

CCW Workshop  
Technical Session on Mobile Cloud Computing

Panelists:

Dijiang Huang (ASU, Moderator)

Mario Gerla (UCLA)

Huan Liu (ASU)

Kui Ren (SUNY Buffalo)

11/9/2012

## **Mobile Cloud Computing**

- A new research area emerging since 2009
  - MobiCloud Workshop in conjunction with MobiCase 2009.
- ....
- IEEE International Symposium on Mobile Cloud, Computing, and Service Engineering 2012
- ACM Mobile Cloud Computing workshop in conjunction with Sigcomm 2012

Mobile Cloud  
Application Scenario:  
Vehicle Cloud  
(Mario Gerla)

Social Aspects of Mobile  
Clouds  
(Huan Liu)

Mobile Cloud Computing  
Panel

Security Implications of  
Clouds  
(Ren Kui)

Mobile Cloud  
Infrastructure and  
Service Models  
(Dijiang Huang)

# Mobile Cloud Computing: Challenges and Opportunities

**Dijiang Huang**

**School of Computing Informatics Decision Systems Engineering  
Arizona State University**

**IEEE Computer Communication Workshop, Sedona Nov. 9, 2012**

# Concepts and Vision of Mobile Cloud Computing

We are in the era of changing our computing platform and shaping our modern life powered by emerging new communication, networking, and mobile computing technologies.

# General Types of Mobile Clouds

- Application Driven
  - Internet – Mobile Clouds
    - Most of current “mobile clouds” belong to this category. E.g., DropBox (storage), Zscaler (security), etc.
  - Urban Clouds
    - E.g., vehicular cloud, environment sensing cloud, smart home/grid cloud, etc.
- Behavior/feature driven
  - Personal Clouds
    - E.g., Personal assistant cloud (accompany), etc.
- Event Driven
  - Mission Critical Clouds
    - E.g., disaster recovery, emergency, military, etc.

# Current Mobile Cloud Computing Features

	Characteristics
Computing enhanced cloud	<ul style="list-style-type: none"><li>• Better execution performance</li><li>• Save energy on mobile devices</li><li>• Flexible and elastic offloading</li></ul>
Storage enhanced cloud	<ul style="list-style-type: none"><li>• Larger storage capacity</li><li>• Synchronization among different devices</li><li>• Data protection, backup, and sharing</li></ul>
Security enhanced cloud	<ul style="list-style-type: none"><li>• Multiple Anti-Virus Engines</li><li>• Security filter and proxy for mobile devices</li><li>• Data loss prevention, remote management, localization, recovery from attacks, etc.</li></ul>

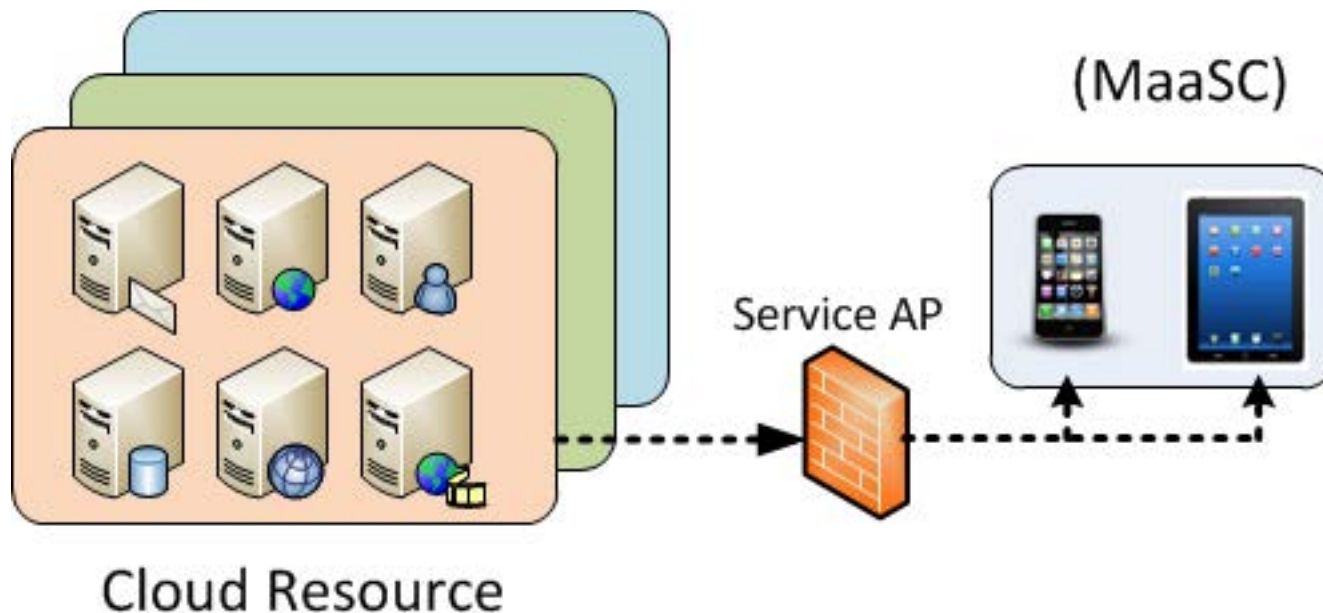
# User-centric Service Views of Mobile Cloud

- Mobile as a Service Consumer (MaaSC)
- Mobile as a Service Provider (MaaSP)
- Mobile as a Service Broker (MaaSB)
- Mobile as a Representor (MaaR)



