Grid Computing

Topic

Mobile Cloud Computing - Architecture, Applications, and Approaches

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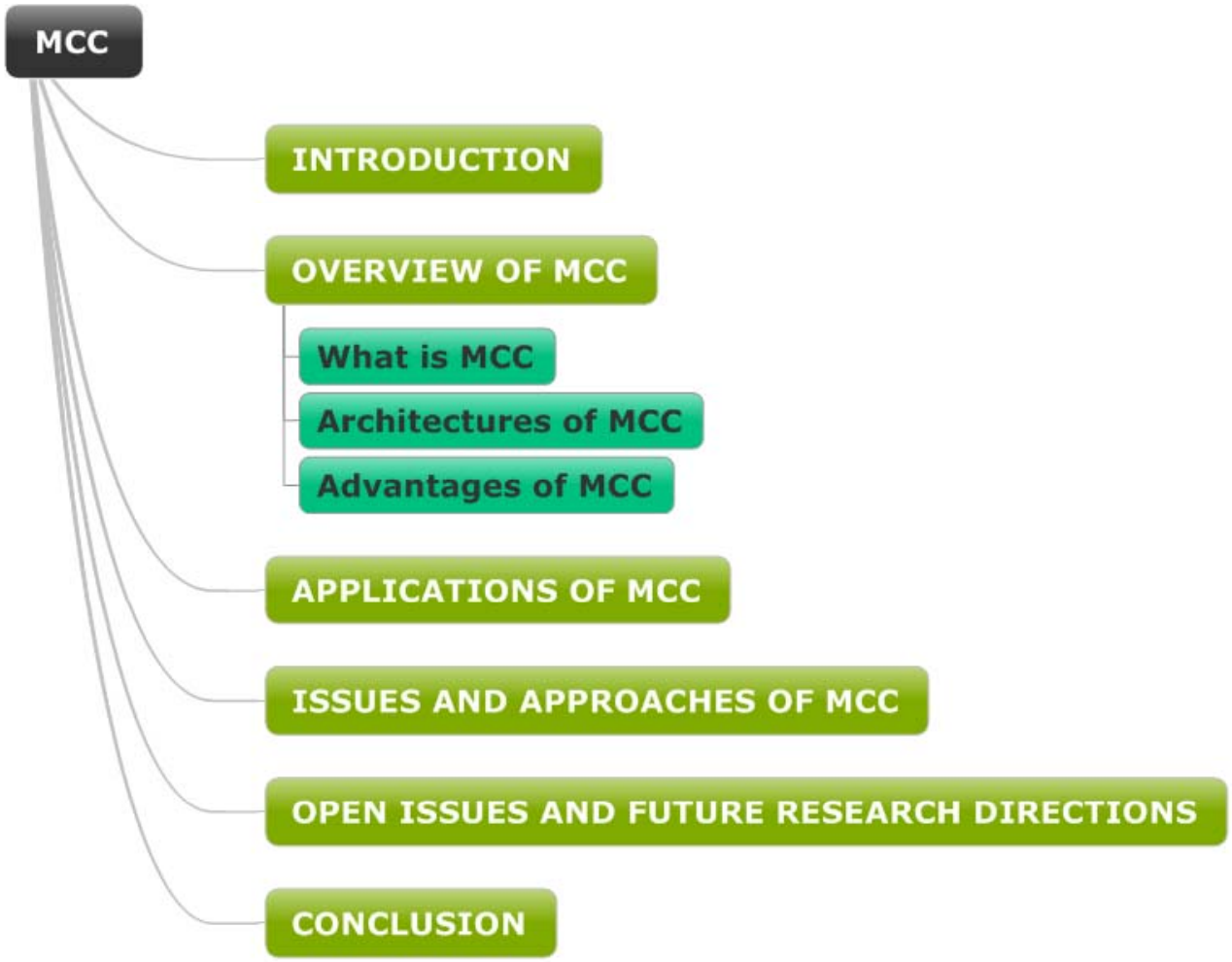
Outline


MCC
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INTRODUCTION

- Mobile devices (e.g., smartphone, tablet pcs, etc) are increasingly becoming an essential part of human life.
- Rich experience of various services from mobile applications (e.g., iPhone apps, Google apps, etc)
- The rapid progress of mobile computing (MC) becomes a powerful trend in the development of IT technology as well as commerce and industry fields.
- The mobile devices are facing many challenges in their resources (e.g., battery life, storage, and bandwidth) and communications (e.g., mobility and security)

INTRODUCTION

- Cloud computing (CC) has been widely recognized as the next generation's computing infrastructure.
- CC offers some advantages by allowing users to use infrastructure (e.g., servers, networks, and storages), platforms (e.g., middleware services and operating systems), and softwares (e.g., application programs) provided by cloud providers (e.g., Google, Amazon, and Salesforce) at **low cost**.
- CC enables users to elastically utilize resources in an **on-demand** fashion.

➡ mobile applications can be **rapidly** provisioned and released with the **minimal management efforts** or service provider's interactions.

➡ mobile cloud computing brings new types of services and facilities for mobile users to take full advantages of cloud computing.

What is MCC

The Mobile Cloud Computing Forum defines MCC as follows [4]:

"Mobile Cloud Computing 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".

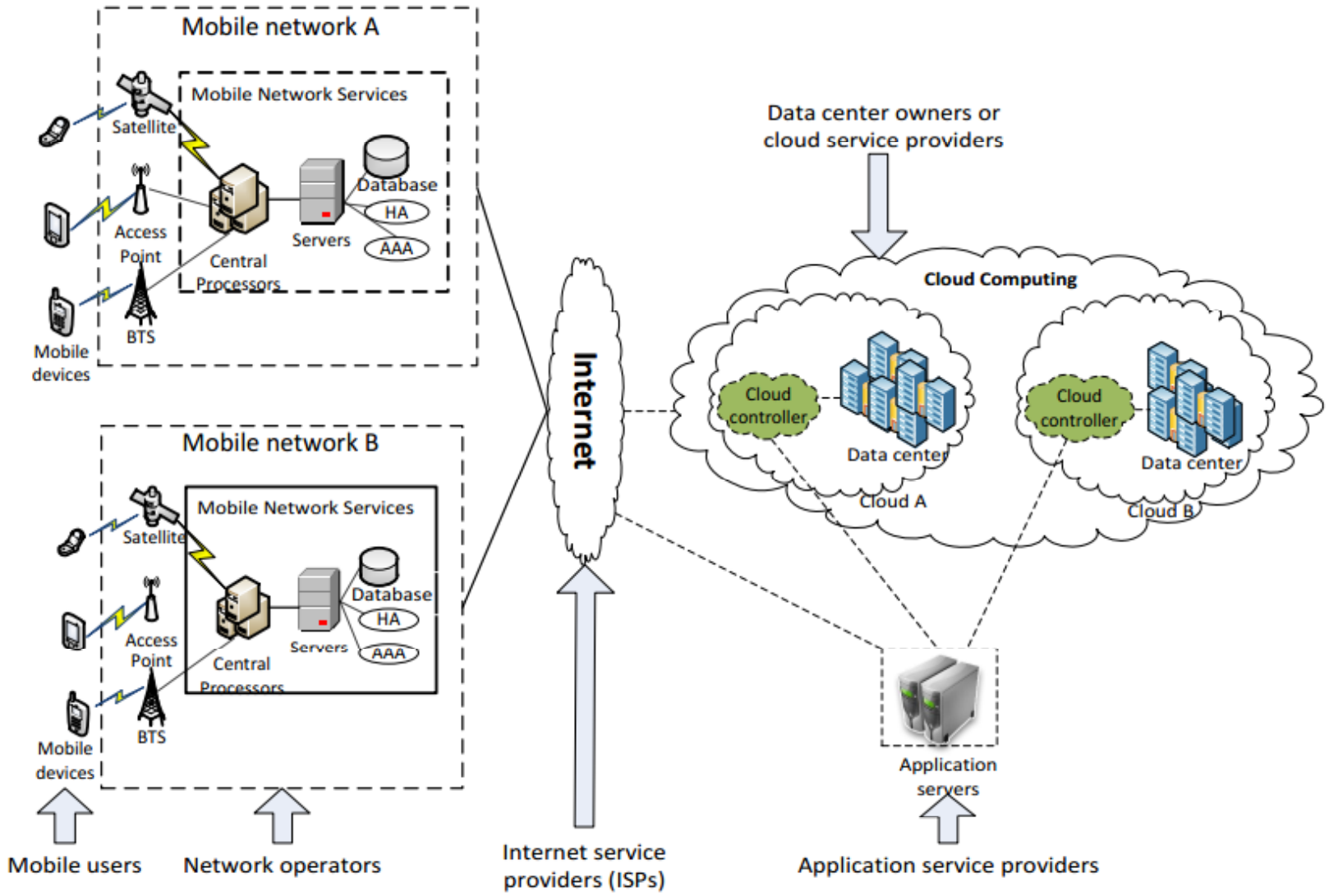
Aepona [5] describes MCC as a new paradigm for mobile applications whereby the data processing and storage are moved from the mobile device to powerful and centralized computing platforms located in clouds. These centralized applications are then accessed over the wireless connection based on a thin native client or web browser on the mobile devices.

