Introduction of Mobile Cloud Computing

What is a mobile cloud computing?

Motivation

Motivation

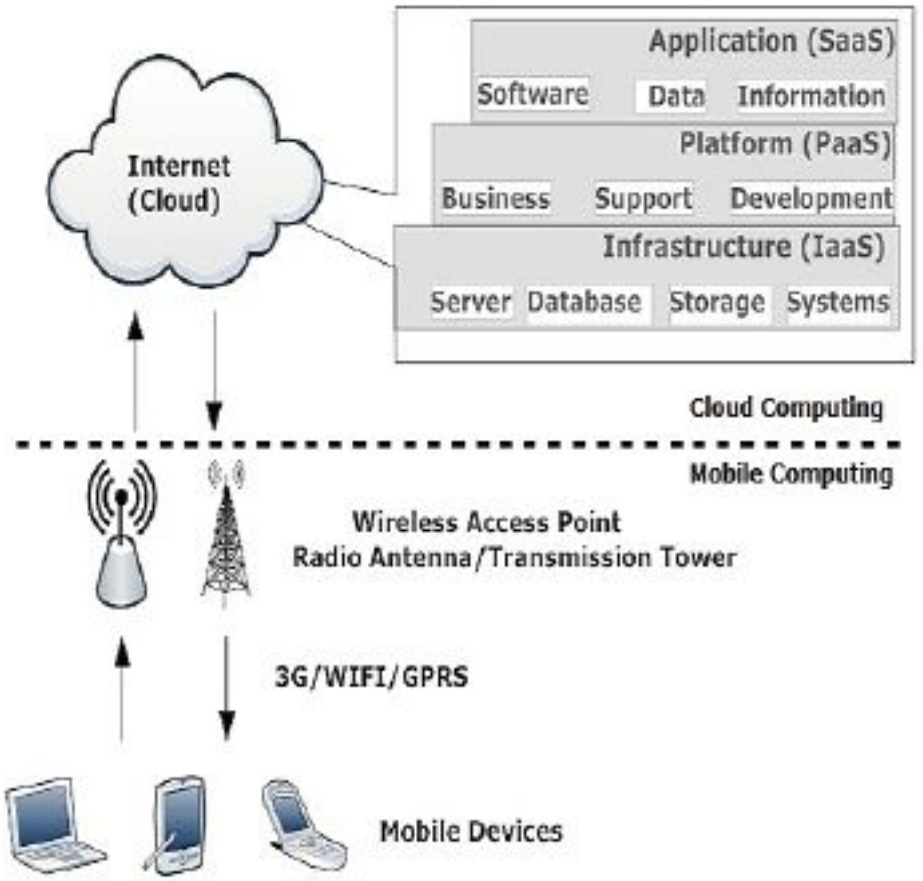
- Mobile devices (e.g., smartphone, tablet pcs, etc) are increasingly becoming an essential part of human life,
- Dream of "**Information at your fingertips anywhere anytime",**
- Mobile devices still lack in resources compared to a conventional information processing device such as PCs and laptops

Soultion

› Mobile Cloud Computing (MCC)

Definitions

- Cloud Computing
- Mobile Network



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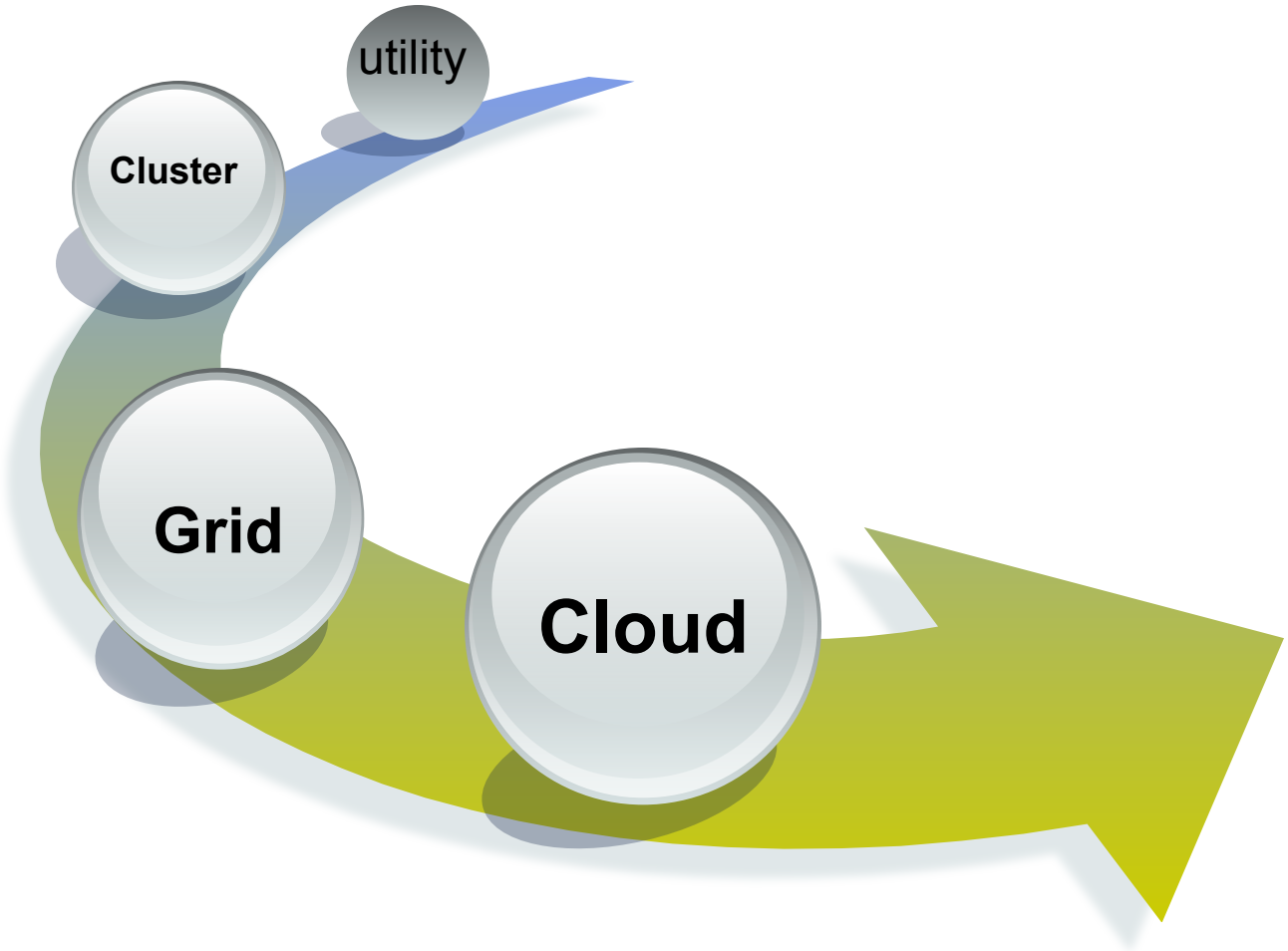

