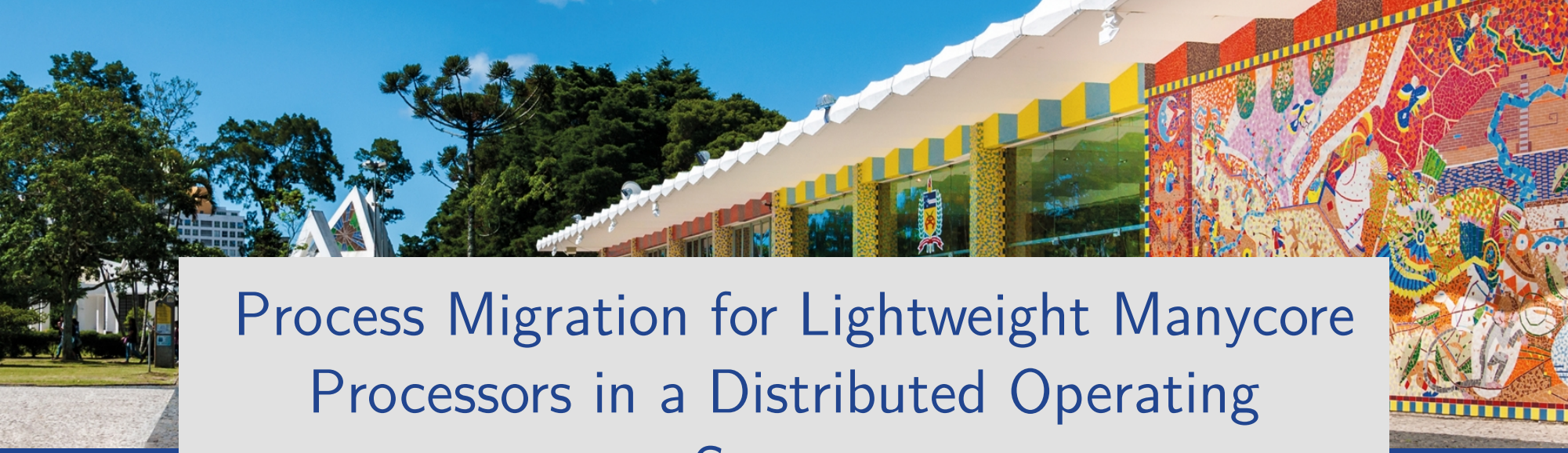

Process Migration for Lightweight Manycore Processors in a Distributed Operating System

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Presentation Outline

1 Introduction

2 Virtualization

3 Migration
- Pre-Copy Migration
- Post-Copy Migration

4 Metrics

5 LW Processors
- Kalray MPPA-256

6 Motivation and Justification

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Introduction

Process Migration

- **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

- Transferring a process between machines
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  - Improved system administration
  - Data access locality
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- Solutions established:
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  - OSF/1 AD TNC (1995)

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Process Migration

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

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Process Migration

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

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Virtualization

Virtualization

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

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Virtualization

- Create a Virtual Version of Computing Resources
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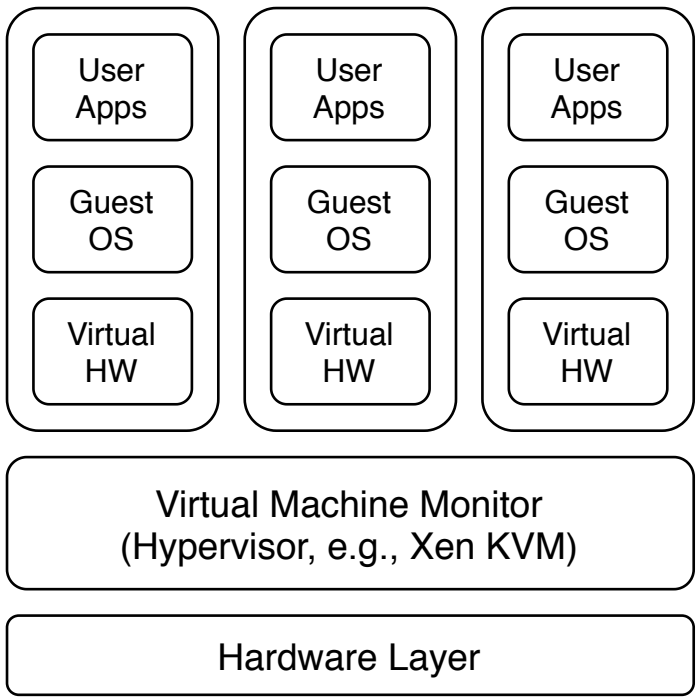
Virtual Machines (VM)

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



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Migration of VMs

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

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Migration of VMs

- Memory content
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  - Application requested memory
- **Disk content**
  - Hypervisor allocated blocks
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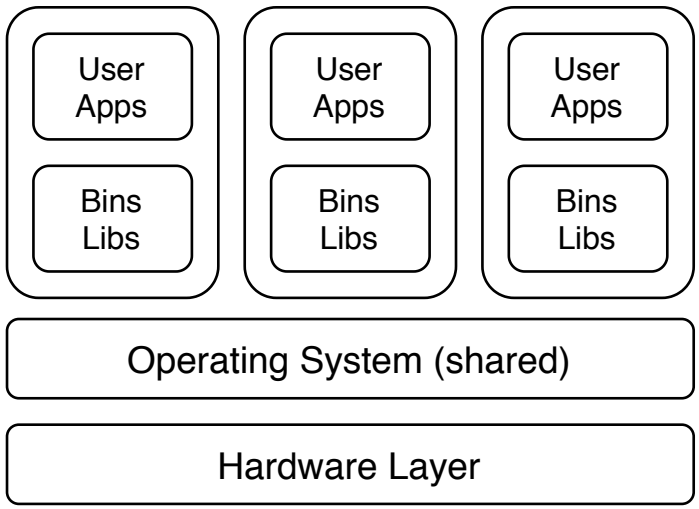
Containers