What is MCC

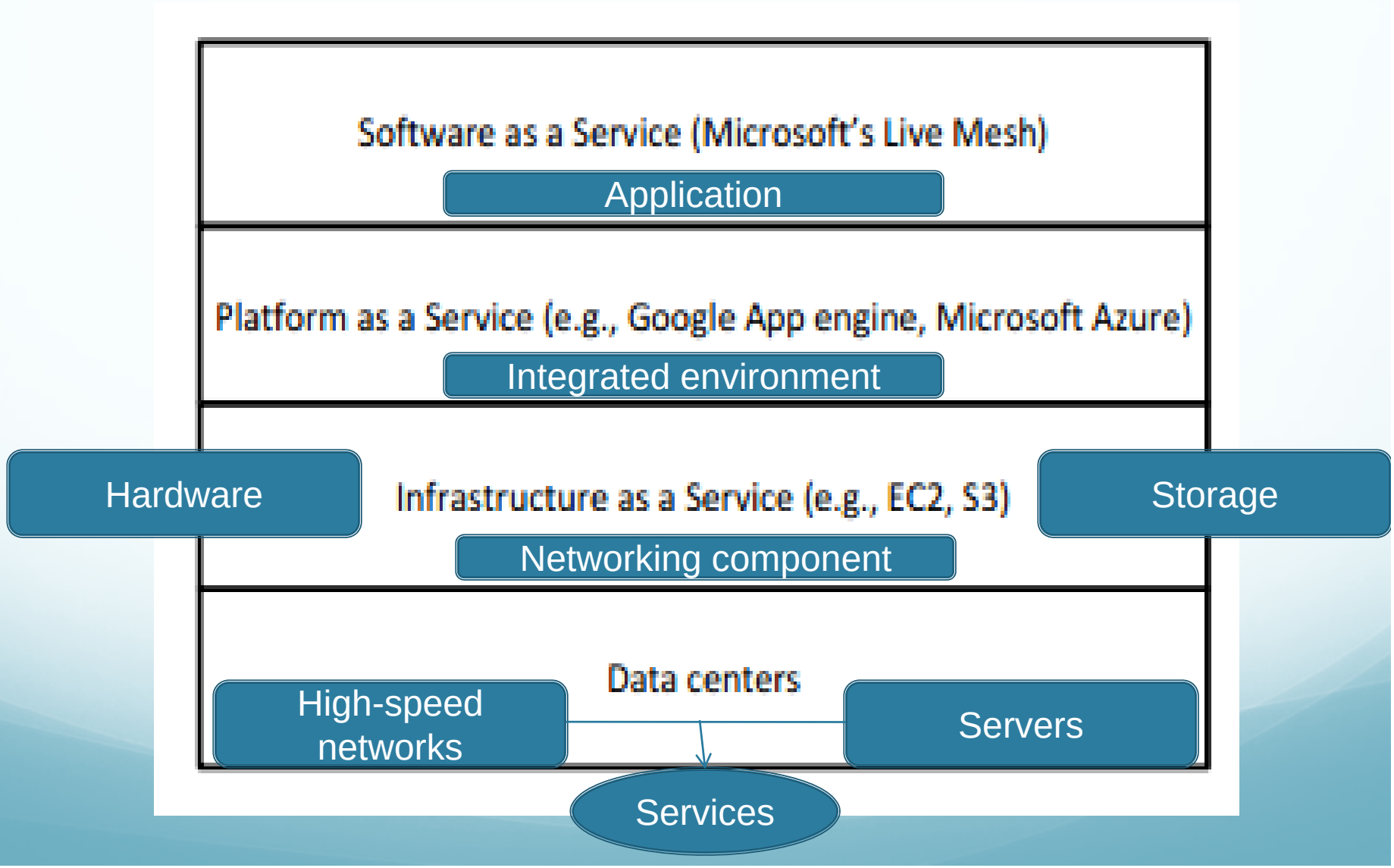
Alternatively, MCC can be defined as a combination of mobile web and cloud computing [6], [7], which is the most popular tool for mobile users to access applications and services on the Internet.

Briefly, MCC provides mobile users with the data processing and storage services in clouds. The mobile devices do not need a powerful configuration (e.g., CPU speed and memory capacity) since all the complicated computing modules can be processed in the clouds.

Architectures of MCC



Architectures of MCC - Detail



Advantages of CC

Extending battery lifetime

- Battery is one of the main concerns for mobile devices

- How to reduce power consumption ?