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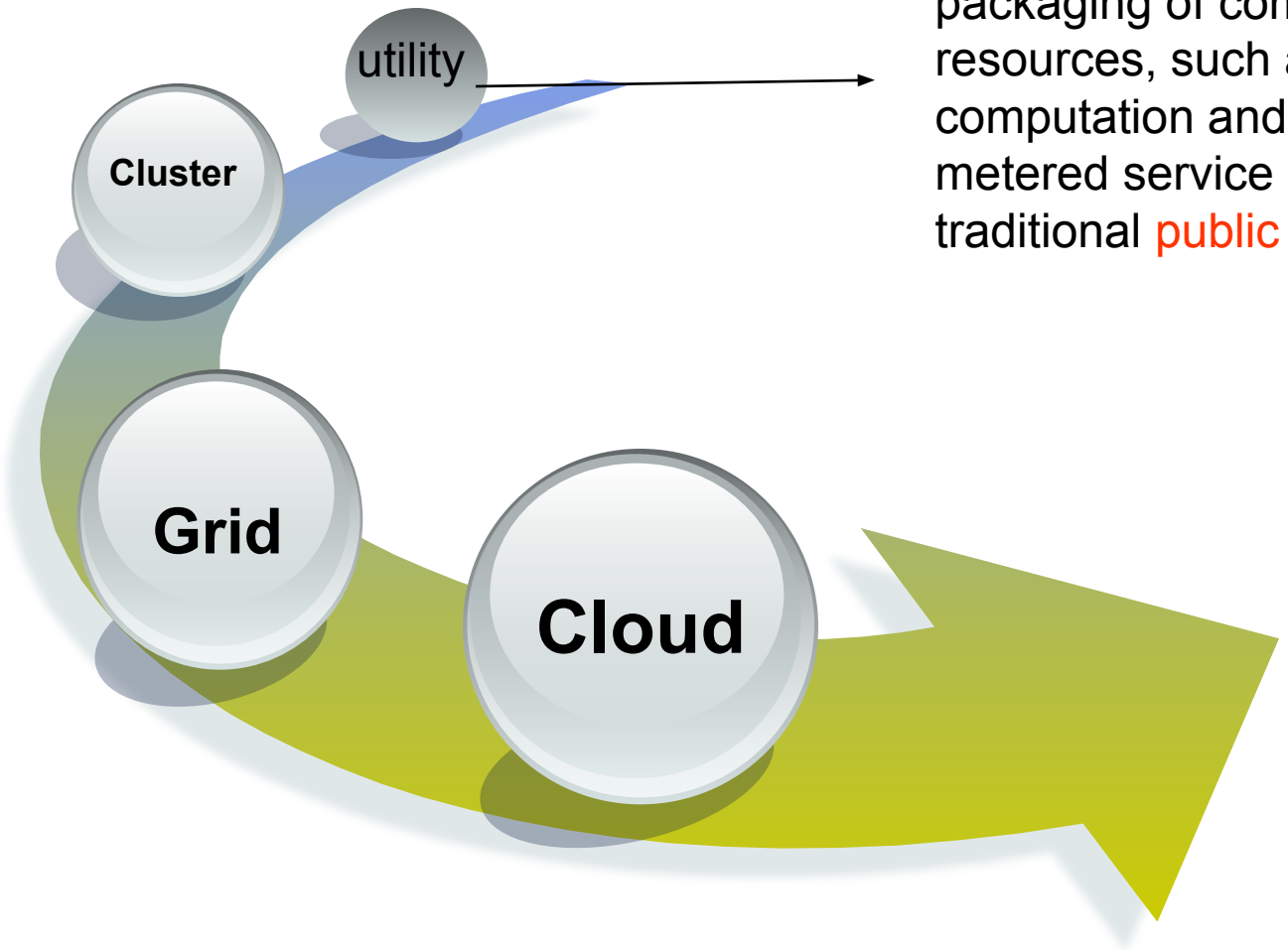
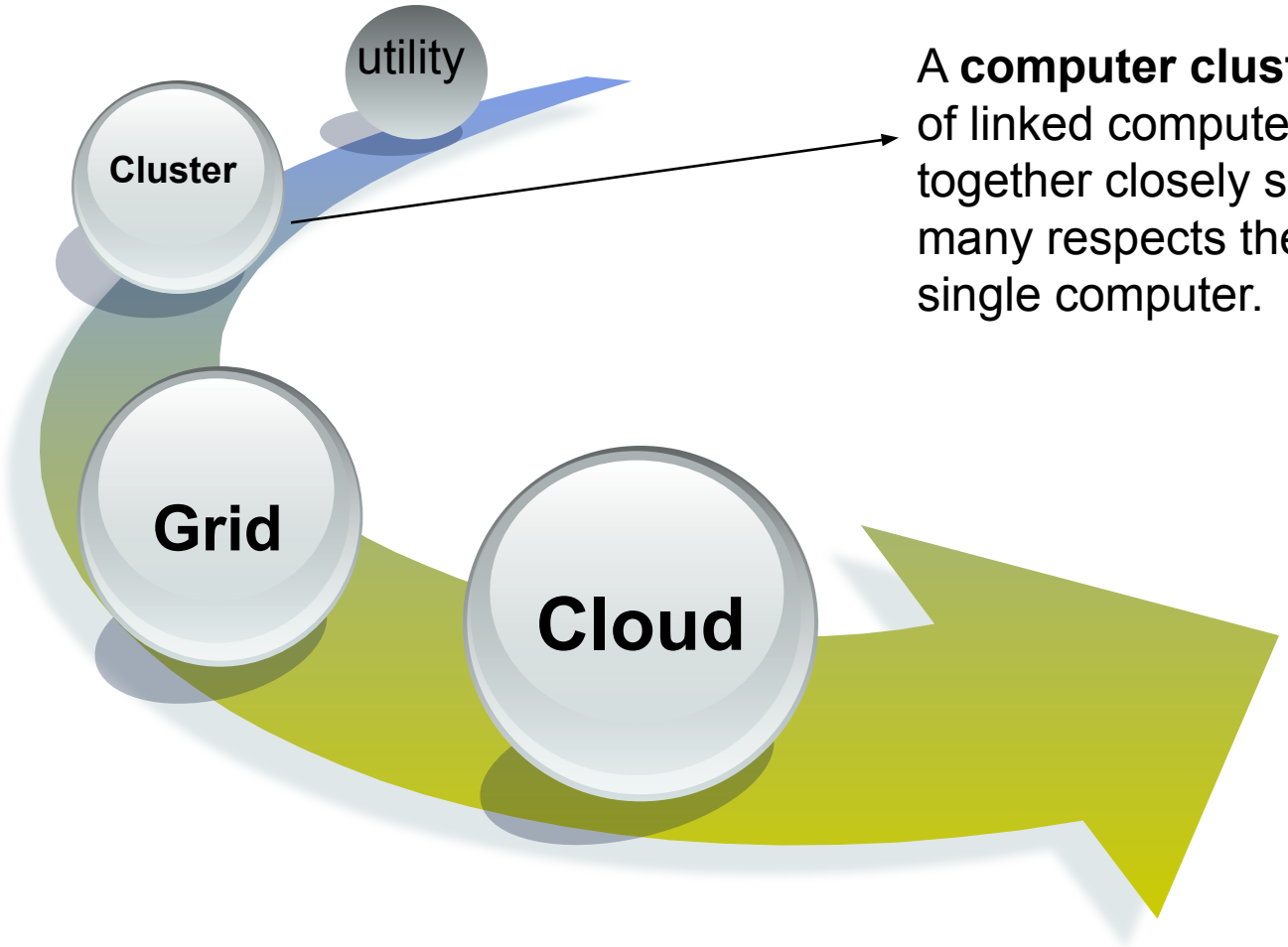


