

# A survey of Virtual Machine Management in Edge Computing

INTRODUCTION

VIRTUALIZATION-BASED FRAMEWORK

VIRTUALIZATION TECHNIQUES

PLACEMENT AND SCHEDULING

SERVERLESS MANAGEMENT IN EDGE COMPUTING

VIRTUALIZATION AND SECURITY

Amazon AWS, Microsoft Azure, Google Cloud

## Advantages

- Providing elastic hardware resources
- Companies: executing large batch-oriented tasks on cloud servers
- Individual users: rely on remote clouds to perform resource-intensive computations for their client devices

## Disadvantages

- Network delay
- latency-sensitive mobile-cloud applications: client devices are mobile devices e.g. smartphones
- latency-sensitive IoT-cloud applications: client devices are Internet-of-Things (IoT) devices

# EDGE COMPUTING

## Edge Computing

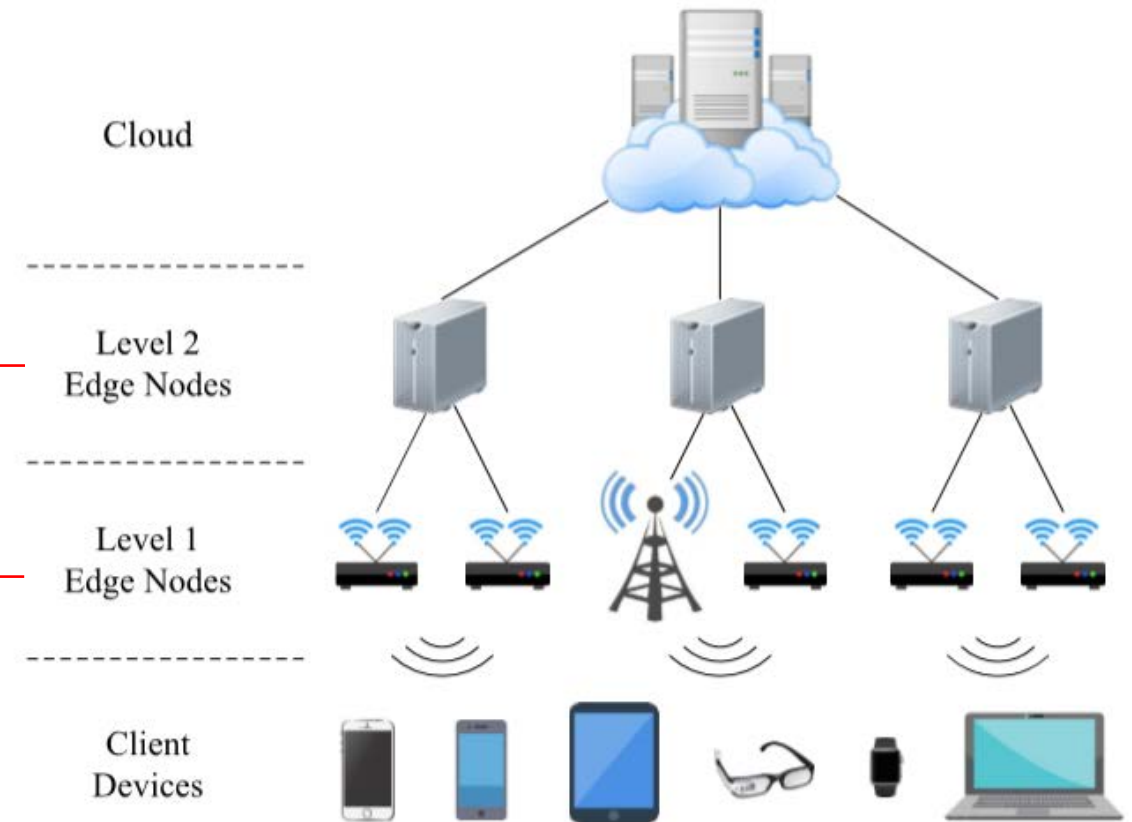
Extension of cloud computing

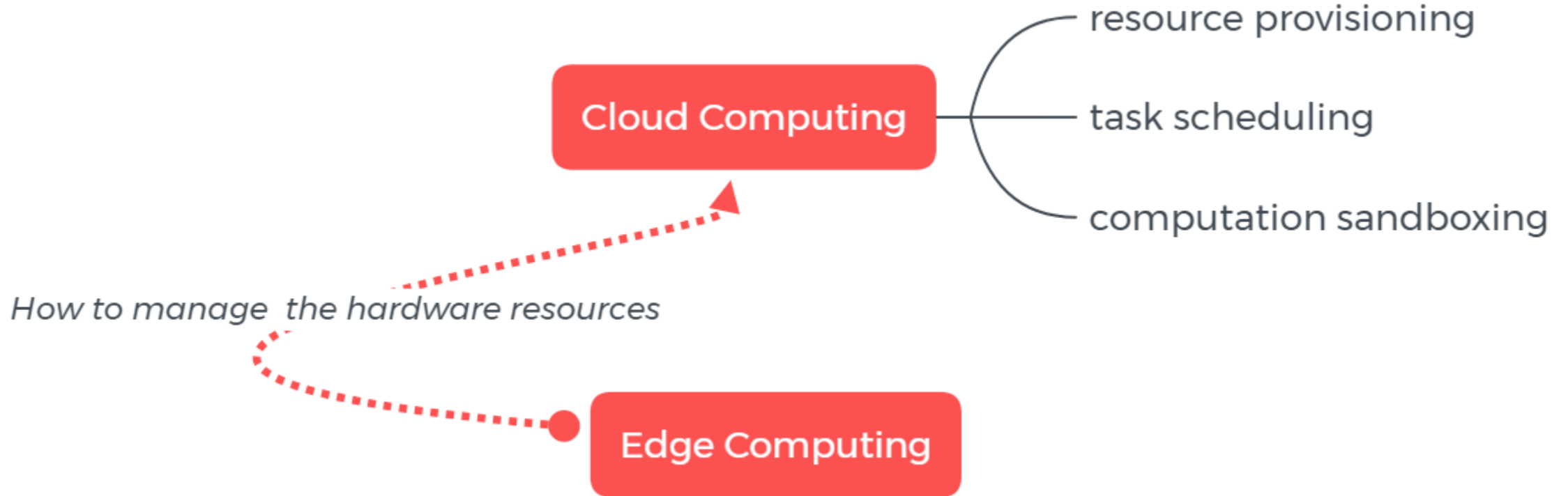
Enabling technology of IoT

big data analytics, video surveillance,  
virtual reality, augmented reality (AR)

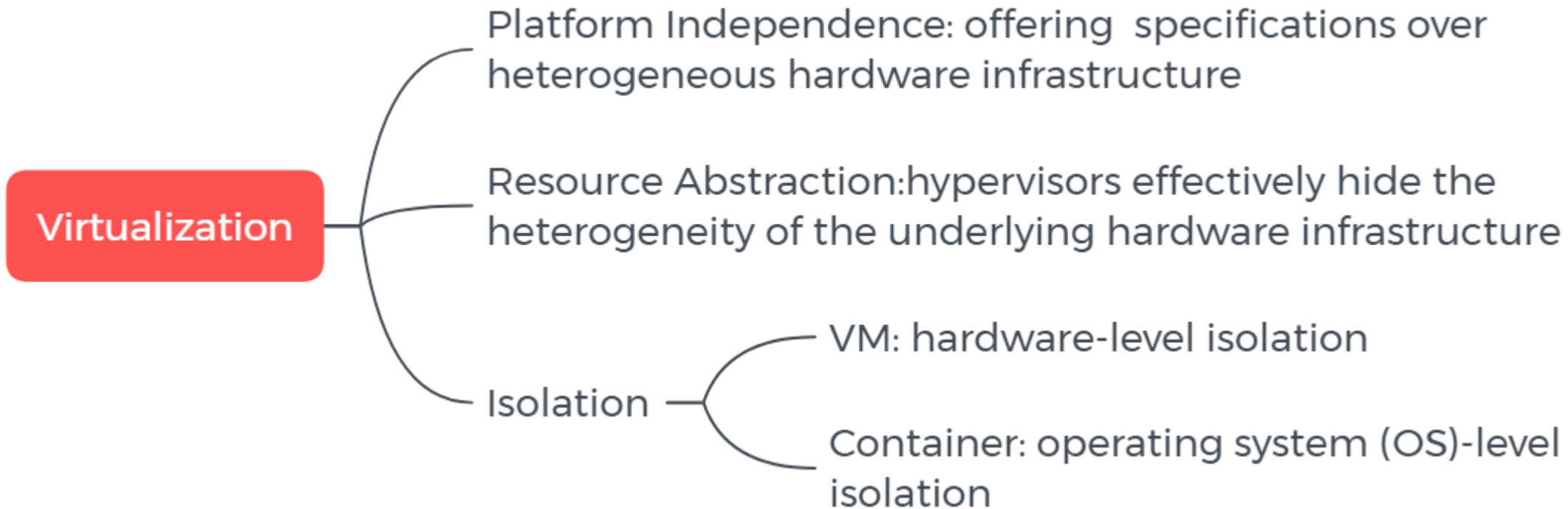
Execute more computational tasks  
simultaneously