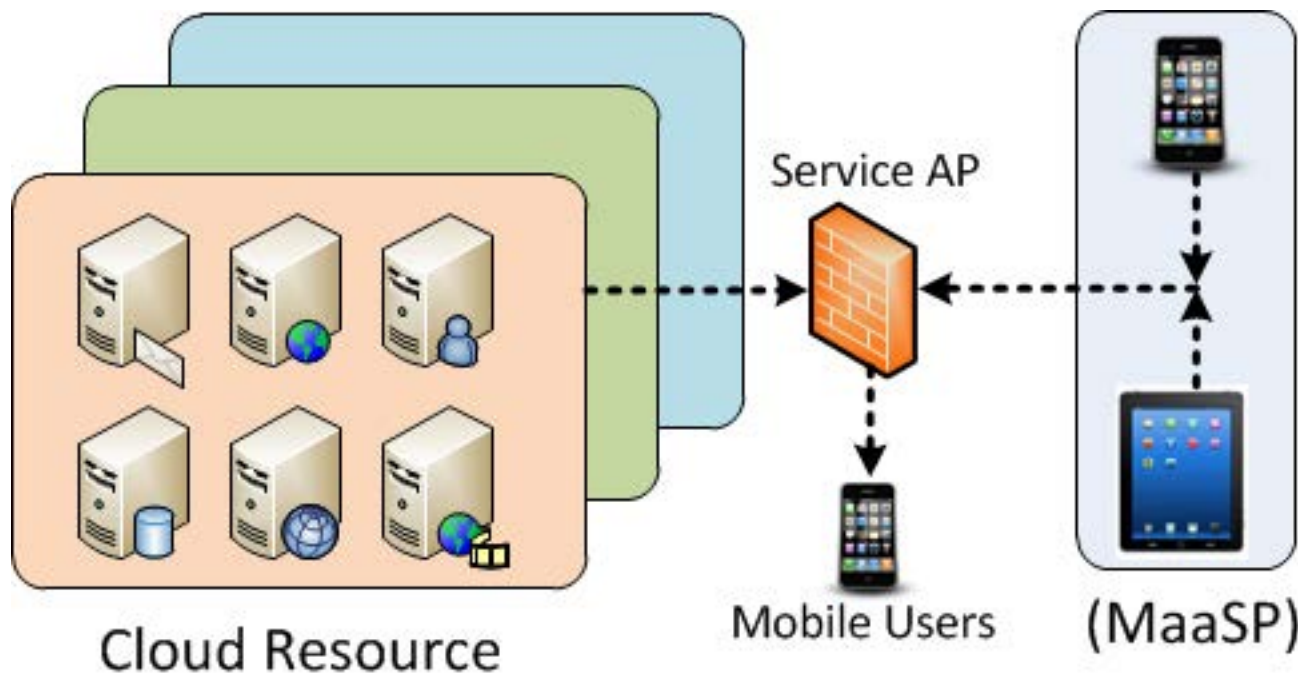
# Mobile as a Service Consumer (MaaS)

- Mobile devices outsource their computation or storage function onto the cloud in order to achieve better performance and more capability.



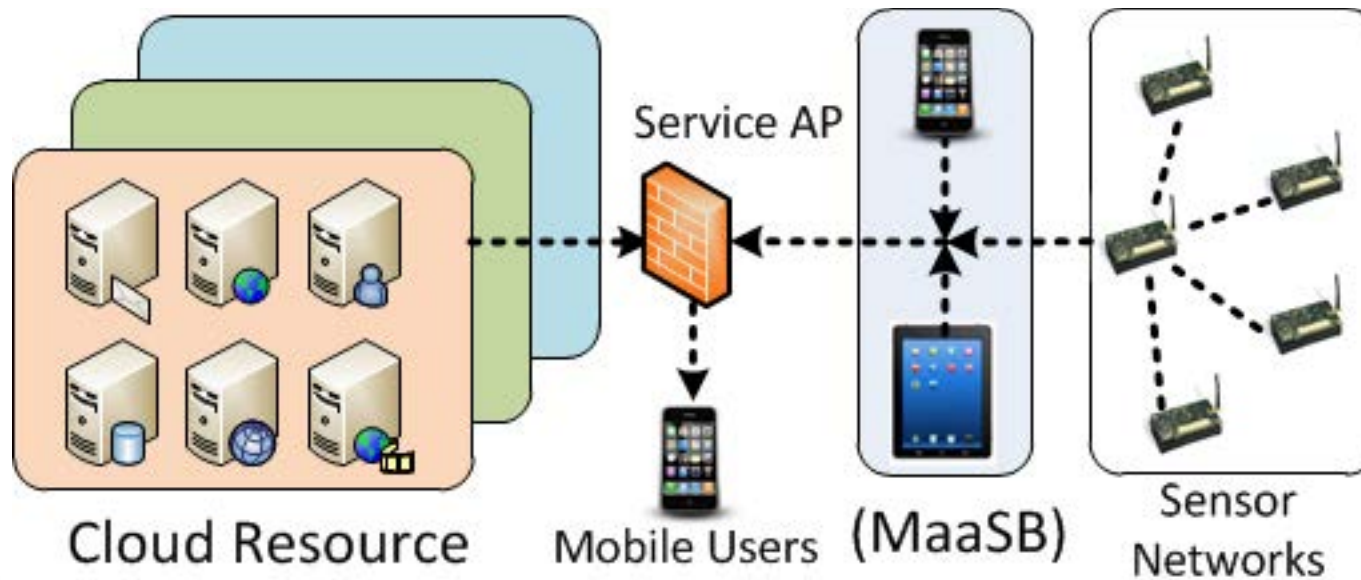
# Mobile as a Service Provider (MaaSP)

- With on-board sensors, i.e., GPS module, camera, gyroscope and etc., mobile devices are able to collect information around and take their unique advantages which cloud servers is impossible to be equipped.