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



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Migration of Containers

- 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

Migration Techniques

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

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Migration Techniques

- Generally, there are three stages of memory transfer:
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  - ***Post-Copy***
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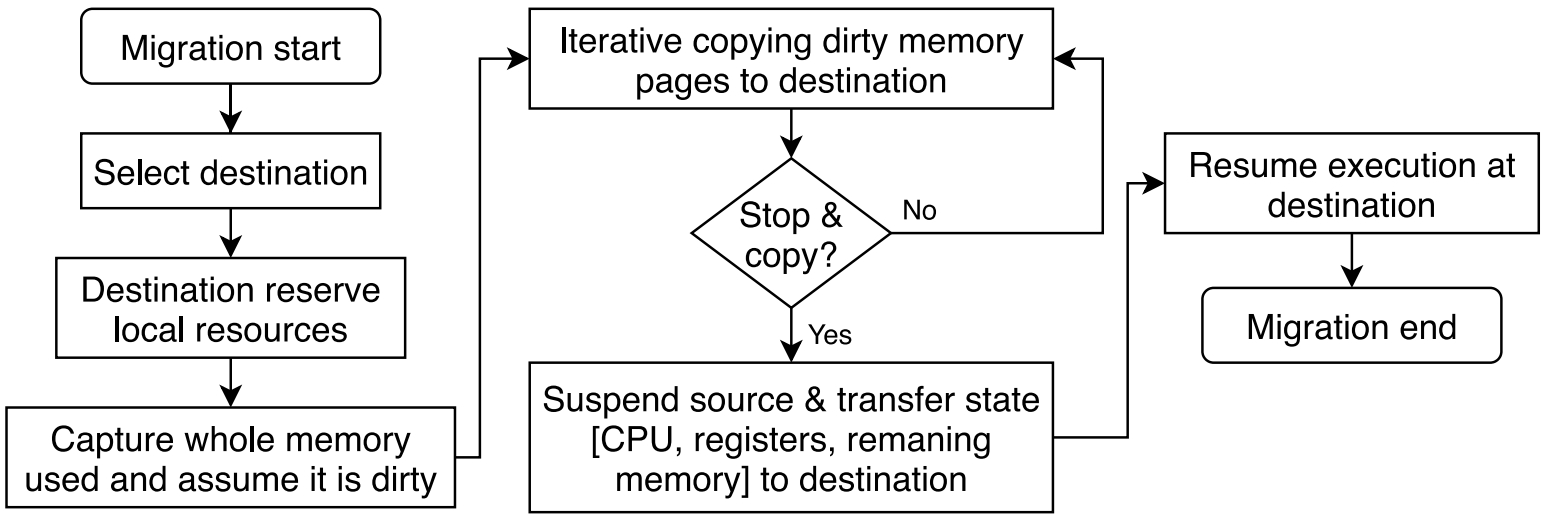
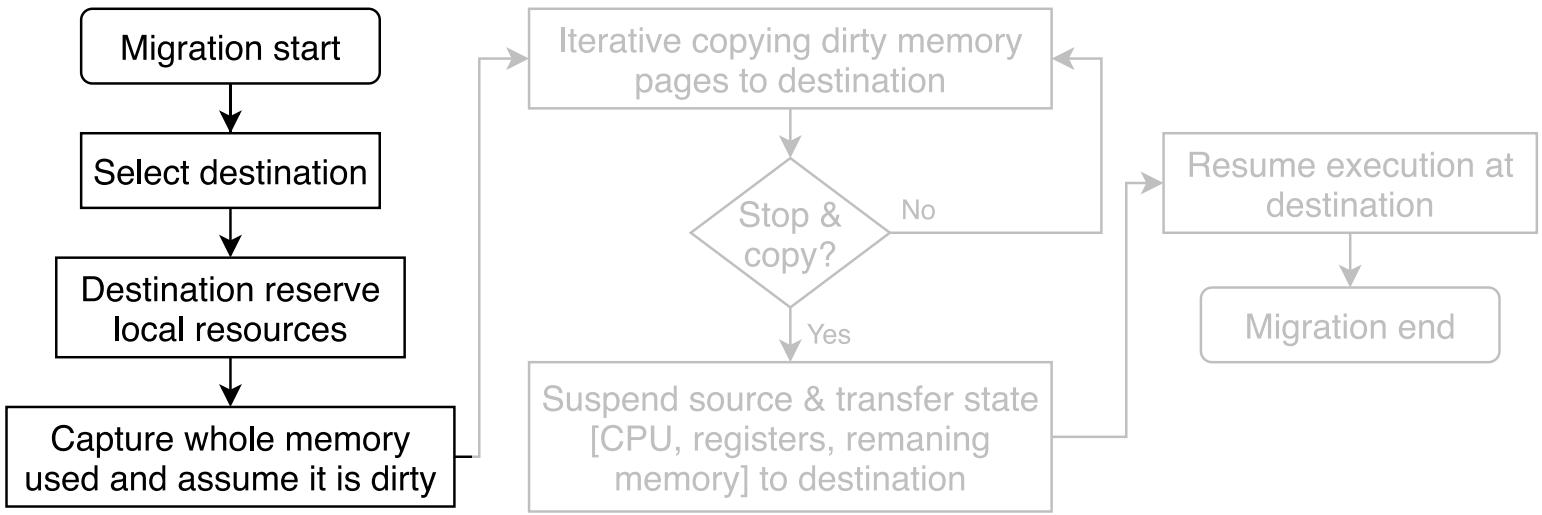
Pre-Copy Migration



