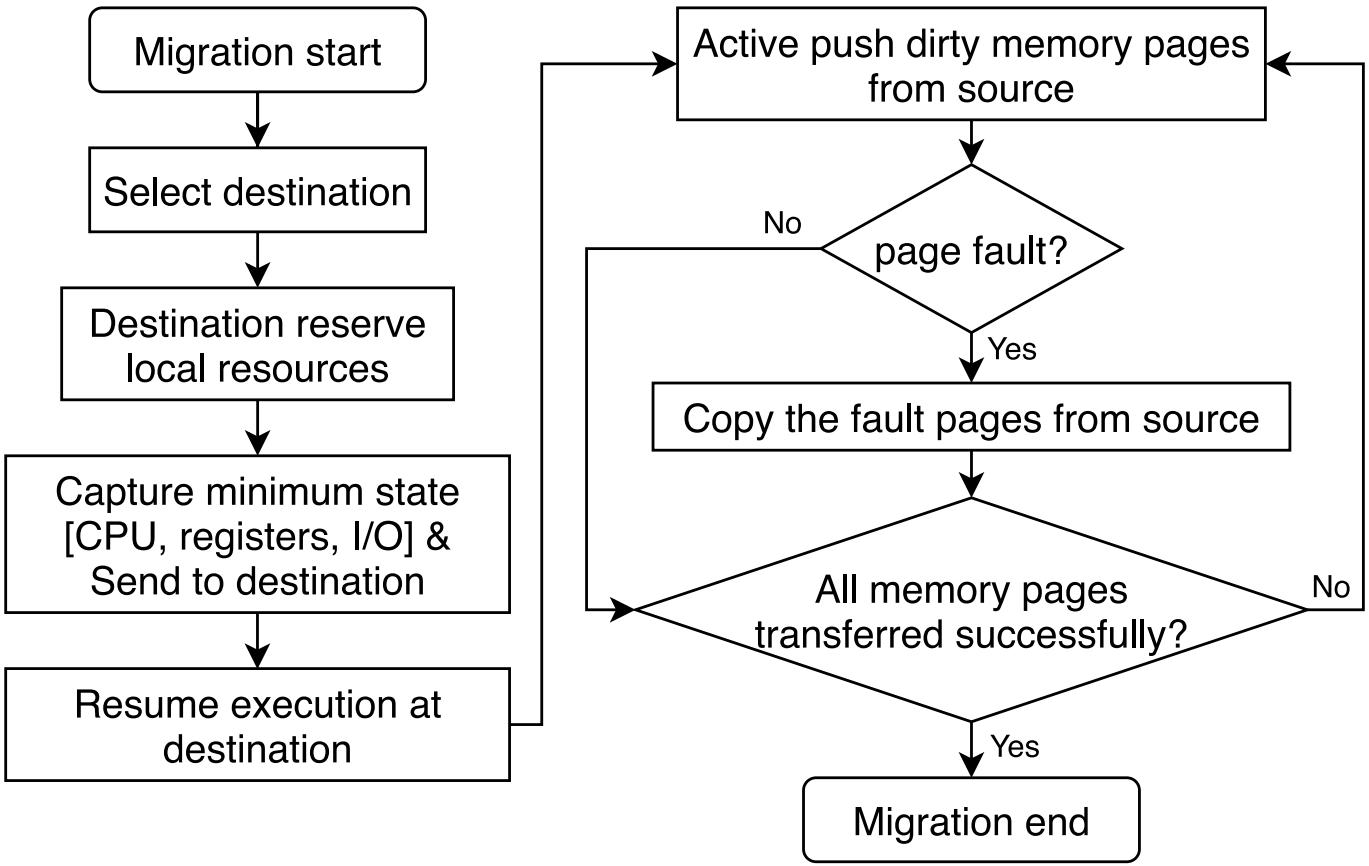

Post-Copy Scenario

Post-Copy Migration

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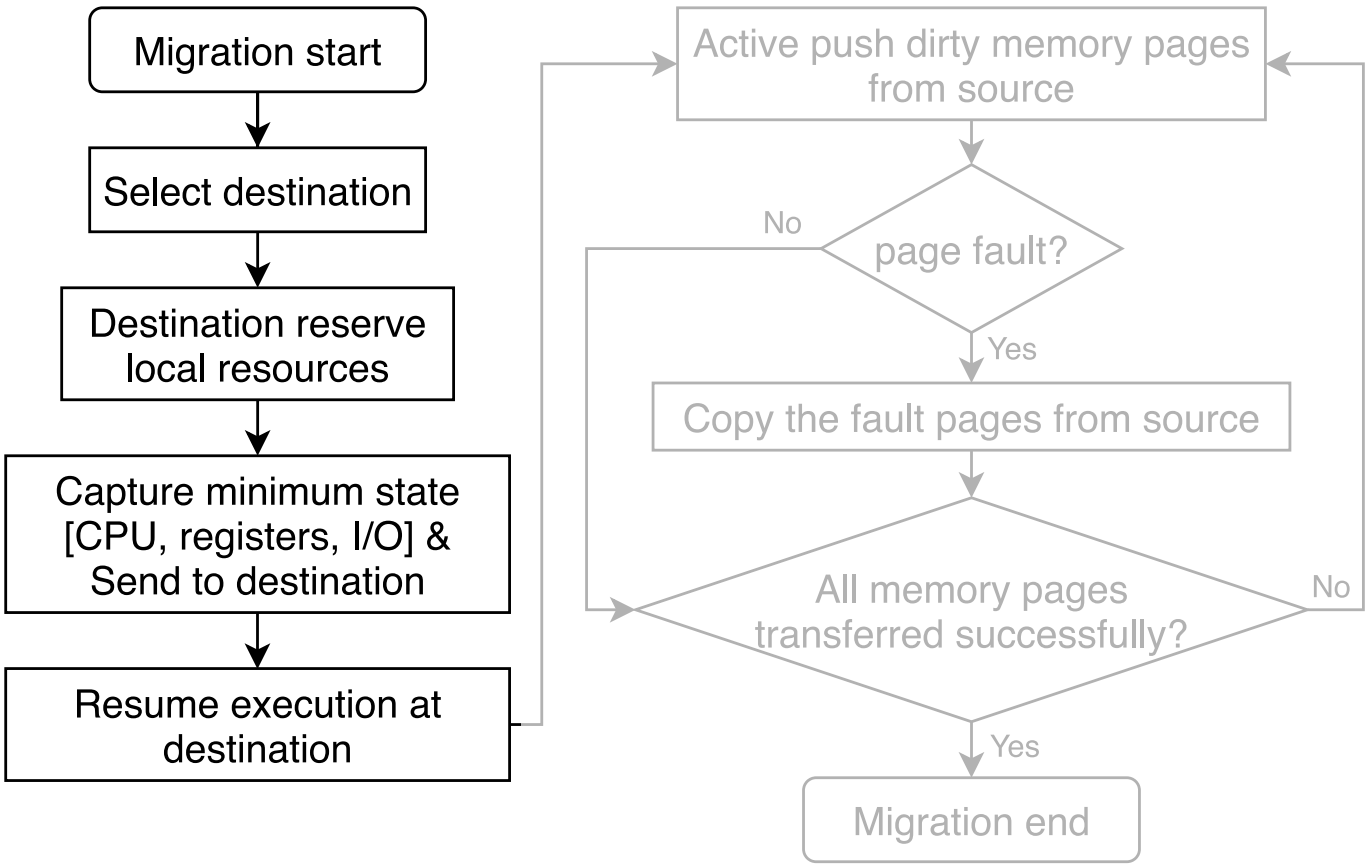