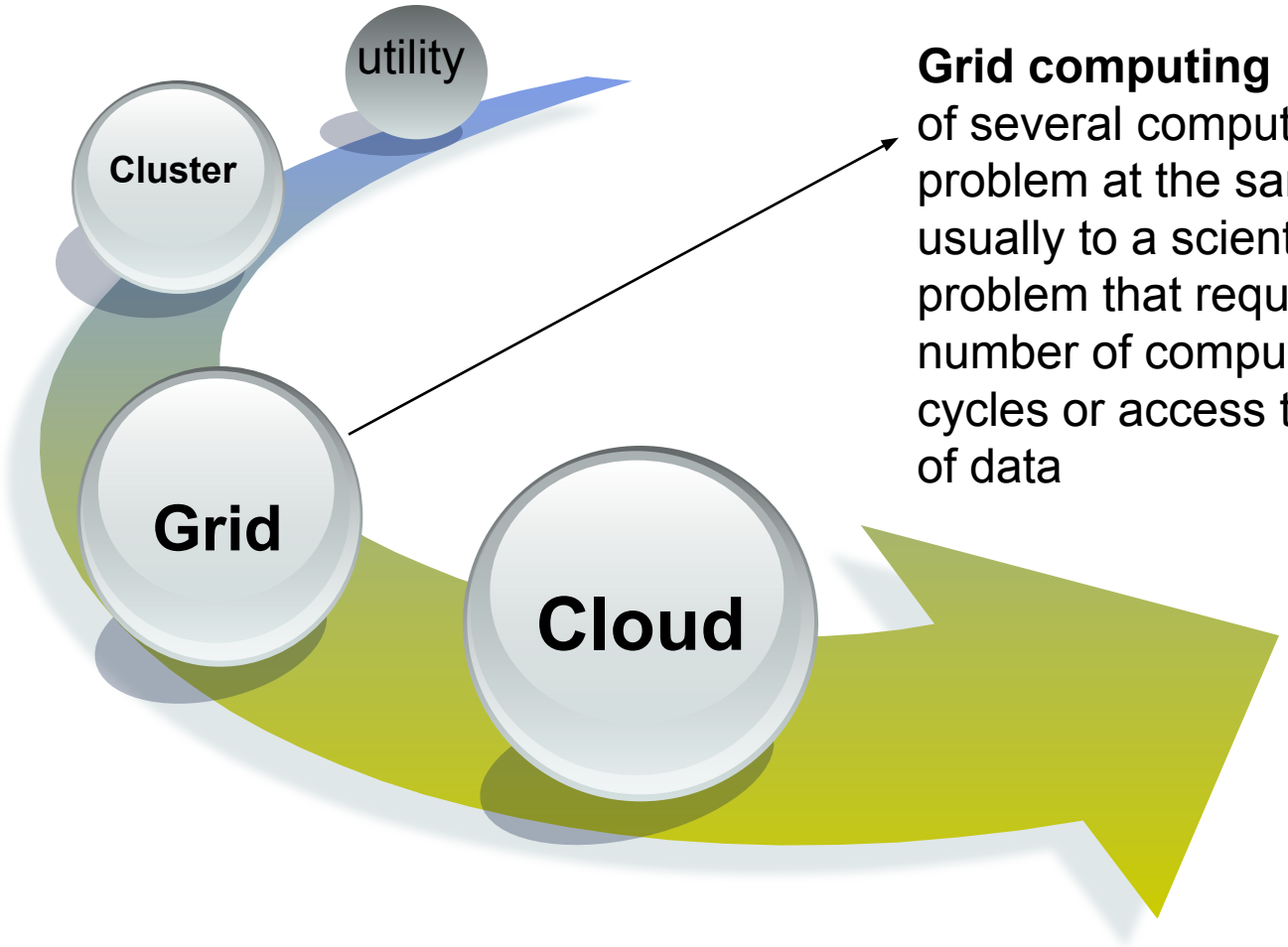
Utility computing is the packaging of computing resources, such as computation and storage, as a metered service similar to a traditional public utility

