



Fog Computing: Current Research and Future Challenges

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The evolution of computing paradigms

Evolution Focus Not so important?

	Paradigm	Evolution Focus		Not so important?	
		Device Ubiquity	Resource Sharing	High Bandwidth	Low Latency
	Mainframe/ Terminal	X	✓	X	X
	PC	✓	X	X	✓
	Cloud/ Mobile	✓	✓	✓	X



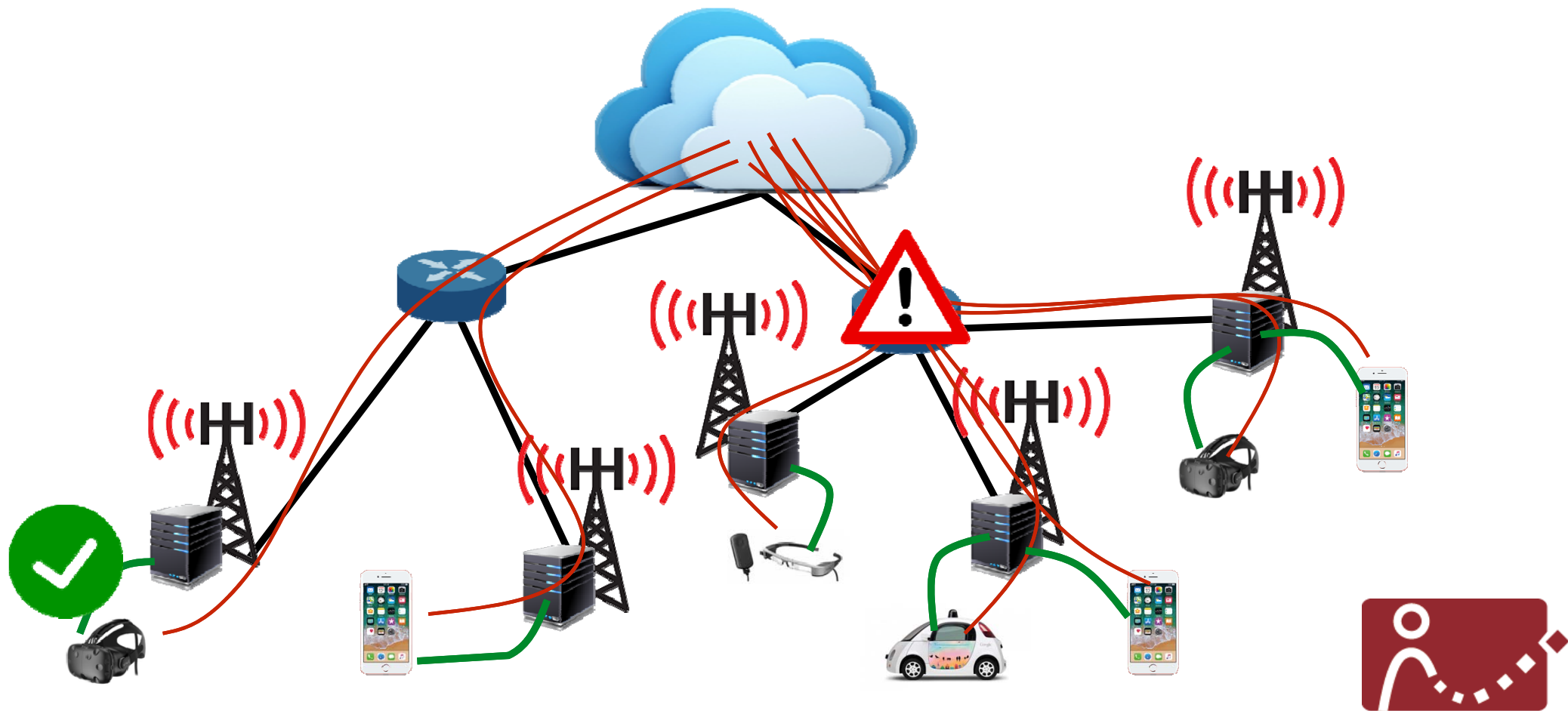
Mobile applications of the near future



Real-time big data processing requires both
