Mobile Cloud Computing & Code Offloading

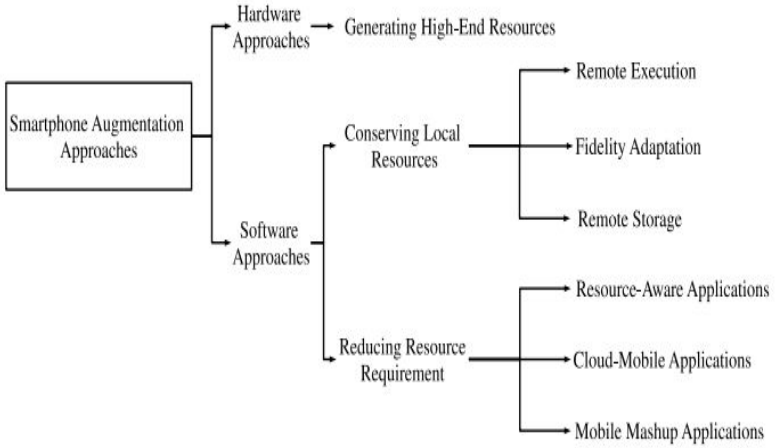
Team 11
Jeffrey Heng
Kurt Tito

What is Mobile Cloud Computing?

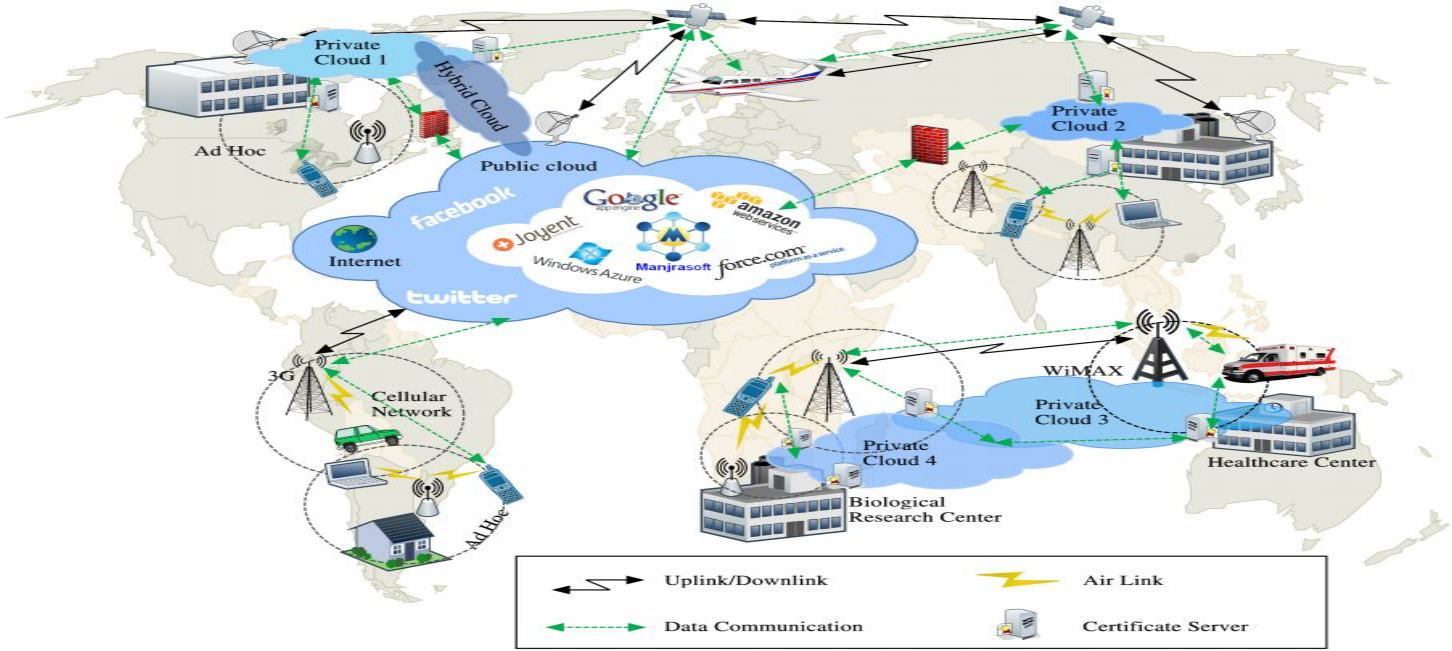
- Mobile Computing
  - The design of small, powerful devices that is expected to be transported allowing for computing on the go
- Cloud Computing
  - Computing technology that uses the Cloud's (data centers) resources for "enabling ubiquitous, convenient, and on-demand services"
- Mobile Cloud Computing
  - Essentially the combination of the above-mentioned definitions
  - MCC is a mobile computing technology that leverages unified resources of varied clouds and network technologies
  - Mobility established on convergent networks is the key attribute that differentiates MCC from cloud computing

