Opportunism and Symbiosis in Mobile Cloud Computing: The Promise and the Challenges

Mostafa Ammar
School of Computer Science
Georgia Institute of Technology
Atlanta, GA

In Collaboration with: Ellen Zegura, Mayur Naik, Cong Shi, Karim Habak, Ahmed Saeed
Alireza Monfared (Georgia Tech), Khaled Harras, Abderahmen Mtibaa (CMU-Q)
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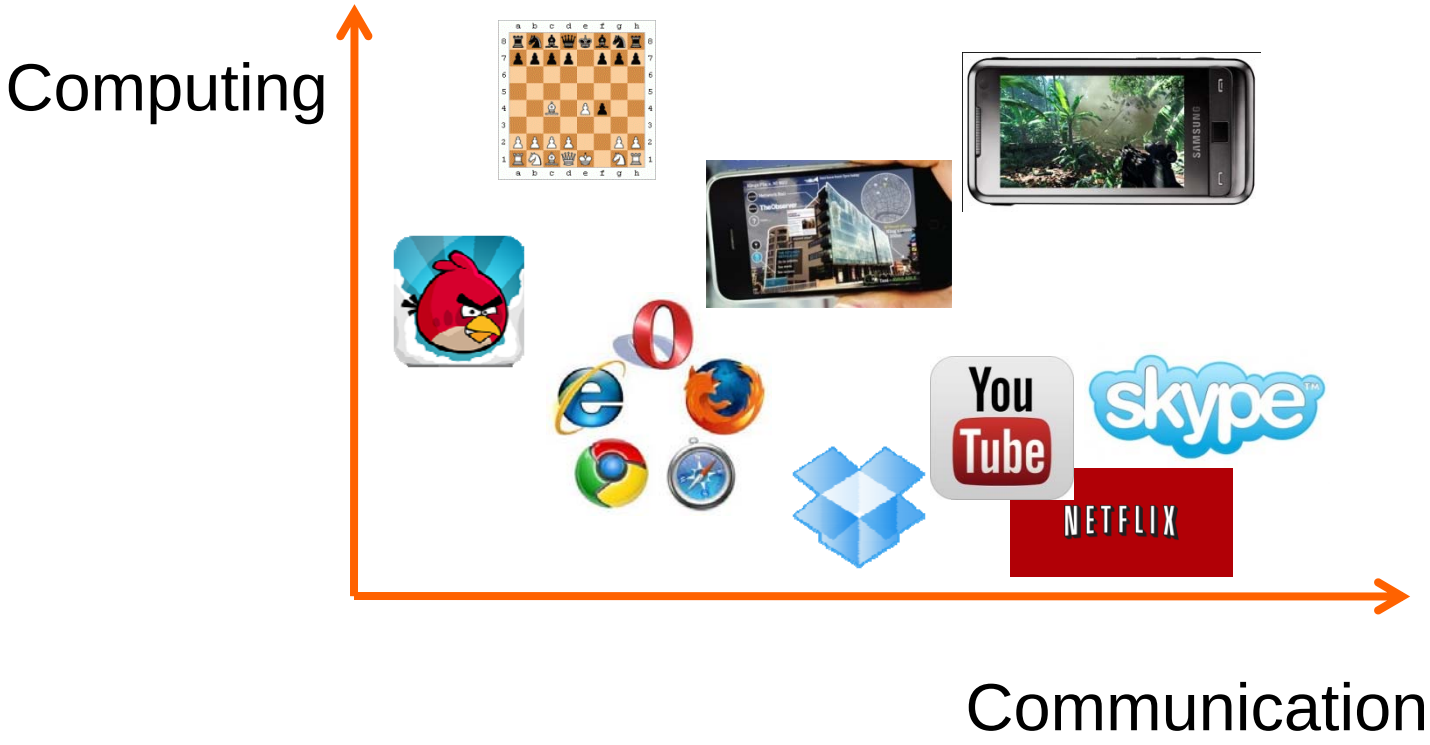
Connectivity and computing power on the go

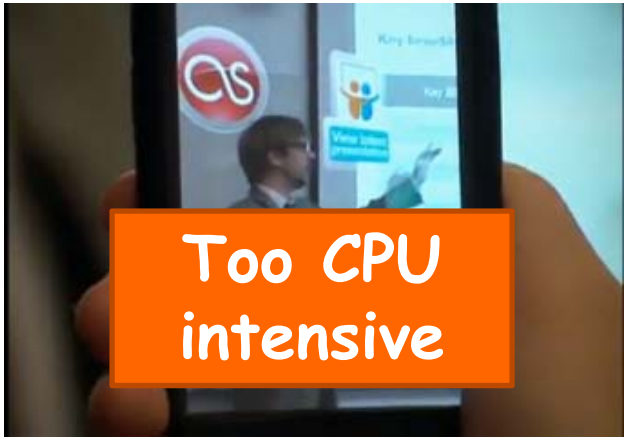
Mobile Applications: Computing and Communication