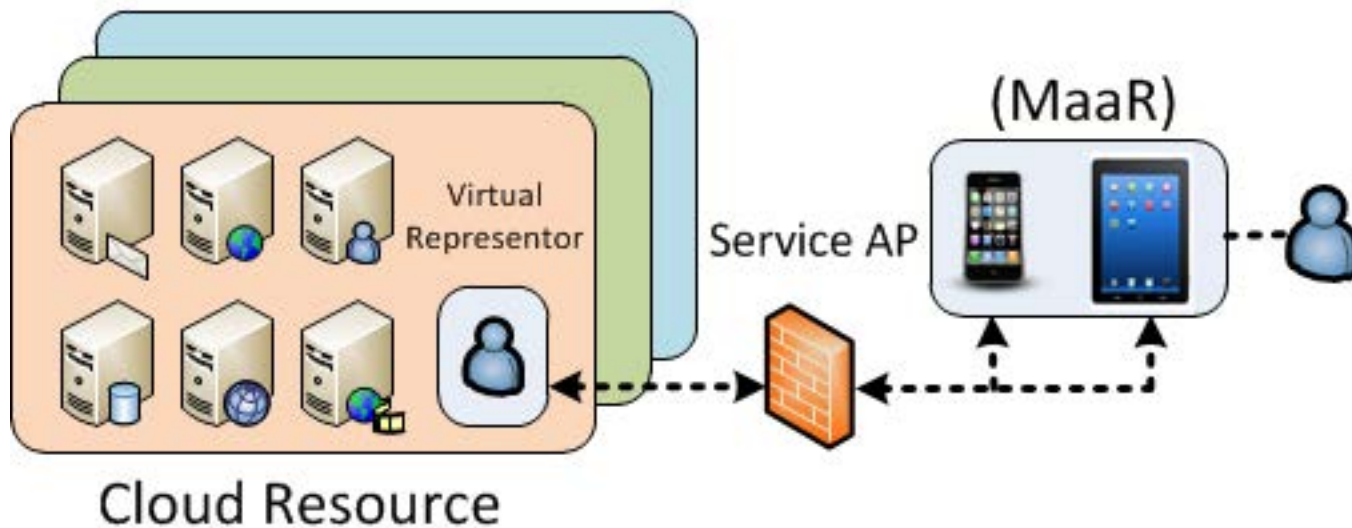
# Mobile as a Service Broker (MaaS)

- Mobile devices can be set as the gateway or proxy of the WSN, which can communicate with the cloud resource through multiple communication interfaces including 3/4G, Bluetooth, WIFI and etc.

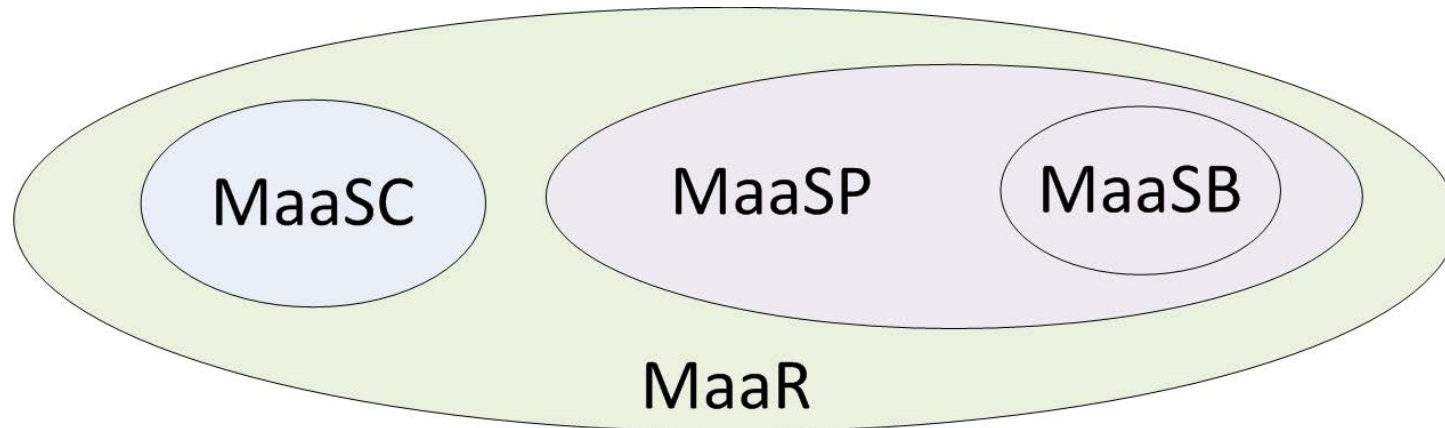


# Mobile as a Represantor (MaaR)

- A user can be represented by his/her virtual life in the Cloud through his/her mobile device. Users' behaviors and attributes can be collected and modeled to their corresponding virtual life.