Definitions



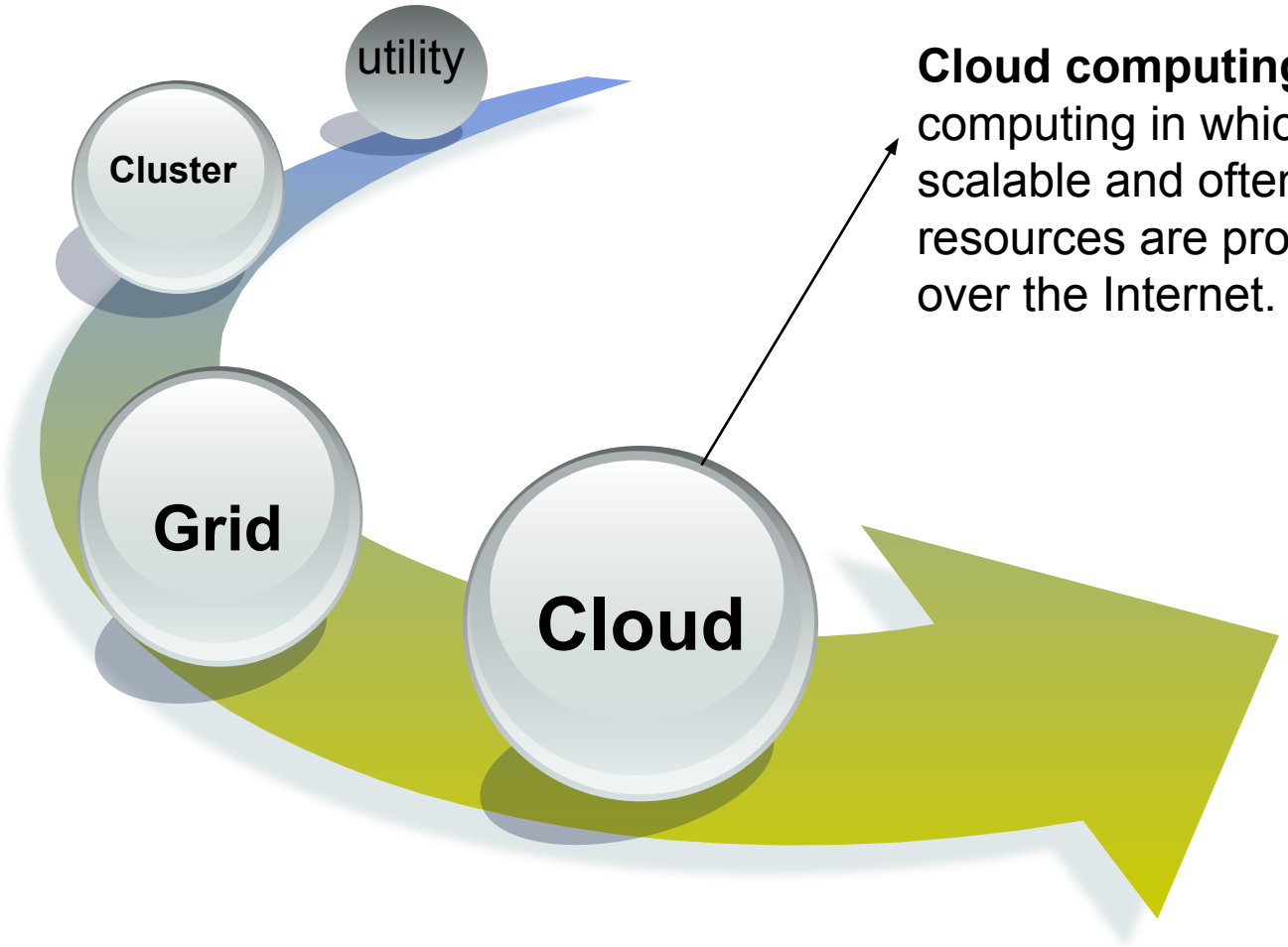
A **computer cluster** is a group of linked computers, working together closely so that in many respects they form a single computer.

Definitions



Grid computing is the application of several computers to a single problem at the same time — usually to a scientific or technical problem that requires a great number of computer processing cycles or access to large amounts of data

Definitions



Cloud computing is a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet.

WHAT IS CLOUD COMPUTING?

NIST Definition

"A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"

Cloud computing is a style of computing in which **dynamically scalable** and often **virtualized** resources are provided as a serve over the Internet.

Major Types of cloud service

SaaS : Software as a Service

PaaS: Platform as a Service

IaaS: Infrastructure as a Service

Cloud computing

From Wikipedia, the free encyclopedia

Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet). The name comes from the use of a cloud-shaped symbol as an abstraction for the complex infrastructure it contains in system diagrams. Cloud computing entrusts remote services with a user's data, software and computation.

There are many types of public cloud computing:[1]

- Infrastructure as a service (IaaS)
- Platform as a service (PaaS)
- Software as a service (SaaS)
- Storage as a service (STaaS)
- Security as a service (SECaaS)
- Data as a service (DaaS)
- Test environment as a service (TEaaS)
- Desktop as a service (DaaS)
- API as a service (APIaaS)
- Backend as a service (Baas)

The business model, using software as a service, users also rent application software and databases. The cloud providers manage the infrastructure and platforms on which the applications run.

Service Delivery Model Examples

Products and companies shown for illustrative purposes only and should not be construed as an endorsement

4 Cloud Deployment Models

- Private cloud
  - -Enterprise owned or leased
- Community cloud
  - -Shared infrastructure for specific community
- Public cloud
  - -Sold to the public, mega-scale infrastructure
- Hybrid cloud
  - -composition of two or more clouds

Cloud Efficiencies and Improvements

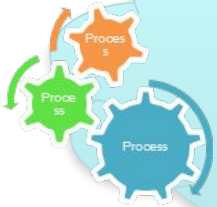
- ✔ Cost efficiencies
- ✔ Time efficiencies
- ✔ Power efficiencies
- ✔ Improved process control
- ✔ Improved security
- ✔ “Unlimited” capacity

- Burst capacity (over-provisioning)

ort-duration projects

- Cancelled or failed missions

- Network connectivity



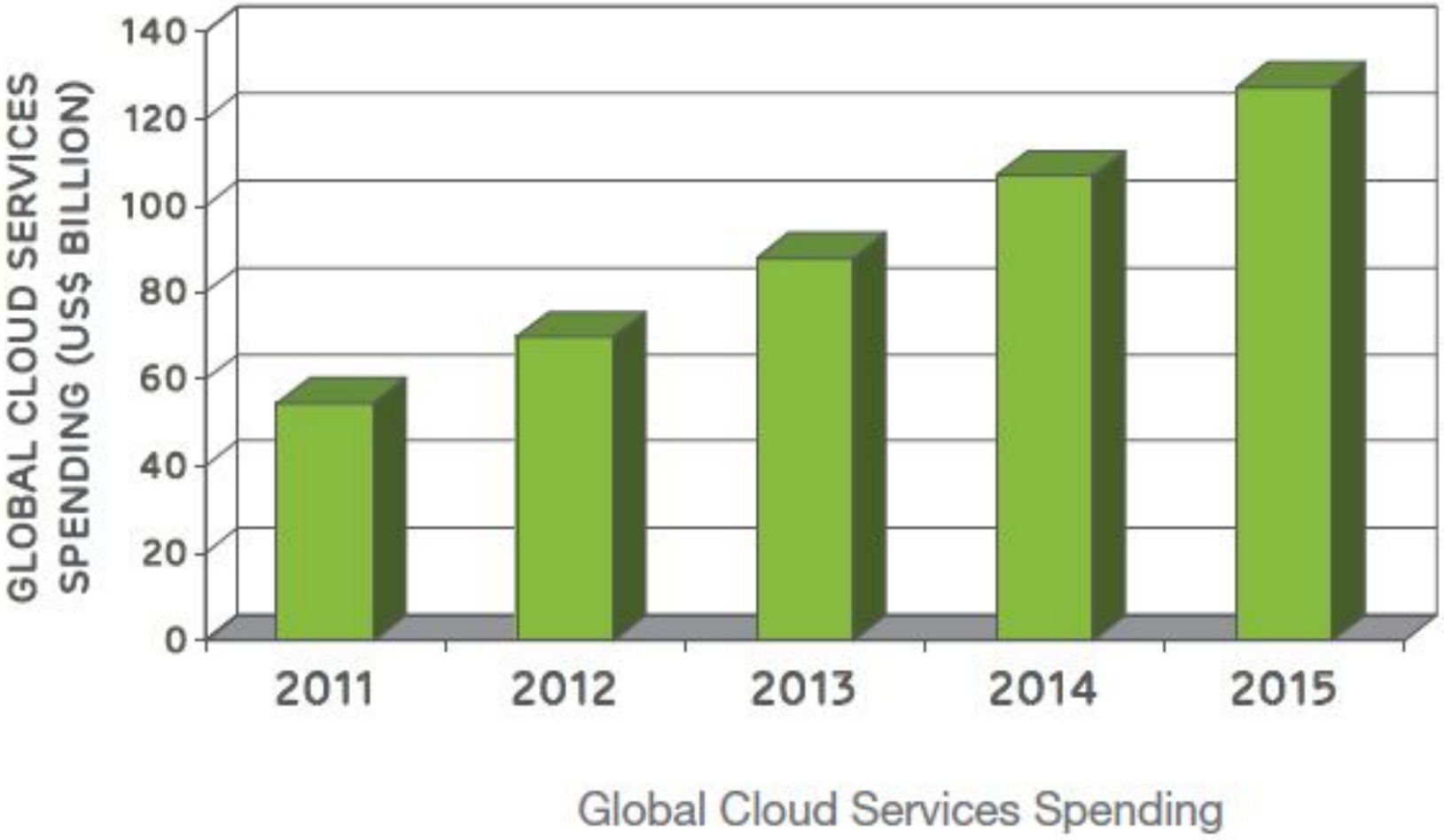
- Standardized, updated base images
- Centrally auditable log servers
- Centralized authentication systems
- Improved forensics (w/ drive image)