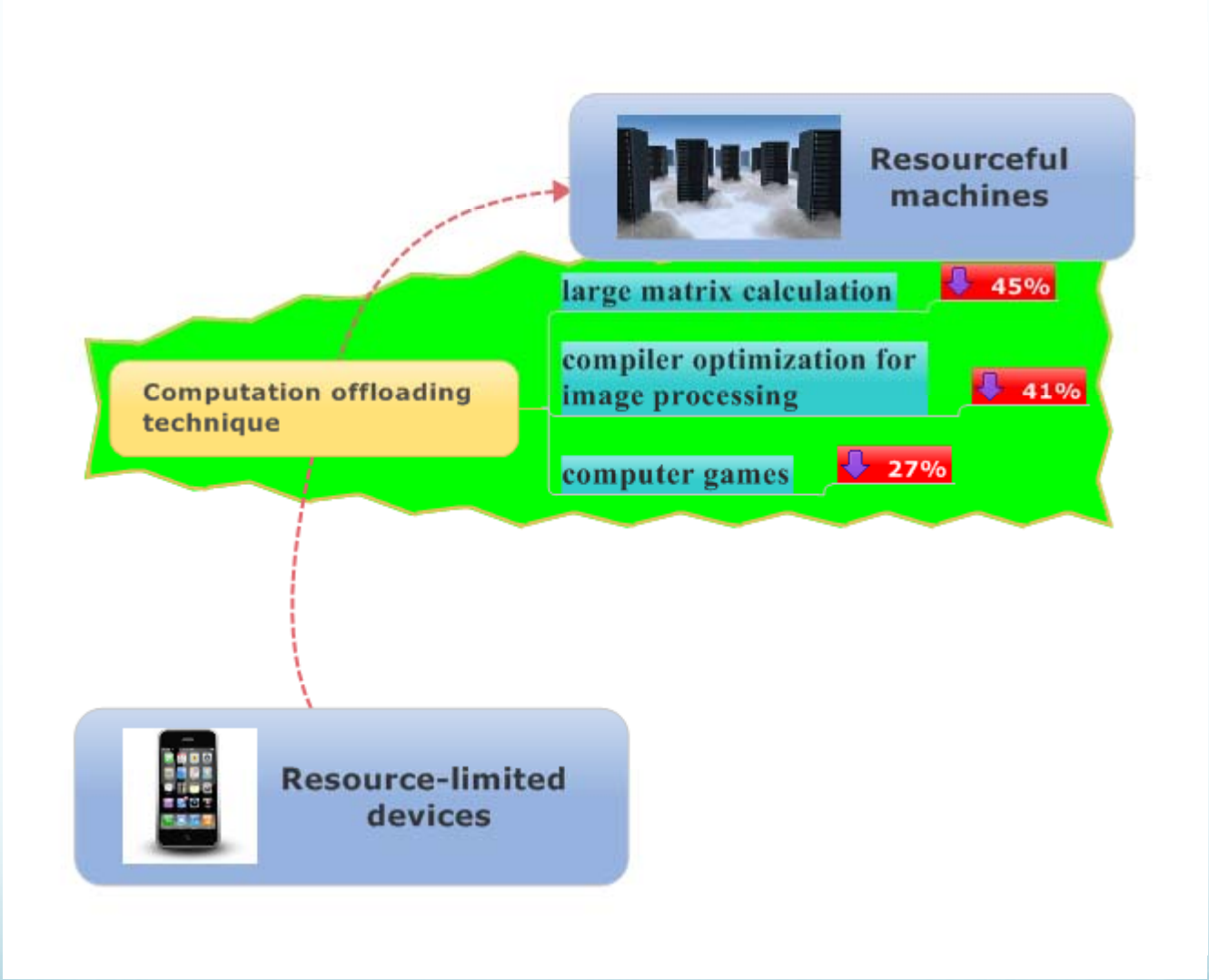
- enhance the CPU performance

- manage the disk and screen in an intelligent manner

→ ✓ Changes in the structure of mobile devices
✓ New hardware

→ ✓ Not be feasible for all mobile devices
✓ Increase COST

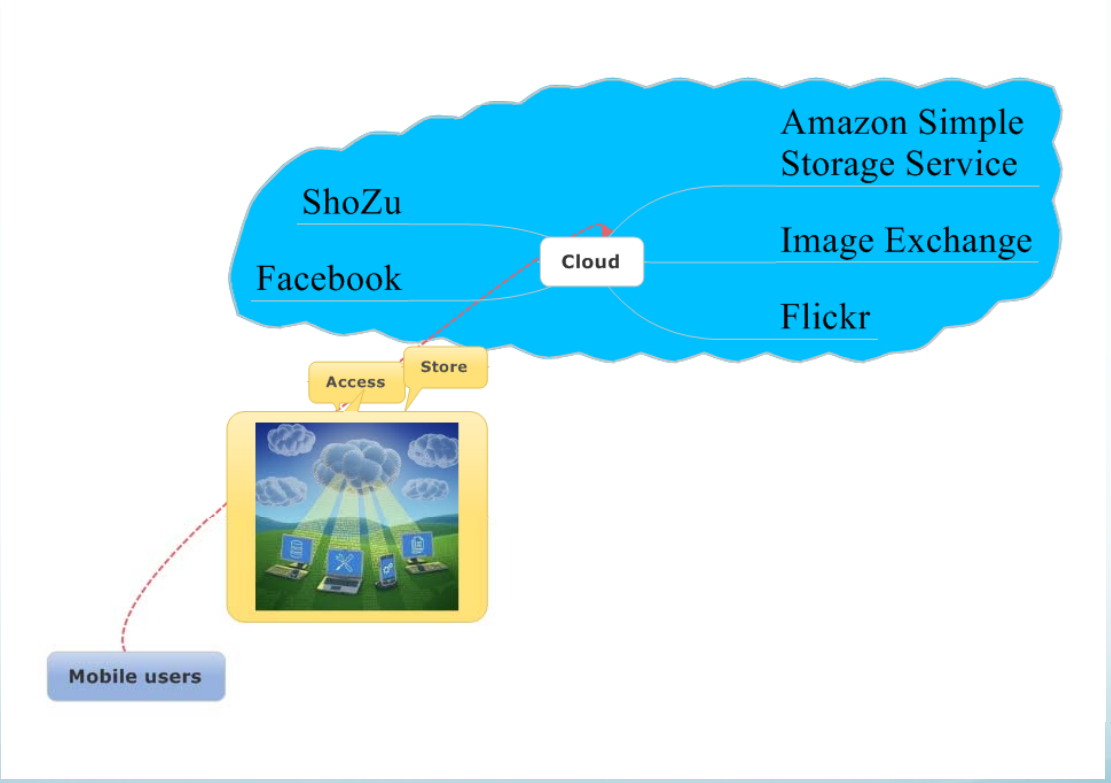
How to reduce power consumption ?



Advantages of CC

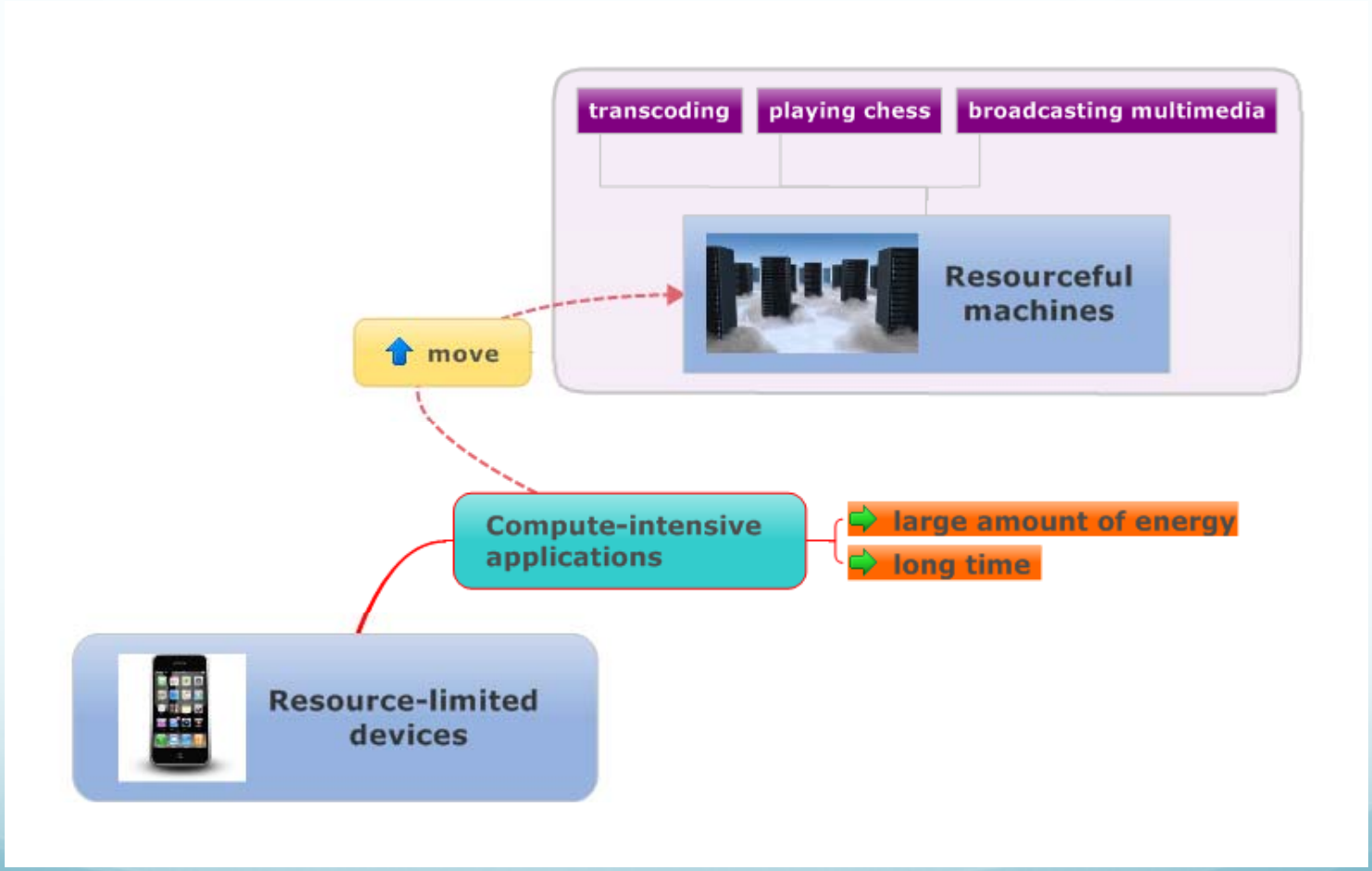
Improving data storage capacity and processing power

- Storage capacity is also a constraint for mobile devices



Advantages of CC

- Improving data storage capacity and processing power



Advantages of CC

Improving reliability

- Storing data or running applications on clouds is an effective way to improve the reliability
- MCC can be designed as a comprehensive data security model for both service providers and users
- The cloud can remotely provide to mobile users with security services
- Cloud-based security services can make efficient use of the collected record from different users to improve the effectiveness of the services

Advantages of CC

Dynamic provisioning

- Dynamic on-demand provisioning of resources

➡ run applications without advanced reservation of resources.