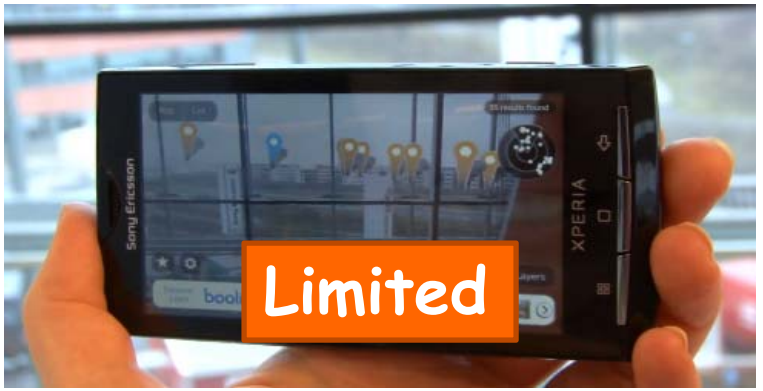


Beyond Device Computing Capability

Speech Translation

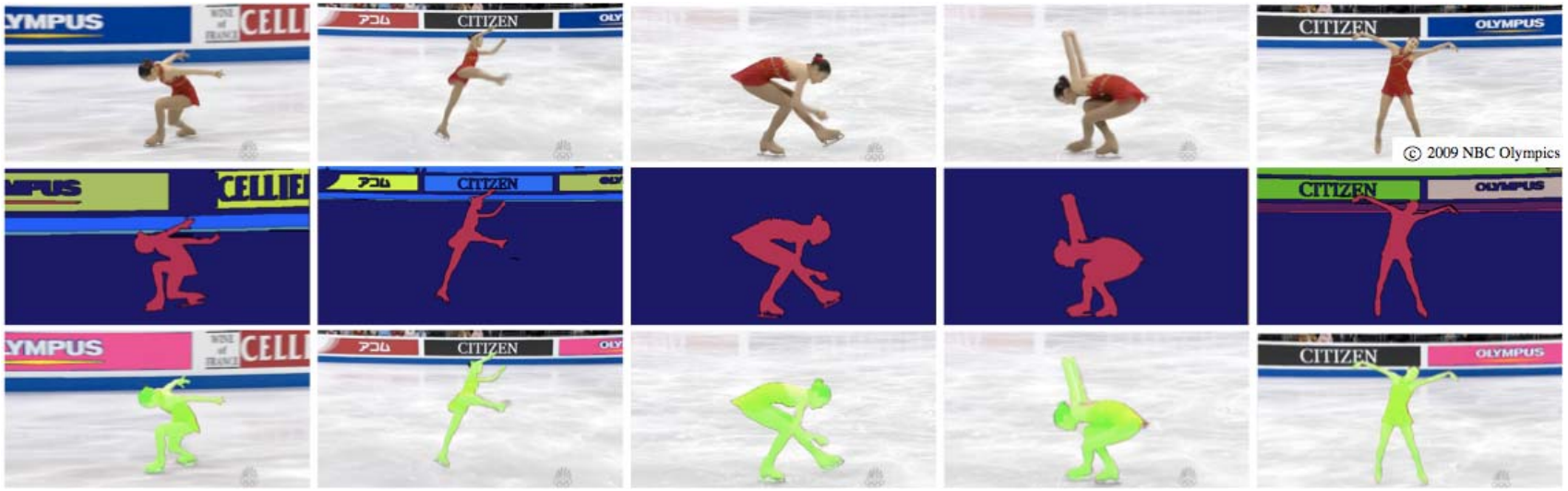
Interactive Games





Augmented Reality

Video Segmentation



Cloud Computing to the Rescue

- Computing resources delivered as a service over the Internet

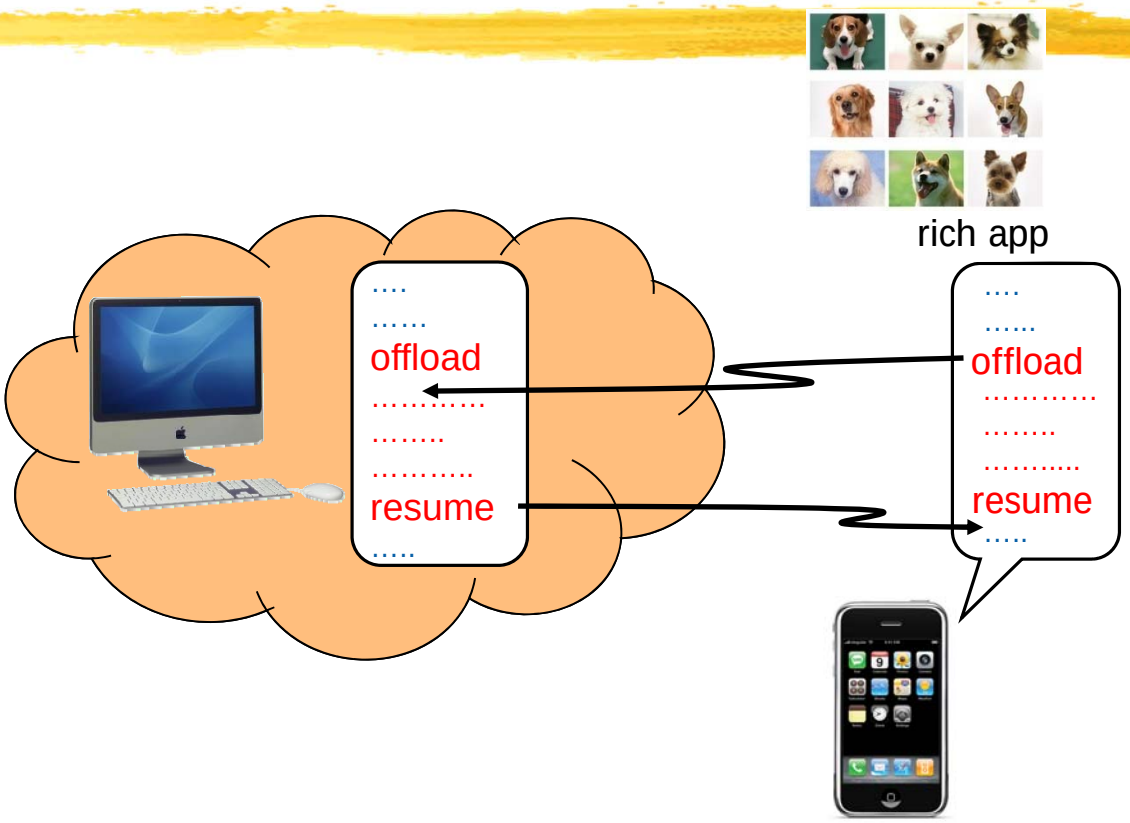
Cloud Computing

- Computing resources delivered as a service over the Internet

Mobile Cloud Computing

- Computing resources delivered as a service over the Internet
- Extension of Cloud Computing to Mobile Services
  - Service delivered to mobile devices

Classic Solution: Offload Computation to the Cloud*



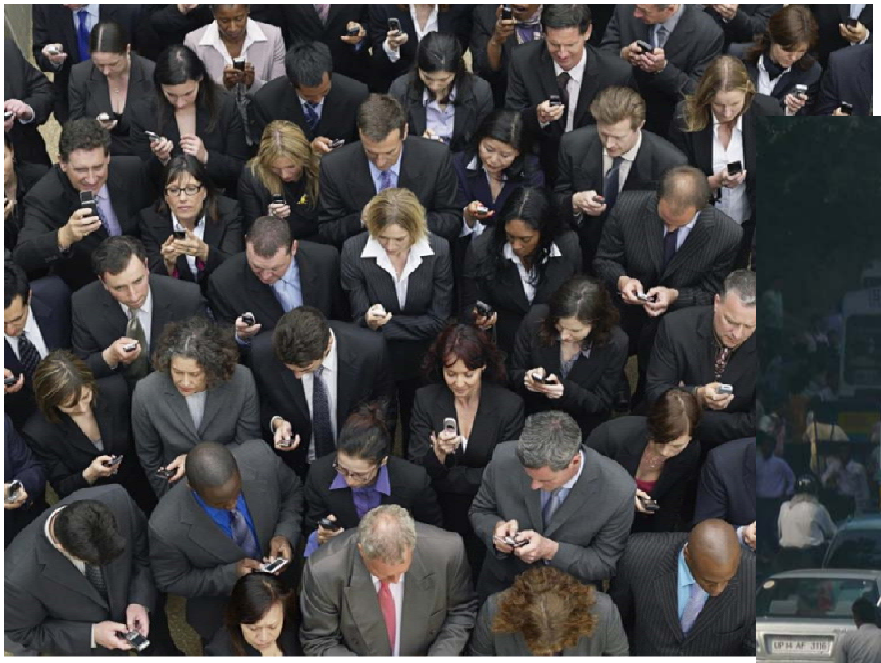
*B. Chun, et al.,*Clonecloud: elastic execution between mobile device and cloud*. In Proceedings of the 6th European Conference on Computer Systems (EuroSys'11), pages 301–314, 2011.

*E. Cuervo, et al., *MAUI: Making smartphones last longer with code offload*. In Proceedings of the 8th International Conference on Mobile Systems, Applications, and Service (MobiSys'10).