Vision of Mobile Cloud Computing

- MCC aims to augment a multitude of mobile devices by alleviating their resource poverty
- Cloud computing can enhance information safety and security



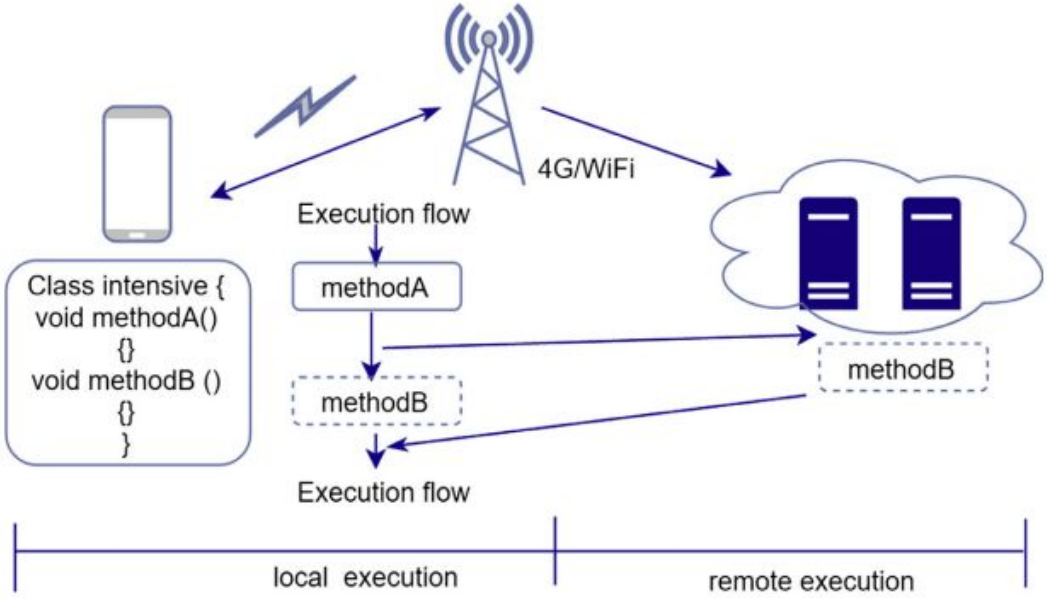
Conceptual View of MCC



What is Computational Offloading?

- One of the main ways, MCC can augment mobile devices
- Computational offloading, or Code Offloading, is the task of sending computation intensive application components to a remote server
- Helps save execution time and energy consumption for mobile devices, assuming the right conditions are met
- Emerged around 1970s, but its potential was not widely explored until wireless communication and internet speed became sufficient enough to support it

Offloading Process Overview



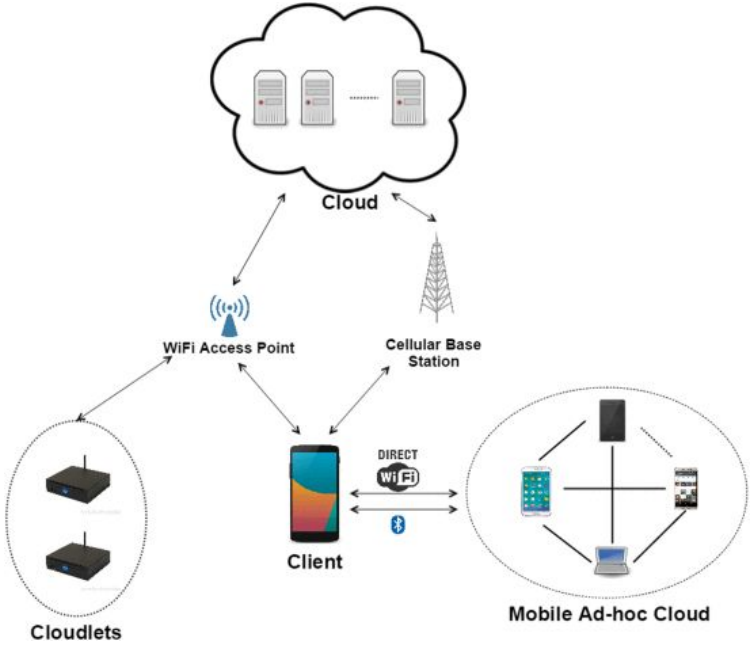
Problems of Offloading in MCC

- Heterogeneity cause interoperability and portability as major challenges in cloud computing
- Context of Mobile Devices continuously changing
  - Network conditions and locations, use of wifi, cellular network, or bluetooth performs differently in terms of speed and energy consumption
- Offloading applications to cloud successfully requires high network bandwidth and low link failure