# Relations Among Various Models



# Mobile Cloud is a Platform



Identity/attribute-based cryptography

Security Federation

Multi-level data protection

Programmable network

24/7 Virtual Presence

Data Presence

Function Presence

Trust Presence

Additional layer of security protection

Private data storage

Virtual trusted domains

Collaborative Computing & Sharing

Peripheral sharing

Communication sharing

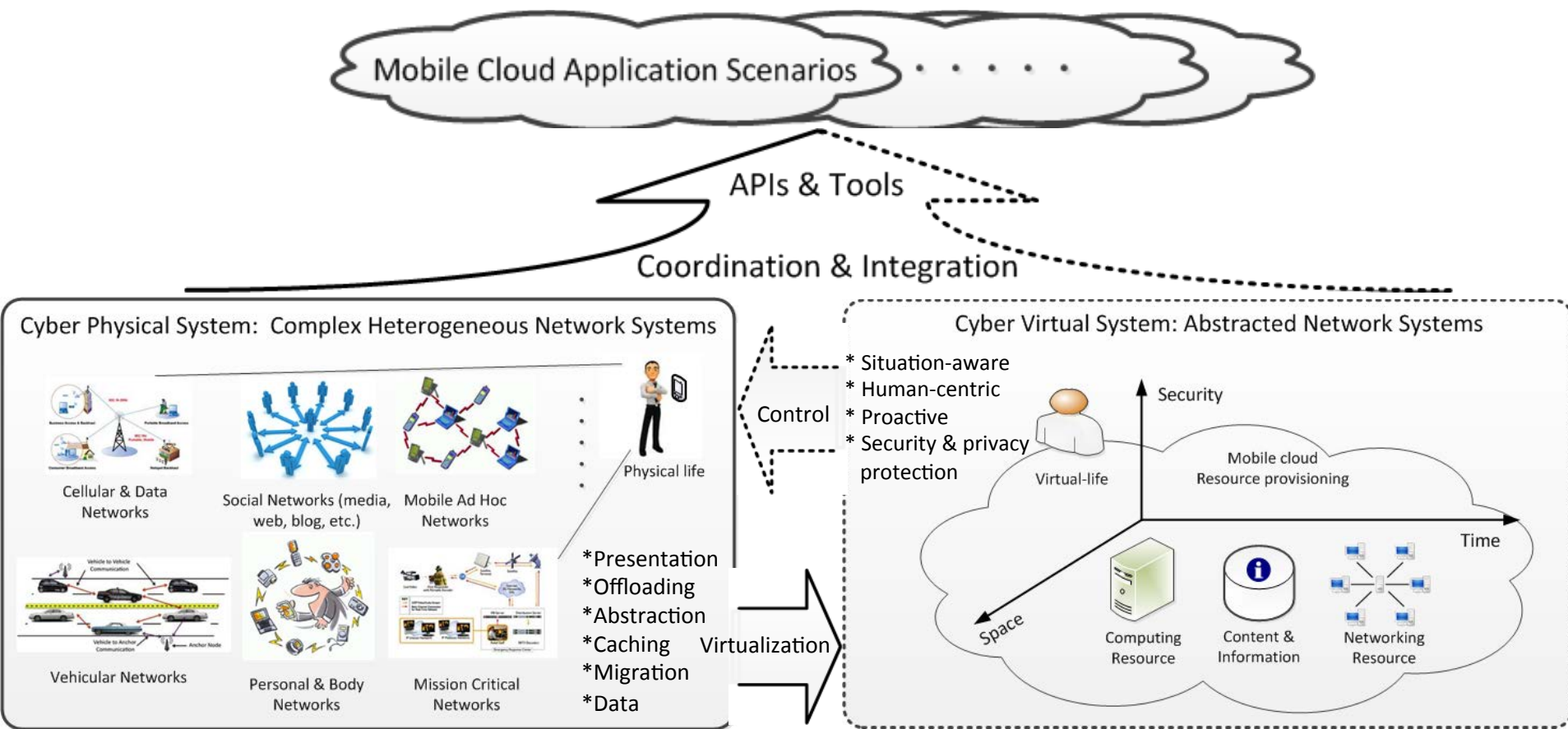
Data sharing

Content caching

Connection caching

Function caching

# Human-centric view on Physical and Virtual Interaction of Mobile Cloud System



# Mobile Service Oriented Architecture for Personal Clouds

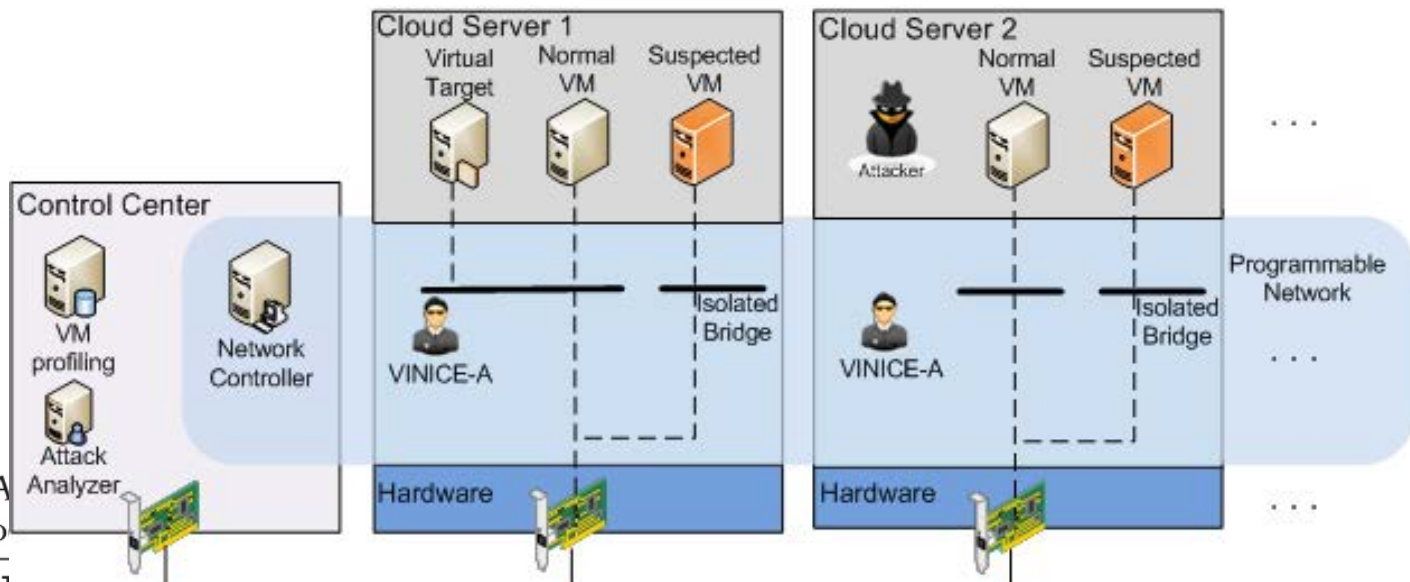
- SoA is introduced for mobile devices' application development to improve reusability and modularization
  - To reduce mobile application complexity
  - To achieve scalability and reusability
  - To offload computing tasks easily among mobile devices and virtual machines





# Moving Target Defensive Mechanism

- Moving Target = Proactive + Programmable + nonintrusive
  - Programmable networks allow a system to change its configurations dynamically according to security situations.
  - Proactive countermeasures can be evaluated according to a comprehensive evaluation of various system metrics
  - Layered structure makes the moving target solution less intrusive.



# What we can develop now based on MobiCloud?



# Mobile Cloud Computing Challenges and Opportunities

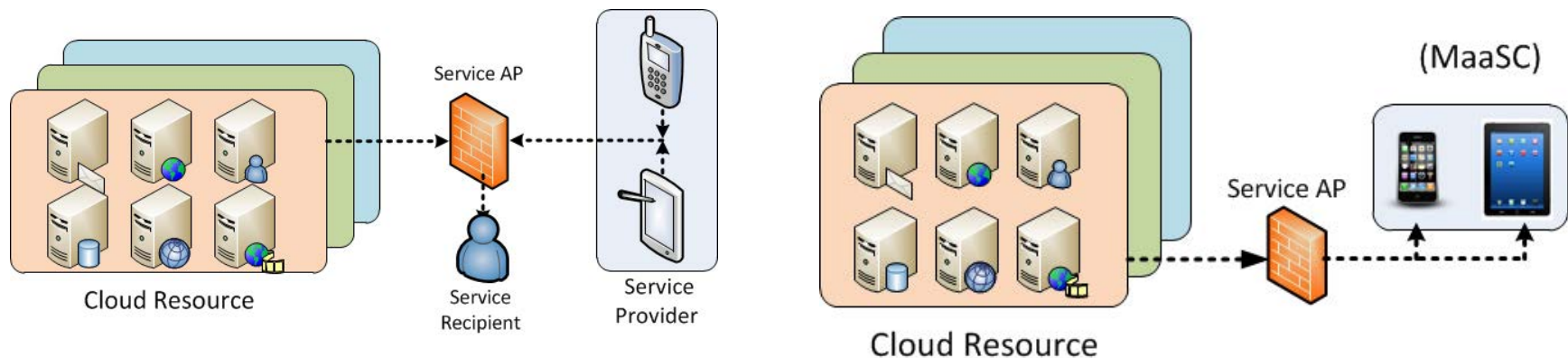
**The challenges as well as opportunities of MCC enable a system seamlessly combining physical and virtual environment for mobile users**

