Realizing Fluid Computing in Cloud 2.0
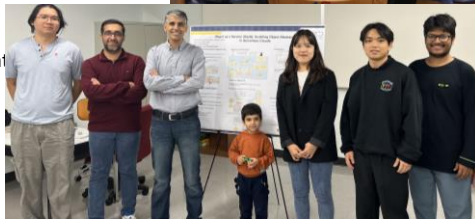
Mohsen Amini Salehi

Director of High-Performance Cloud Computing (HPCC) Lab

Assoc. Prof. at Computer Science & Engineering Department

University of North Texas (UNT)

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Introduction

- Dr. Mohsen Amini Salehi
  - PhD at Melbourne University 2012
  - **Associate Professor at University of North Texas (now)**

- Director of the HPCC Lab
  - 7 members: 6 PhD + 1 MS + 2 BS student
  - In total 33 students/postdoc/visitors
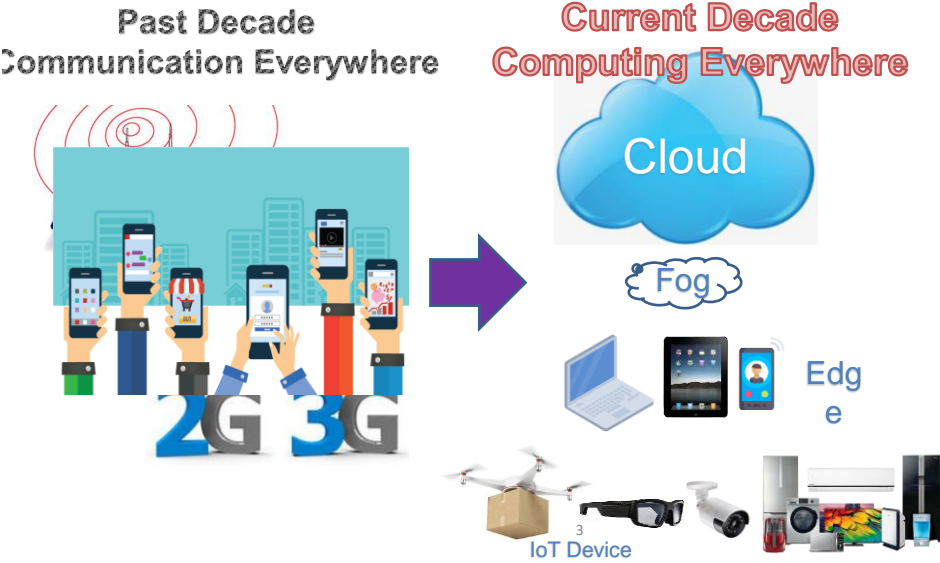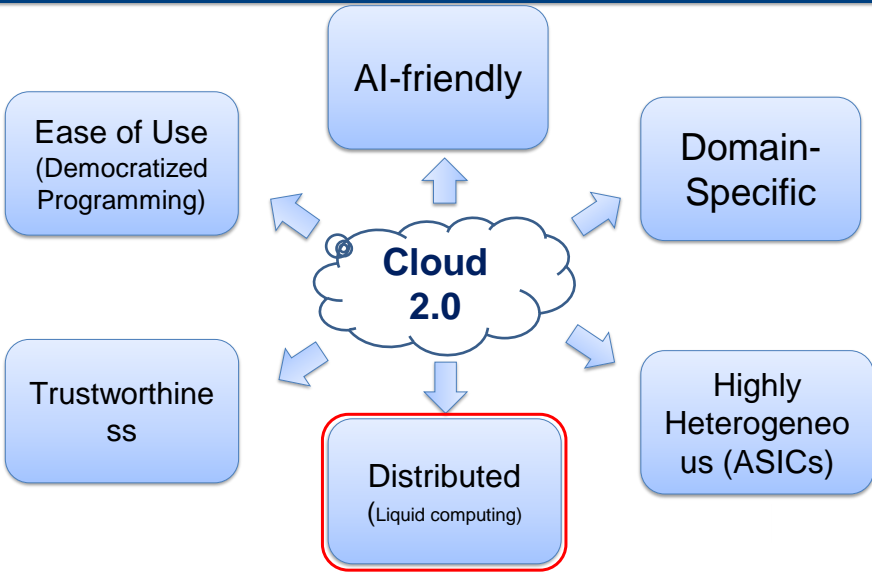 - > 70 peer-reviewed publications