Provide lower delay





## Advantages of adopting the virtualization technology

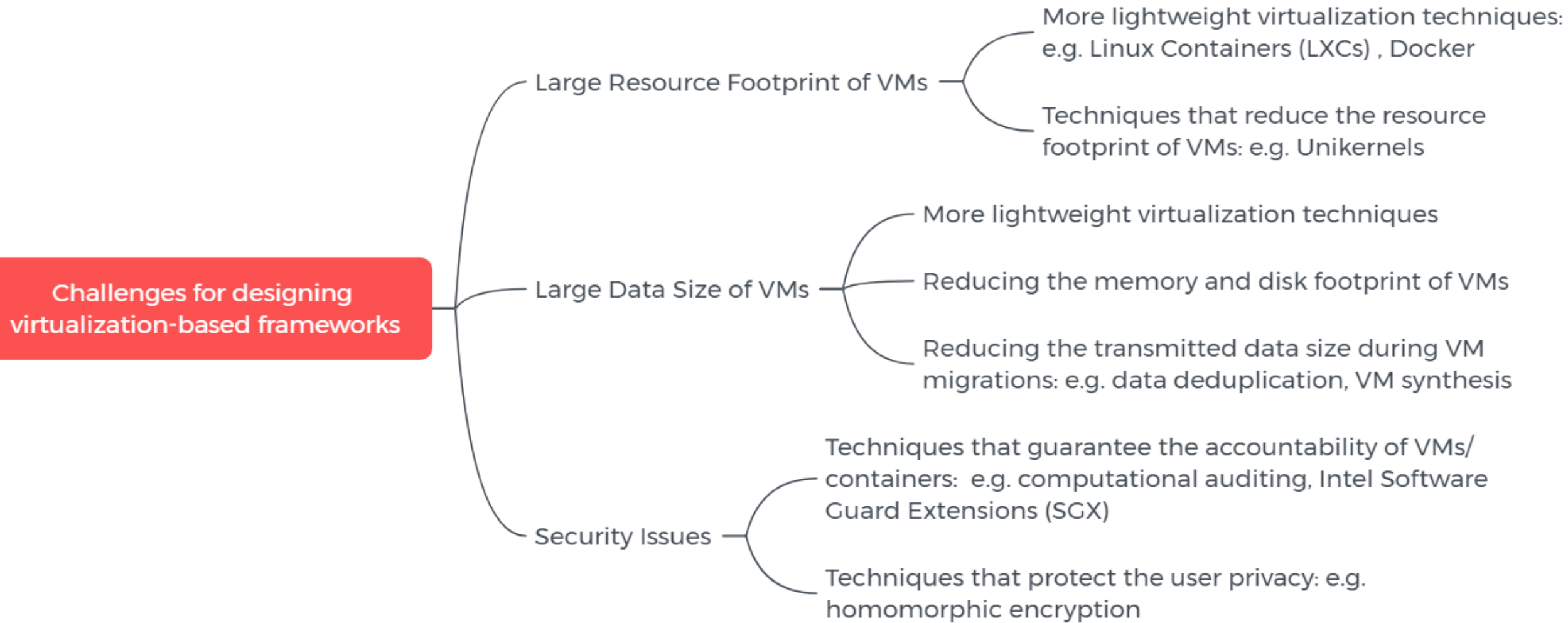


## Challenges to the management of VMs

### Characteristics of Edge Computing

- Sparse Distribution — Longer time to migrate → how to provide seamless services
- Limited Resource — Limited number of VMs & containers → how to schedule the VMs/containers
- Limited Service Range — Limited service range → how to guarantee frequently migration
- Mobility of Edge Nodes
- Poor Reliability — Frequent failures and network partitions → provide effective failover mechanisms for the VMs/containers
- Vulnerability to Attacks — Operated by third parties or individuals

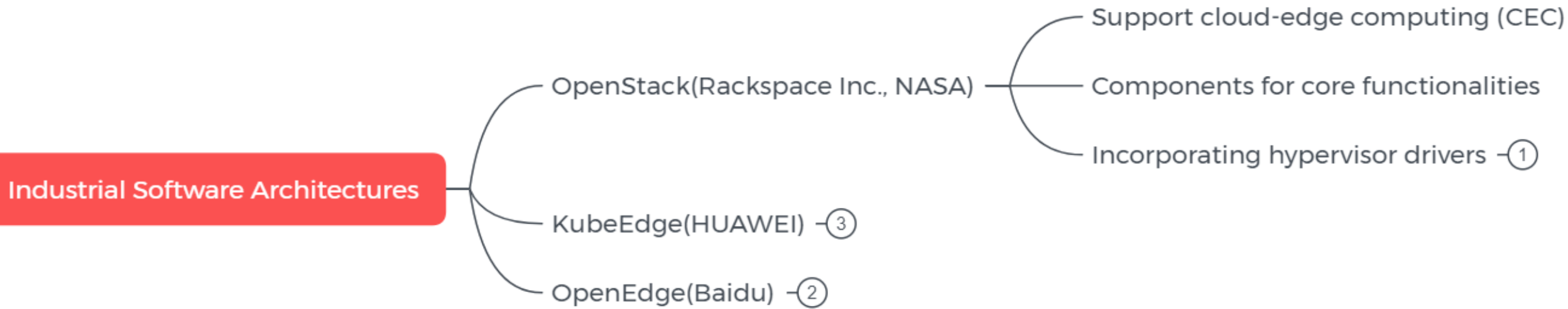
# VIRTUALIZATION-BASED FRAMEWORK





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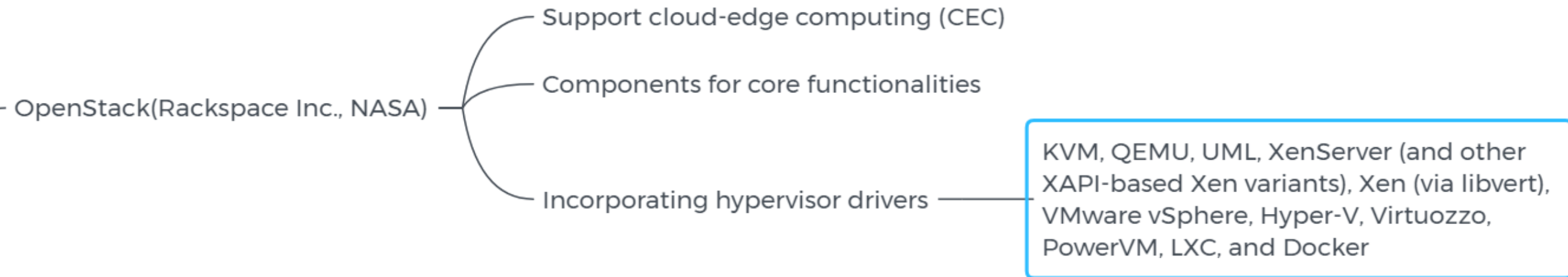
# VIRTUALIZATION-BASED FRAMEWORK

## Components for core functionalities

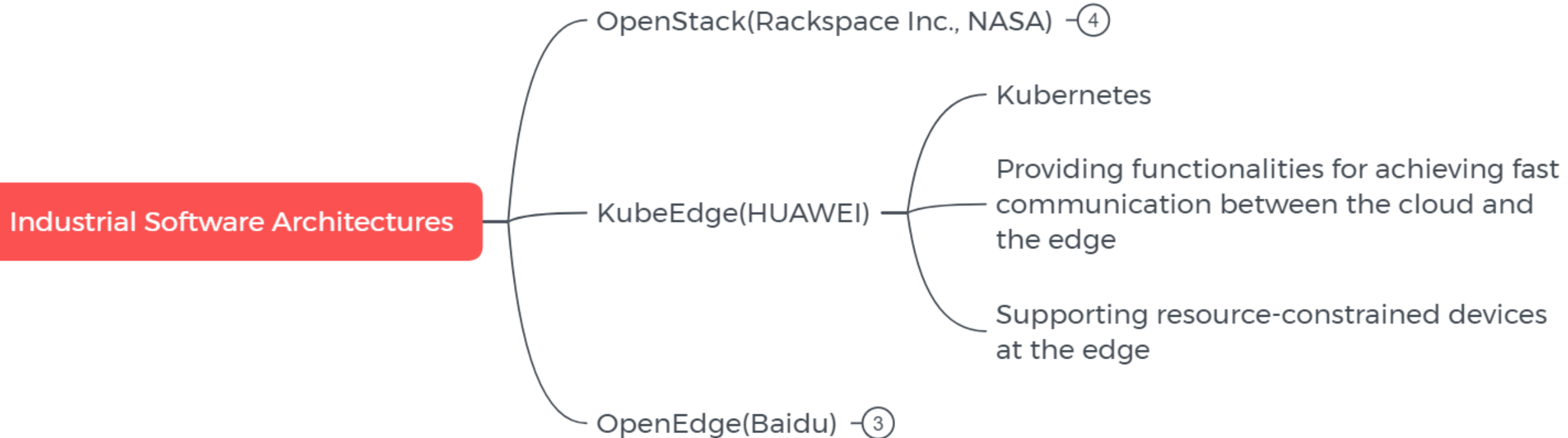
Category	Component	Description
Compute	Nova	Managing compute resources including virtual machines and containers
Storage	Cinder	Virtualizing the management of block storage devices
	Swift	Providing a distributed, eventually consistent object storage service
Networking	Neutron	Delivering networking-as-a-service (NaaS) based on SDN technologies
Shared Services	KeyStone	Providing authentication, service discovery, and authorization services
	Glance	Discovering, registering, and retrieving virtual machine images
Orchestration	Heat	Orchestrating the resources for applications based on templates
Telemetry	Ceilometer	Collecting information for customer billing and resource tracking
Web Frontend	Horizon	Implementing a web-based user interface to the OpenStack services