Solution: mCloud

- A new context-aware offloading framework, for the heterogeneous mobile cloud environment
- Takes advantages of the changing context of a mobile device and cloud resources to provide an adaptive and seamless mobile code offloading services
- Aims to improve the MCC's performance and service availability by considering different offloading destinations(cloudlets, mobile ad-hoc, and cloud resources) and wireless channels (wifi, cellular, bluetooth, wifi-direct)

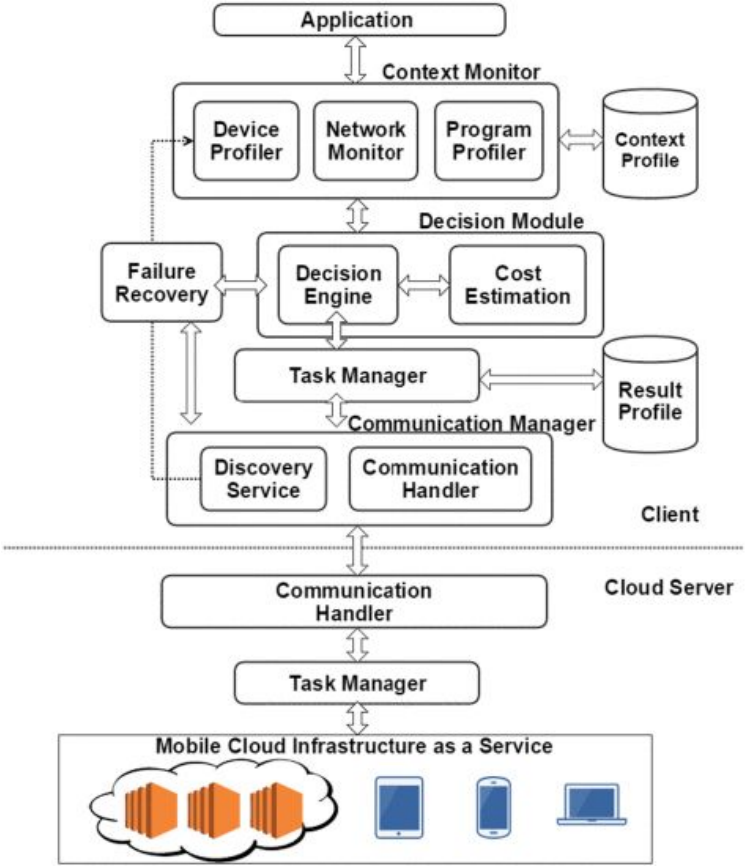
mCloud Environment



- Cloud
  - Provides IaaS (AWS, GCE, Azure, etc) with high computation and storage
  - Used to host tasks requiring high computation and communication
- Cloudlet
  - Local “datacenter in a box” with a high-bandwidth WLAN connection and lower power consumption
  - Suitable for tasks with limited delay-resistances
- Mobile Ad-hoc Cloud
  - Formed by group of mobile devices in the client’s proximity
  - Connects via short-range communication technologies, eg. Bluetooth and Wifi Direct

Framework Components

- Context Monitor
- Decision Module
- Task Manager
- Communication Manager
- Failure Recovery



Context Monitor

- Program Profiler
  - Tracks the execution of a program on the method level
  - Monitors attributes such as: overall instructions executed, execution time, memory allocated, etc.
- Device Profiler
  - Tracks the operating conditions of the mobile device being monitored
  - Profile includes: avg CPU frequency, aver CPU usage, max CPU frequency, and battery level
- Network Monitor
  - Collects network information of mobile device asynchronously at runtime
  - Network conditions monitored: cell connection + Bandwidth, wifi connection +Bandwidth, Bluetooth state, signal strength of cell and WiFi connection

Decision Module

- Cost Estimation
  - Based on context profiles, provides a set of cost estimation model that calculates the execution time of each offloadable task running on the 3 types of mobile cloud infrastructure
- Decision Engine
  - Applies the cost estimations to the context-aware decision making algorithm to provide the offloading decisions