HIGH bandwidth and **LOW** latency

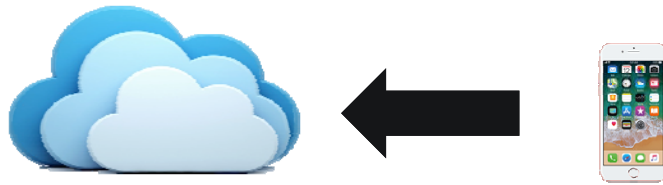


The solution – fog computing

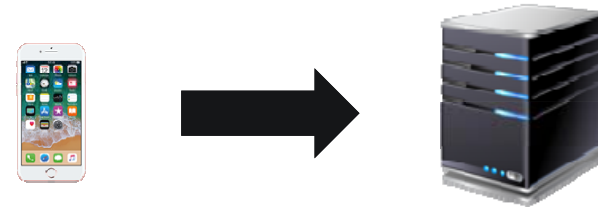


Current research

▪ Computation offloading



CloneCloud [EuroSys11]
Orleans [SoCC11]
ThinkAir [INFOCOM12]
TONO [INFOCOM13]
COSMOS [MobiHoc14]

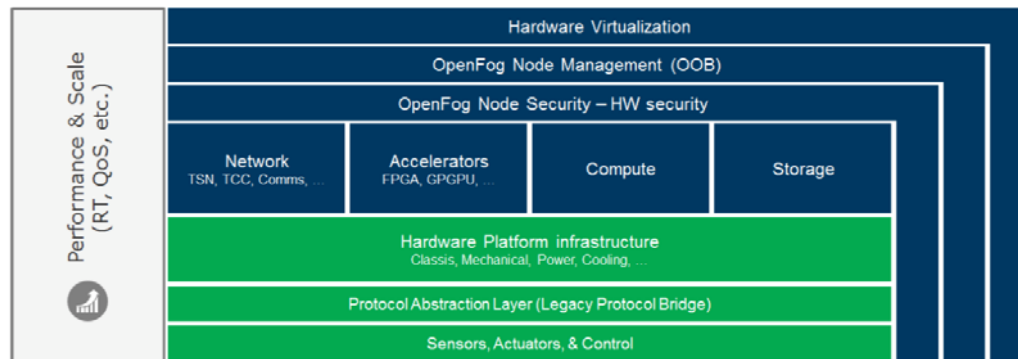


Cloudlet [CM2008]
MAUI [MobiSys10]
Odessa [MobiSys11]
Comet [OSDI12]
Tango [MobiSys15]

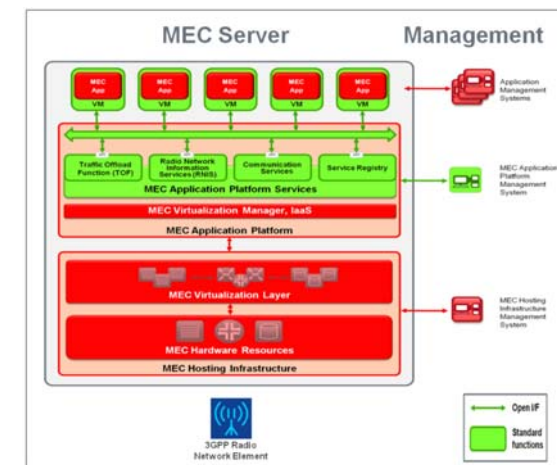


Current research (contd.)