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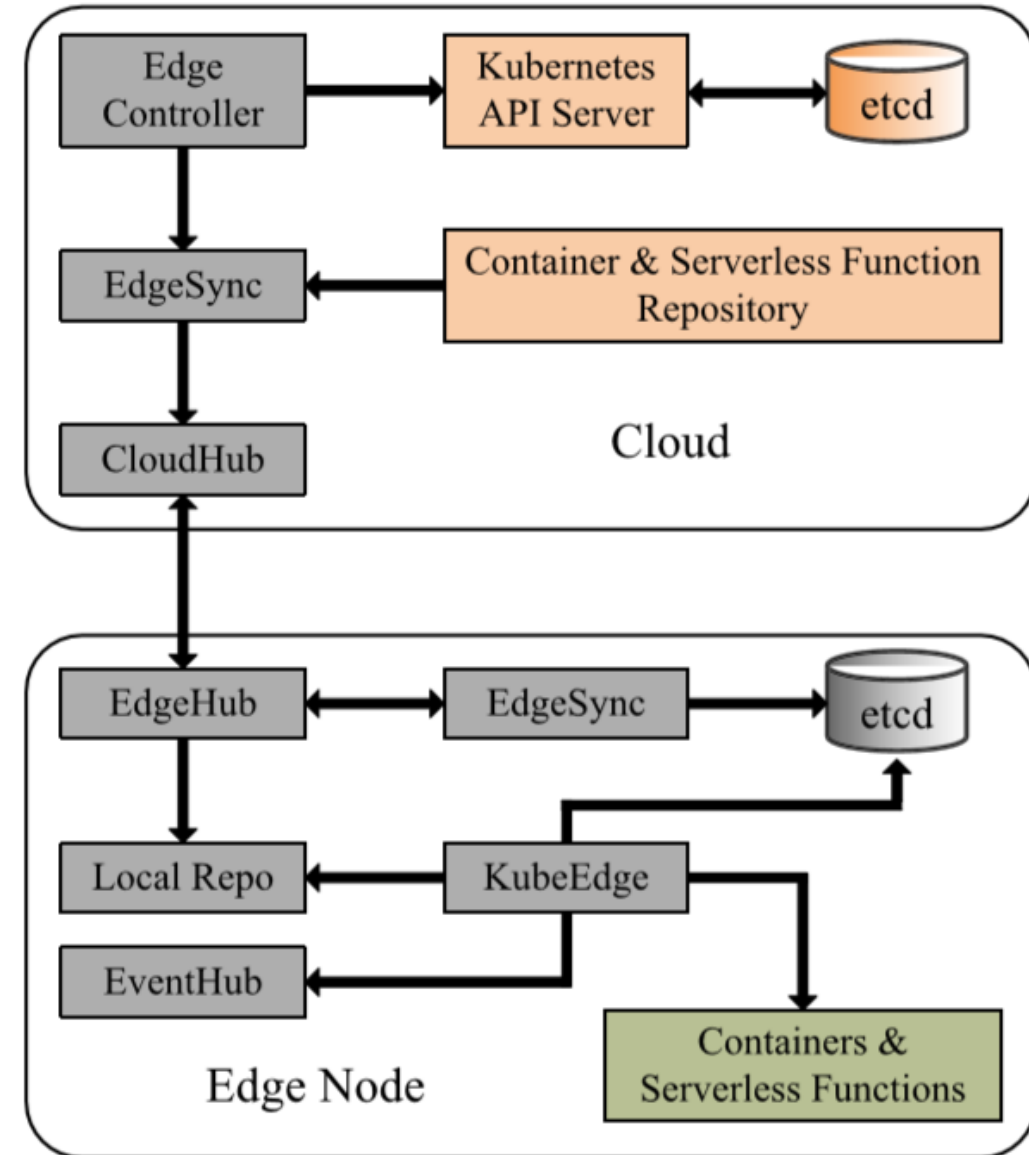
Blocks in orange: components of Kubernetes  
Blocks in gray: components of KubeEdge

**EdgeHub:** communication between KubeEdge and the cloud

**EdgeSync:** synchronize Information about the containers and serverless functions among the edge nodes

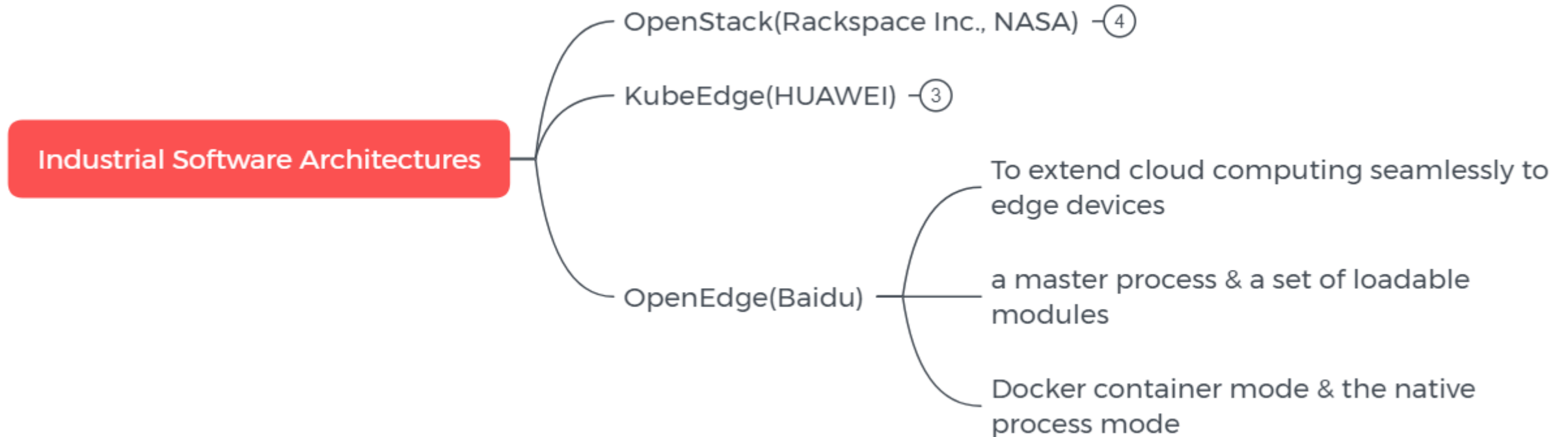
**EventHub:** collect events from end devices