Scalability

- The deployment of mobile applications can be performed and scaled

➡ meet the unpredictable user demands

- Service providers can easily add and expand an application and service

Advantages of CC

Multi-tenancy

- Service providers can share the resources and costs

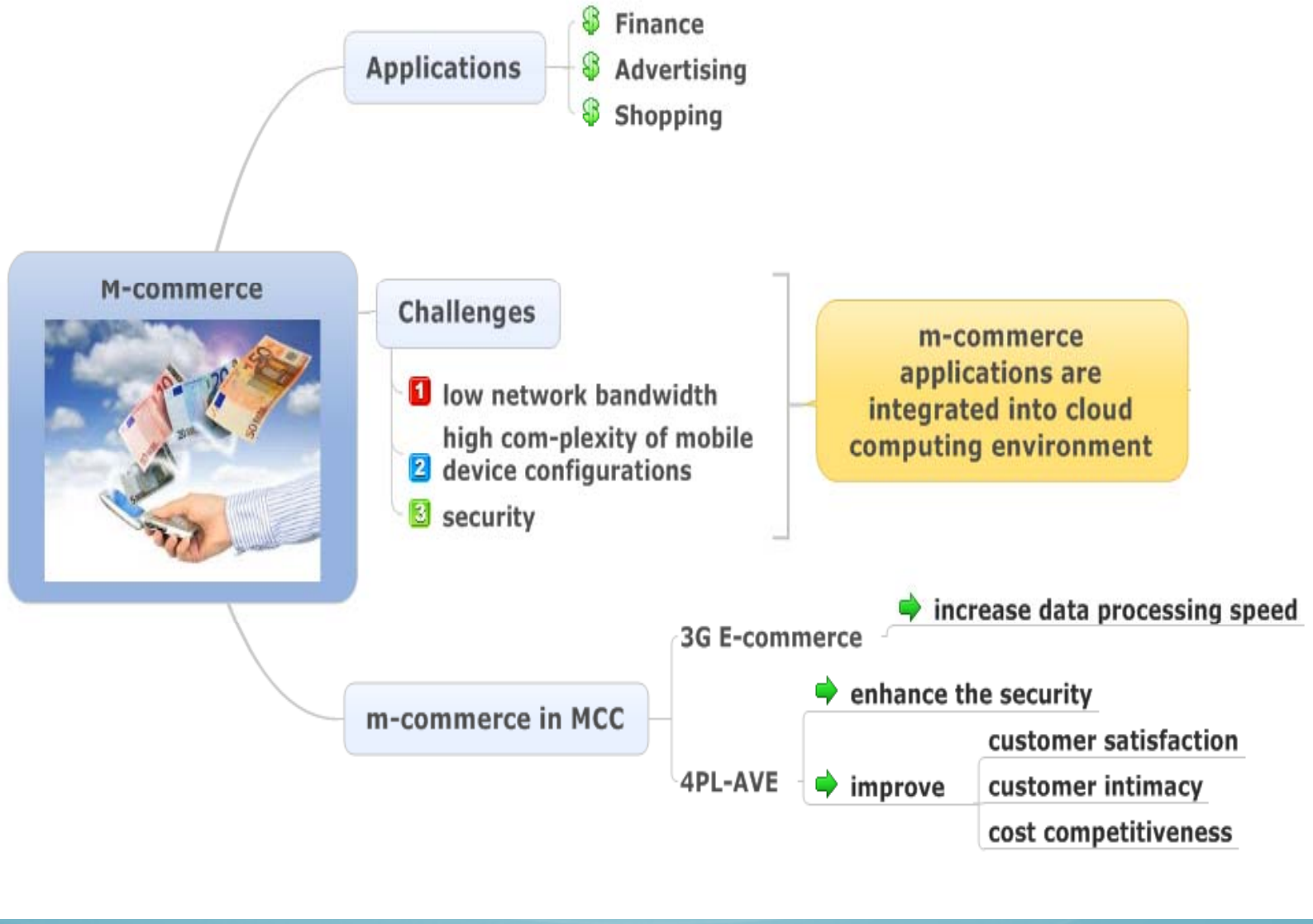
⇨ support a variety of applications and large number of users.

Ease of Integration

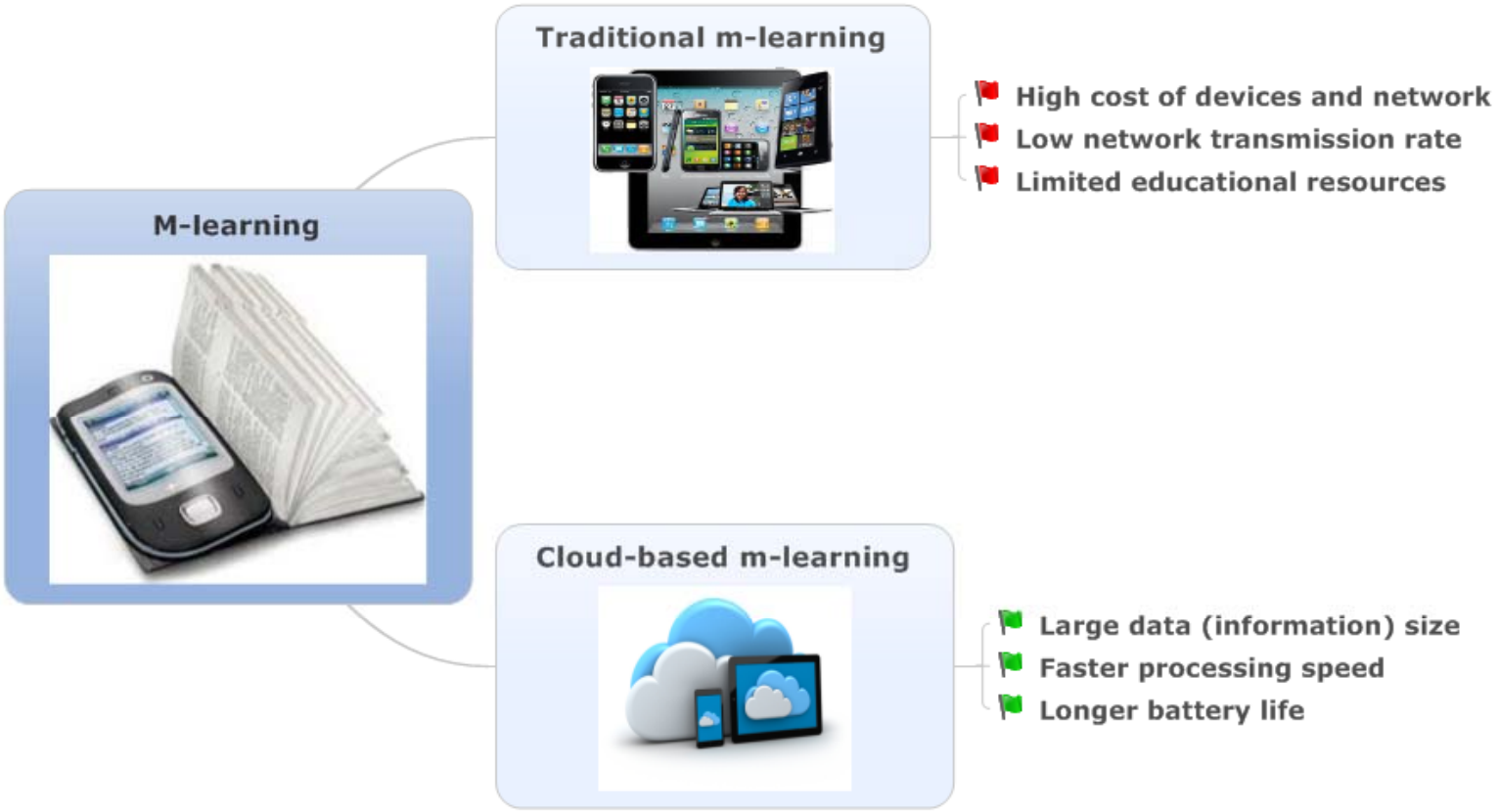
- Multiple services from different service providers can be integrated easily through the cloud and the Internet