Challenges in Mobile Cloud Computing

- Connectivity Issues
  - Bandwidth
  - Intermittency
- High Latency
- Cost

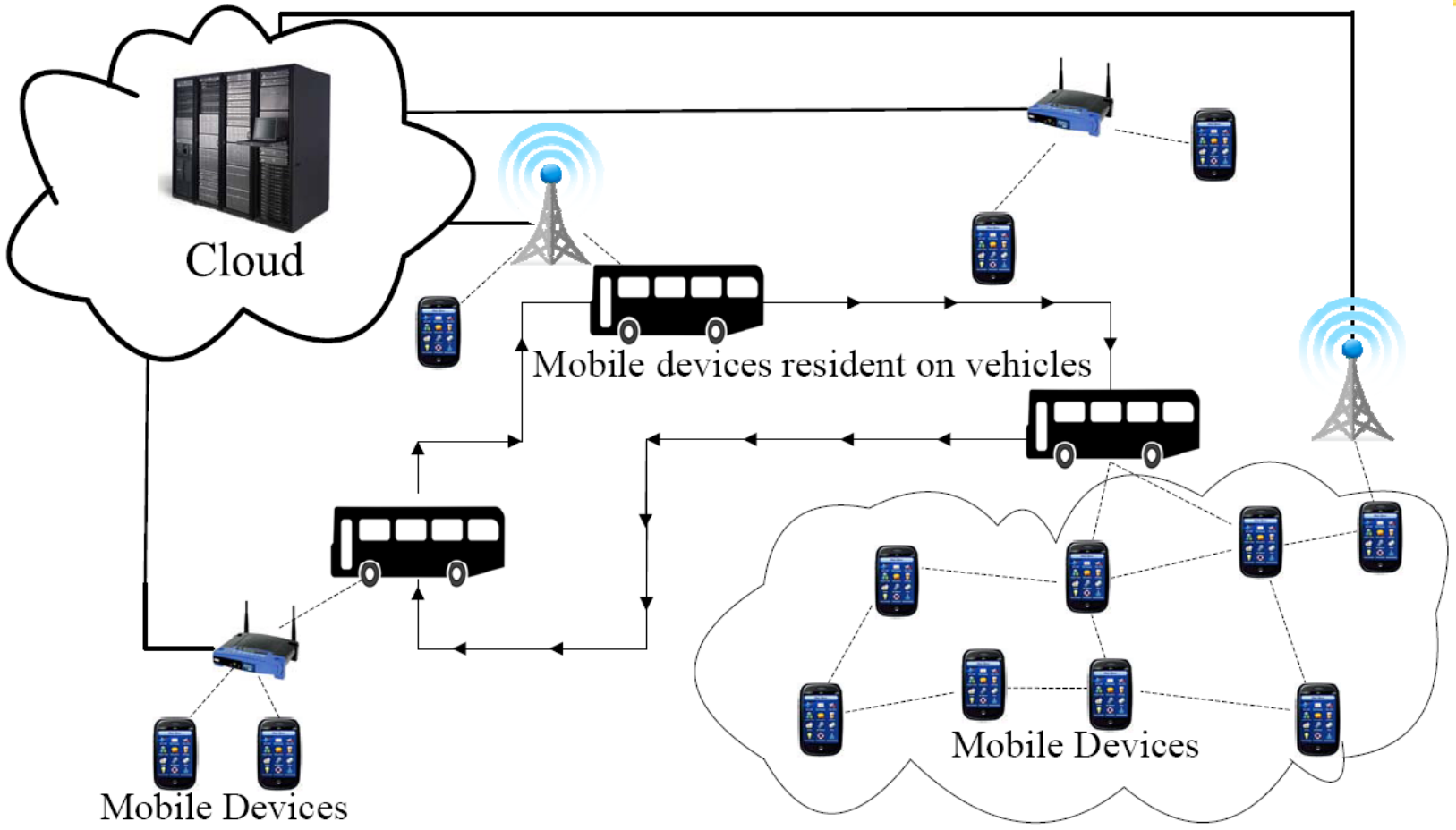
Observation: lots of idle resources!



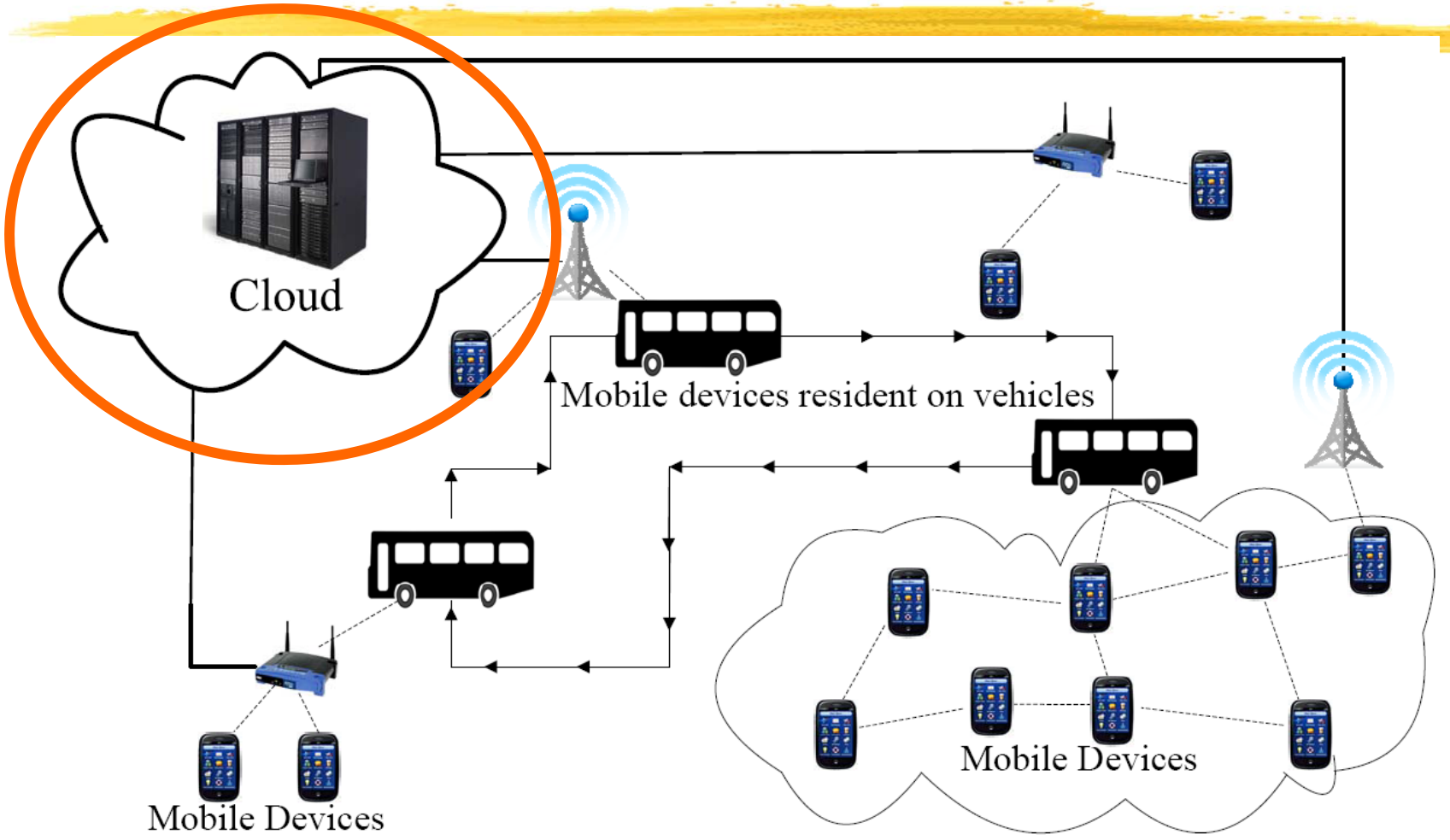
Opportunistic/Symbiotic Mobile Cloud Computing