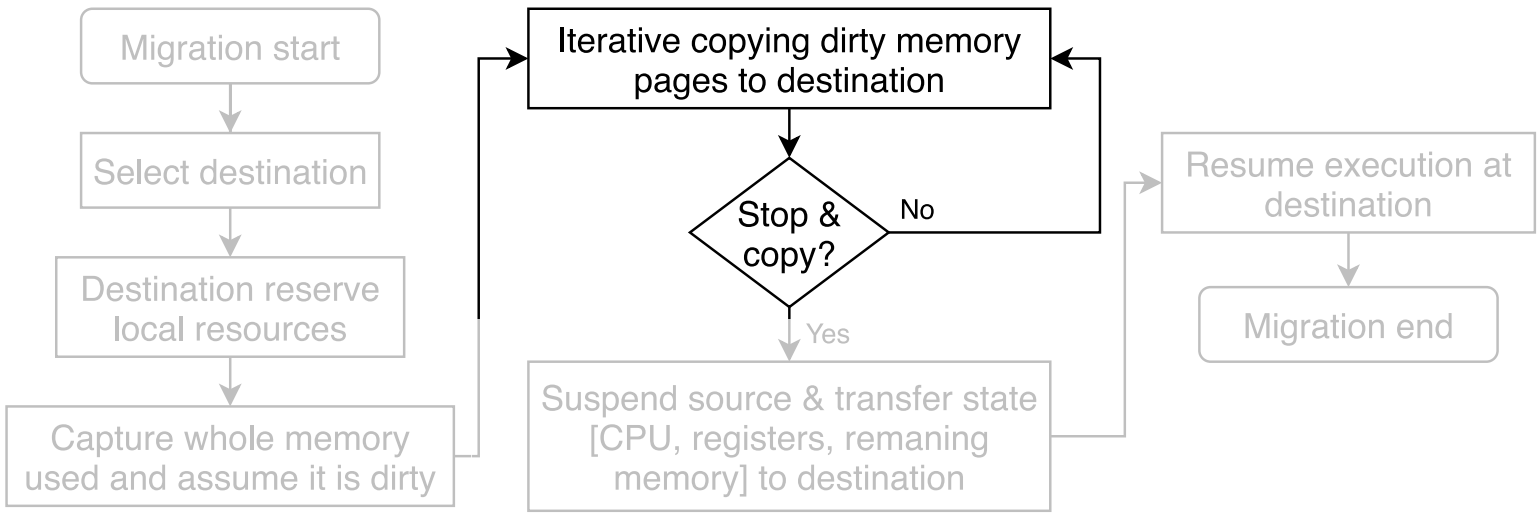
Pre-Copy Scenario

Pre-Copy Migration



Resource reservation and **transfer preparation**

Pre-Copy Migration



Sending the memory pages before the execution context