**KubeEdge:** retrieve events from end devices

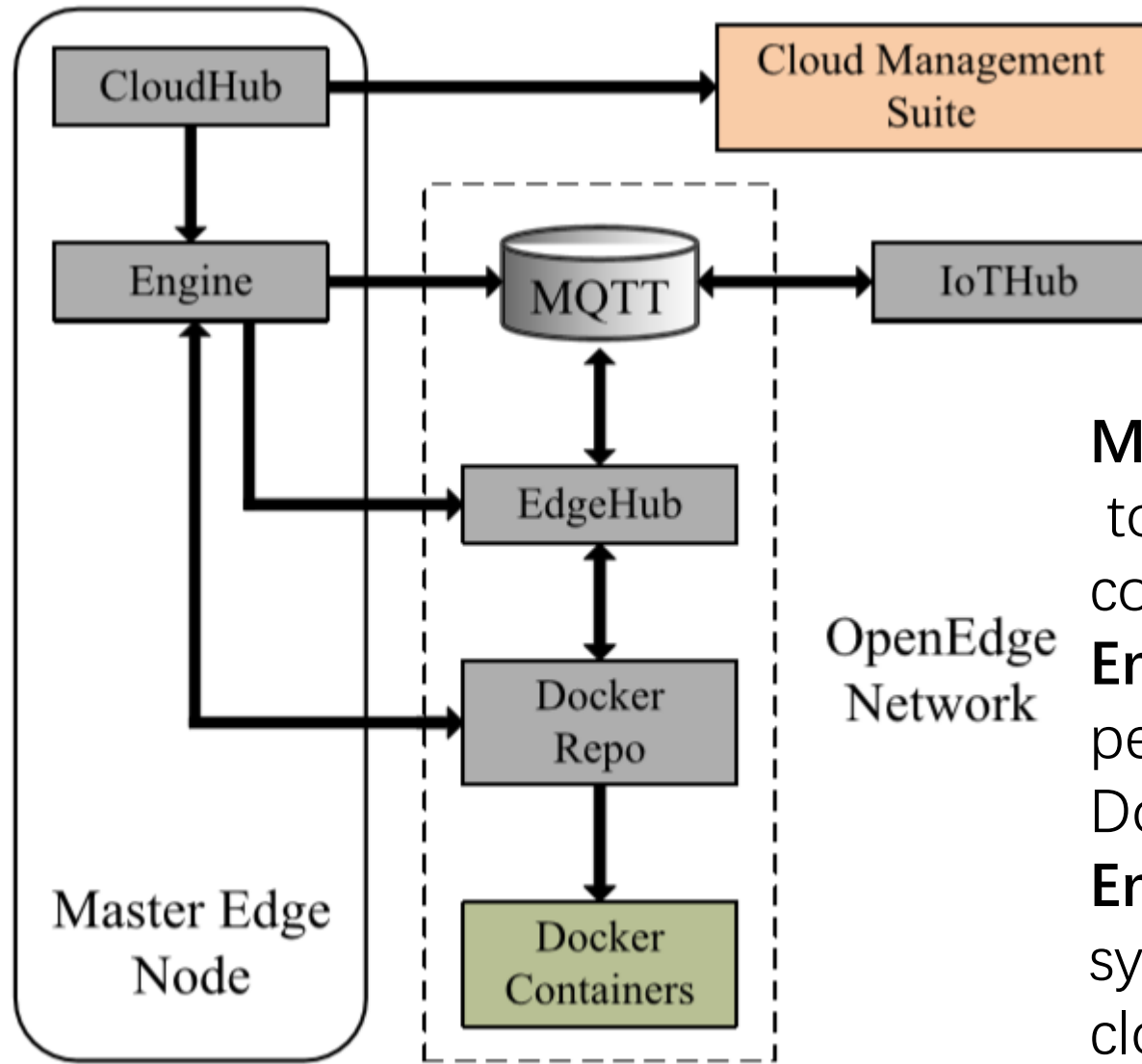


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Blocks in orange: for cloud

Blocks in gray: components of OpenEdge

**MQTT:** for the engine component to fetch IoT events from the IoT Hub component

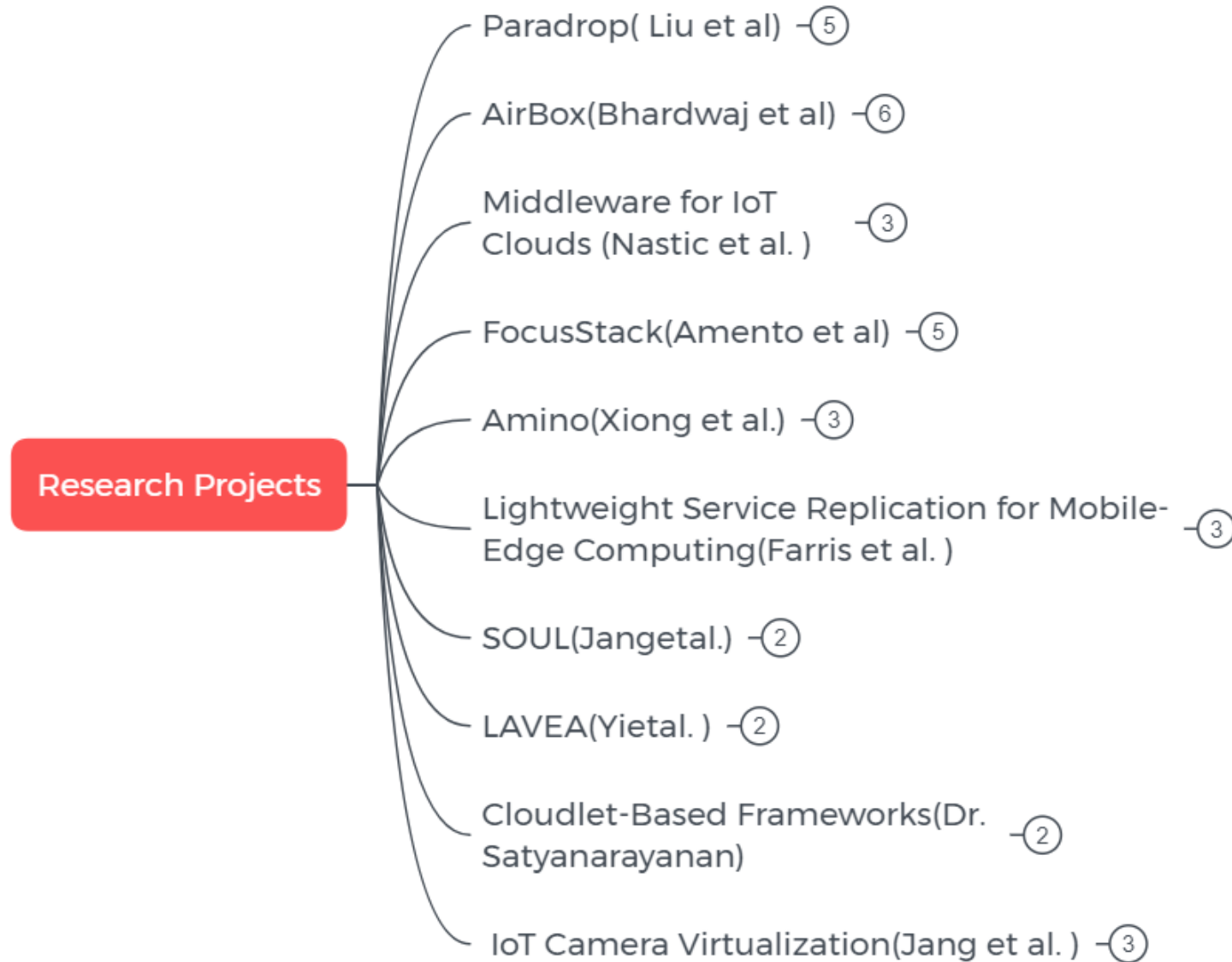
**Engine & EdgeHub & Docker Repo :** perform the corresponding computations in Docker containers