- Opportunism and Symbiosis: Two additional tools to address MCC challenges
- Opportunism: Make use of all available compute resources as they are available.
- Symbiosis: Mobile devices help each other

Opportunistic and Symbiotic Cloud Computing Environment



Opportunistic and Symbiotic Cloud Computing Environment

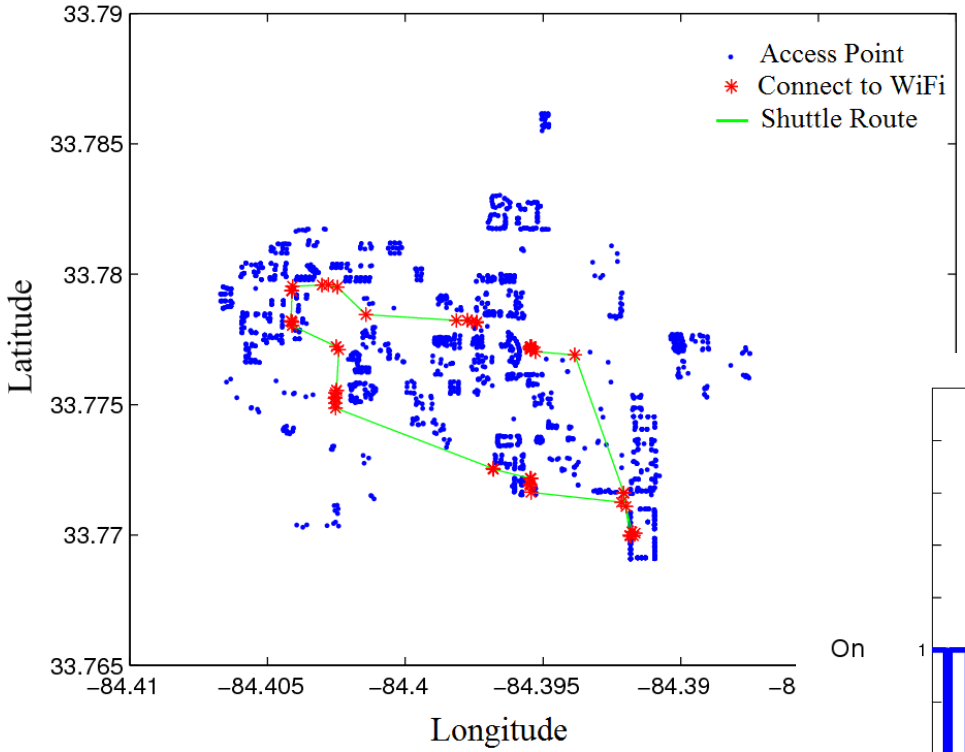


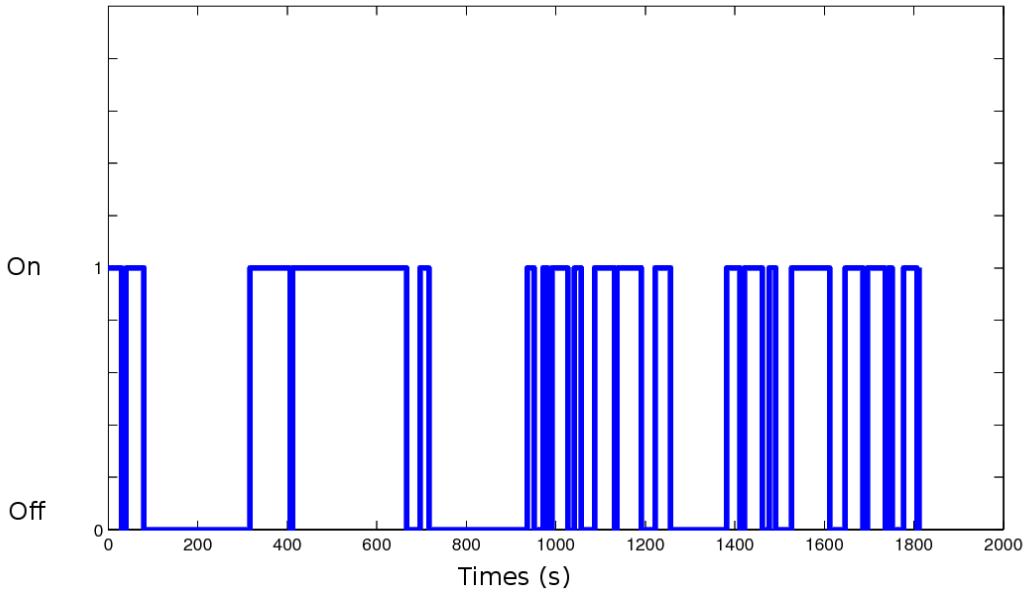
Opportunistic offloading to remote cloud