▪ Fog computing infrastructure



OpenFog



ETSI

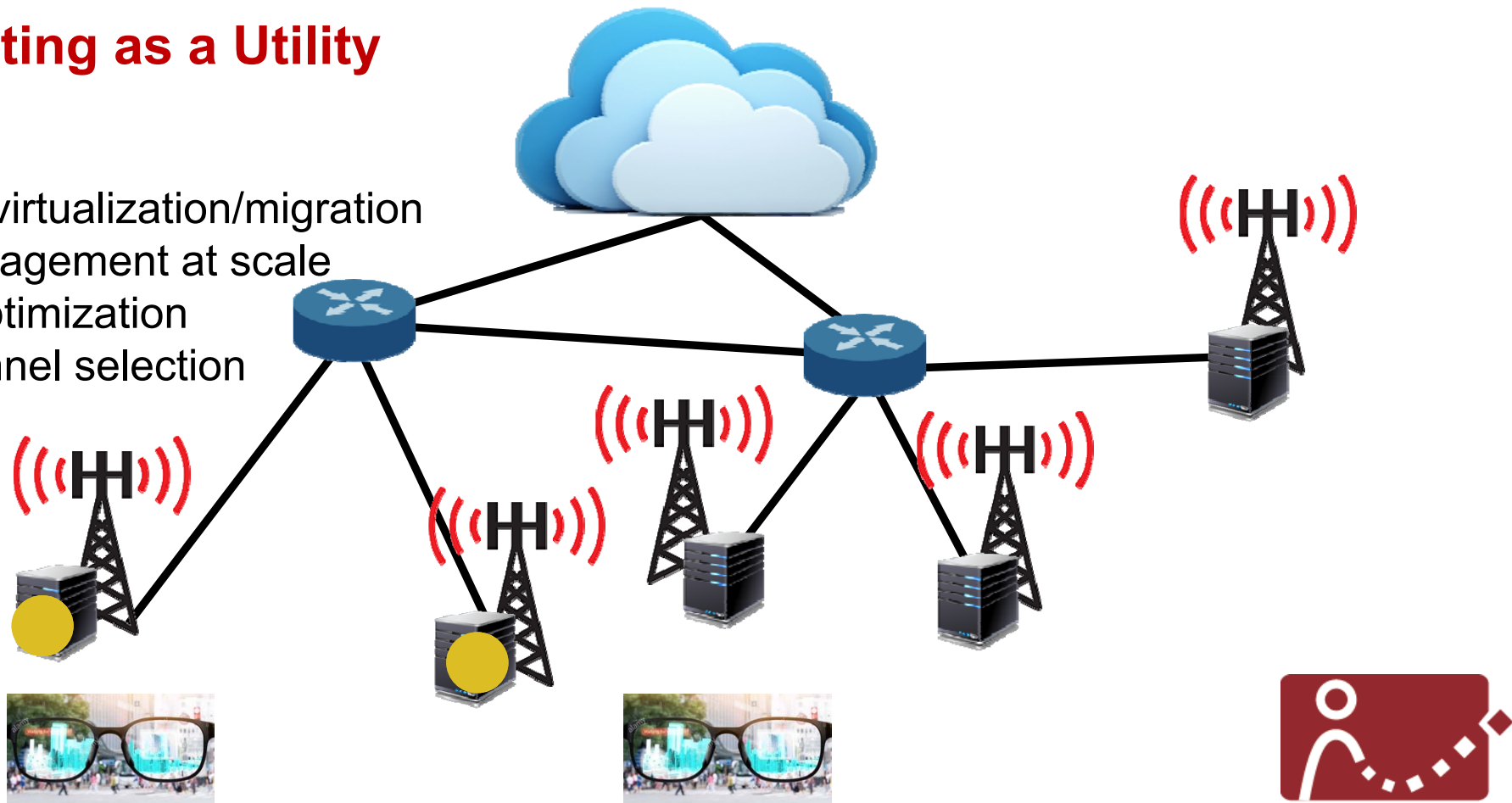


Our vision

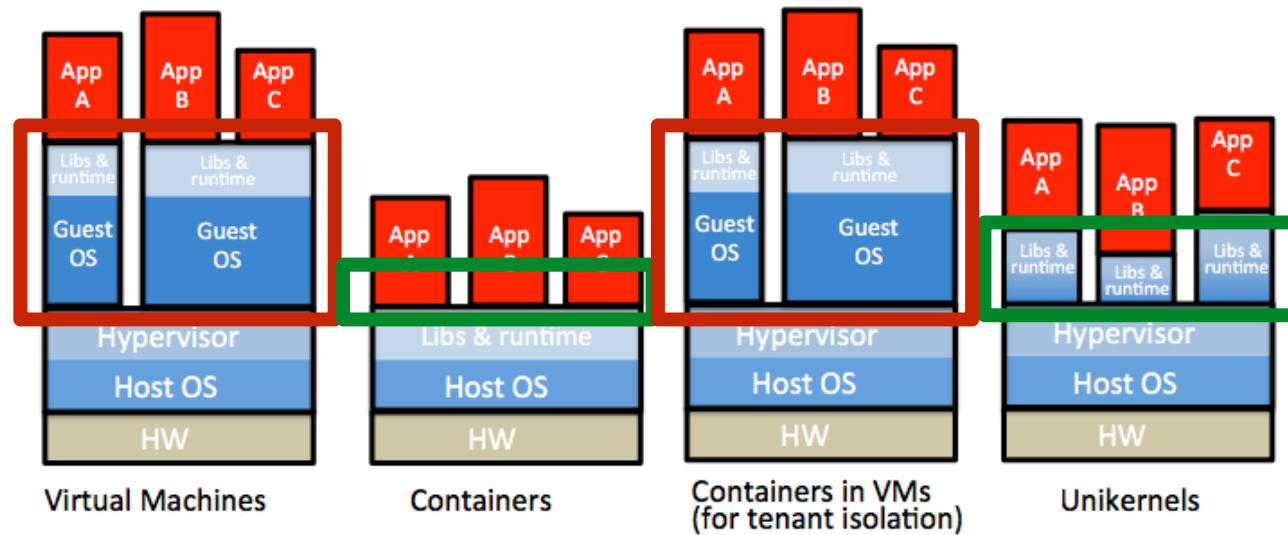
Fog Computing as a Utility

Challenges:

- Lightweight virtualization/migration
- System management at scale
- Resource optimization
- Comm. channel selection