Push Copy Stage

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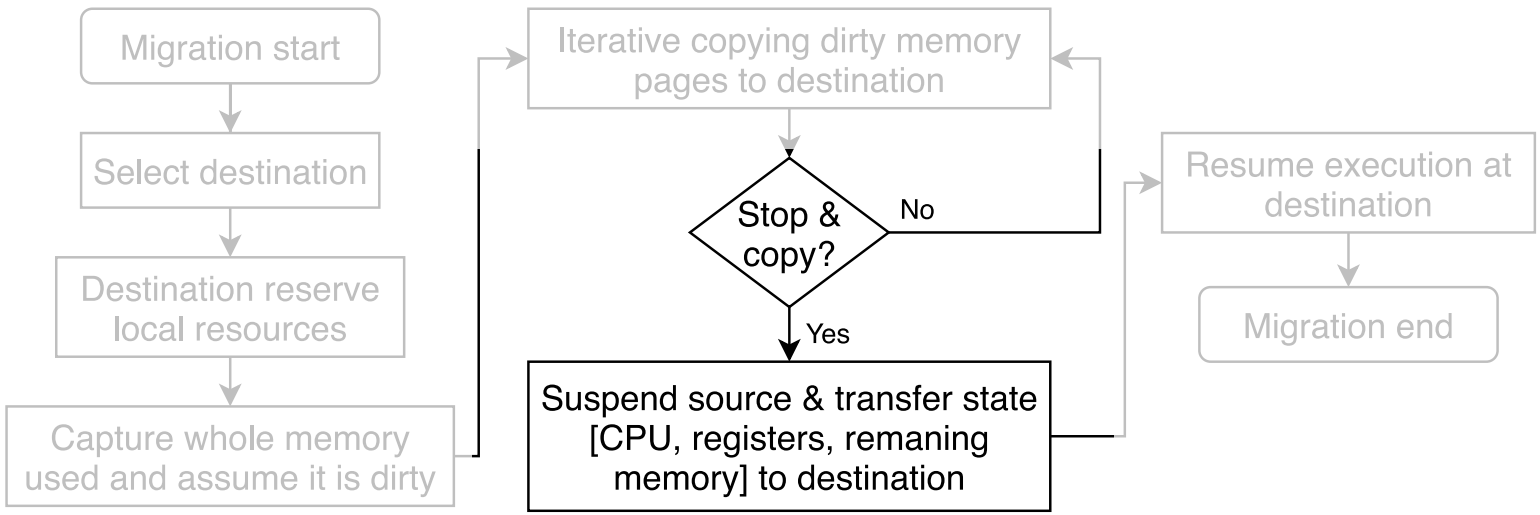
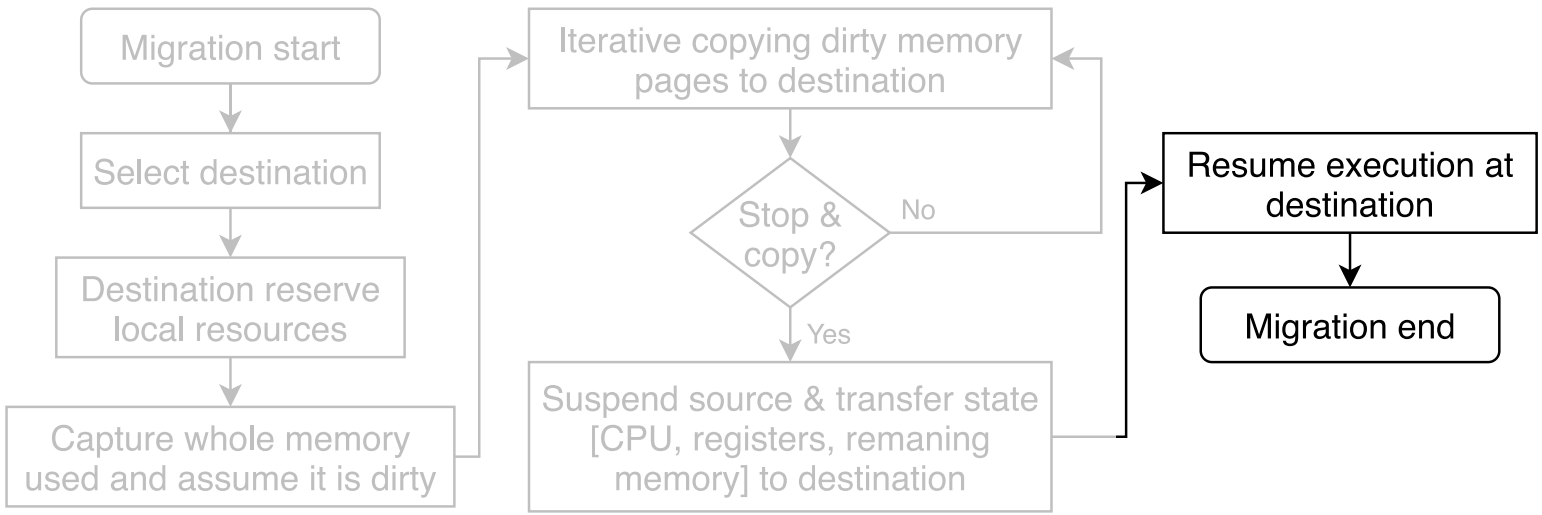
Pre-Copy Migration