- The COSMOS System*
  Computational Offloading as a Service

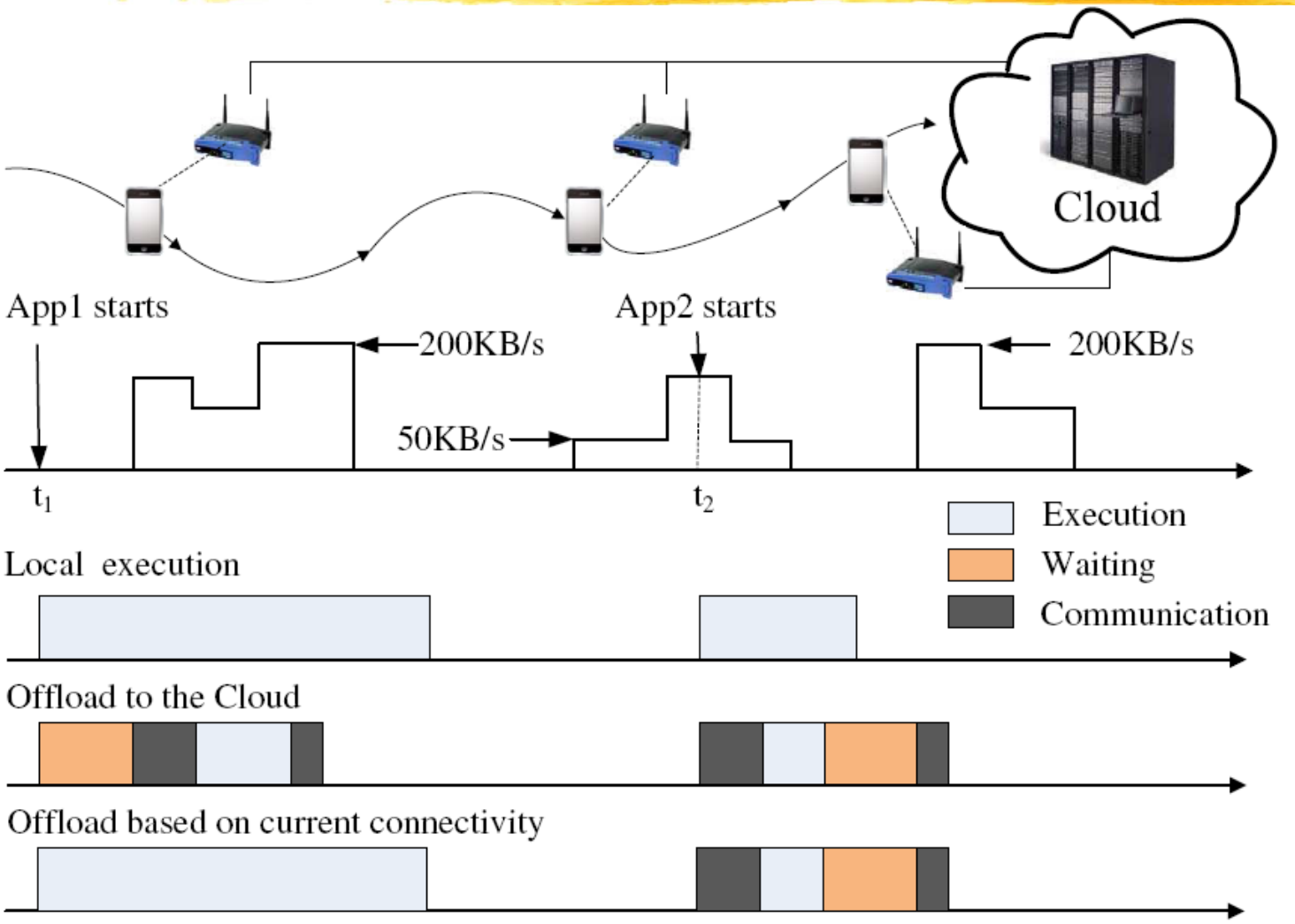
*Shi et al, ACM Mobihoc 2014

Outdoor Wireless:
Intermittent Connectivity on Campus Shuttle





Offloading Decision with Variable Connectivity

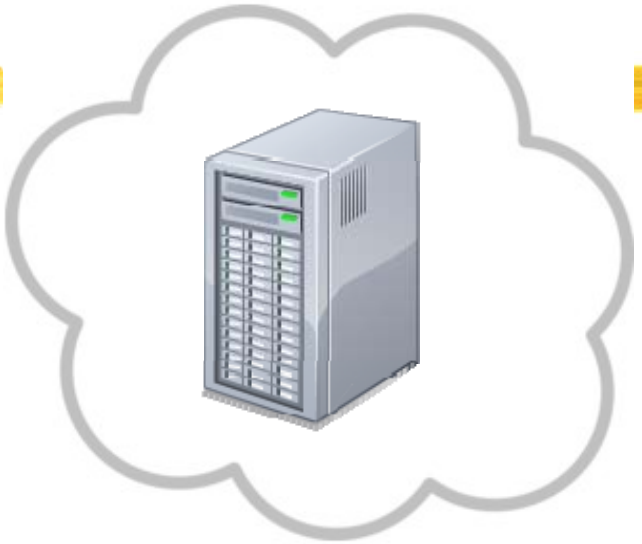


Cloud/Mobile Mismatch

Cloud provider

1- Long setup time
2- Long lease quantum
3- Connectivity Agnostic

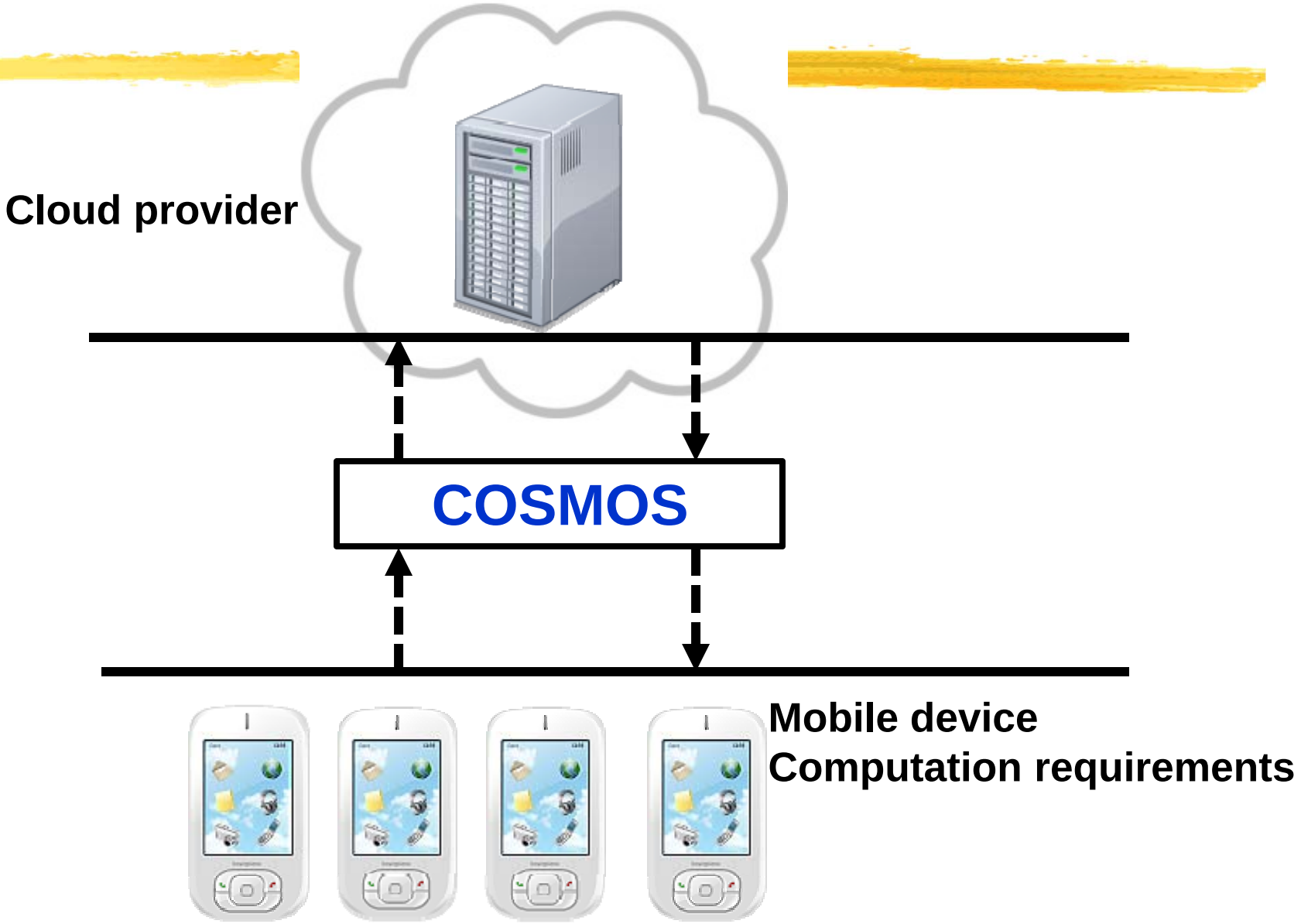
Cloud/Mobile Mismatch