Sends execution context before memory pages

Stop-and-Copy Stage

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Post-Copy Migration

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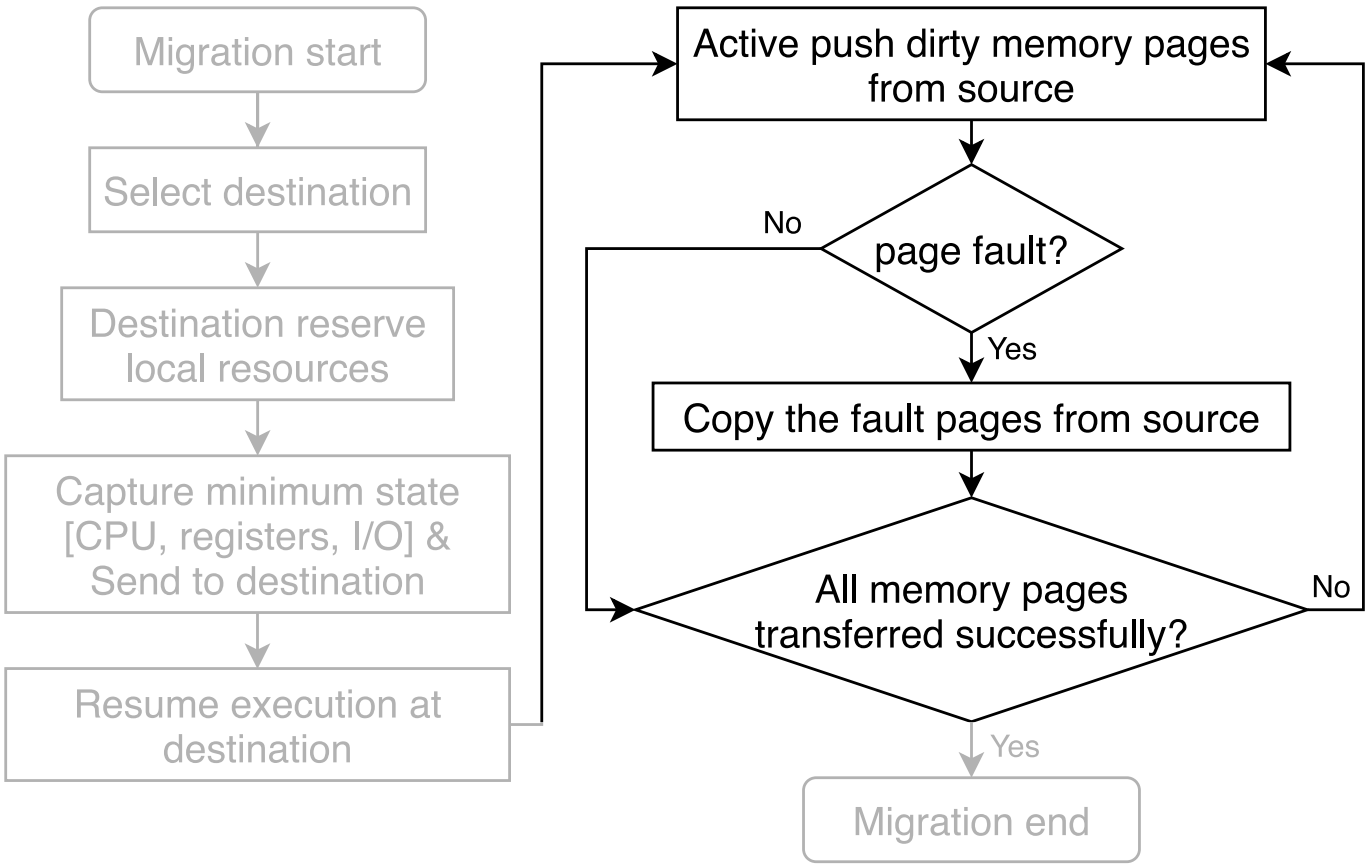