**Engine & Cloud Management Suite:** synchronize the master edge node with the cloud, fetch uncached Docker images

**Fig. 3.** High-level design of OpenEdge.

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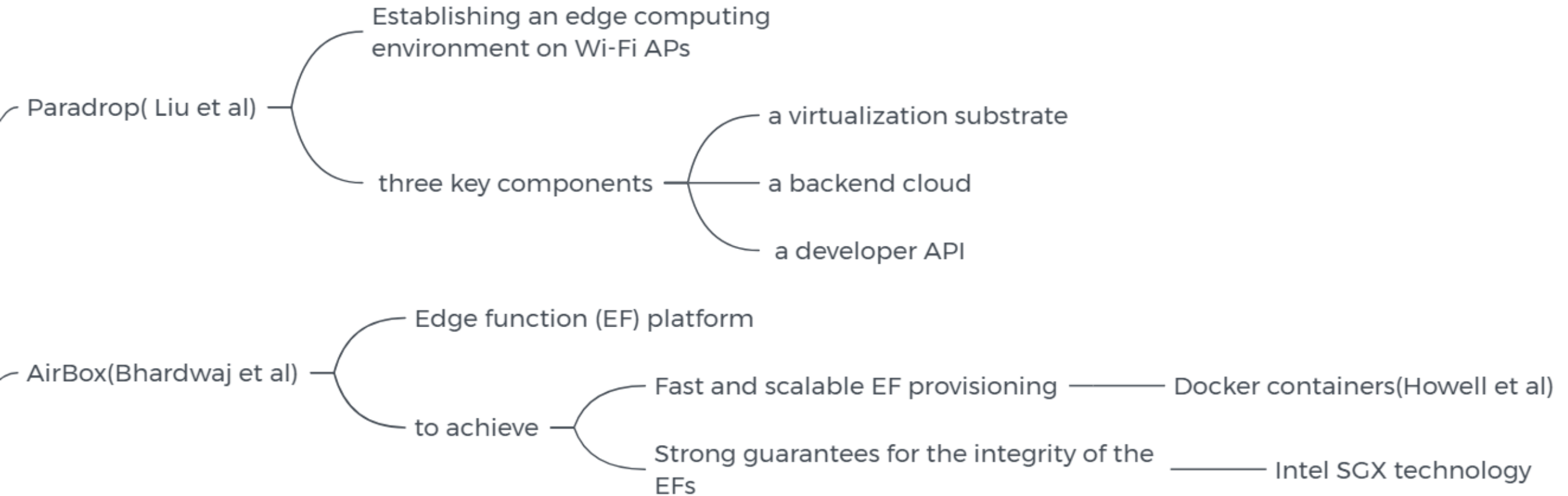
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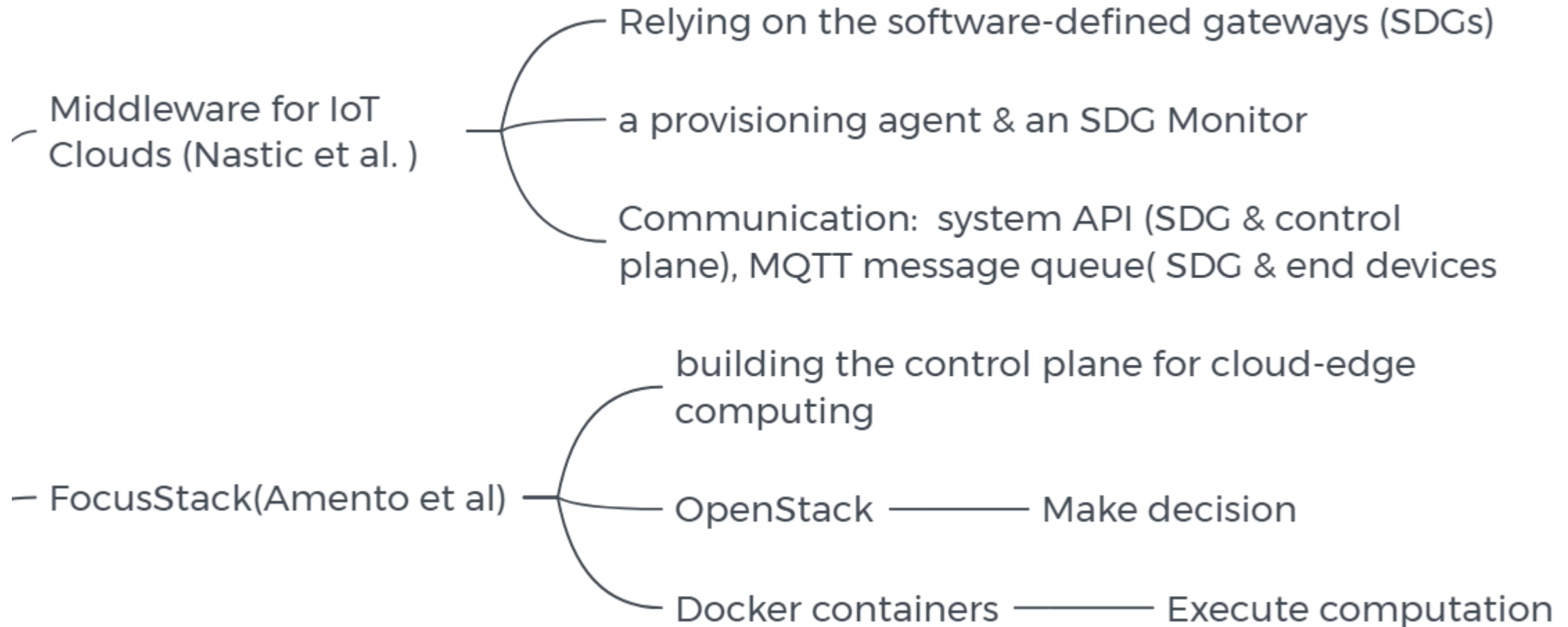
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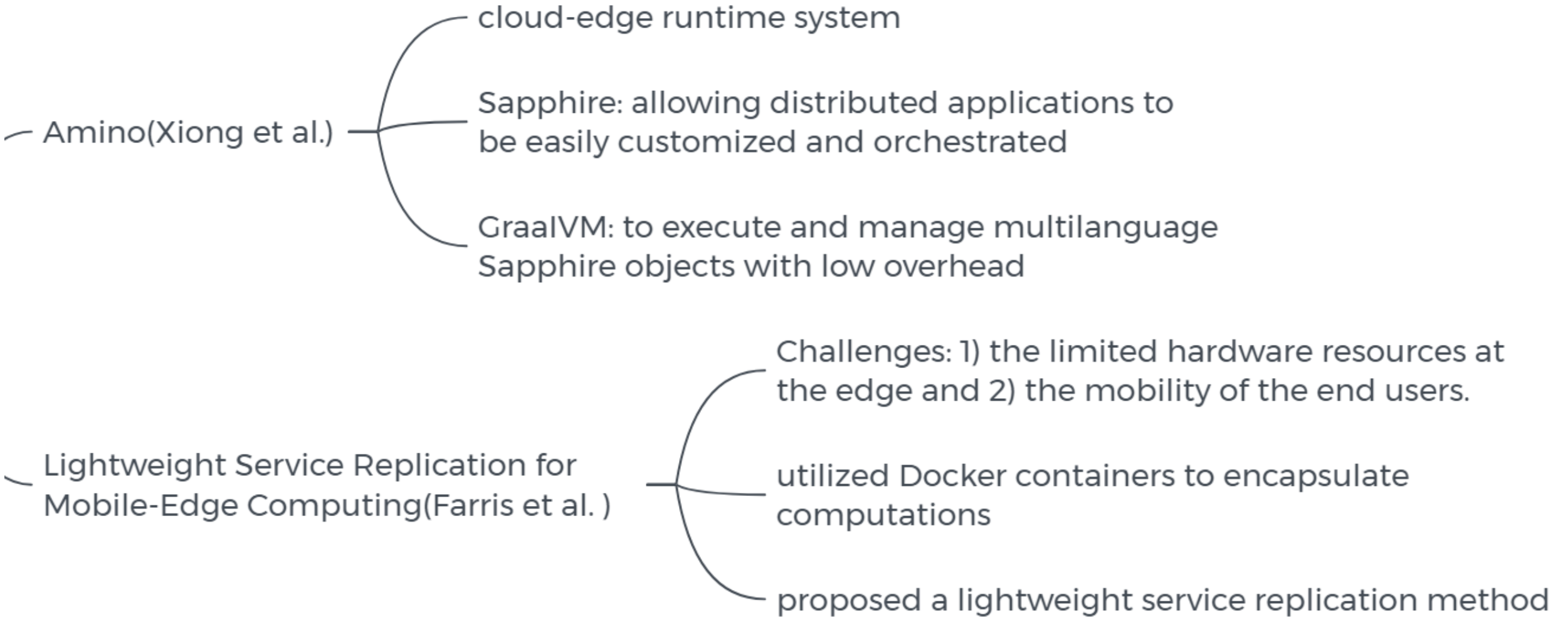
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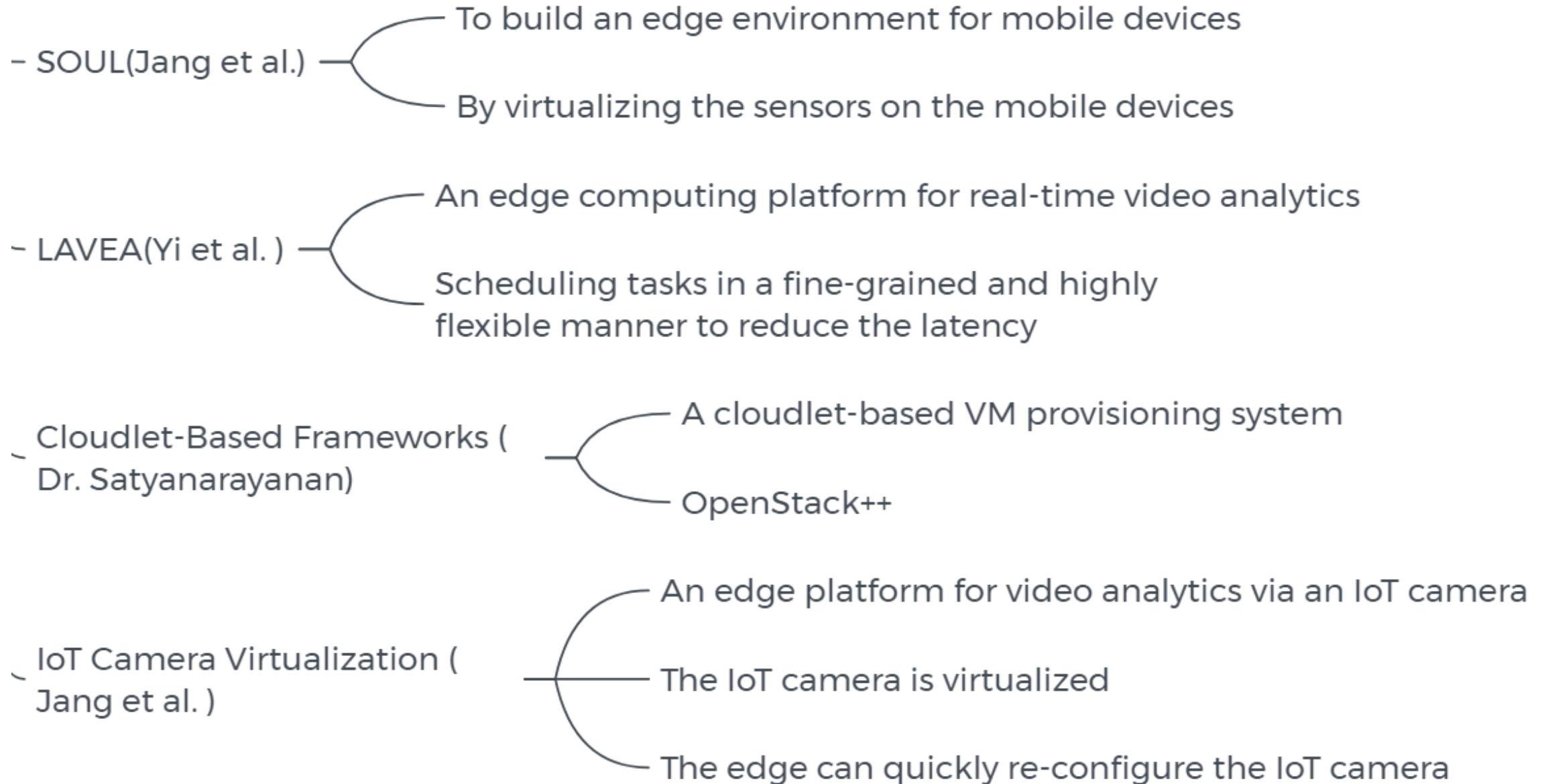
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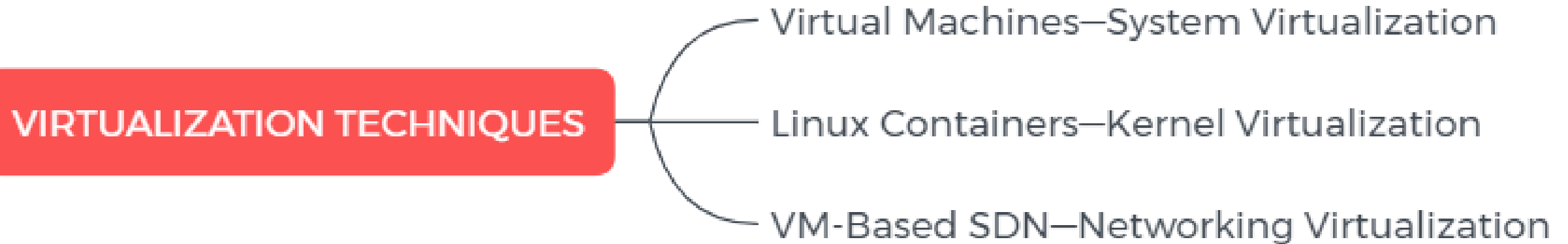
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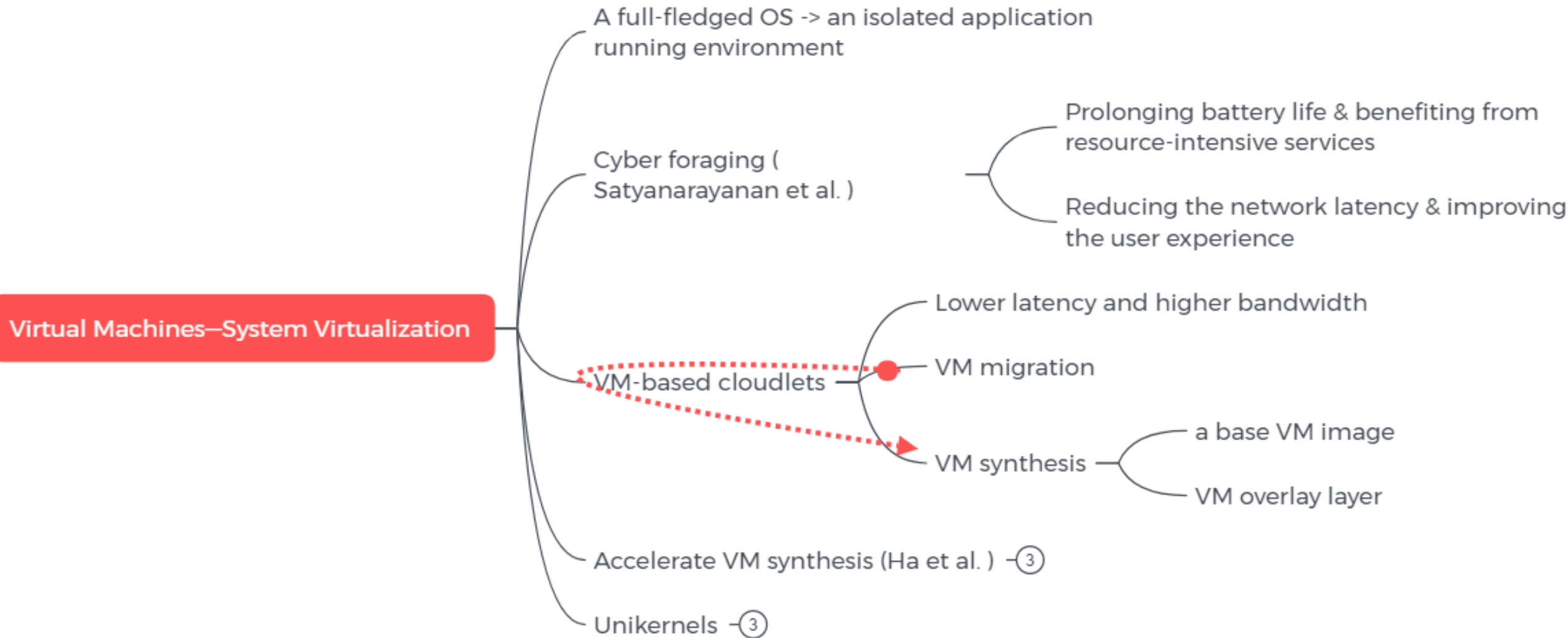