Where is the MCC?

Definition

- *Mobile Cloud Computing (MCC) at its simplest, refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smartphone users but a much broader range of mobile subscribers”*

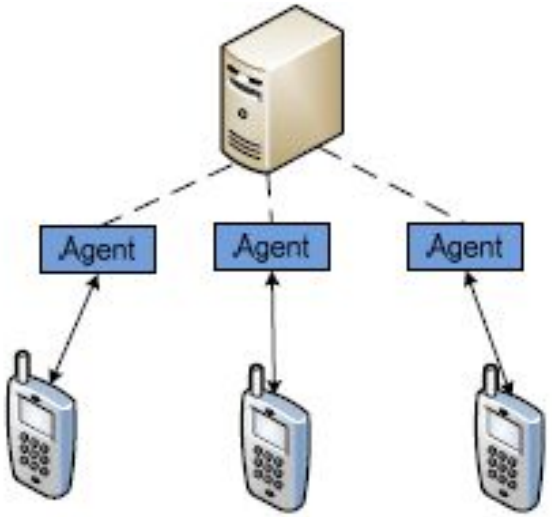
Market Trend



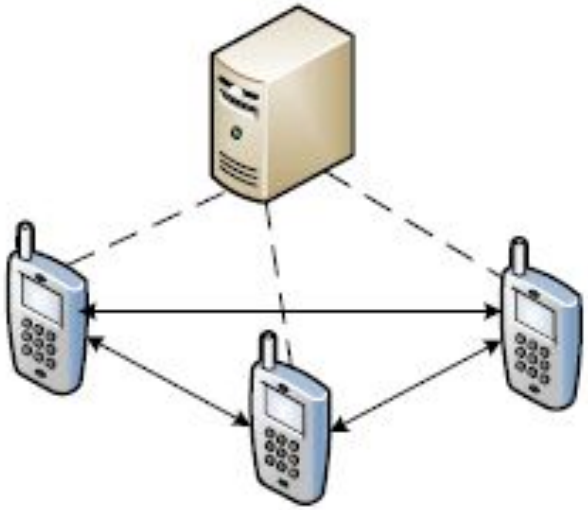
Global Cloud Services Spending

Different Perspective for Architecture of MCC

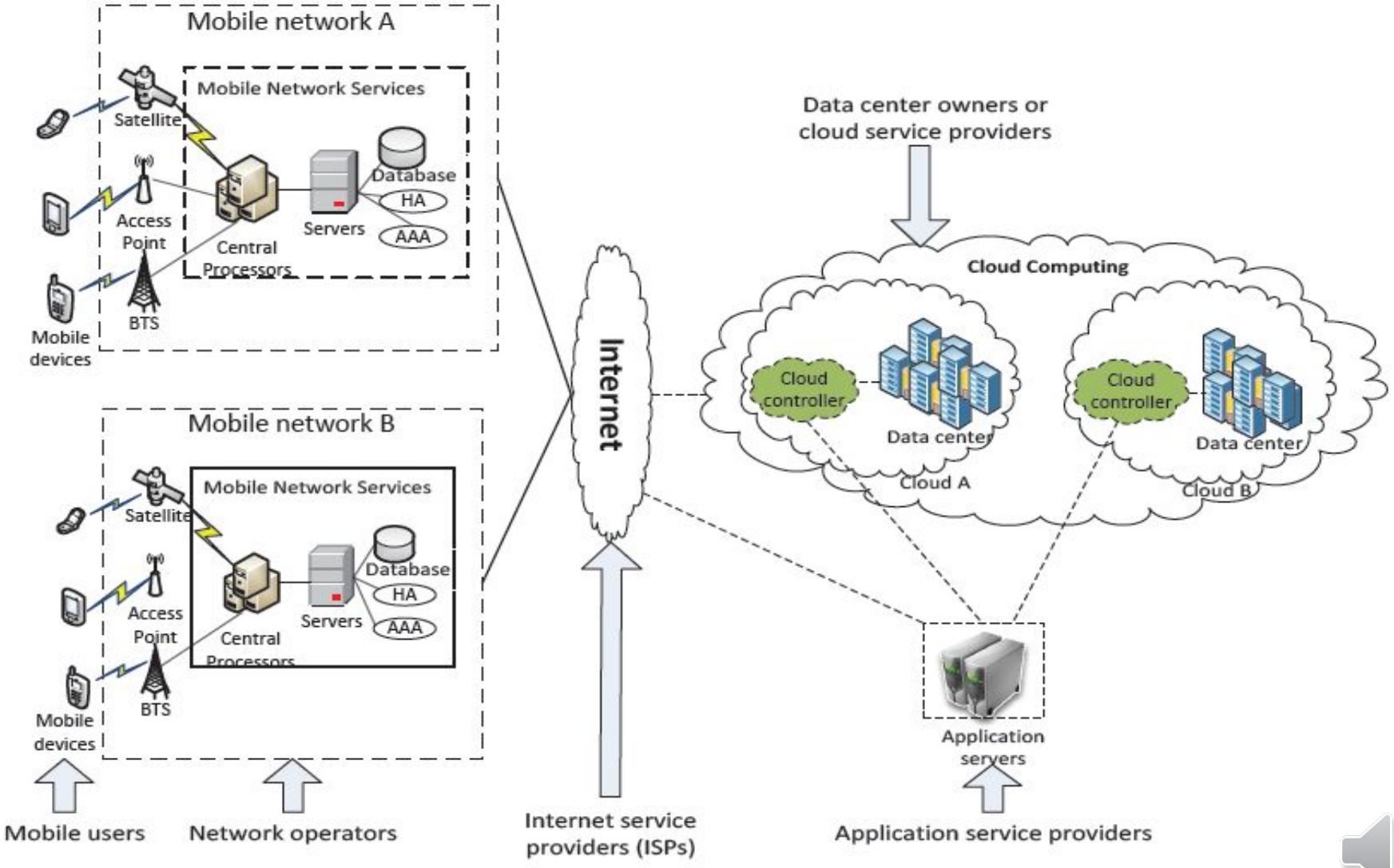
Agent-client scheme



Collaborated scheme



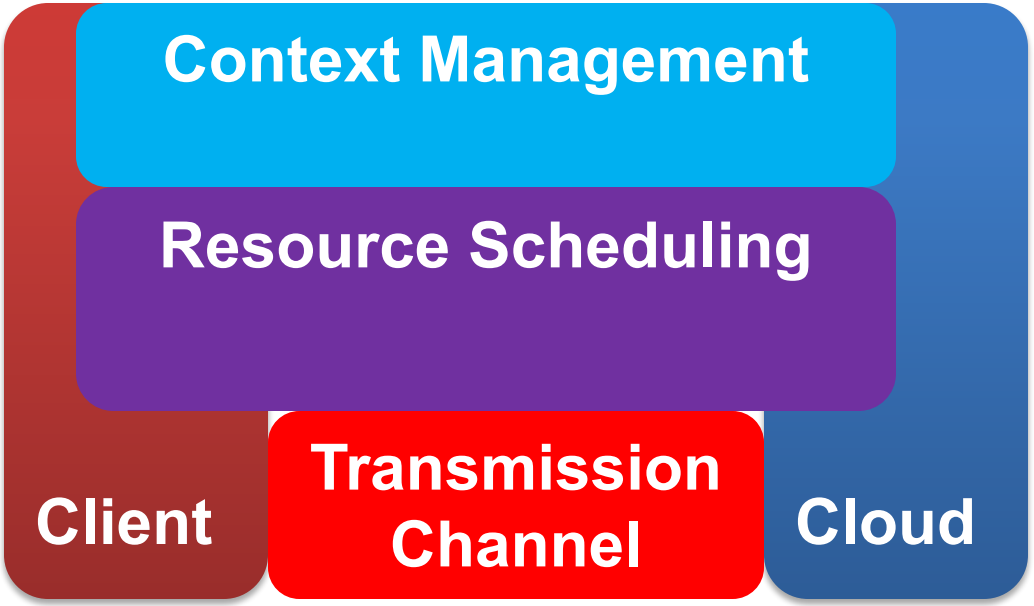
Architectures of MCC



Protocol Model

The concept model of cloud computing cannot be directly applied to the MCC.

While MCC focuses on the connection between client and cloud, which may differ from common features of cloud computing.



Resource Scheduling

- Resource scheduling components address the schedule of resource, such as **computing resource** and **storage resource**.

- **Assign the appropriate pricing mechanism to maximize the revenue of mobile cloud computing systems and provide incentives for mobile users,**
- **Considering different cases, e.g., resource may be stable but applications may transmit to other places.**

Context Management

- Context Enabled features of mobile device allow us to ascertain additional information from the computing device itself without the need for explicit user input.
- Two major classes of contexts:
  - Social Context,
  - Spatial context

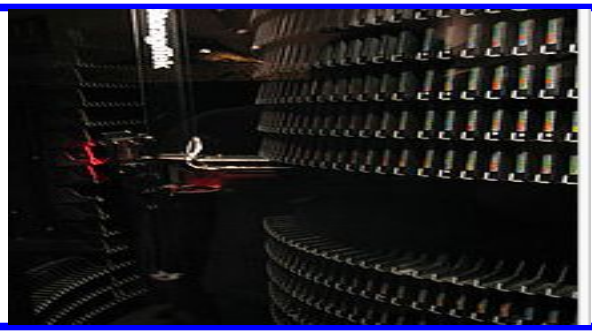
Two major approaches

- **Application partition** and **offloading technology** play an important role for the implementation of elastic applications.
- Application partition decompose complex workload to atomic ones, thus can be processed concurrently.
- Offloading application can free burden of mobile devices.

Advantageous of MCC

- Extending battery lifetime

- Improving data storage capacity and processing power



- Improving reliability

How MCC Can Extend Battery Lifetime?

Challenges:

- Battery is one of the main concerns for mobile devices,
- Traditional approaches need to **changes the structure of mobile devices**.
- The additional cost for the end mobile users is not appealing in wireless networks.

MCC's solution:

- **Computation offloading technique:**
  - Immigrate the large computations and complex processing from resource-limited devices (i.e., mobile devices) to resourceful machines (i.e., servers in clouds).