⇨ meet the users' demands

MCC applications



MCC applications



MCC applications

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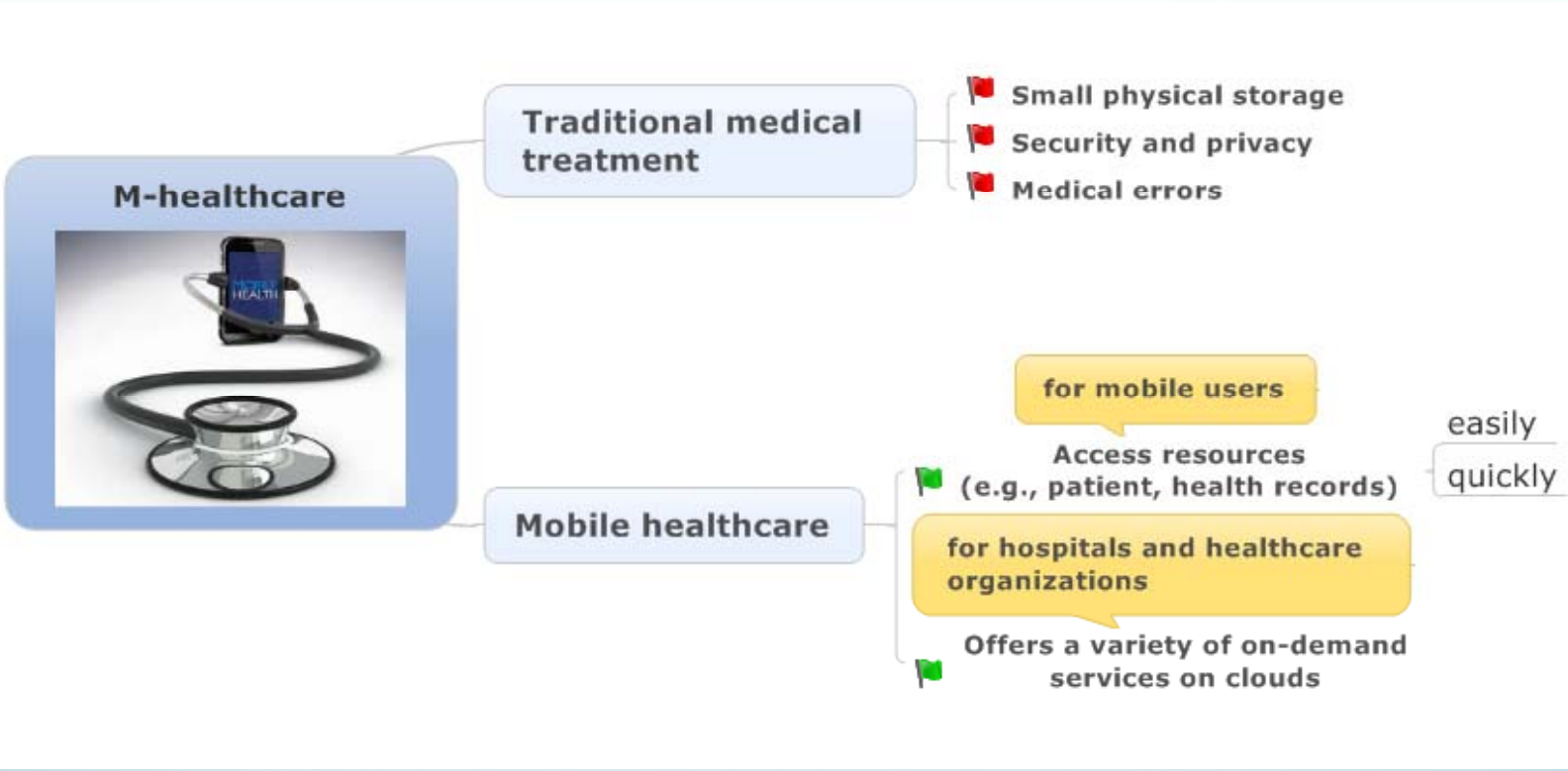
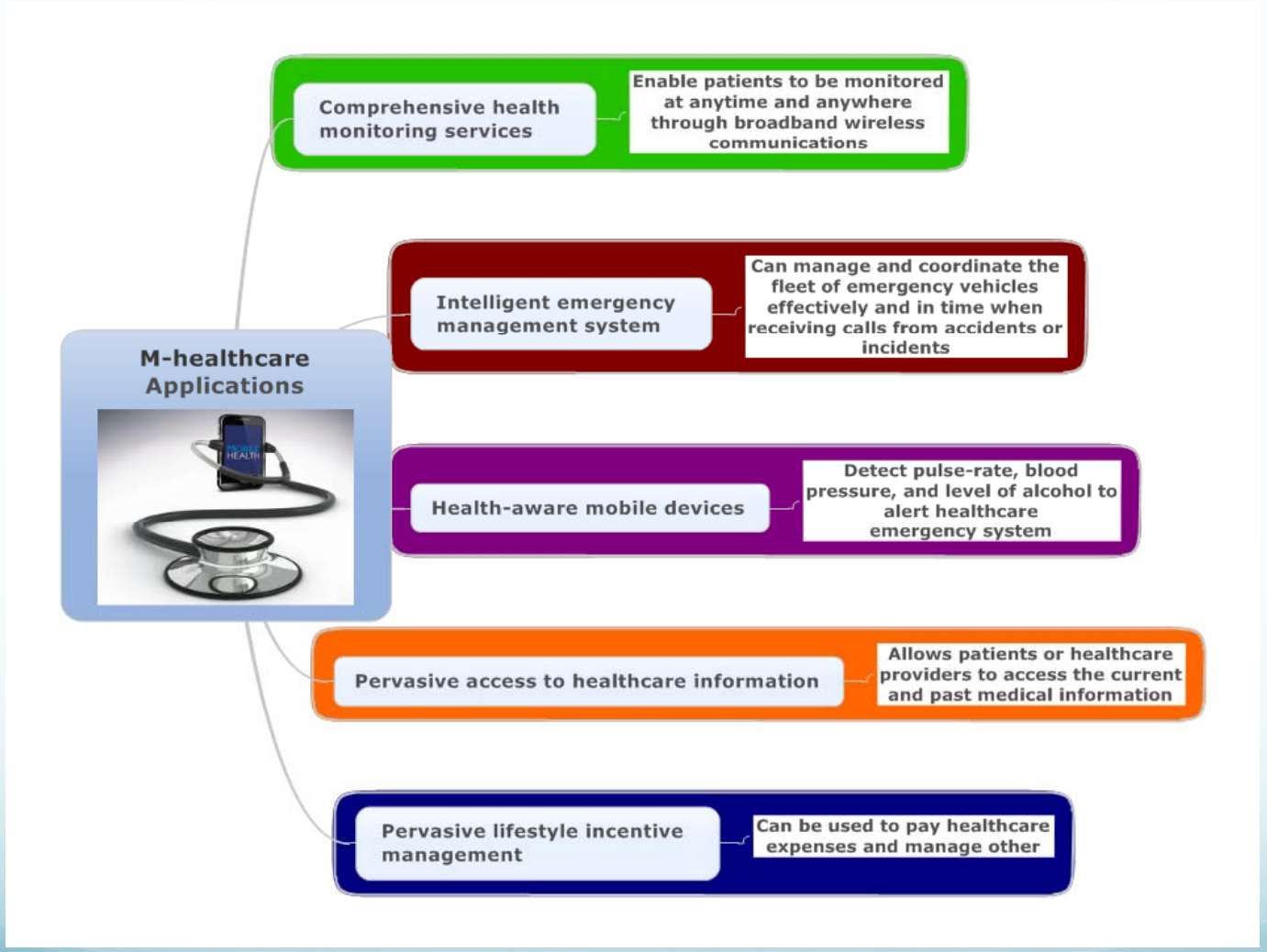
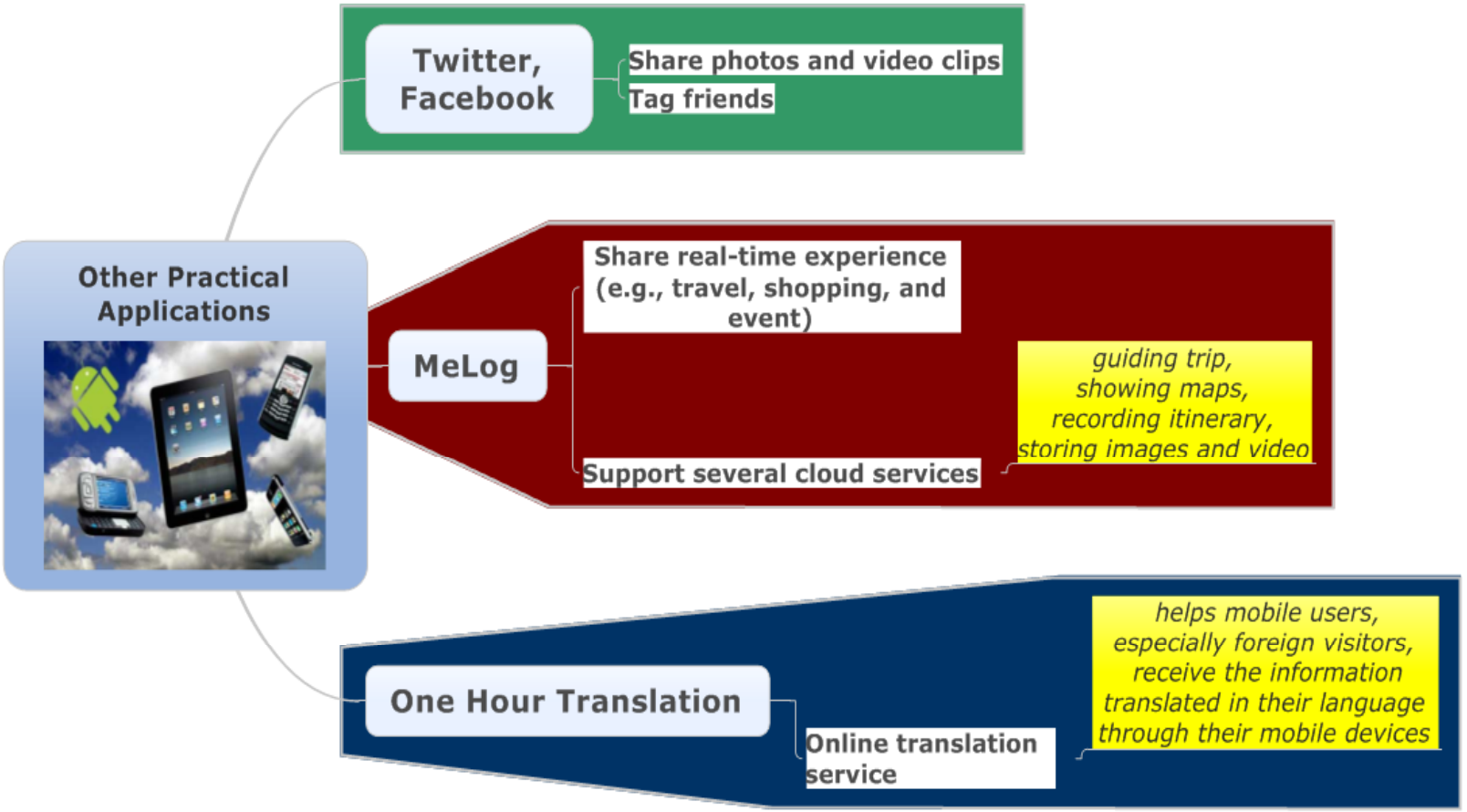