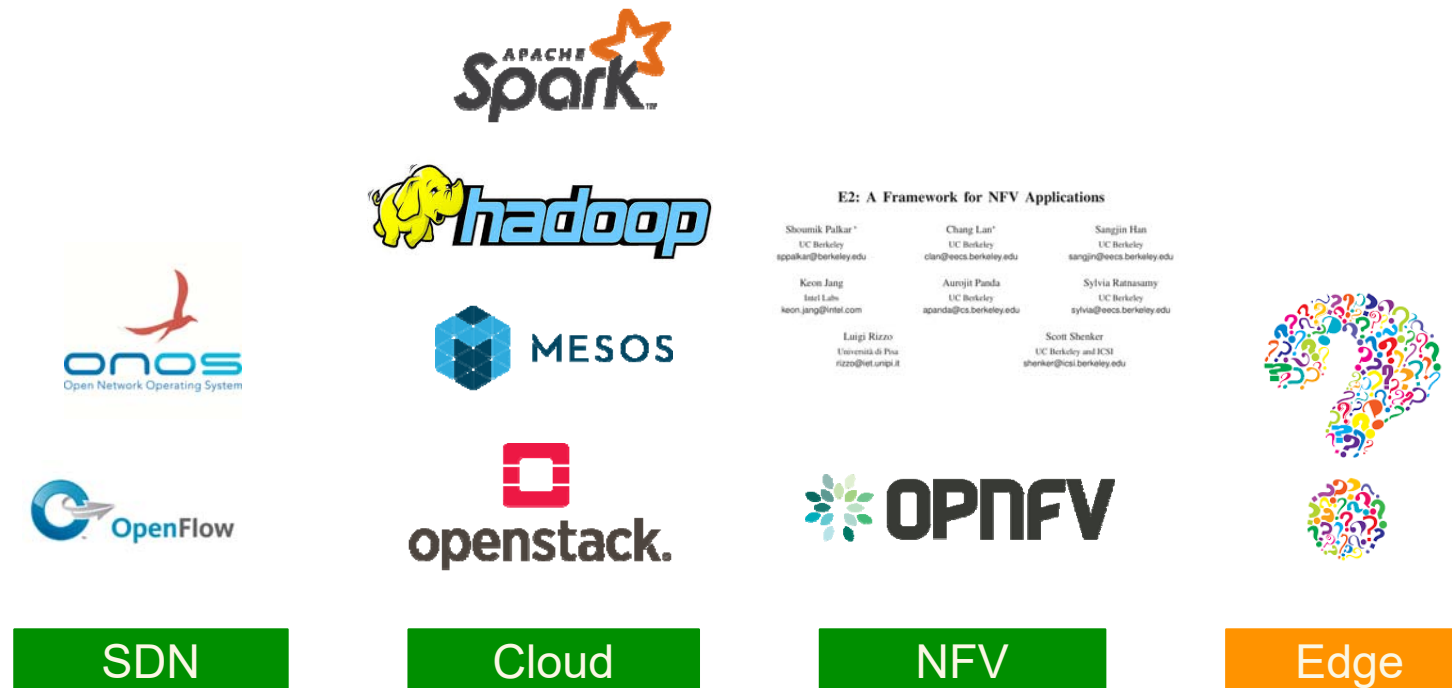
Lightweight virtualization



sharing vs. **isolation**



System management



System management (contd.)

▪ A general framework that

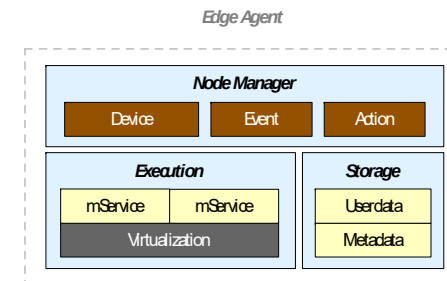
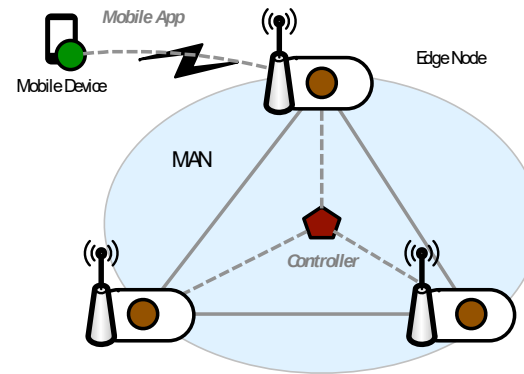
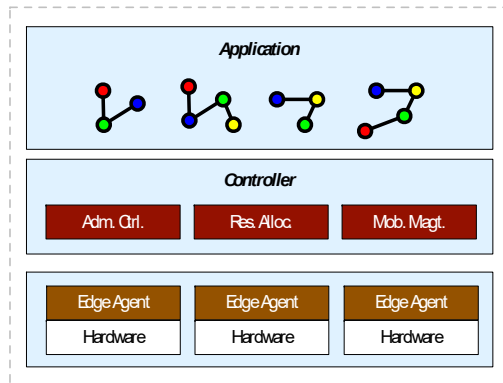
- Provides hardware abstraction for application development
- Handles common tasks such as resource management

▪ Requirements

- Loose coupling between the device and edge infrastructure
- Highly-responsive in interaction loops
- Resource efficient to fully utilize the resources



System management (contd.)