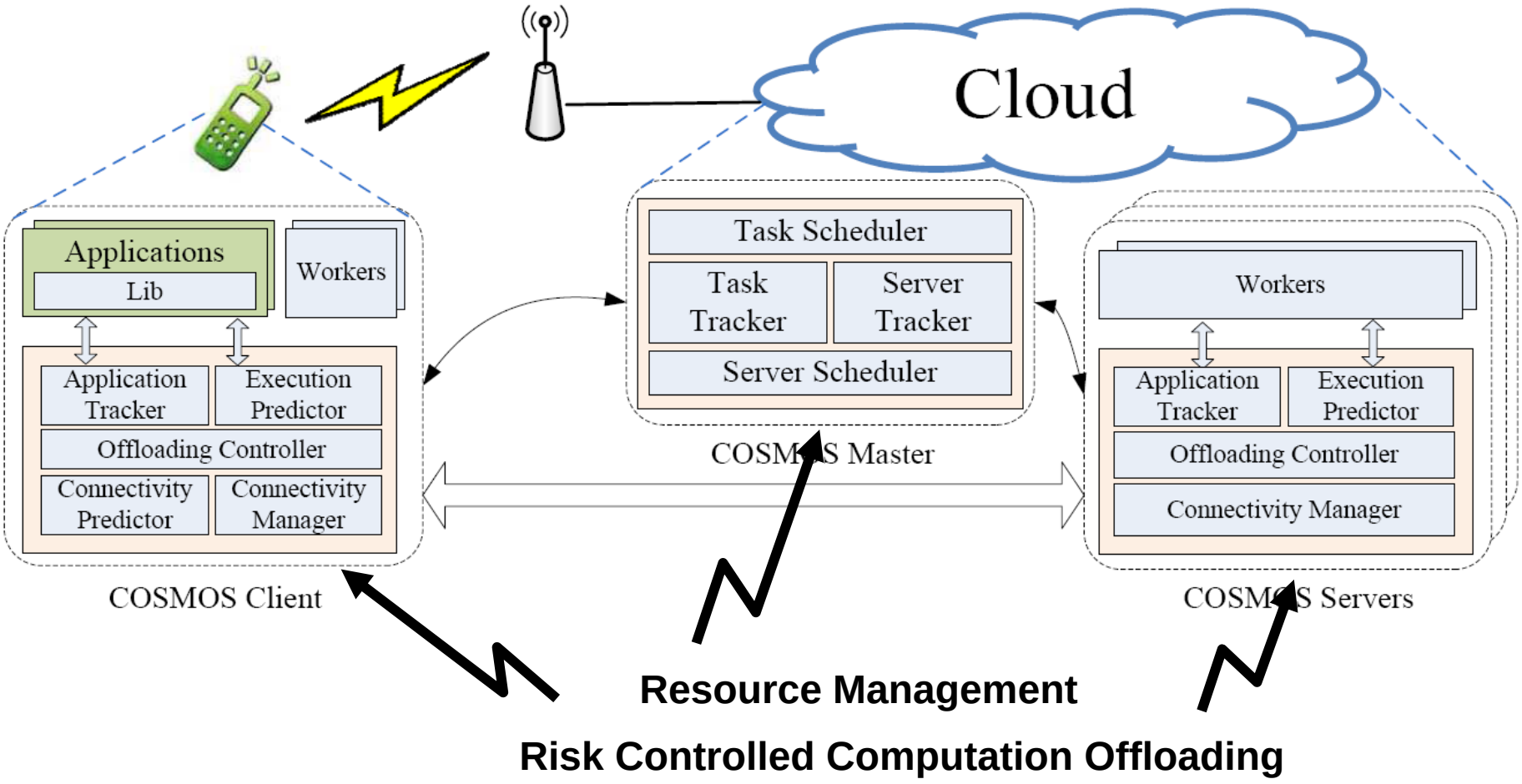
1- Quick response
2- Infrequent
3 - Variable connectivity

Mobile device
Computation requirements

COSMOS Bridges Gap



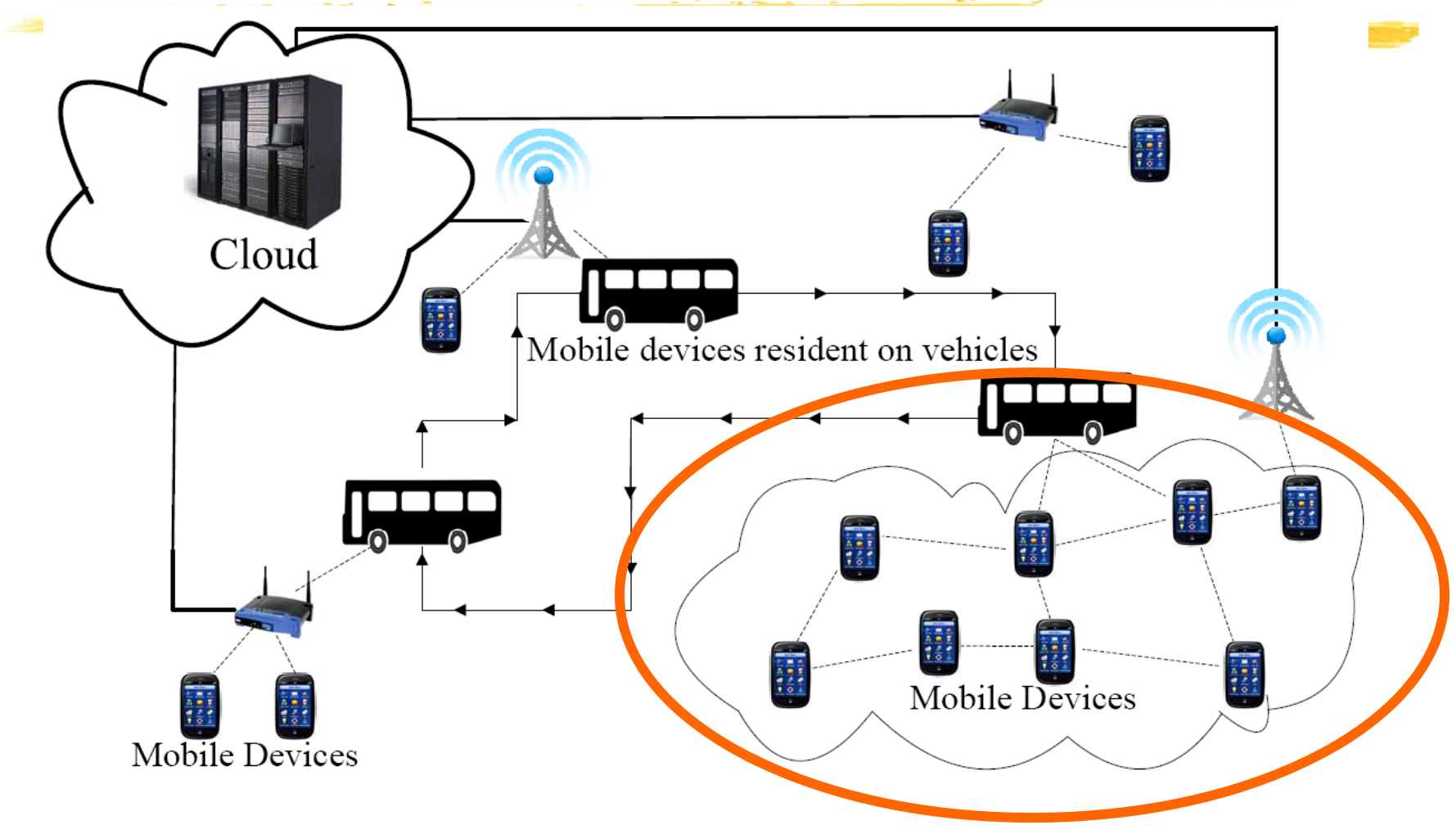
COSMOS Architecture



Challenges

- When to offload
  - Always Offload
  - Never Offload
  - Smart Offload: Offload when expected performance is improved
- Cloud Server deployment
  - Handle variable load
  - Maintain low cost
- By Deploying smart policies: significantly improve task speedup