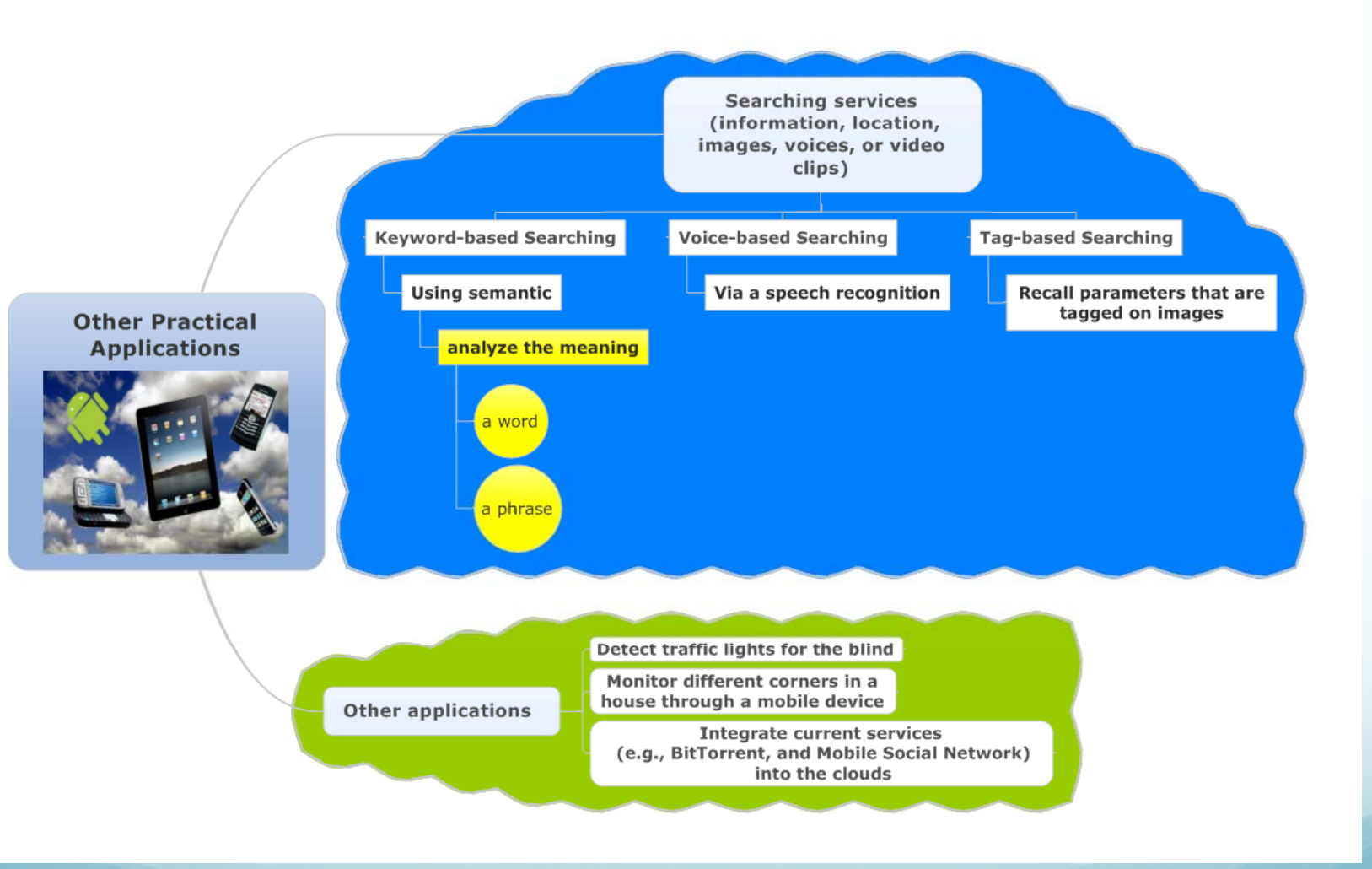
MCC applications



MCC's application



MCC applications



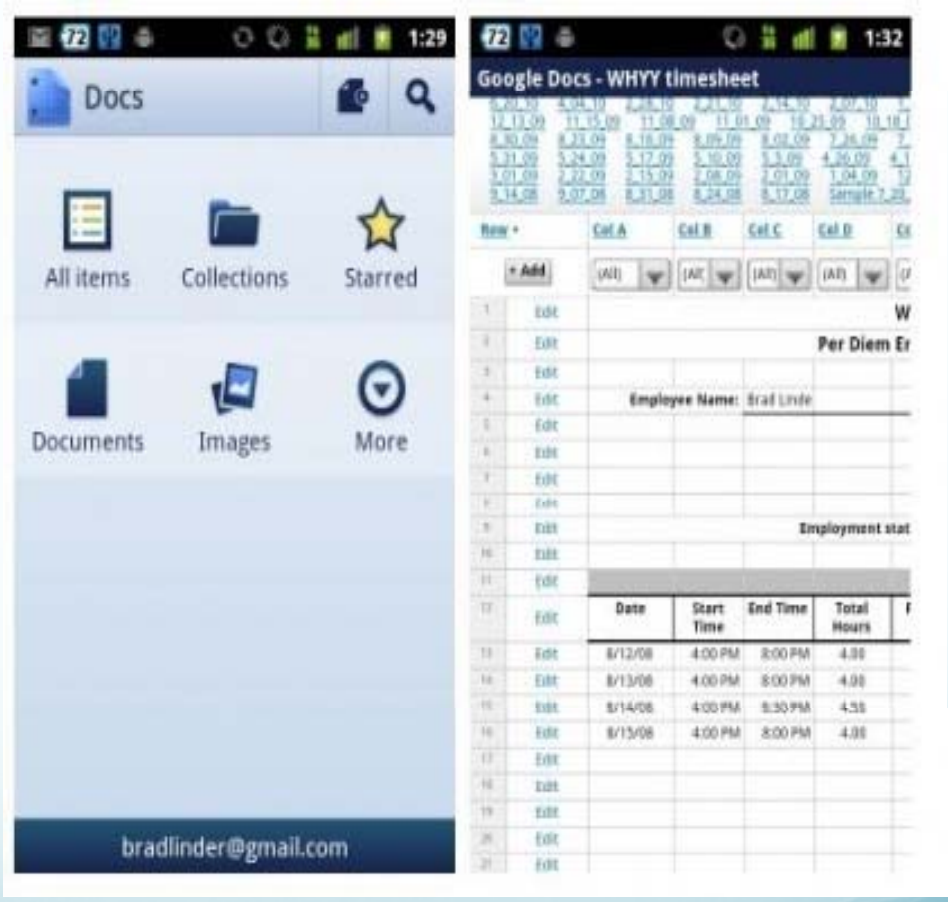
Best Applications for Android

- Google docs

This is a cloud computing application that enables a reader to read or write a document on the web.