When enough memory has been transferred, send the execution context

Stop-and-Copy Stage

Pre-Copy Migration



Resume stopped execution context in the destination

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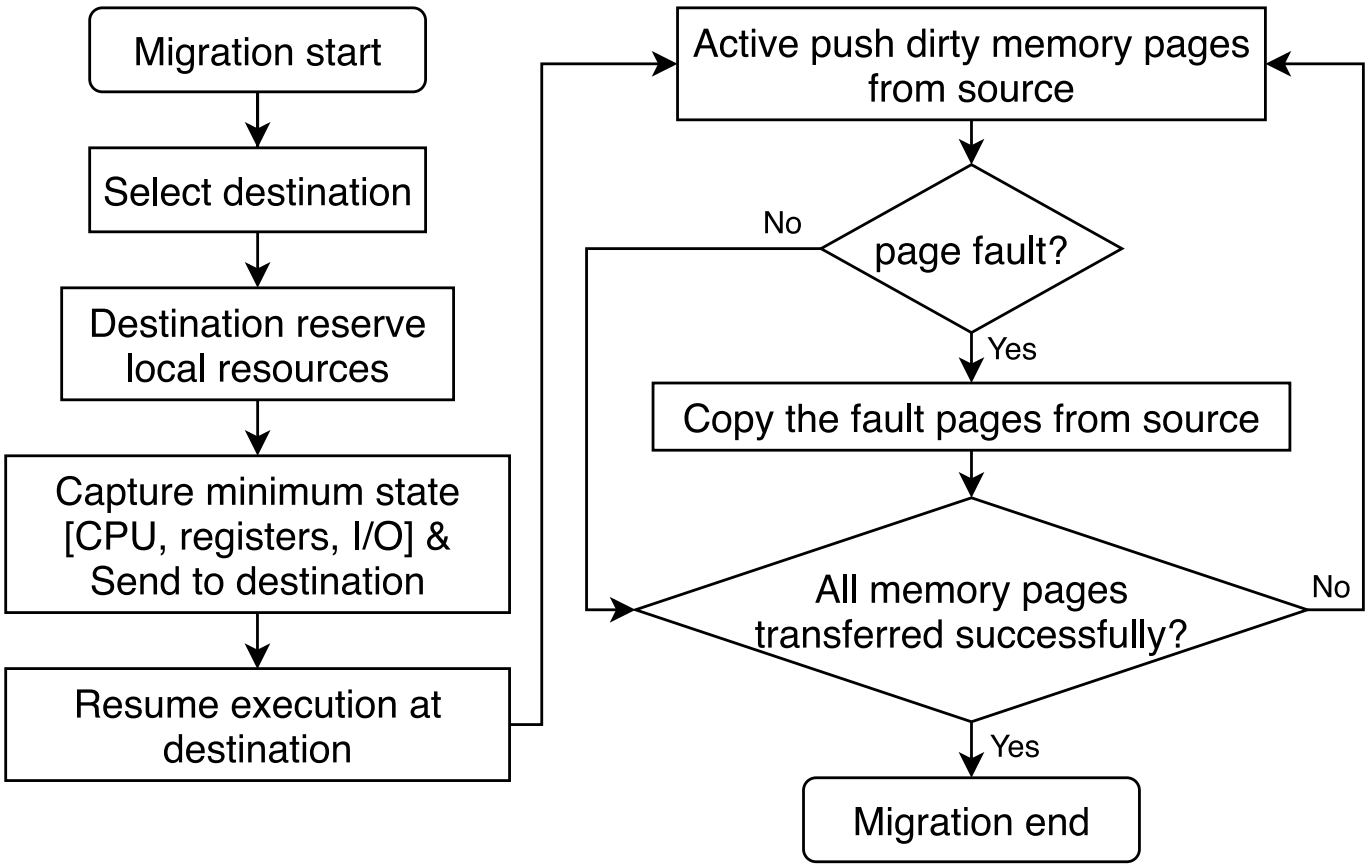
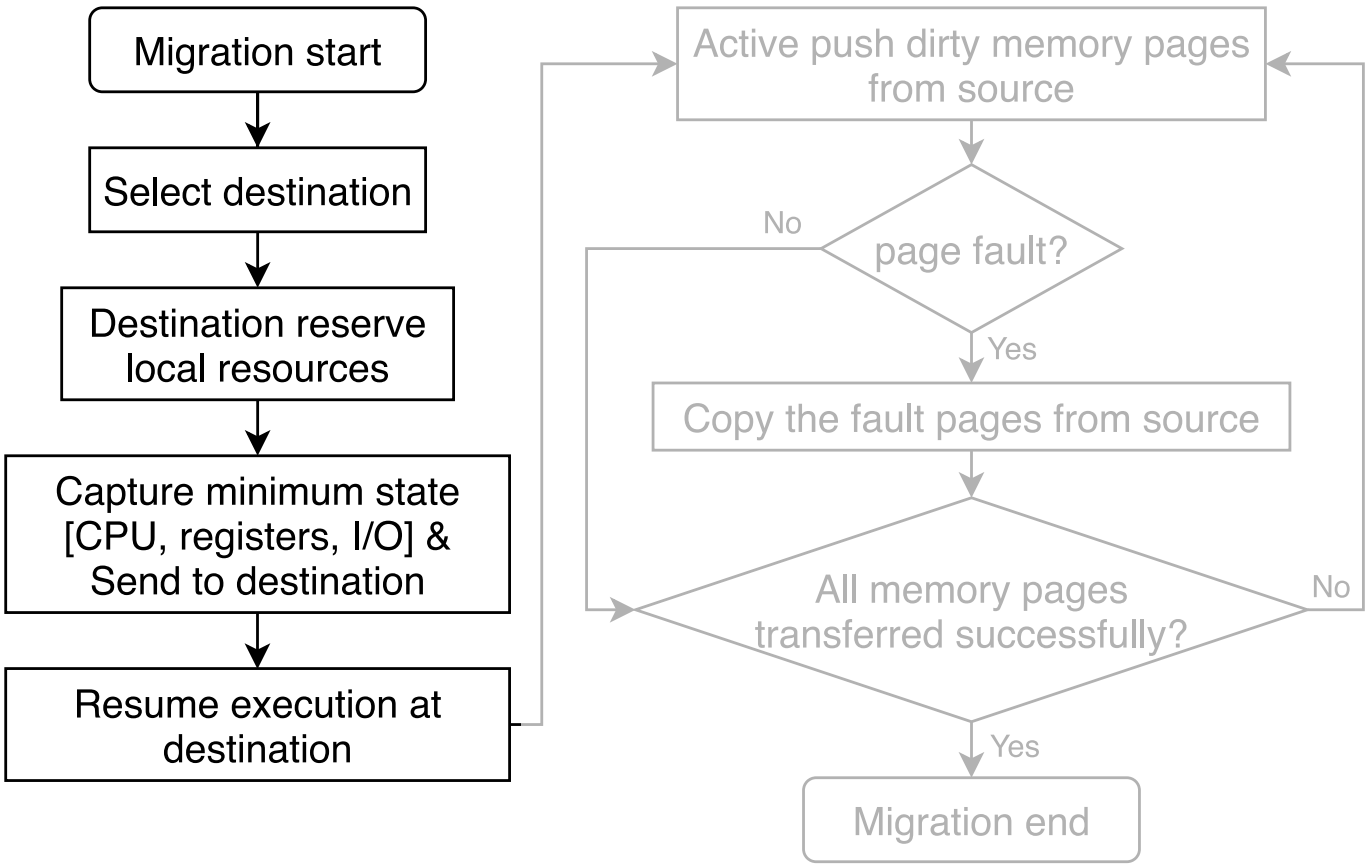
Post-Copy Migration