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Research Vision

Past Decade
Communication Everywhere

Current Decade
Computing Everywhere

Cloud

Fog

Edge

IoT Device

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Research <u>Vision</u>: **Cloud 2.0**

AI-friendly

Ease of Use
(Democratized
Programming)

Domain-Specific

Cloud 2.0

Trustworthiness

Distributed
(Liquid computing)

Highly Heterogeneous (ASICs)

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Liquid Computing across Edge-Cloud

Edge lacks elasticity!

Demo video:
http://y2u.be/BK_PyvRpr1A

- UMS/NIMS

Cloud (⎈ kubernetes)

Edge (🌀 K3S)

Live Service

Gaming Service

High priority user arrives

Low-priority users playing
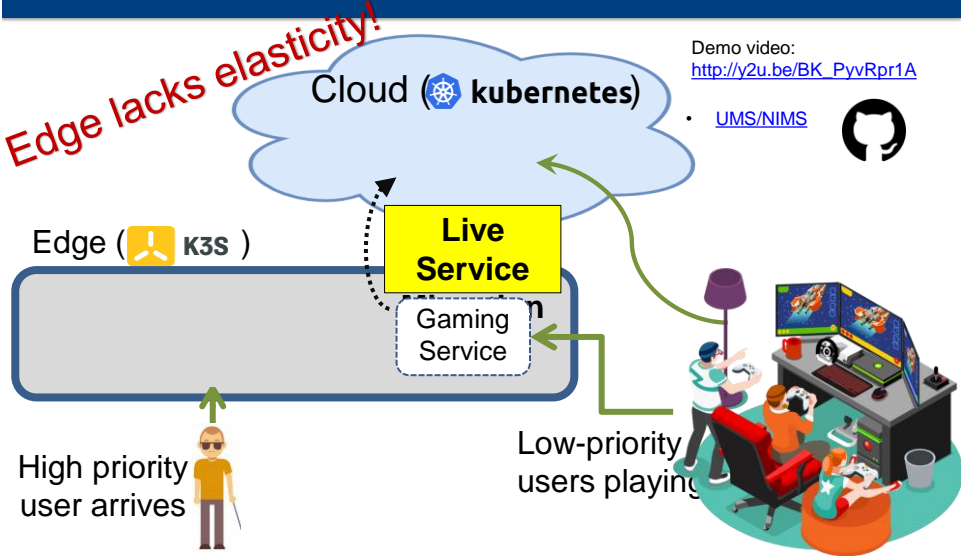
* Presented at SC '22 and at Globecom '23

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Our Research Goal

Multi-cloud

Edge to cloud

Fluid Computing

service move freely

service move freely

service move freely

move

cloud 1

cloud 2

edge server 1

edge server 2

edge device 1

edge device 2
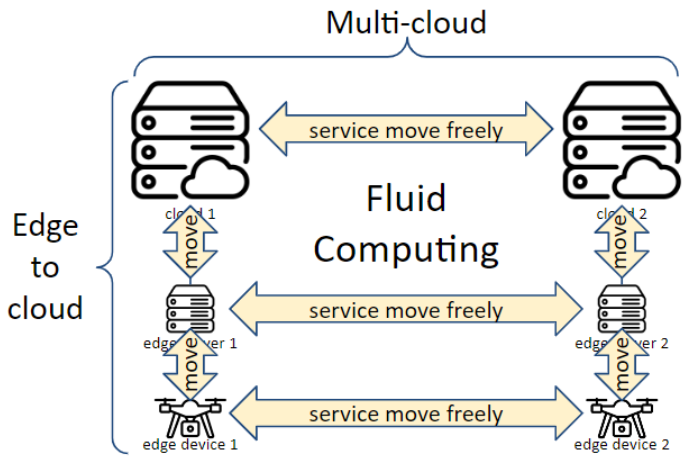
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Service Restoration Problem

Kubernetes, Mesos, ...
GKE, AKS, EKS, ...