Merges **pull rest of memory pages** and any page that generate **page faults**

Pull Copy Stage

Post-Copy Migration

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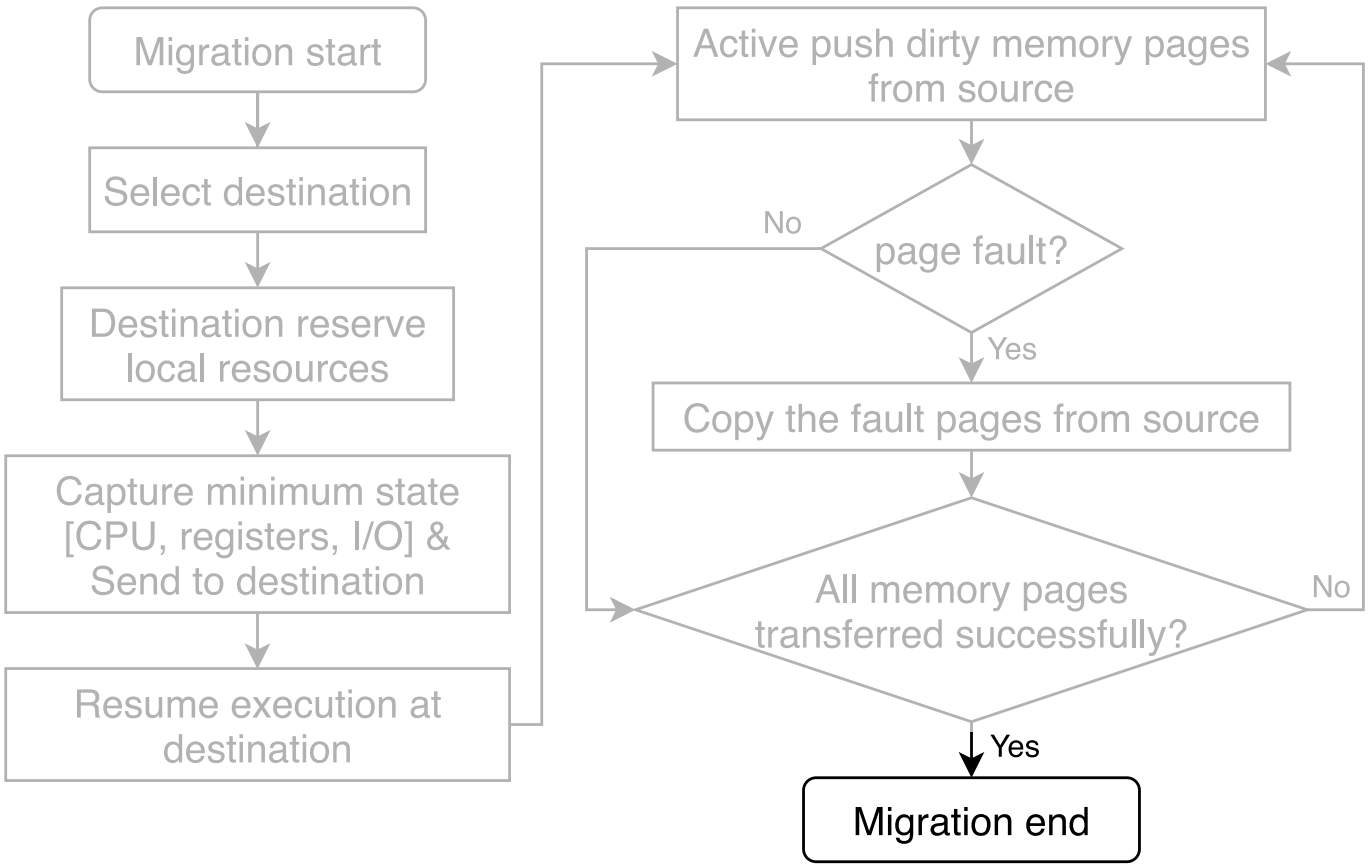