Post-Copy Scenario

Post-Copy Migration



Sends execution context before memory pages

Stop-and-Copy Stage

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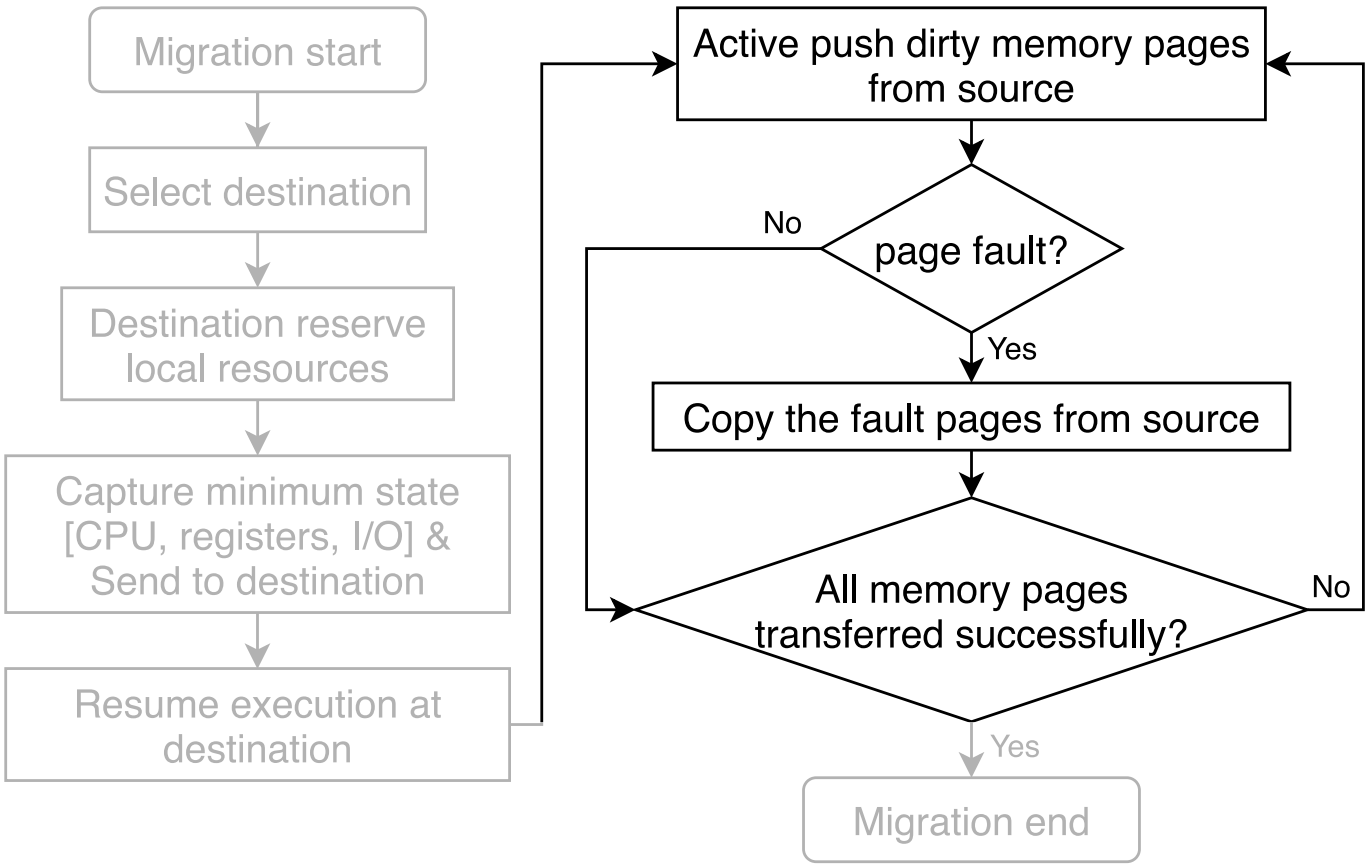
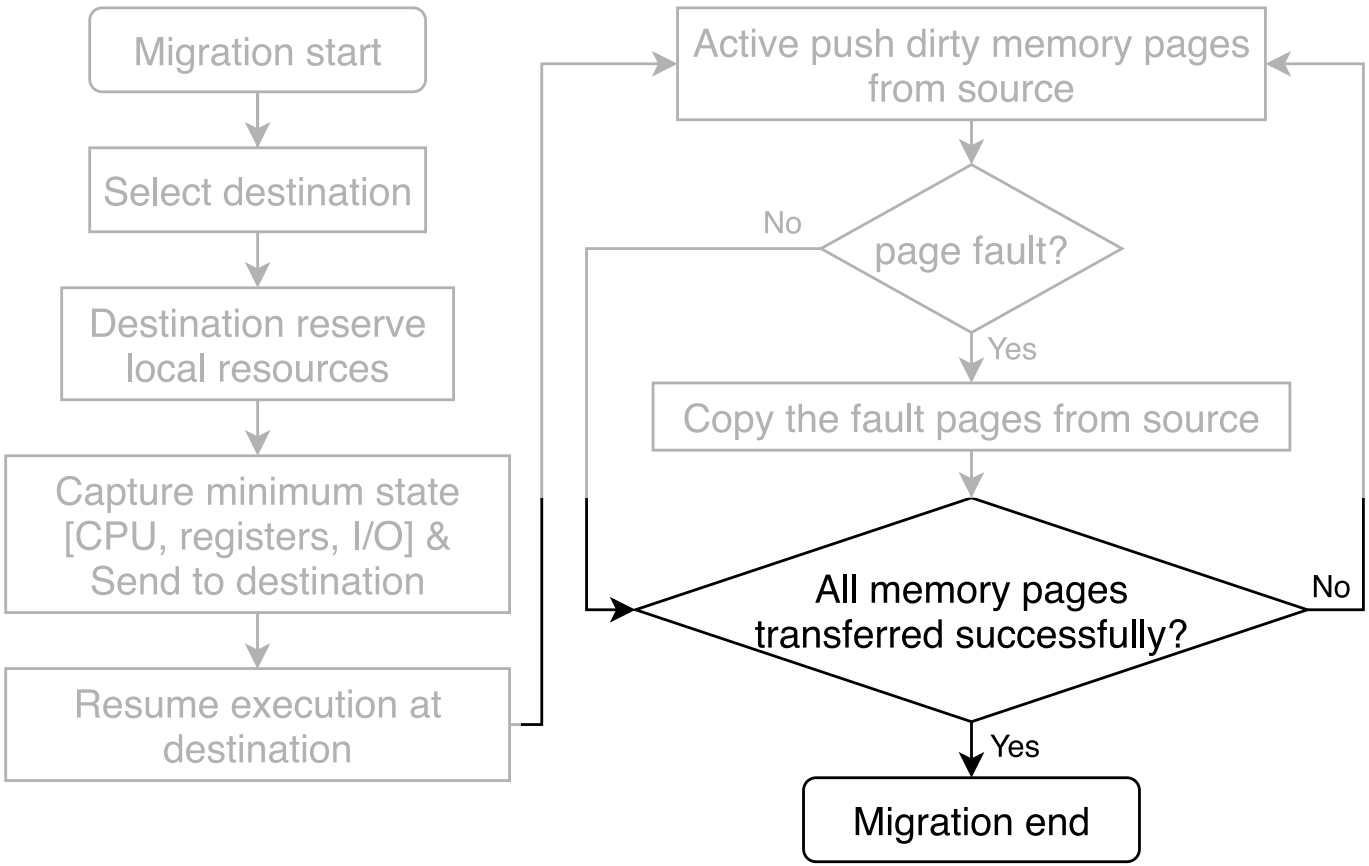
Post-Copy Migration