☐ container
☐ process

Container Orchestrator

Container Orchestrator

✖

App → App

output #1
output #2
output #3

output #4
output #5
output #6

HPC lab.

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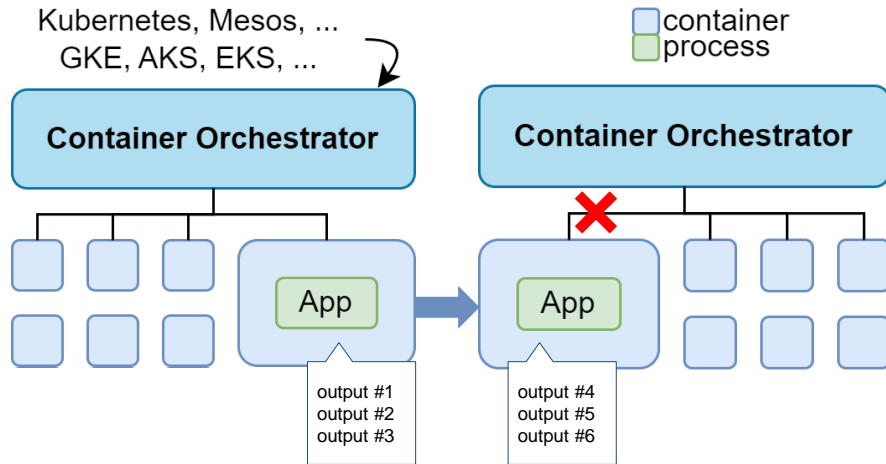
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Research Question

We want a **live service migration solution**
that can offer the best of both worlds:
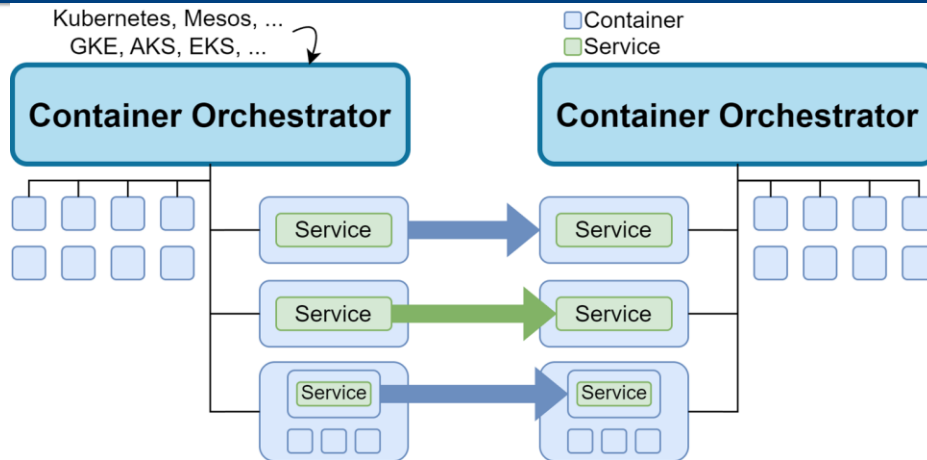
(i) operating ubiquitously across autonomous
systems and <u>heterogeneous orchestrators</u>;

(ii) maintaining the migration efficiency.

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UMS: Ubiquitous Migration Solution

Kubernetes, Mesos, ...
GKE, AKS, EKS, ...