## Topics

1. Distributed Service Architecture
2. Service Oriented Architecture
3. Heterogeneous Context Awareness
4. Tri-Root Trust Model
5. Moving Target Defensive mechanism
6. Proactive Traffic Management
7. Mobile Cloud based Education

# Distributed Service Architecture

- MaaS and MaaS transfer the traditional way of mobile devices getting involved in the Cloud. Mobile devices are not only service recipients, but also service providers. By enabling this new architecture, services type and data source could be diverse.



# Mobile Service Oriented Architecture for Personal Clouds

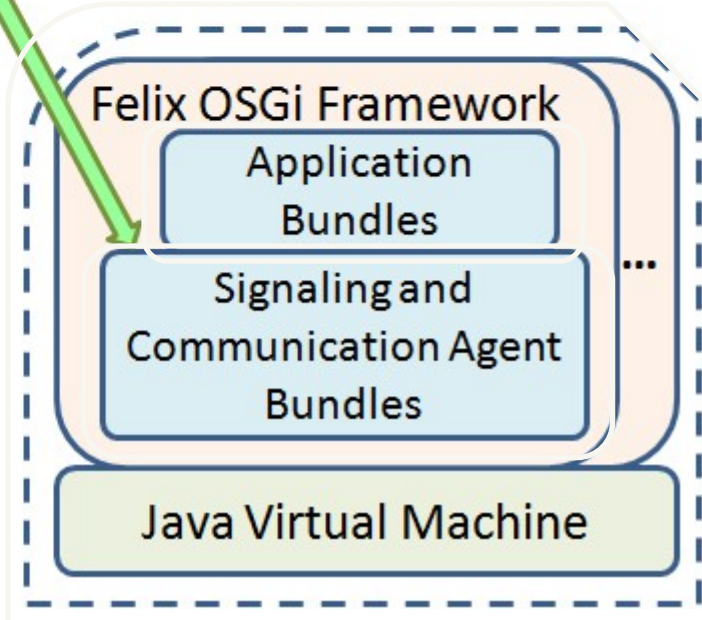
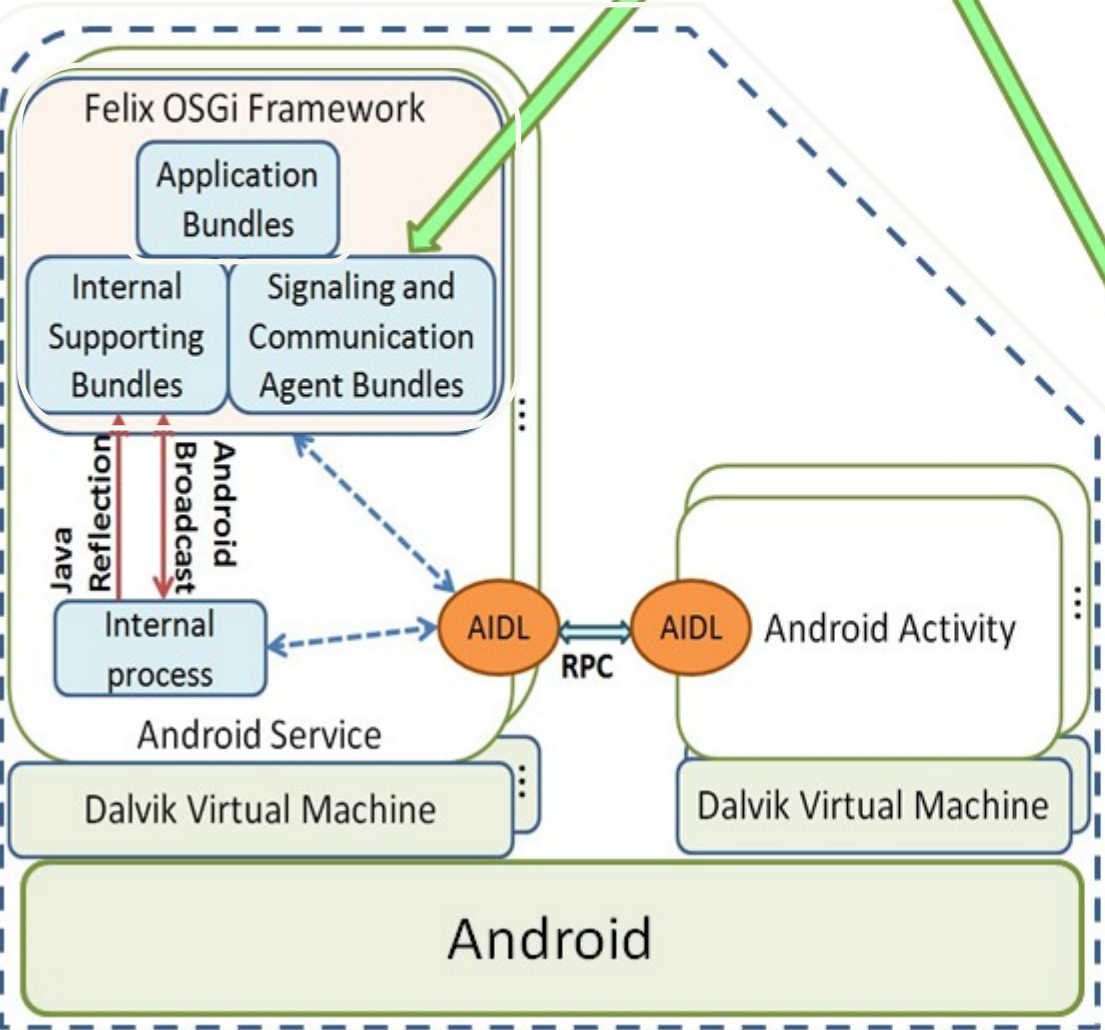
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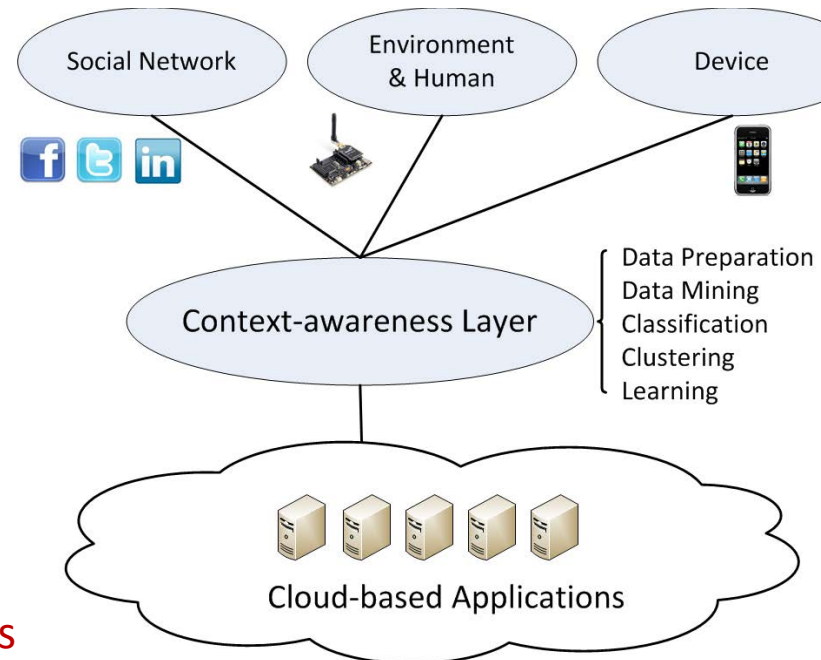
# Signaling and Communication Service