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

Pull Copy Stage

Post-Copy Migration



Continues execution normally

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Metrics

Performance Metrics

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

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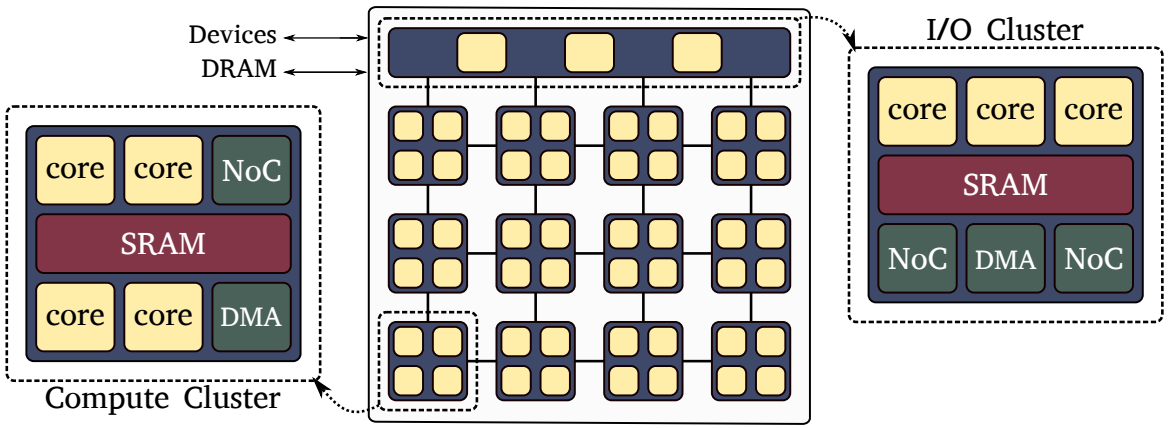
LW Processors

Lightweight Manycores Processors



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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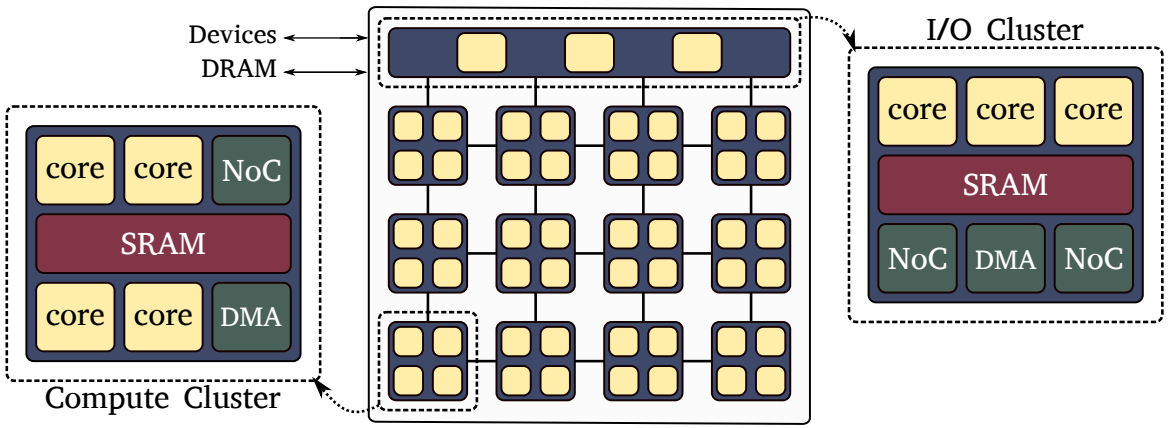
Lightweight Manycores Processors