☐ Container
☐ Service

Container Orchestrator

Container Orchestrator

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Contributions

- **Developing UMS**, a framework that enables seamless and lightweight live migration of containerized services across autonomous computing systems with heterogeneous orchestrators

- **Developing live container migration approaches** operating at the orchestrator, container, and service levels

- **Demonstrating the feasibility of live migration** of containerized services across heterogeneous orchestrators (Kubernetes, Mesos, K3S, and Minishift) and between Microsoft Azure and Google Clouds
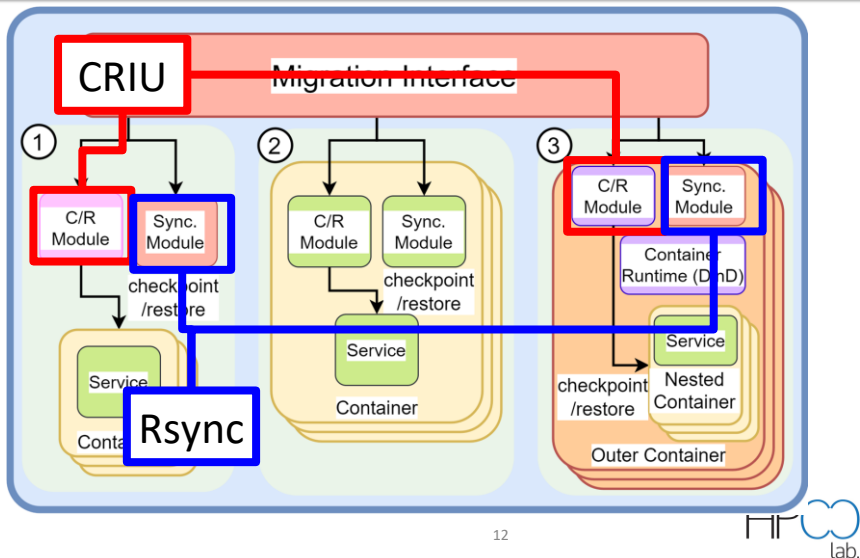
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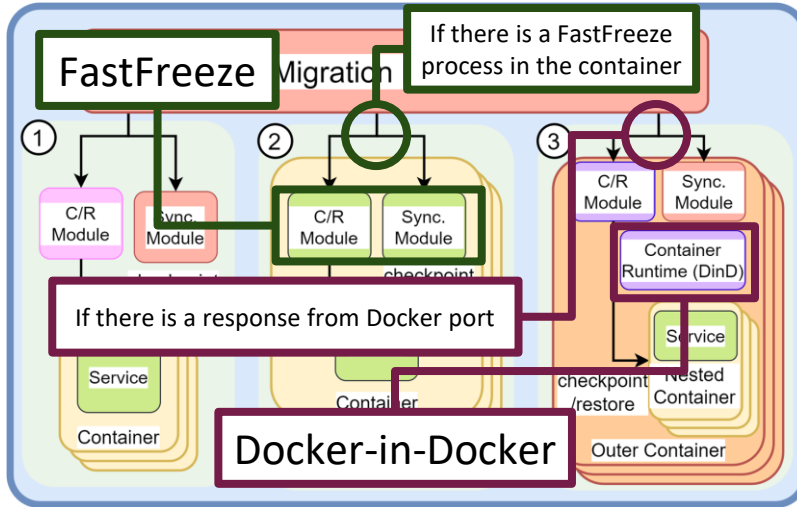10