Continues to run normally

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Lightweight Manycores Processors

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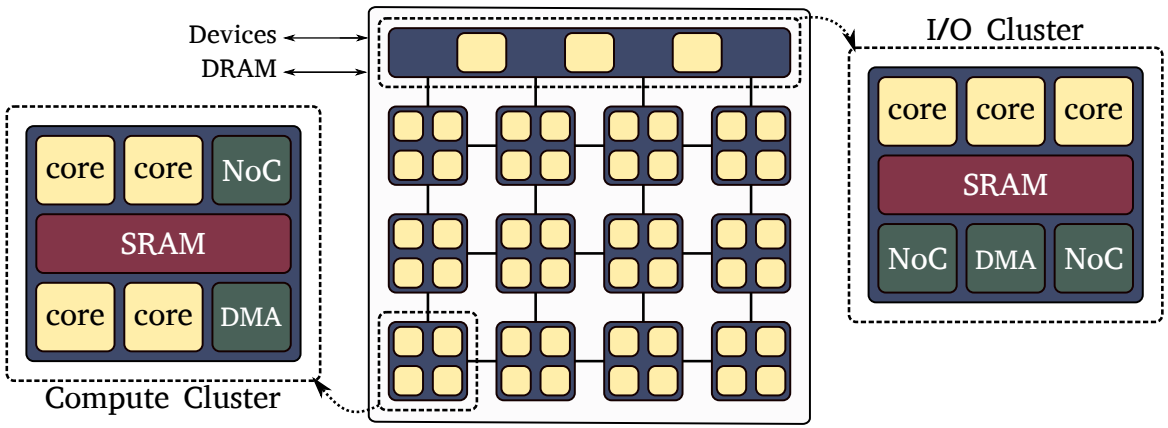

Overview of a Manycore

- **Hundreds of Lightweight Cores**
  - Expose Massive thread-level parallelism
  - Feature low-power consumption
  - Target MIMD workloads
- Distributed Memory Architecture
- On-Chip Heterogeneity

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Lightweight Manycores Processors