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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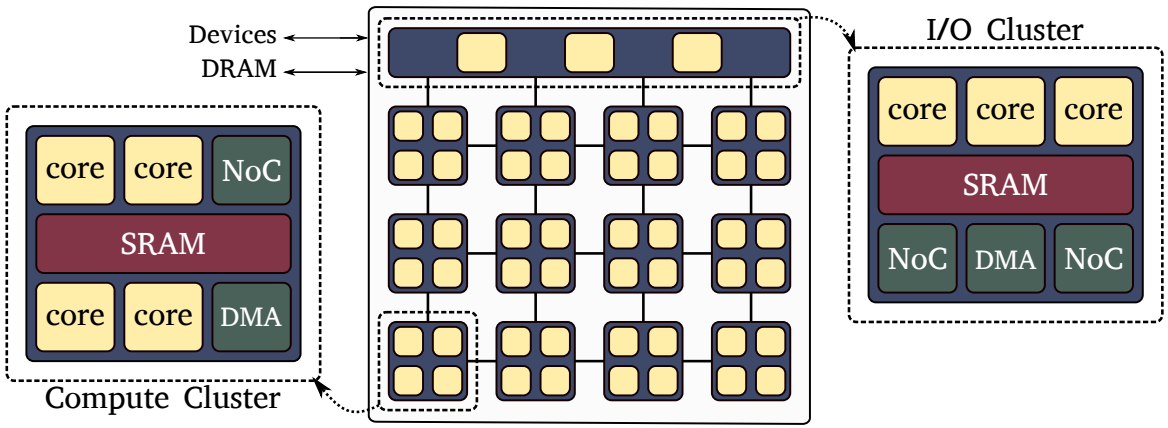
Lightweight Manycores Processors



Overview of a Manycore

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

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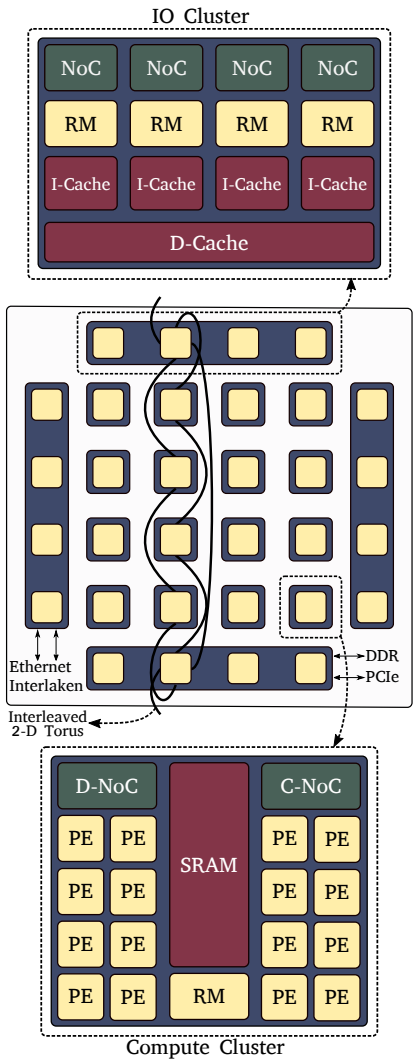
Kalray MPPA-256

A Lightweight Manycore Processor

- **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



Motivation and Justification

Motivation

- Bring the **benefits of migration and process virtualization to lightweight manycores**
- Load balancing
- Fault tolerance
- System administration
- Data locality
- Power management
- Security

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Motivation

- Bring the benefits of migration and process virtualization to lightweight manycores
- **Load balancing**
  - Better work distribution
- Fault tolerance
- System administration
- Data locality
- Power management
- Security

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Motivation

- Bring the benefits of migration and process virtualization to lightweight manycores
- Load balancing
- **Fault tolerance**
  - Save/restore processes state
- System administration
- Data locality
- Power management
- Security

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Motivation

- Bring the benefits of migration and process virtualization to lightweight manycores
- Load balancing
- Fault tolerance
- **System administration**
  - Allow multiuser execution and management
- Data locality
- Power management
- Security

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Motivation

- Bring the benefits of migration and process virtualization to lightweight manycores
- Load balancing
- Fault tolerance
- System administration
- **Data locality**
  - Move processes to closer to the data source
- Power management
- Security

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Motivation

- Bring the benefits of migration and process virtualization to lightweight manycores
- Load balancing
- Fault tolerance
- System administration
- Data locality
- **Power management**
  - Separate CPU-bound processes to improve heat dissipation
- Security

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Motivation

- Bring the benefits of migration and process virtualization to lightweight manycores
- Load balancing
- Fault tolerance
- System administration
- Data locality
- Power management
- **Security**
  - Better isolation and kill suspicious processes

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Justification

- **Parallel and distributed nature** of lightweight manycores
- Memory restrictions do not support a complete virtual environment like VMs
- Explore lighter forms of virtualization as at the OS level
- Integrate virtualization into a distributed OS designed for lightweight manycores

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Justification

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Thank you!
Questions?

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Citations

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- (CLARK et al., 2005)
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- (Hosseini Shirvani; RAHMANI; SAHAFI, 2020)
- (WANG et al., 2019)

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