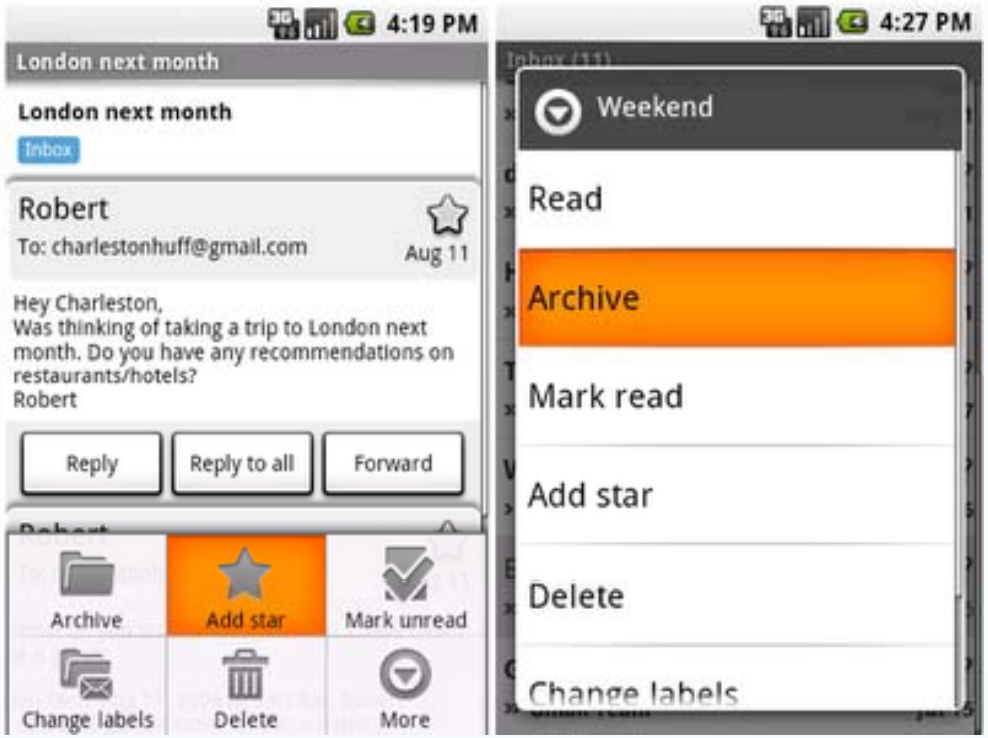
Cloud computing enables the user to access the documents that is stored in the cloud and facilitate him/her reading it without having a copy on his mobile phone.

This application is supported by android operating system and is one of the best android cloud computing apps.



Best Applications for Android

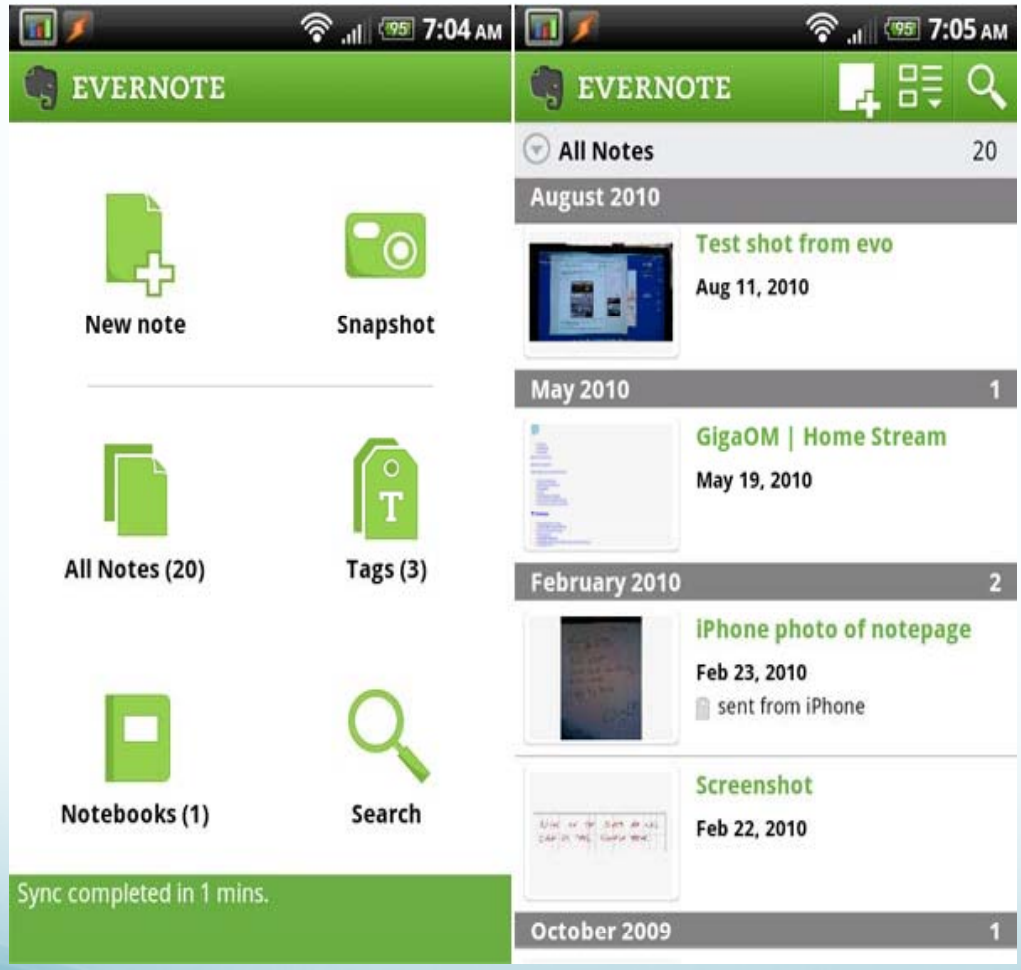
- Email



Email cloud computing services reduces memory requirements in an android phone hence making it very important android phone application.

Best Applications for Android

- Evernote



This mobile application enables one to sync everything between smartphone, the cloud and smart phone.

Using this application it is possible to clip data all a part of a webpage and then synchronize it in the desktop.

It is also a very popular android cloud computing application.

ISSUES AND APPROACHES OF MCC

- Issues in Mobile Communication Side
  - Low Bandwidth
  - Availability
  - Heterogeneity
- Issues in Computing Side
  - Computing Offloading
  - Security
  - Enhancing the Efficiency of Data Access

Issues in Mobile Communication Side(cont)

- Low Bandwidth:
  - Bandwidth is one of the big issues in MCC since the radio resource for wireless networks is much scarce as compared with the traditional wired networks.
  - A solution to 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)
  - Only applied in the case when the users in a certain area are interested in the same contents. It does not consider a distribution policy which leads to a lack of fairness about each user's contribution.

Issues in Mobile Communication Side(cont)

- Availability
  - Service availability becomes more important issue in MCC than that in the cloud computing with wired networks
  - Mobile users may not be able to connect to the cloud to obtain service due to traffic congestion, network failures, and the out-of-signal
  - Propose solutions to help mobile users in the case of the disconnection from clouds: discovery mechanism to find the nodes in the neighbor of a user whose link to cloud is unavailable. After detecting nearby nodes that are in a stable mode, the target provider for the application is changed.
  - In this way, instead of having a link directly to the cloud, mobile user can connect to the cloud through neighboring nodes

Issues in Mobile Communication Side(cont)

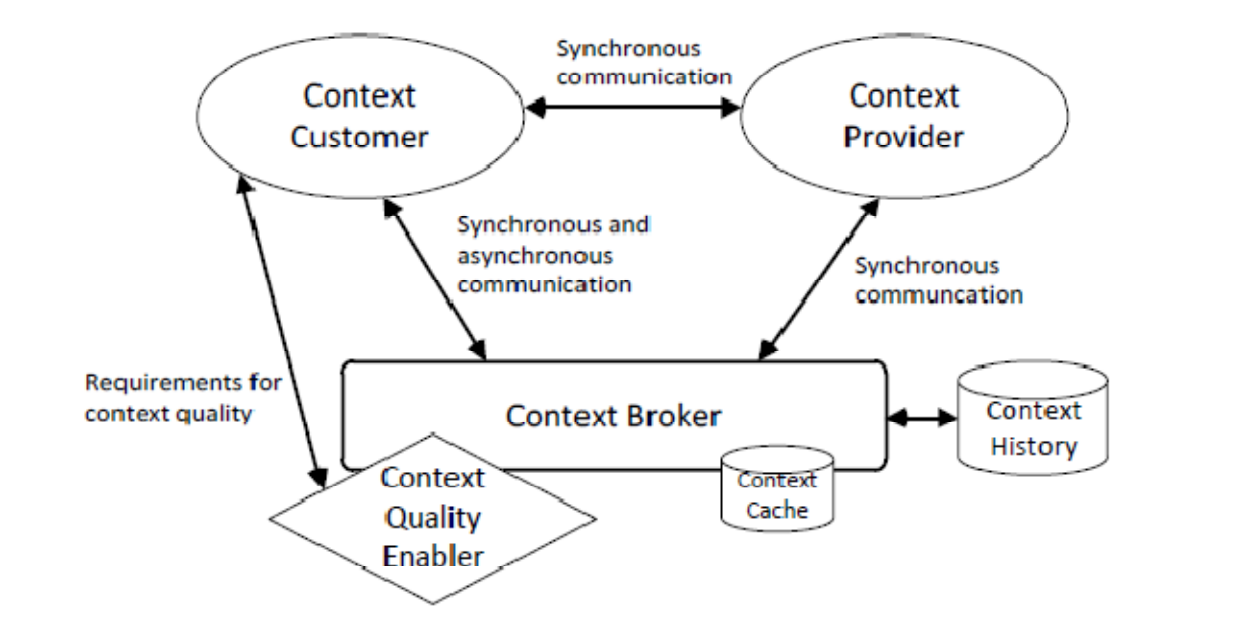
- Heterogeneity
  - MCC will be used in the highly heterogeneous networks in terms of wireless network interfaces
  - Different mobile nodes access to the cloud through different radio access technologies such as GPRS, WiMAX, and WLAN
  - An issue of how to handle the wireless connectivity while satisfying MCC's requirements arises (e.g., always-on connectivity, on-demand scalability of wireless connectivity, and the energy efficiency of mobile devices).