Architectural Overview of UMS
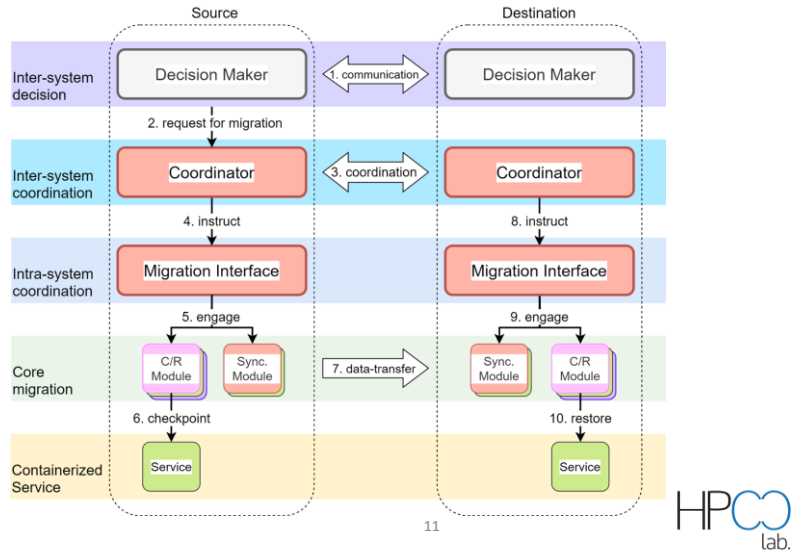
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Establishing Service Migration Approaches Operating at Different Levels

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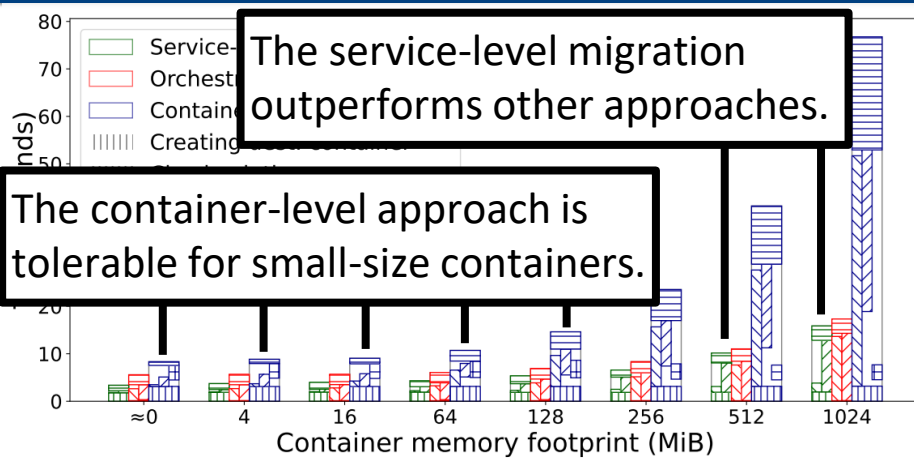## Establishing Service Migration Approaches Operating at Different Levels

FastFreeze

If there is a FastFreeze process in the container

If there is a response from Docker port

Docker-in-Docker

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Overhead of Live Container Migration

The service-level migration outperforms other approaches.

The container-level approach is tolerable for small-size containers.
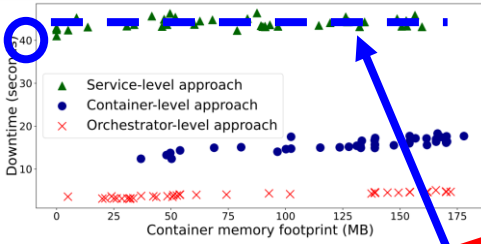
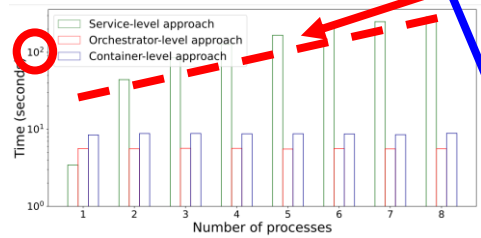Container memory footprint (MiB)

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Impact of Dynamic Memory Footprint on the Migration

The service-level approach **depends on** the number of processes running in the container, **rather than** the container memory footprint.

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Live Migration across Heterogeneous Orchestrators

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Further Resources

- Demo videos

- GitHub

- How we fix FastFreeze

- Contact us!
  - thanawat.chanikaphon1@louisiana.edu
  - mohsen.aminisalehi@unt.edu

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