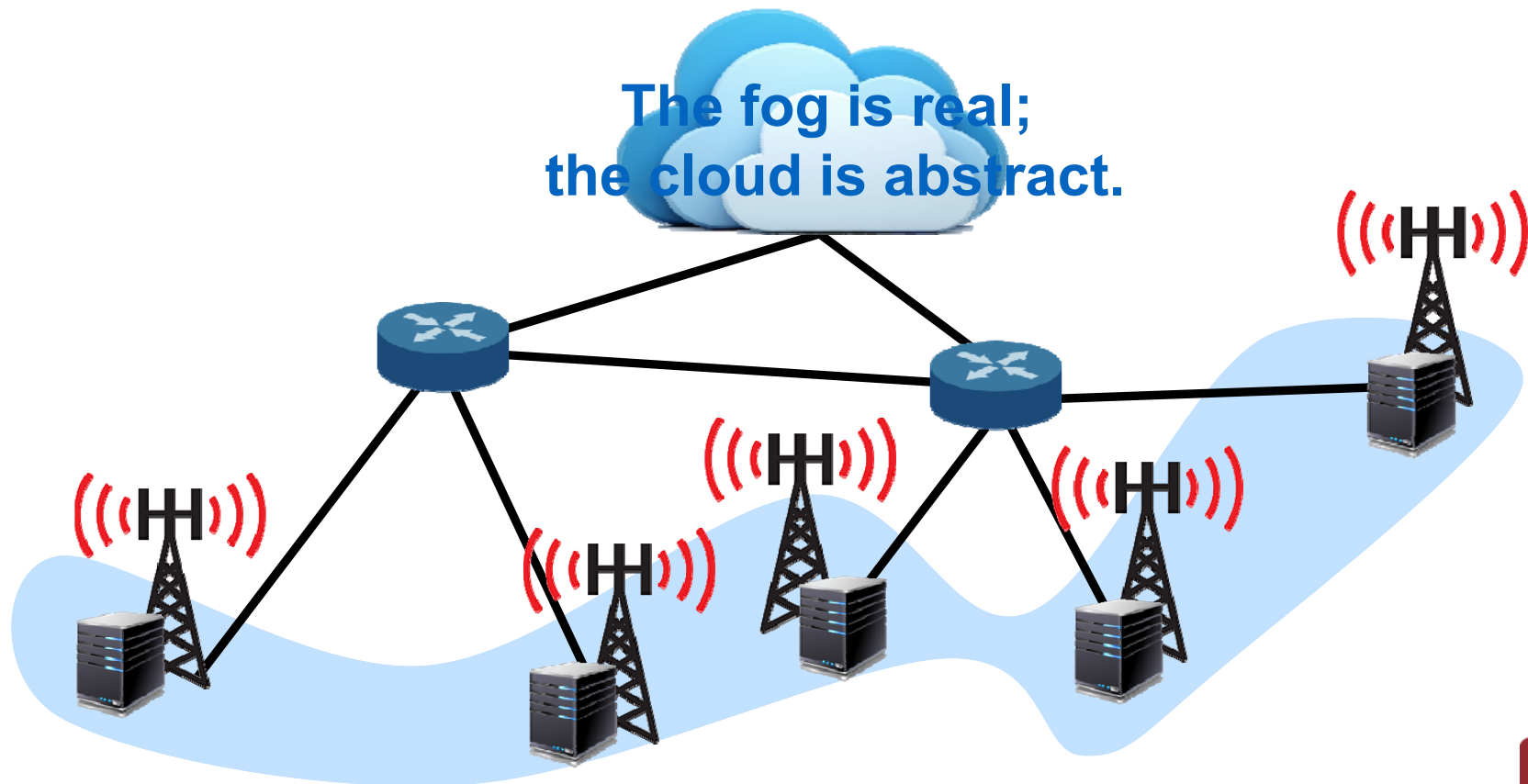


▪ Fog computing framework

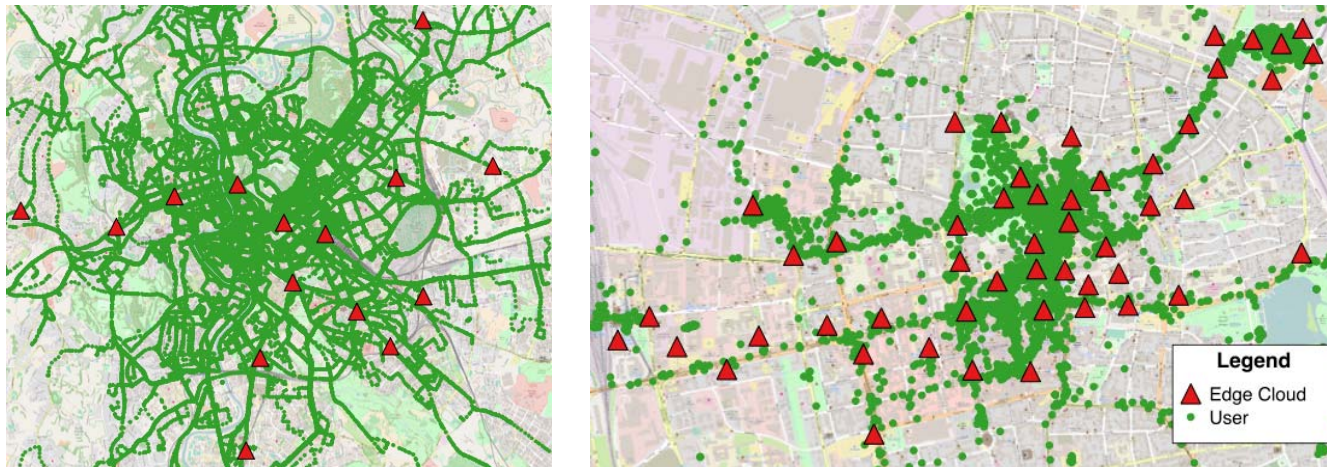
- Execution subsystem: event-based microservices
- Control subsystem: admission control, resource allocation, mobility management