# VIRTUALIZATION TECHNIQUES

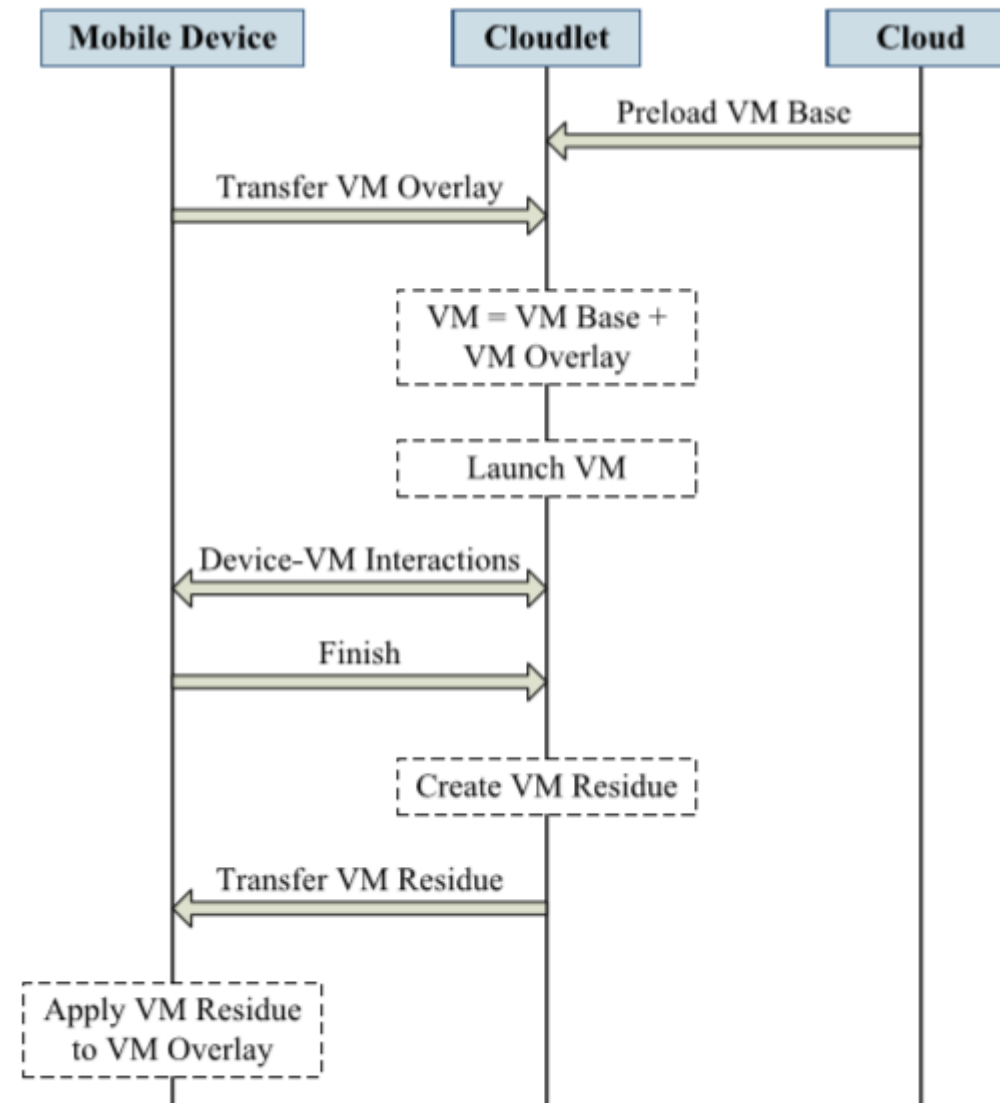
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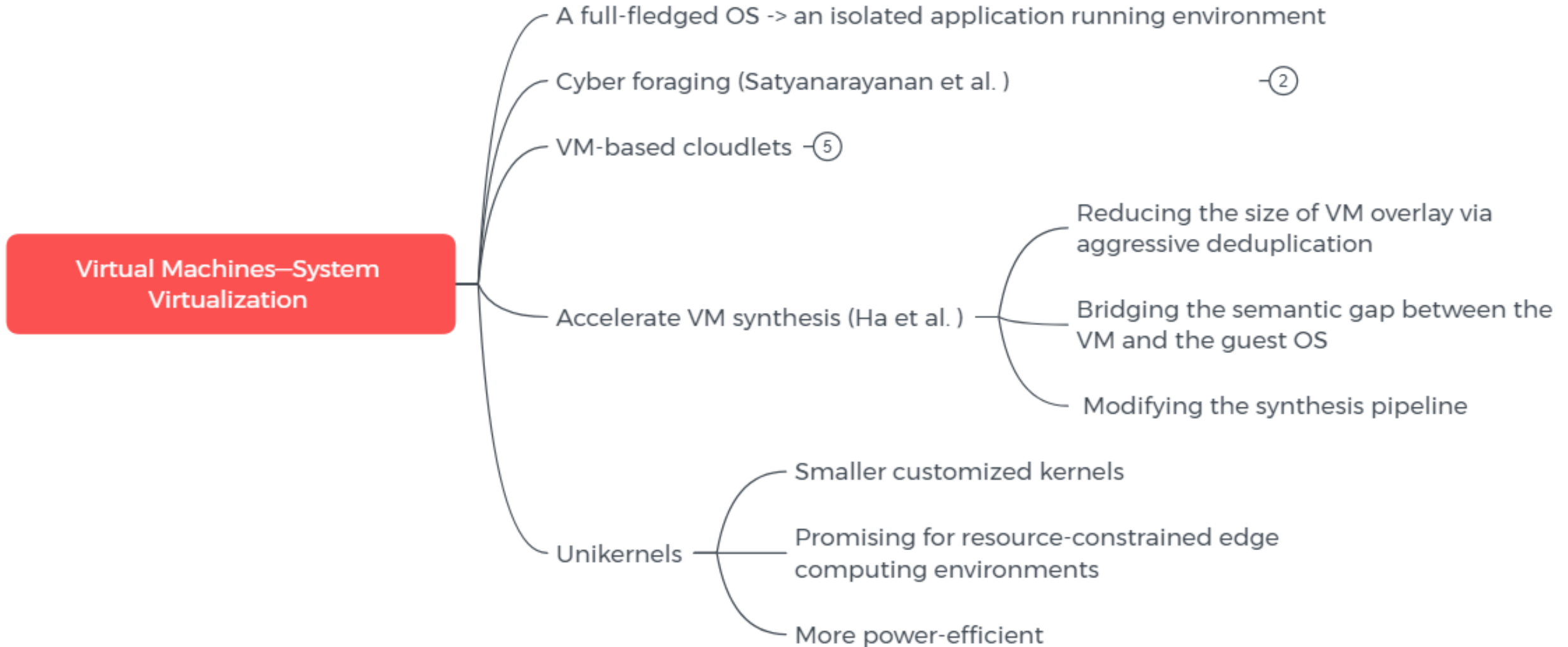