Sponsored by ONR



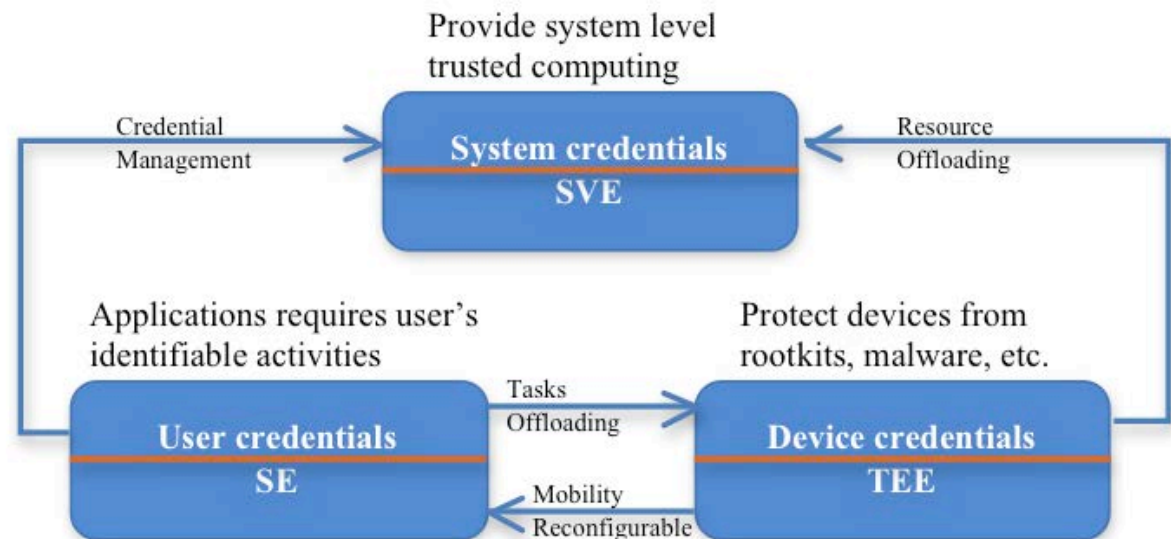
# Heterogeneous Context Awareness

- Heterogeneous Data source
  - Social network, environment & human body, device
- Context awareness abstract layer
  - Data processing including mining, classification, clustering and learning.
  - How to mine using heterogeneous data



# Trust Root Problems for Mobile Applications

- Root of trust issues
  - A mobile device is semi-trusted:
    - Problems due to malware and vulnerable mobile device operating system.
  - A SIM (smart) card is semi-trusted:
    - Problems due to hardware lost, stolen, and attacks (e.g., power analysis attacks).
  - The Cloud is semi-trusted:
    - Problems due to big-brother concerns (privacy issues) and in-secure cloud services.