- This avoids taking a **long application execution time** on mobile devices which results in **large amount of power consumption.**

How MCC Can Improve Storage Capacity?

Challenges

- Users need more and more capacity for saving the essential information on mobile devices,
- Need to change the device,
- More capacity, more weight

MCC's solution

- MCC is developed to enable mobile users to store/access the large data on the cloud through wireless networks,
- Examples of existing services:
  - Amazon Simple Storage Service (Amazon S3),
  - Image Exchange,
  - Flickr, ShoZu.

How MCC Can Improve Reliability?

Challenges

- Users need reliable backup for their information,
- Lack of data security model for both service providers and users in existing mobile users,

MCC's solution

- Storing data or running applications on clouds is an effective way to improve the reliability since the data and application are stored and backed up on a number of computers.

Other advantageous of MCC

- Dynamic provisioning,
- Scalability,
- Multi-tenancy,
- Ease of integration.

Applications of MCC

- Mobile commerce,
- Mobile healthcare,
- Mobile learning,
- Mobile Gaming.

Mobile Commerce

- Mobile commerce (m-commerce) is a business model for commerce using mobile devices.

Mobile Commerce

- Some categories of M-commerce:
  - Finance,
  - Advertising,
  - Shopping.

Application Classes	Type	Examples
Mobile Financial application	B2C (Business to Customer), B2B (Business to Business)	Banks, brokage firms, mobile-user fees
Mobile Advertising	B2C	Sending Custom made advertisement according to users' physical location
Mobile Shopping	B2C, B2B	Locator/order certain products a mobile terminal

Mobile Learning (M-LEARNING) = (E-LEARNING) + Mobility

Traditional m-learning applications have limitations in terms of

1- High cost of devices and network,

2- Low network transmission rate,

3- Limited educational resources

Cloud-based m-learning applications are introduced to solve these limitations.

For example, utilizing a cloud with the large storage capacity and powerful processing ability, the applications provide learners with much richer services in terms of data (information) size, faster processing speed, and longer battery life.

Mobile-healthcare

- Comprehensive health monitoring services,
- Intelligent emergency management system

- Health-aware mobile devices detect pulse-rate,
- Pervasive access to healthcare information,

- Pervasive lifestyle incentive.