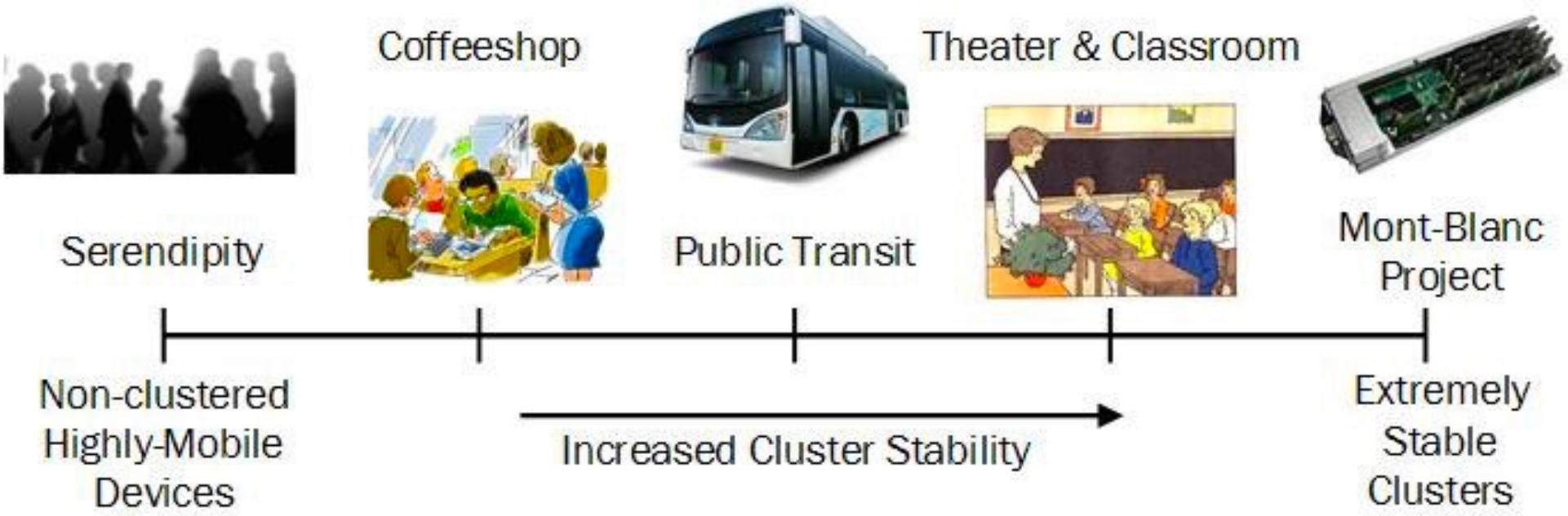
Opportunistic and Symbiotic Cloud Computing Environment



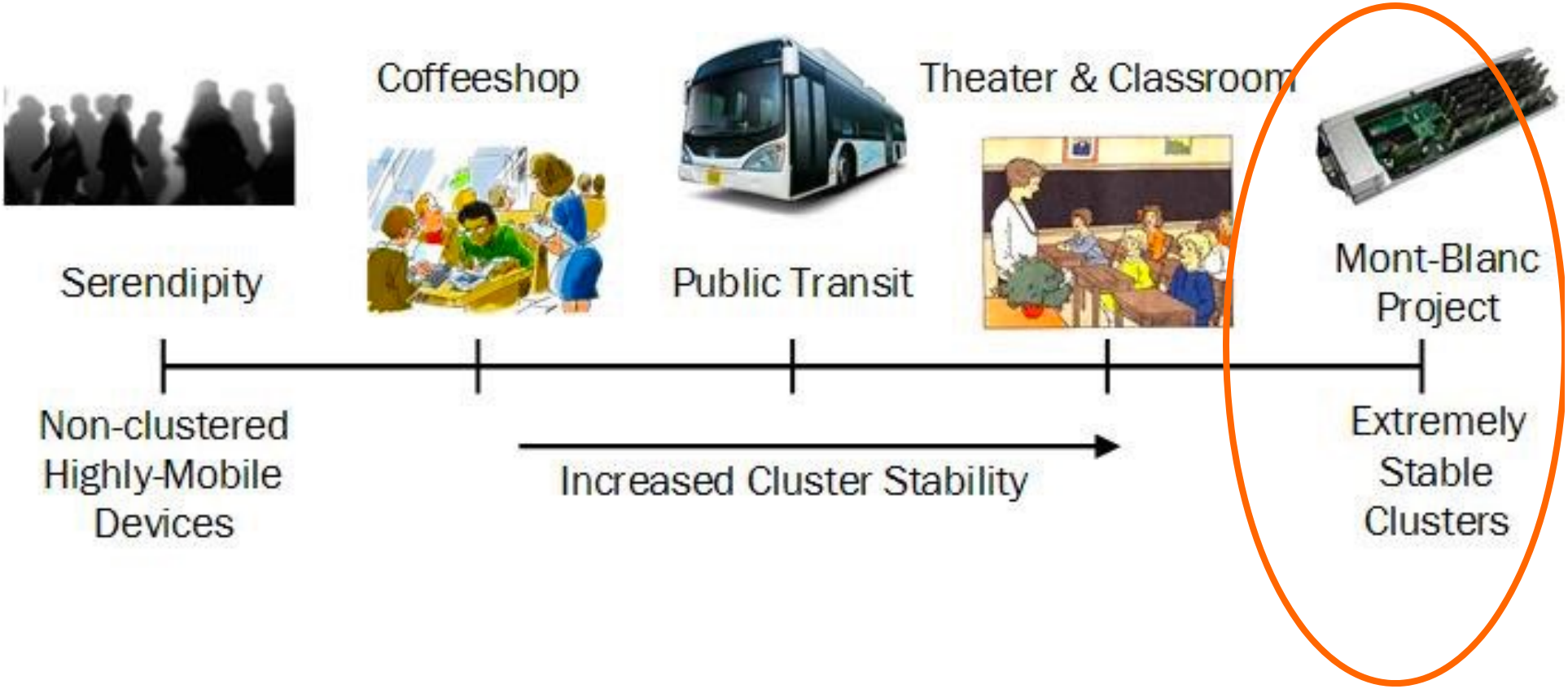
Main Idea

- Significant idle compute resources
- Challenge: How to configure into a meaningful resource.

A Spectrum of Cluster Stability



A Spectrum of Cluster Stability



Highly Stable Clusters

- Mont Blanc Project

- Our work: Highly Collaborative Devices
  - Mobile Device Clouds*
  - SymbIoT: Internet of Things**