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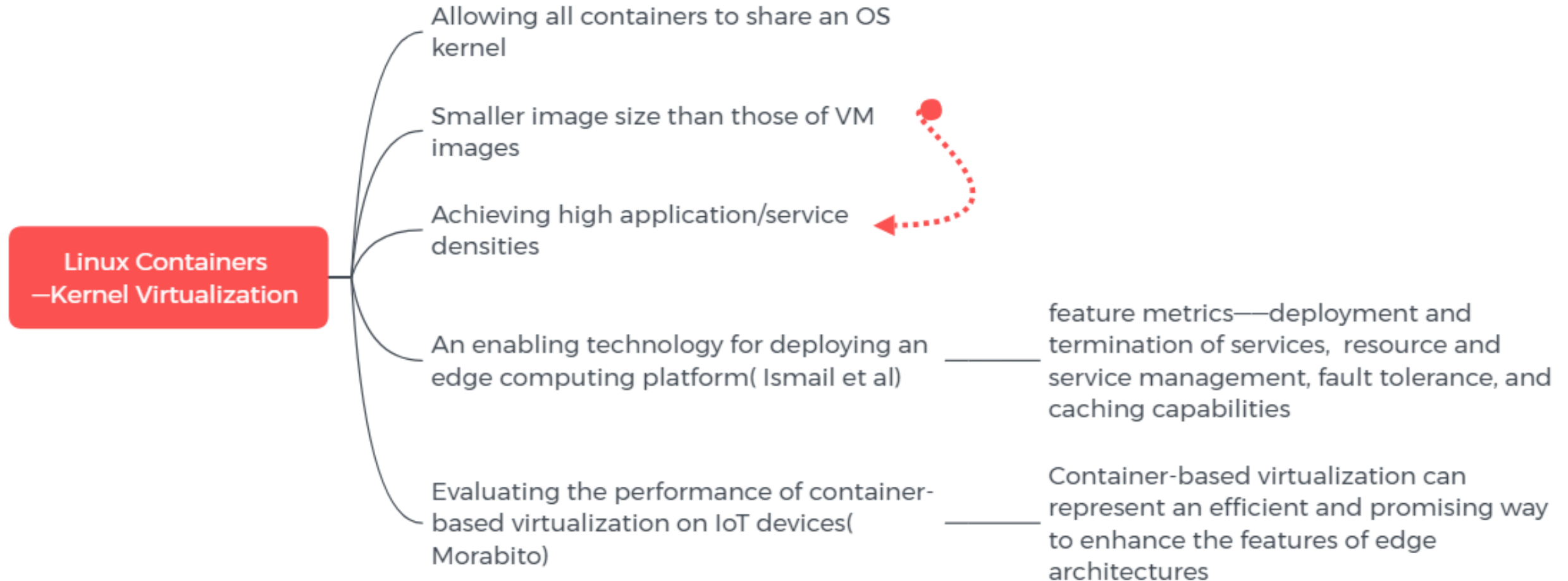
**Fig. 5.** *Dynamic VM synthesis in cloudlets.*

# VIRTUALIZATION TECHNIQUES

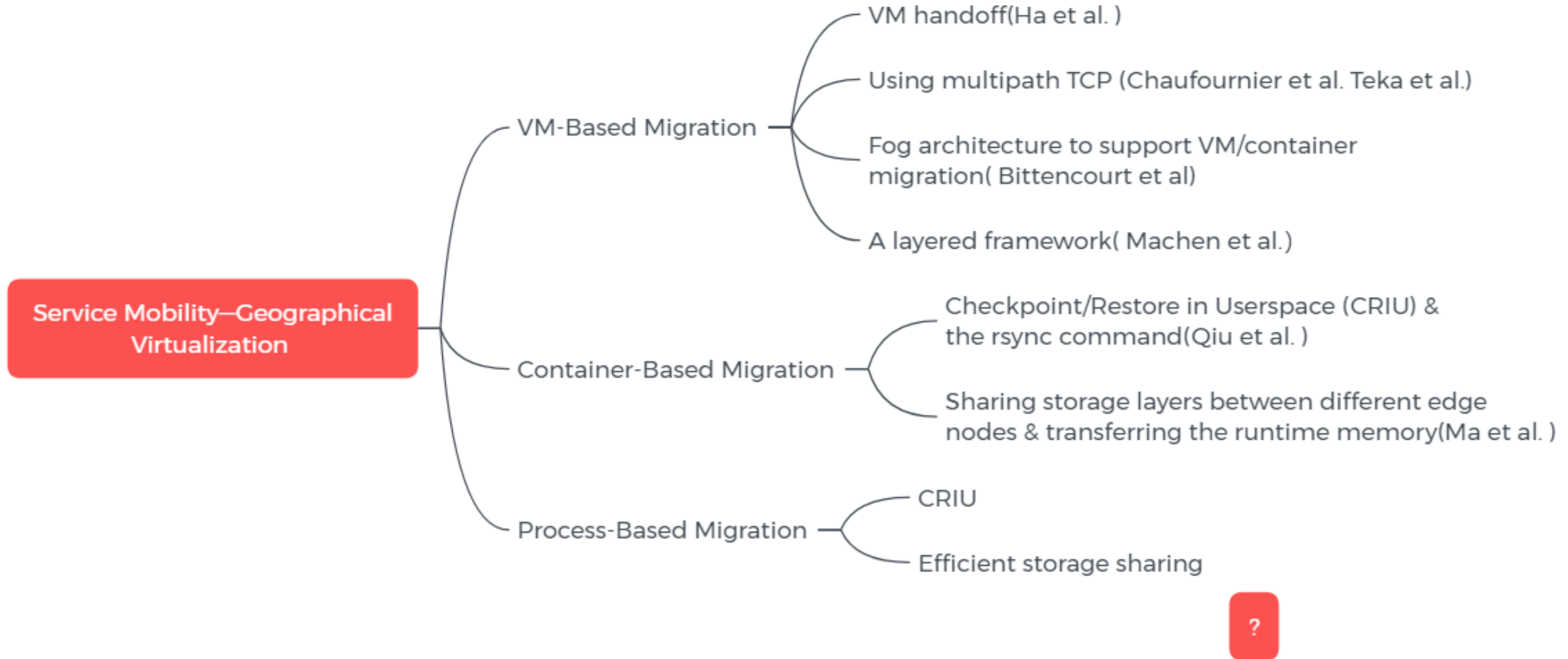




# VIRTUALIZATION TECHNIQUES



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## VM-Based SDN—Networking Virtualization

NEED: high bandwidth, low latency & dynamic networking configurations

SDN ——— Dynamic, manageable, cost-effective & adaptable

VM techniques—NetVM

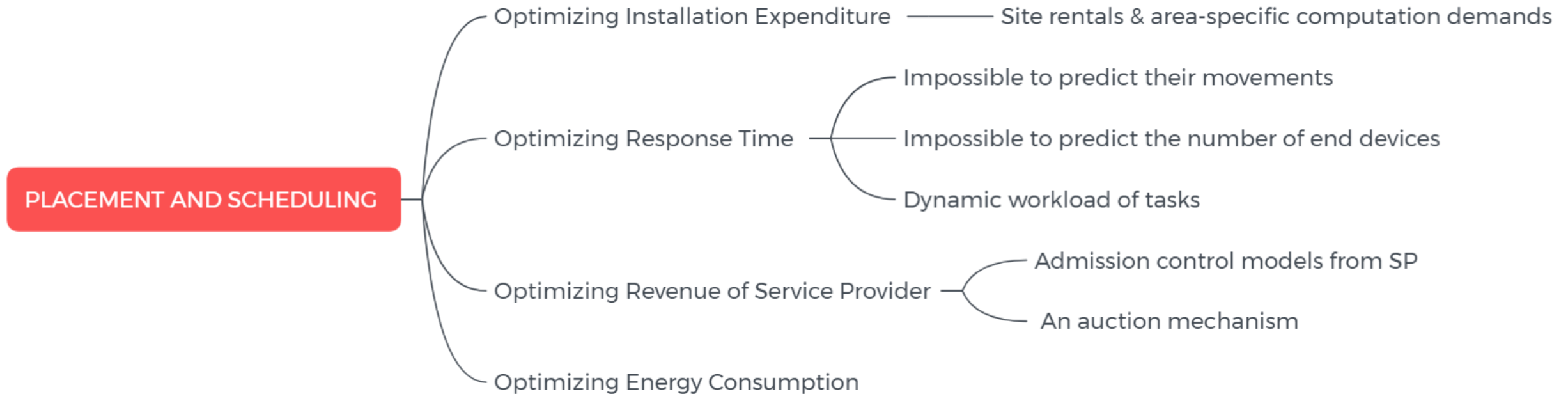
Reducing the overhead of copying packet data

Improving the throughput of the data plane

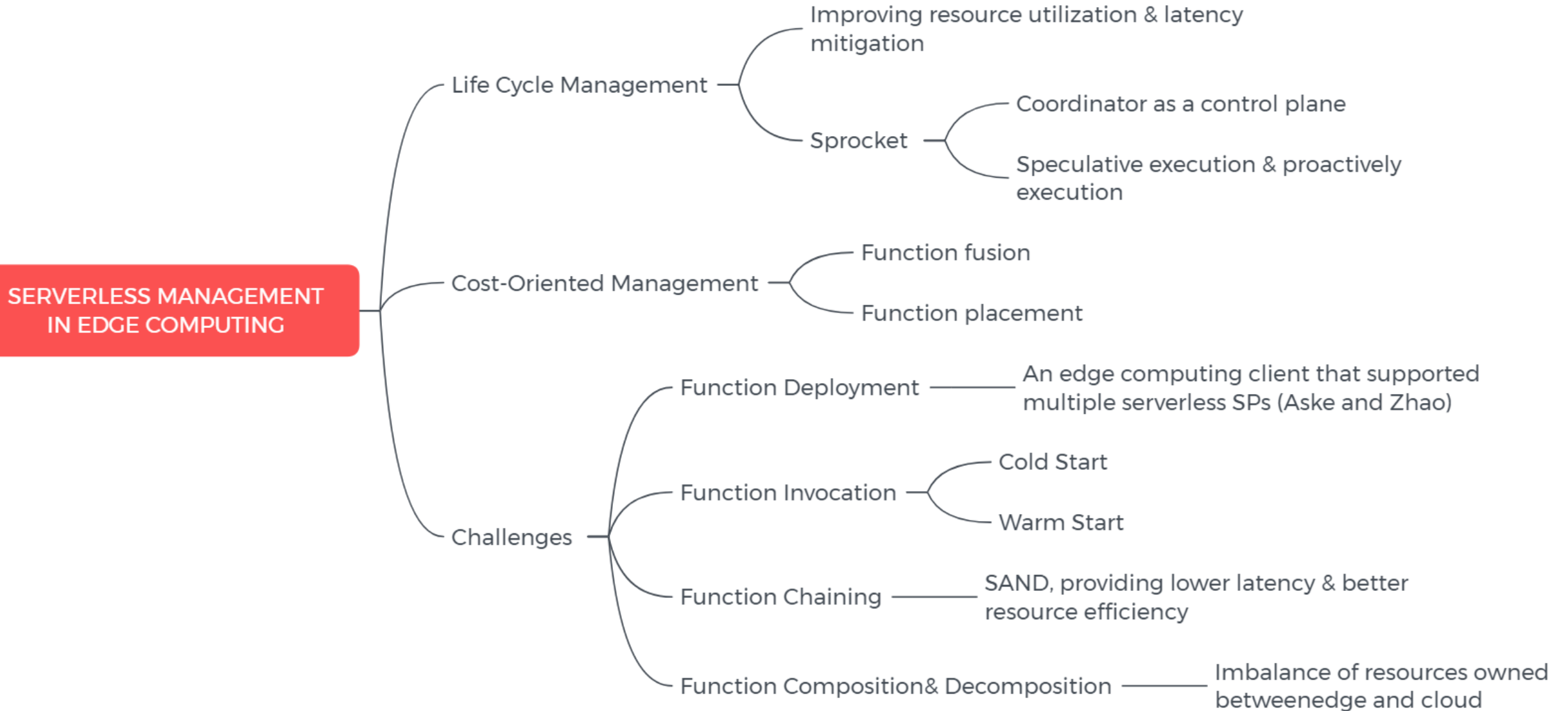
Limitation (hardware support)