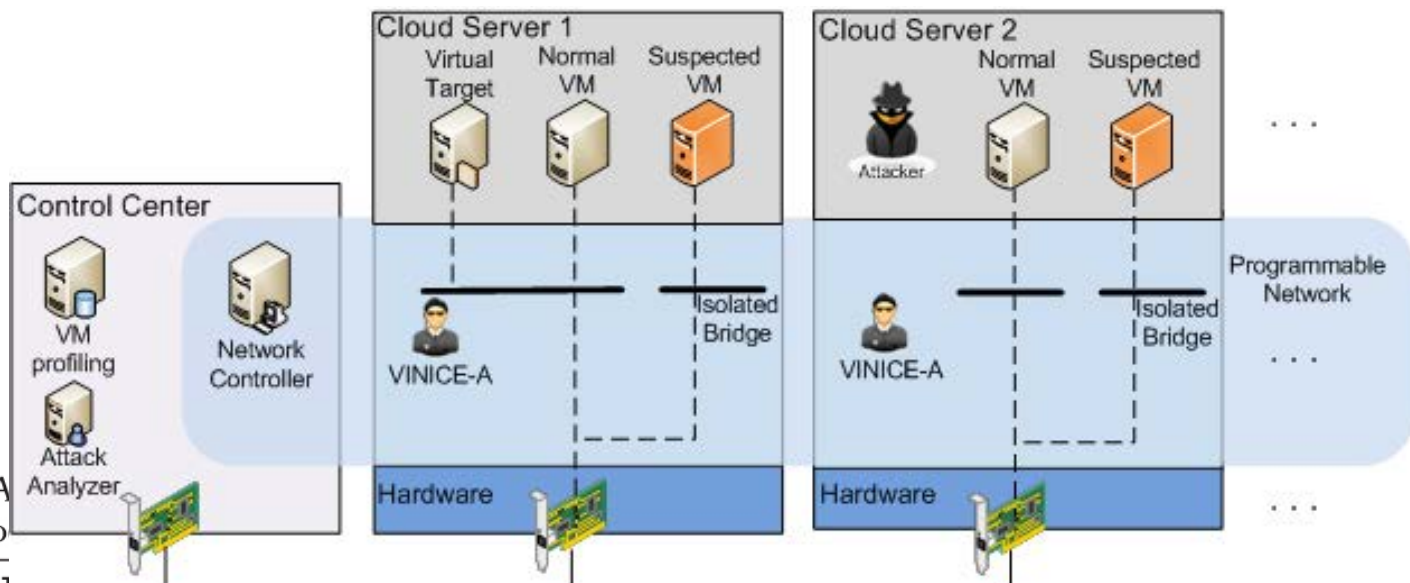


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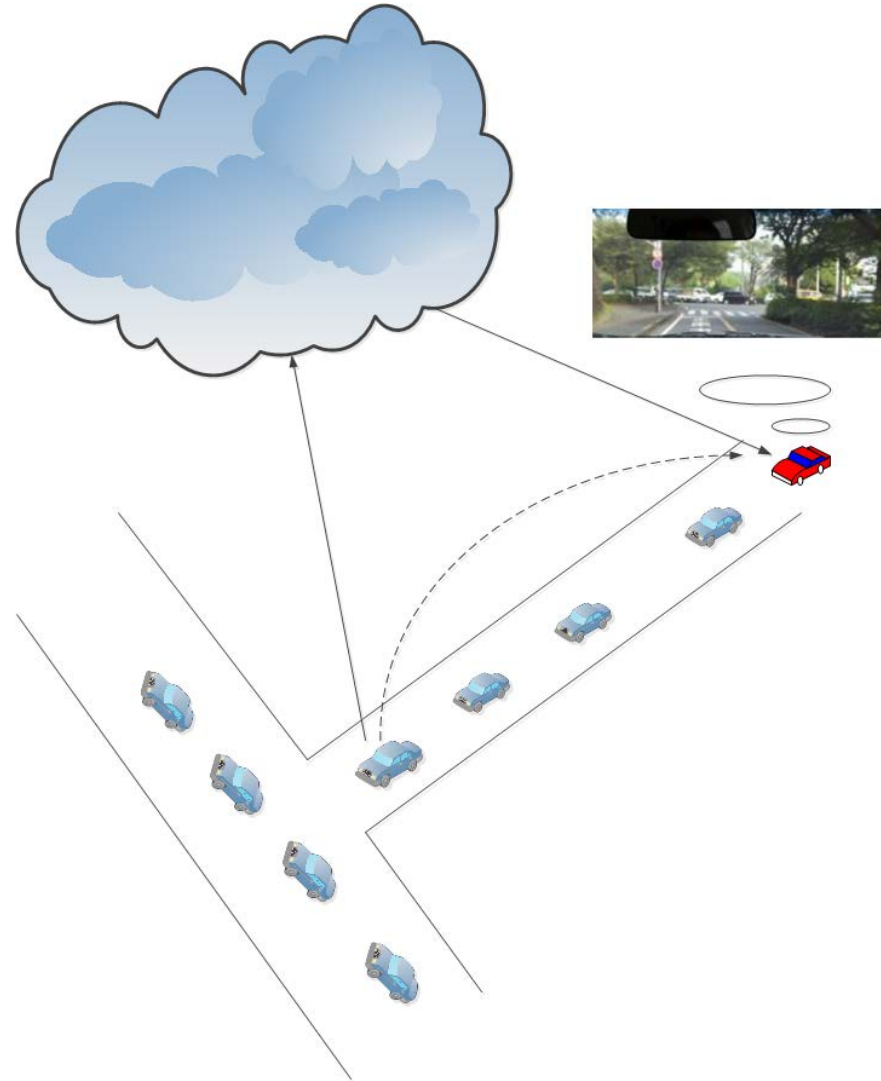
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# Traffic Management

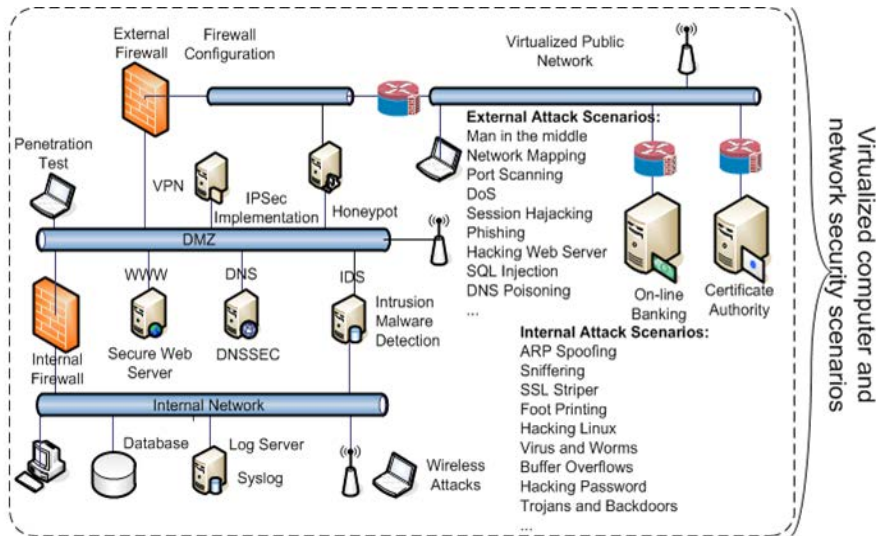
- Vehicle can inspect traffic at any location of the road
- Comprehensive (bird view) of the traffic system can be generated in the cloud
- Require a mobile cloud service-oriented model