Mobile Gaming

- Mobile game (m-game) is a potential market generating revenues for service providers.
- M-game can completely offload game engine requiring large computing resource (e.g., graphic rendering) to the server in the cloud, and gamers only interact with the screen interface on their devices.

Other applications on MCC

- Keyword based searching
- Voice based searching
- Tag- Based searching

›ISSUES AND APPROACHES OF MCC

Due to the integration of two different fields, i.e., **cloud computing** and **mobile networks**, MCC has to face **many technical challenges**.

Issues in Mobile Communication Side

- Network latency and limited bandwidth

- Availability

- Heterogeneity

Low Bandwidth Solutions

Share the limited bandwidth among mobile users who are located in the same area (e.g., a workplace, a station, and a stadium) and involved in the same content (e.g., a video file).

X. Jin, etal, “Cloud Assisted P2P Media Streaming for Bandwidth Constrained Mobile Subscribers,” (ICPADS), pp. 800, January 2011.

Data distribution policy which determines when and how much portions of available bandwidth are shared among users from which networks (e.g., WiFi and WiMAX).

E. Jung, etal “User-profile-driven collaborative bandwidth sharing on mobile phones” in MCS, no. 2, 2010.

Availability Solutions

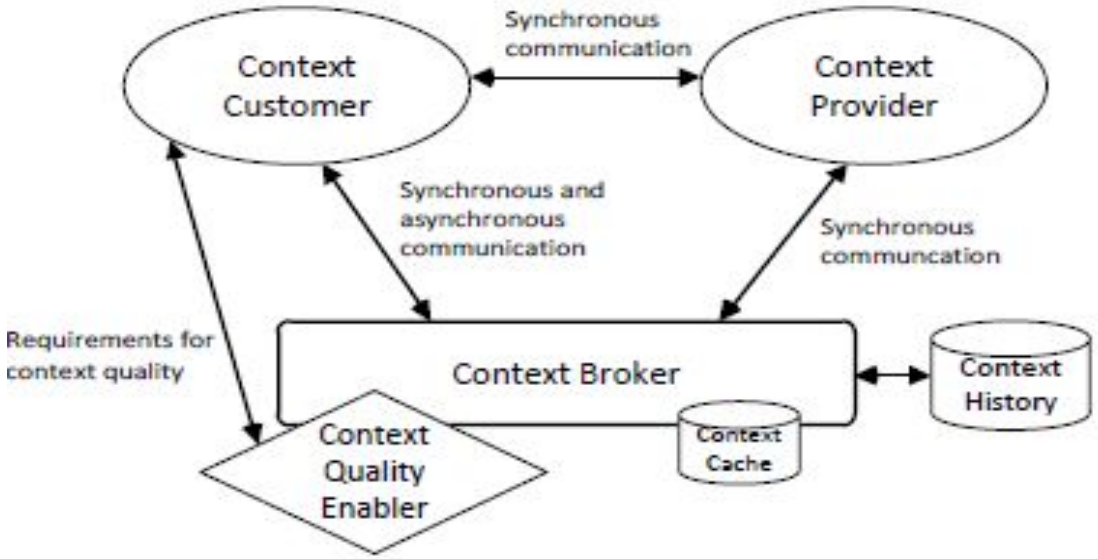
- **Finding stable neighbour**
- **WiFi multi-hop networking system**

› G. Huerta “A virtual cloud computing provider for mobile devices,” in MCS, 2010.

› L. Zhang,, “WiFace: a secure geosocial networking system using WiFi-based multi-hop MANET,” in MSC, 2010.

Heterogeneity Solutions

- **Context management architecture based on Intelligent Radio Network Access**



A. Klein, et.al, “Access Schemes for Mobile Cloud Computing,” in MDM, June 2010.

Issues in Computing Side

- Computing offload
- Security
- Enhancing the efficiency of data access
- Context aware mobile cloud services

Issue and Solutions in Computing Offload

- Offloading in the statistic environment is not always the efficient way to save energy
  - For small calculation and depending on the transmission technology;
  - Tradeoff between communication and computation cost.

G. Chen, et.al, “Studying energy trade offs in offloading computation/compilation in Java-enabled mobile devices,” *IEEE Transactions on Parallel and Distributed Systems*, …2004.

Issue and Solutions in Computing Offload

- For the dynamic environment, offloading encounter new problems as
  - Changing connection statues and bandwidth,
  - Data may reach not to the end users.

Changes	Priority level	Description
Client side power level	1	Power can be divided into sufficient and insufficient power levels, which will depend on the particular situation.
Connection status	2	The connection status can be faded, disconnected from the mobile network, or re-connected to the mobile network
Bandwidth	3	The bandwidth varies from time to time, and depends on several factors, such as the network traffic condition, etc.

Issues in Computing Side

- Security
  - Security for mobile users,
    - Security for mobile applications,
    - Privacy
  - Security of data on cloud
    - Integrity
    - Authentication,

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- Security
  - Security for mobile users,
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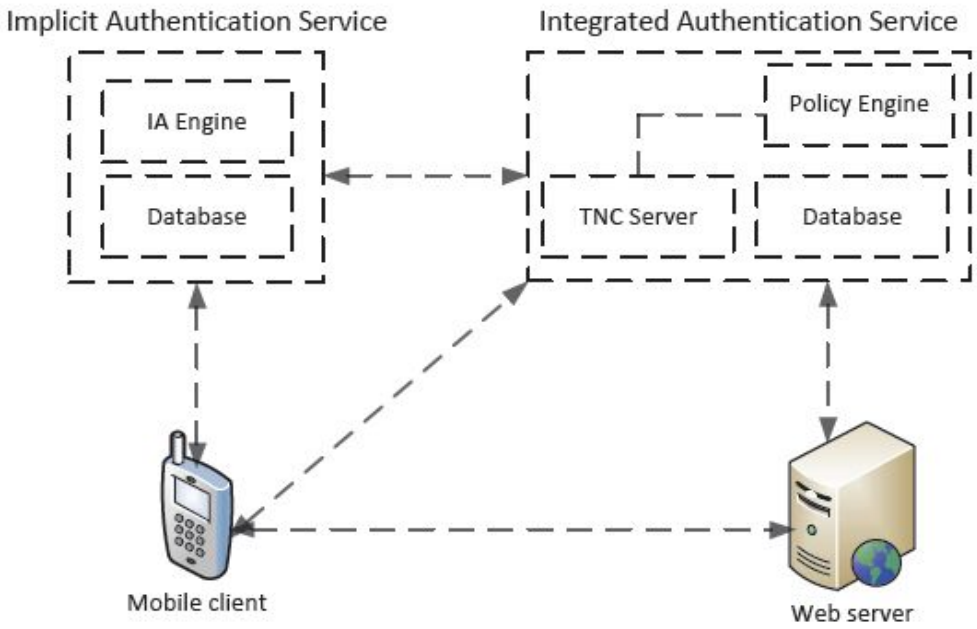
  Solutions

  Installing and running security software on the cloud.