Issues in Mobile Communication Side(cont)

- Heterogeneity
  - Proposes an architecture to provide an intelligent network access strategy for mobile users
  - This architecture is built based on a concept of Intelligent Radio Network Access (IRNA)
  - To apply IRNA in MCC environment, the authors propose a context management architecture (CMA) with the purpose to acquire, manage, and distribute a context information.

Issues in Mobile Communication Side(cont)

- Heterogeneity



  - In this architecture, when a context consumer wants to communicate with a context provider, the context consumer will request the URI (Uniform Resource Identifier) of context providers at the context broker.

ISSUES AND APPROACHES OF MCC

- Issues in Mobile Communication Side
  - Low Bandwidth
  - Availability
  - Heterogeneity
- Issues in Computing Side
  - Computing Offloading
  - Security
  - Enhancing the Efficiency of Data Access

Computing Offloading

- Offloading is one of the main features of MCC to improve the battery lifetime for the mobile devices and to increase the performance of applications.
- However, there are many related issues including efficient and dynamic offloading under environment changes

Offloading in the static environment

- Offloading is not always the effective way to save energy.
- For a code compilation, offloading might consume more energy than that of local processing when the size of codes is small
- For example:
  - When the size of codes after compilation is 500KB, offloading consumes about 5% of a device's battery for its communication while the local processing consumes about 10% of the battery for its computation → the offloading can save the battery up to 50%.
  - However, when the size of codes is 250KB, the efficiency reduces to 30%. When the size of codes is small, the offloading consumes more battery than that of local processing.

Offloading in the static environment(cont)

- Therefore, it is a critical problem for mobile devices to determine whether to offload and which portions of the application's codes need to be offloaded to improve the energy efficiency.
- Suggests a program partitioning based on the estimation of the energy consumption (communication energy and computation energy) before the program execution.
- The optimal program partitioning for offloading is calculated based on the trade-off between the communication and computation costs.

Offloading in the static environment(cont)

- The communication cost depends on the size of transmitted data and the network bandwidth, while the computation cost is impacted by the computation time.
- However, information such as the communication requirements or/and the computation workload may change in different execution instances. Thus, optimal decisions of a program partitioning must be made at a runtime dynamically.

Offloading in the Dynamic Environment

TABLE III

COMMON MOBILE COMPUTING ENVIRONMENTAL CHANGES.

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.

- This subsection introduces a few approaches to deal with offloading in a dynamic network environment (e.g., changing connection status and bandwidth)
- The transmitted data may not reach the destination, or the data executed on the server will be lost when it has to be returned to the sender.

Offloading in the Dynamic Environment(cont)

- In the case of connection status (e.g., disconnection during the program execution) changes, the server will periodically check the connection status with the client and maintain the execution information about the particular running tasks.
- When the disconnection is recovered, the server will send the execution results for the client. If the server cannot re-connect to the client, the server will wait for the pre-defined time interval and the tasks will be deleted.

Security

- Protecting user privacy and data/application secrecy from adversary is a key to establish and maintain consumers' trust in the mobile platform, especially in MCC.
- Security for Mobile Users
  - Security for mobile applications
  - Privacy
- Securing Data on Clouds
  - Integrity
  - Authentication
  - Digital rights management

Security for mobile applications

- Installing and running security softwares such as Kaspersky, McAfee, and AVG antivirus programs on mobile devices are the simplest ways to detect security threats (e.g., virus, worms, and malicious codes) on the devices.
- However, mobile devices are constrained in their processing and power, protecting them from the threats is more difficult than that for resourceful device (e.g., PC)

Privacy

- With the advantages of GPS positioning devices, the number of mobile users using the location based services (LBS) increases.
- However, the LBS faces a privacy issue when mobile users provide private information such as their current location. This problem becomes even worse if an adversary knows user's important information

After receiving mobile users' requests, LTS gathers their location information in a certain area and cloaks the information called "cloaked region"

Securing Data on Clouds

- Although both mobile users and application developers benefit from storing a large amount of data/applications on a cloud, they should be careful of dealing with the data/applications
  - Integrity
  - Authentication
  - Digital rights

Enhancing the Efficiency of Data Access:

- With an increasing number of cloud services, the demand of accessing data resources (e.g., image, files, and documents) on the cloud increases. As a result, a method to deal with (i.e., store, manage, and access) data resources on clouds becomes a significant challenge

Enhancing the Efficiency of Data Access:

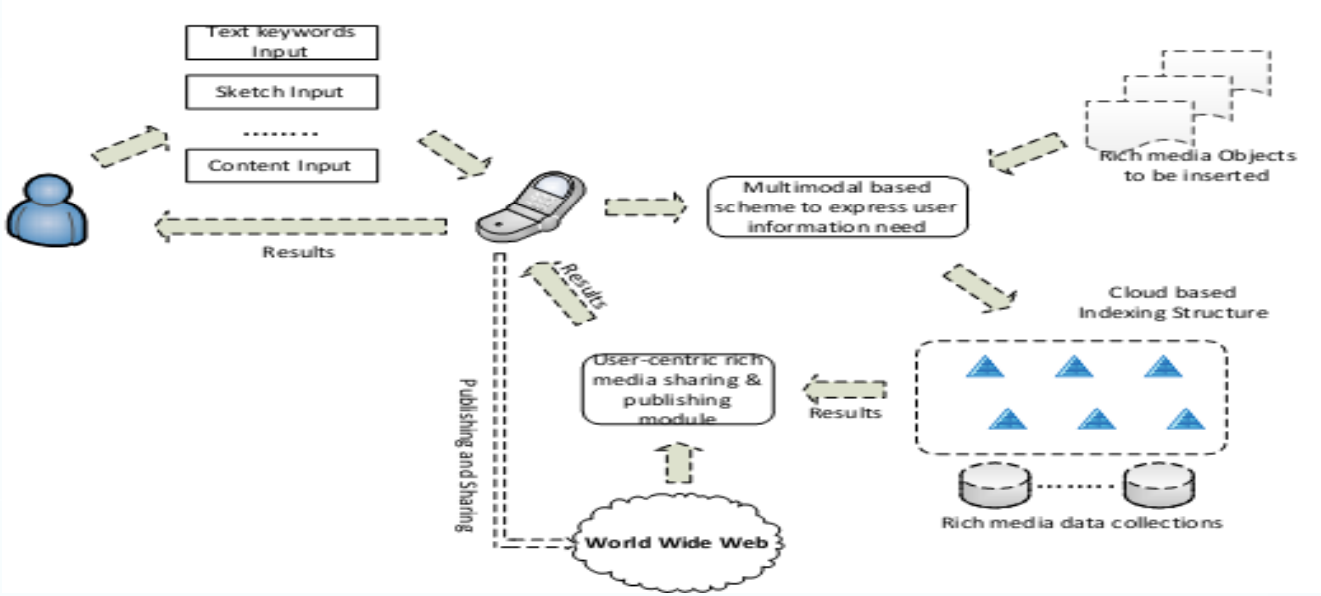


Fig. 7. *Architecture of E-Recall System*

- To build a novel infrastructure in managing, searching, sharing
- There are three main functional blocks as follow: Query formulation, Cloud based indexing structure, and User-centric media sharing and publishing.

FUTURE RESEARCH DIRECTIONS

- Low Bandwidth
  - 4G network: capable of providing up to128 Mbit/s (for "WirelessMAN-Advanced" standard) for mobile users
- Network Access Management
  - An efficient network access management not only improves link performance for mobile users but also optimizes bandwidth usage.
- Quality of Service
- Pricing
- Standard Interface → HTML5

CONCLUSION

- Mobile cloud computing is one of mobile technology trends in the future since it combines the advantages of both mobile computing and cloud computing.
- Provided an overview of mobile cloud computing in which its definitions, architecture, and advantages have been presented.
- The applications supported by mobile cloud computing including mobile commerce, mobile learning, and mobile healthcare have been discussed
- Then, the issues and related approaches for mobile cloud computing (i.e., from communication and computing sides) have been discussed

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[2] White Paper, "Mobile Cloud Computing Solution Brief," AEPONA, November 2010.

[3] http://www.mobilecloudcomputingforum.com/

[4] http://en.wikipedia.org/wiki/Mobile_cloud_computing

THANK YOU !

Q&A?