# PLACEMENT AND SCHEDULING

Optimizing Objective	Model	Technique	Reference
Installation Expenditure	Mixed-Integer Non-Linear Programming(MINLP)	ILP-based Algorithm/Solver	[84]–[86]
Response Time	K-Cloudlets Placement Optimization Problem	K-Mean, Min-Max Solver	[87]–[90]
Energy Consumption	Bin Packing Problem	Particle Swarm Optimization(PSO)	[91], [92]
Revenue of Service Provider	General Optimization	Auction-based Profit Maximization semi-Markov decision process(SMDP)	[93]–[95] [96]

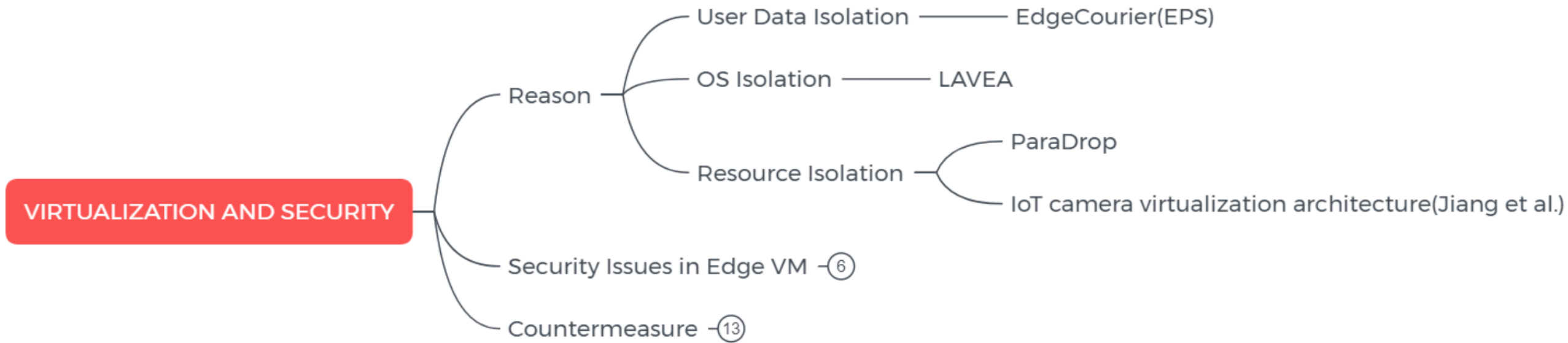


# SERVERLESS MANAGEMENT IN EDGE COMPUTING

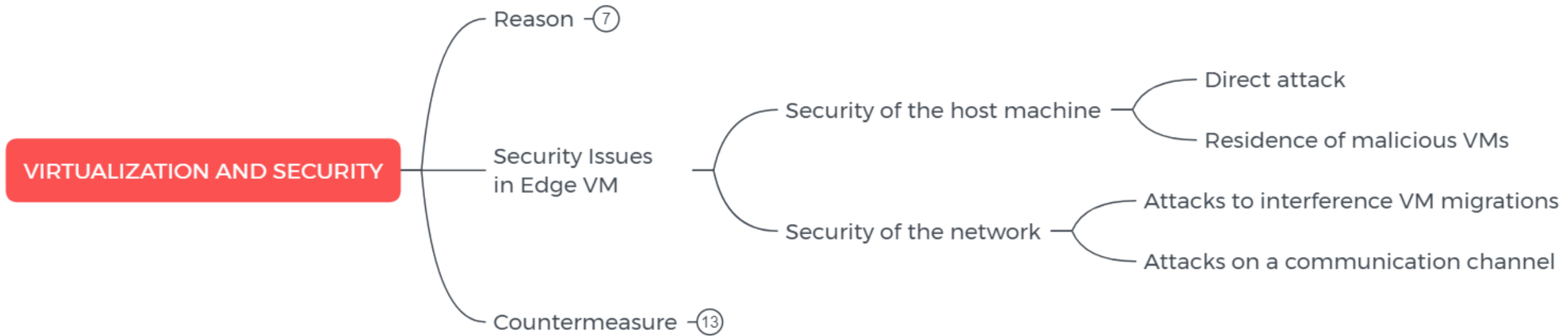


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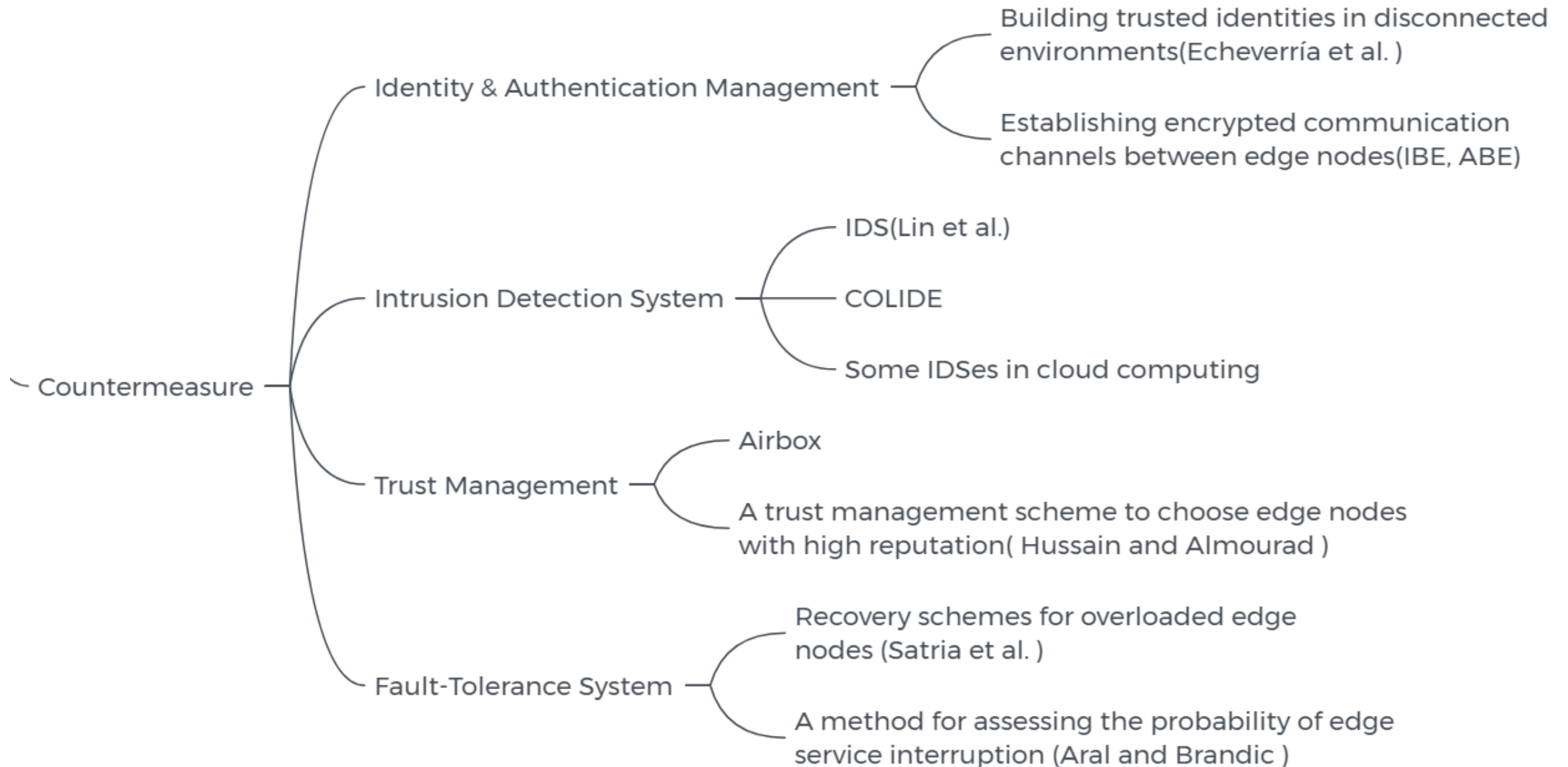
# VIRTUALIZATION AND SECURITY



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