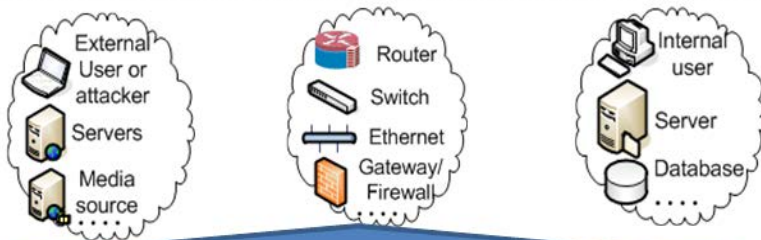
# VIRTUAL NETWORK LABORATORY

- Powered by Mobile Cloud Computing

Sponsored by NSF CCLI



Virtualized computer and network security scenarios



Virtualization

Cloud Computing Technologies

- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. Hardware/software Virtualization</li> <li>2. Dynamic resource sharing and management</li> <li>3. Remote leaning</li> </ol> | <ol style="list-style-type: none"> <li>1. Collaborative and escalated learning</li> <li>2. Networking and computing resource sharing</li> <li>3. Web 2.0</li> </ol> |
|--|---|

## Project Objectives:

1. Provide segregated virtual environments to establish a user-specified testing system (agile and customizable).
2. Support remote access and minimize the network system establishment and management overhead.
3. Support multiple-laboratory testing environments (economic and flexible).
4. Easy for test establishment and system maintenance.
5. Crowdsourcing-based testing, evaluation, and learning environment

## Application Platform

- Remote learning and training by dynamically allocating network and system resources based on users' specified requirements.

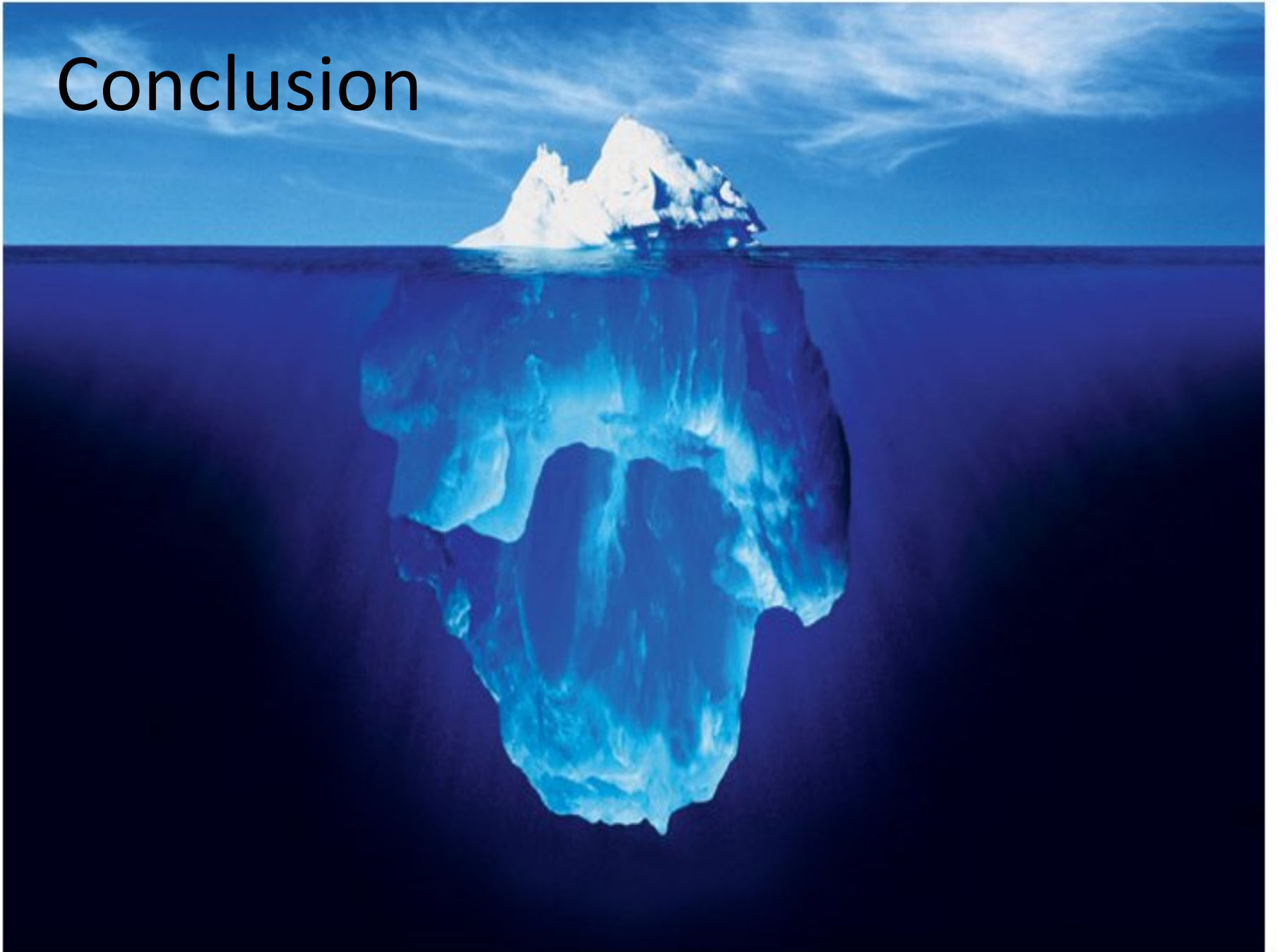
## Testing Platform:

- Assist users to share their lab testing materials.
- Provide virtual segregated environments to confine the lab experiments without introducing interferences among different lab experiments.
- Provide fast and reconfigurable testing networking environments.
- Establish a testing environment for cloud computing based applications.

- Just image what if you have a “second life” in a virtualized mobile cloud environment



# Conclusion



Thank you.