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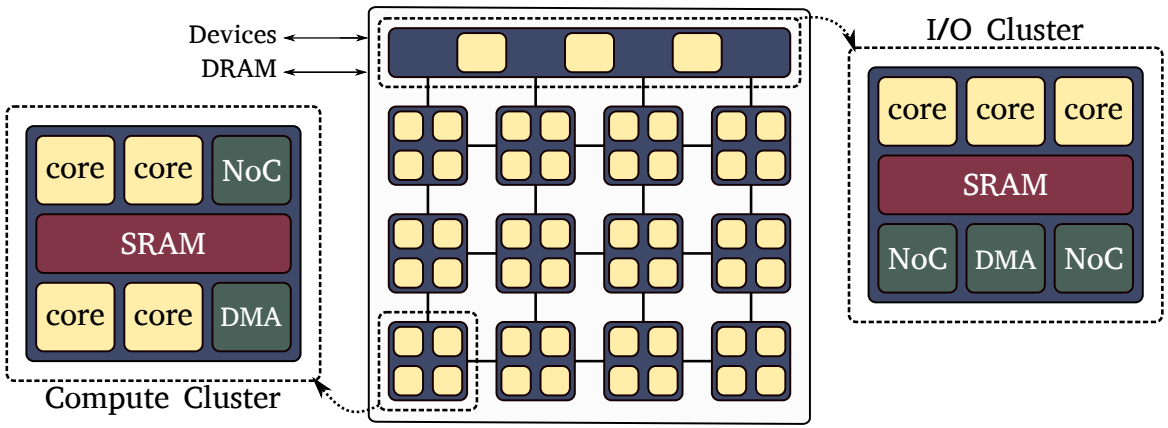

Overview of a Manycore

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

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Lightweight Manycores Processors

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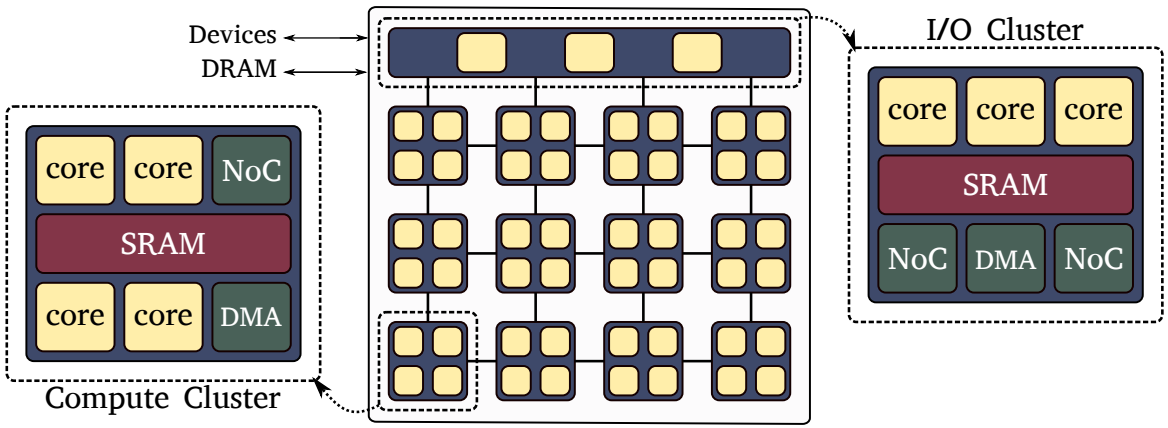

Overview of a Manycore

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

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Kalray MPPA-256

A Lightweight Manycore Processor

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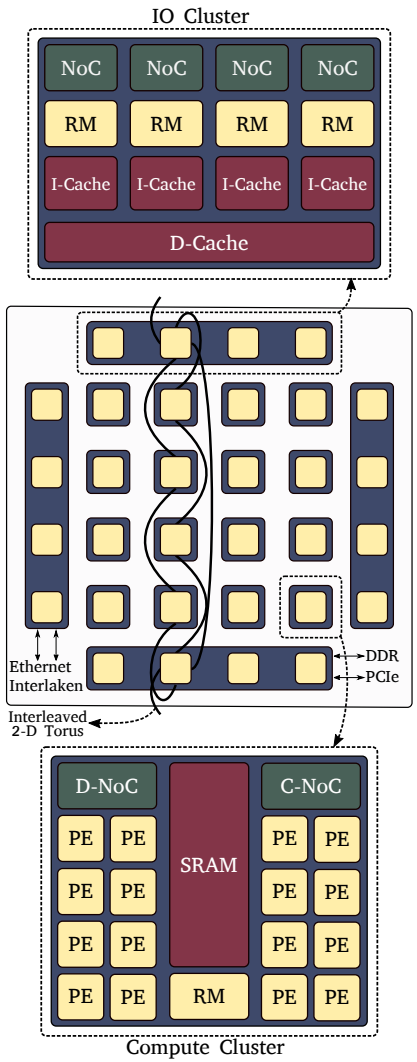
Motivation And Justify

- **288 processing cores**
  - 16 Compute Cluster (CC)
  - 4 I/O Cluster (IO)
- **Data NoC (D-NoC)**
  - 256 RX slots
  - 8 TX channels
  - 8 μthreads for async TX
- **Control NoC (C-NoC)**
  - 128 RX slots
  - 4 TX channels



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Conclusions

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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)**

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Thank you!
Questions?

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