Issues in Computing Side

- Security of data on cloud
  - Integrity
  - Authentication,
- Enhancing the efficiency of data access,
- Context aware mobile cloud services,



Open Issues

- **How to combine the two technology seamlessly?**
  - **The main aim of MCC is to provide PC_like services to mobile devices,**
  - **How can the services from PC's platforms be transplanted to mobile devices?**

Low bandwidth

- Mobility of users
- Increasing the demand of mobile users,
  - More Bandwidth is required to offer MCC.

- Solutions
  - 4G networks (based on LTE)
  - Femto cells
  - Cognitive radios

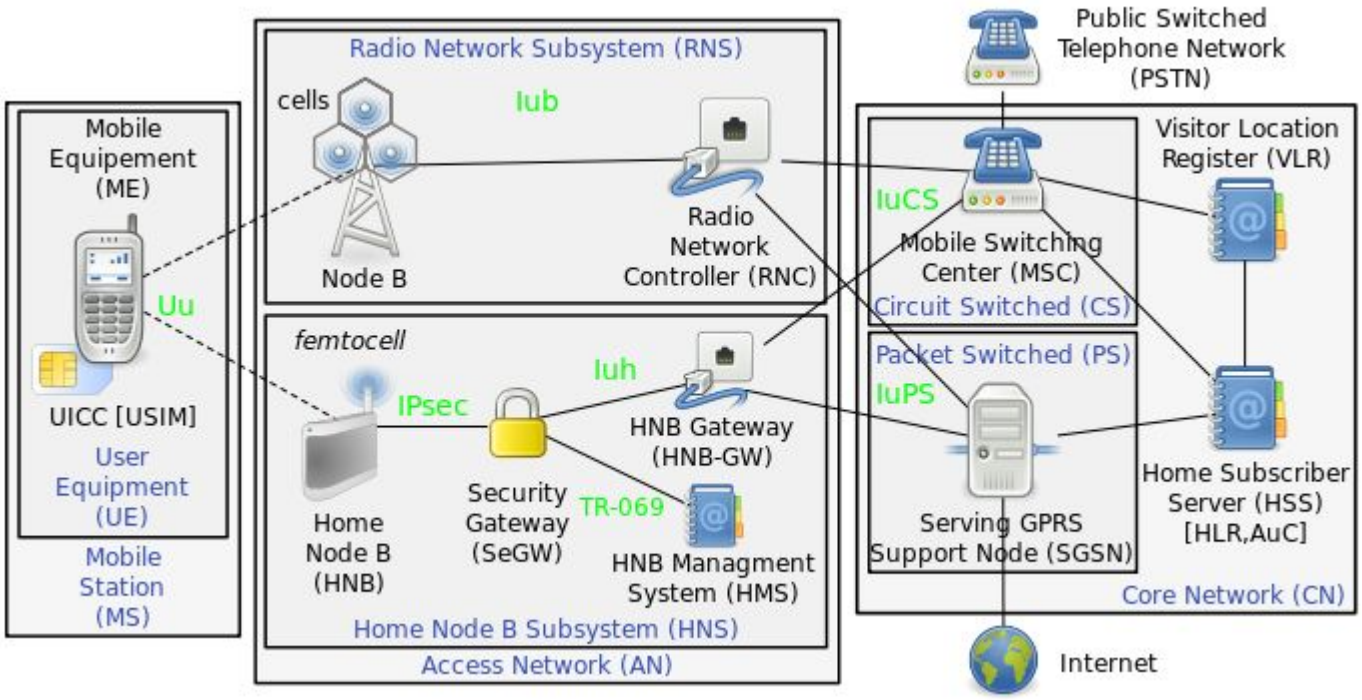
Low bandwidth: 4G Solutions

- Increases bandwidth for subscribers up to 100 Mbit/s (for “LTE Advanced” standard) and 128 Mbit/s (for “Wireless MAN-Advanced” standard);
- Wider mobile coverage area,
- Quicker and reliable handoff,
- Varied services,

- Quality of service guarantee in LTE and Wi-Fi;
- Coexistence with other networks (HSPA+, GSM, WiMax)

Low bandwidth: Femto Cells Solutions

- Provides very good coverage for small area with high capacity,
  - Heterogonous Standards for access layer and Mac layer
  - Discontinuity in coverage



Low Bandwidth: Cognitive Radios Solutions

- Cognitive radio can be expected as a solution to achieve more spectrum utilization in mobile communication environnent and increase the bandwidth efficiency.
  - Cost
  - Complexity
  - Heterogeneity
  - No- Interface
  - None standard protocols

Handover (HO) in MCC

- Due to mobility of users, MCC encounters HO of users during the services
  - Internetworking HO
  - Intranetworking HO

- Latency
- Disconnection
- No protocol for HO between networks in MCC

Pricing Mechanism

- Using services in MCC involves with
  - Mobile service provider (MSP)
  - Cloud service provider (CSP).

- MSPs and CSPs have different services management, customers management, methods of payment and prices.

Service Convergence

- The development and competition of cloud service providers can lead to the fact that in the near future these services will be differentiated according to the types, cost, availability and quality.
- A single cloud is not enough to meet mobile user's demands.
- The new scheme is needed in which the mobile users can utilize multiple cloud in a unified fashion
- The **mobile sky computing**, will enable providers to support a cross-cloud communication and enable users to implement mobile services and applications.

References

[1] Hoang T. Dinh, etal, “A survey of Mobile Cloud Computing: architecture, applications, and approaches”, Wireless communications and Mobile Computing – Wiley, 2012.

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[3] Le Guan, etal. “A survey of research on mobile cloud computing”, IEEE/ACIS, 2010.

[4] H. Qui, etal. “Research on mobile cloud computing: review, trend and perspective”, IEEE 2012.

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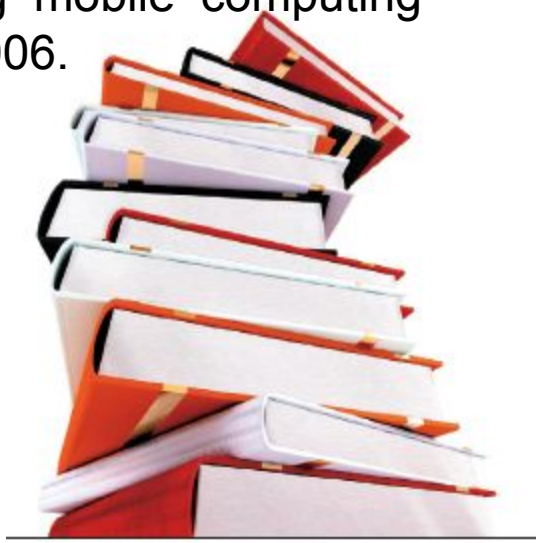

Thank you