Holistic resource allocation



Mobility-agnostic online resource allocation



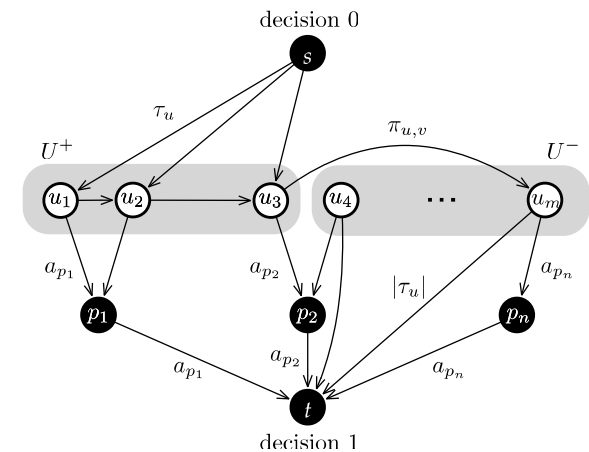
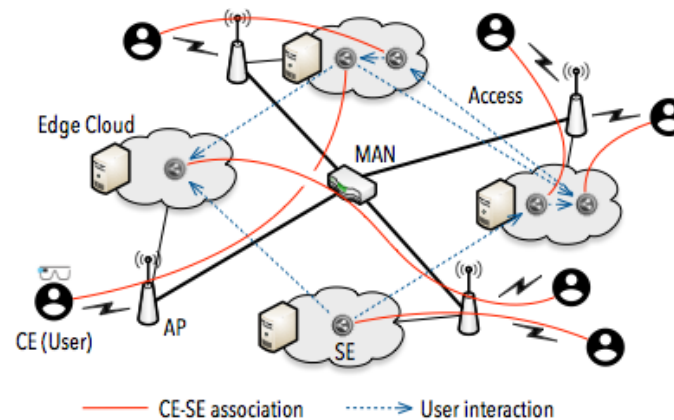
- **Mixed integer program**
- **Competitive analysis (constant competitive ratio)**

Lin Wang, Lei Jiao, Jun Li, Max Mühlhäuser, “Online Resource Allocation for Arbitrary User Mobility in Distributed Edge Clouds”, ICDCS 2017.

Lin Wang, Lei Jiao, Jun Li, Julien Gedeon, Max Mühlhäuser, “MOERA: Mobility-agnostic Online Resource Allocation in Edge Computing”, TMC, under revision.



Service entity placement for VR/AR



- **Social communication between service entities, resource contention at the edge/fog node**
- **Graph-cut-based optimal placement algorithm**

Lin Wang, Lei Jiao, Ting He, Jun Li, Max Mühlhäuser, "Service Entity Placement for Social Virtual Reality Applications in Edge Computing", INFOCOM 2018.



Future challenges

- **Data/application migration**

- Highly mobile scenarios
- Proactively migration based on predicted mobility

- **Seamless interplay between fog and cloud**

- **Business models**

- Incentives for telco and service providers, business impact

- **Security and privacy**

- Fog can help to improve privacy, but how?
- Movement traces of users



In closing...

“Edge/fog computing is transformative. It enables new applications. It is truly disruptive. It is here!”

- Mahadev Satyanarayanan



Thank
You
Questions?



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