*ACM MCC 2013
**ACM MCS 2015

Mont Blanc European Project

Barcelona SuperComputer Center

512 Nvidia Cores, 512 GFLOPS

0.15 GFLOP/W

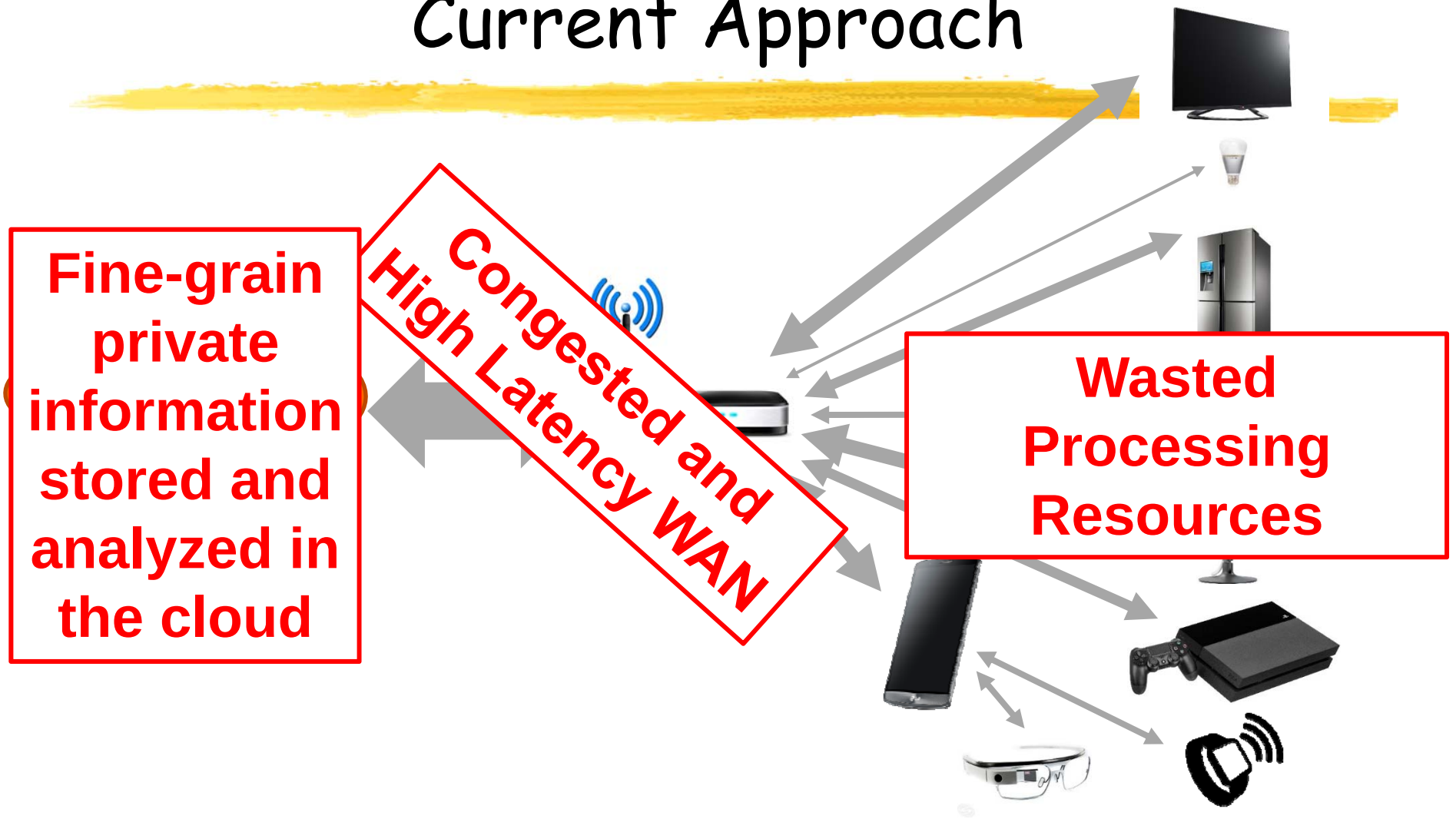
MDC
Collaboration to achieve global objective

- Mobile Device Cloud:

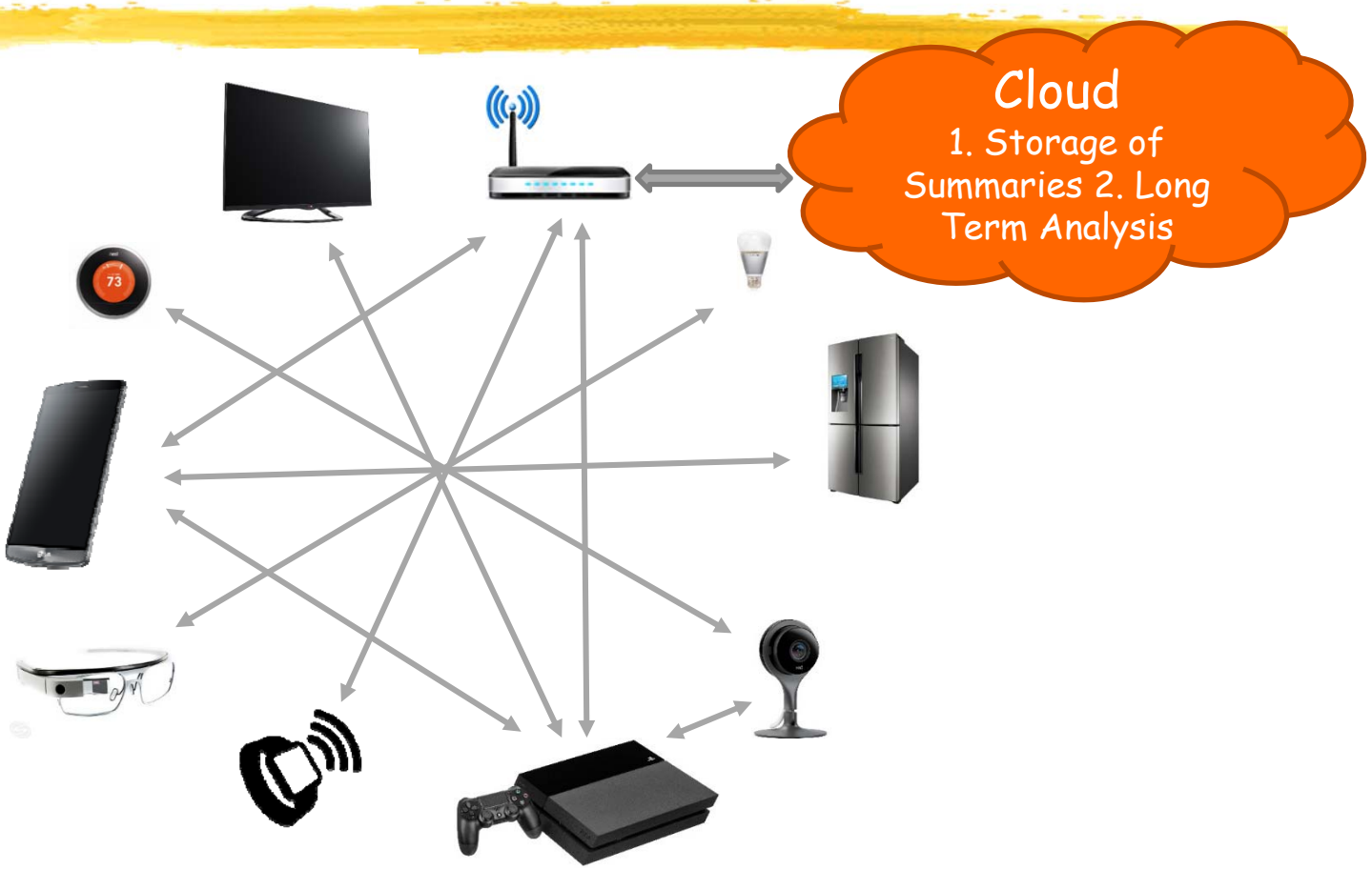
Single owner/administrator

- Collaborate to compute tasks to achieve global objective
  - extending battery lifetime of collective

Internet of Things Cluster
Current Approach



Symbiosis in the Internet of Things



Devices can cooperate to match the services provided by the cloud

Symbiosis in the Internet of Things
SymbIoT

- Enablers
  - Powerful "Things" – processing, storage, …
  - Device-to-Device: LTE, 802.15
- Design Goals
  - Reducing Internet bandwidth consumption
  - Matching and improving on cloud's performance
  - Improving resource utilization within the same LAN