Task Manager

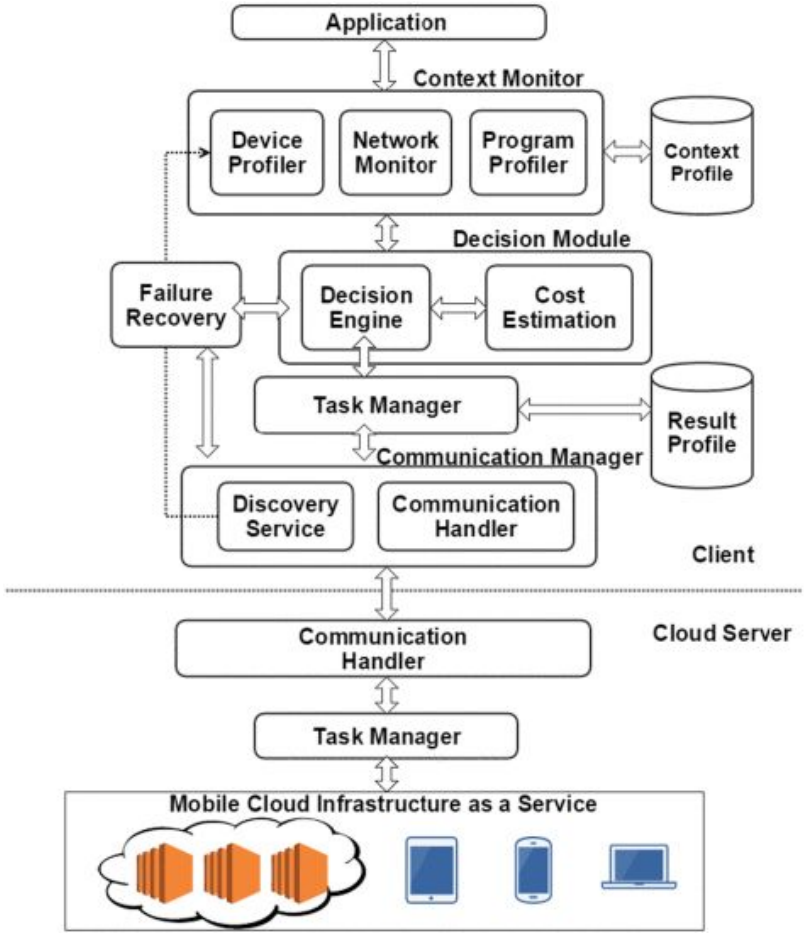
- Middle Layer between Decision Module and Communication Manager
- Receives the decision (method name, offloading location, network interface) from upper layer
- After receiving, it collects related information, eg: libraries for running offloaded task, network address of offloading location, method inputs
- Lastly, it puts the above information into a Task Specs format and passes it to the Communication Manager
    - When receiving task results, the Task Manager stores them locally on the device database

Communication Manager

- Component found in both the client and server side to handle connections between client (mobile device) and the remote execution in mobile ad-hoc or remote cloud VMs
- 2 Inner Components
  - Discovery Service
    - For detecting available mobile devices in the MANET, cloudlets, and cloud VMs.
  - Communication Handler
    - Handles communication between the client and cloud server

Failure Recovery

- Works together with the Decision Module and Communication Manager to detect the failures and recover the system
- Uses the Failure Detection Policy Algorithm to pinpoint the remote node crash which then recovers the system
- Recovery
  - Decision Engine packs all information of failed task and chooses another available cloud resource, if no other suitable nodes, the task is then executed locally on device instead


Application
Context Monitor
Device Profiler
Network Monitor
Program Profiler
Context Profile
Decision Module
Failure Recovery
Decision Engine
Cost Estimation
Task Manager
Result Profile
Communication Manager
Discovery Service
Communication Handler
Client
Cloud Server
Communication Handler
Task Manager
Mobile Cloud Infrastructure as a Service

Decision Making Algorithm

In mCloud, the decision making algorithm considers six criteria related to performance when selecting the wireless interface:

- energy cost of the channel
- the link speed of the channel
- the availability of the interface
- monetary cost (i.e., cost when using mobile data)
- the congestion level of the channel (RTT)
- and the link quality of the channel (signal strength)

Algorithm: Context-Aware Decision Alg.

$para[] \leftarrow context$

$task[] \leftarrow tasks$

$programProfile \leftarrow get\ method\ profile$

$start\ discovery\ service\ and\ gather\ resources\ profiles$

$local_cost \leftarrow estimate\ execution\ cost\ on\ client\ device$

$manet_cost \leftarrow estimate\ execution\ cost\ on\ mobile\ device$

$cloud\ using\ MinMin\ heuristic$

$cloudlet_cost \leftarrow estimate\ execution\ cost\ on\ cloudlet$

$cloud_cost \leftarrow estimate\ execution\ coston\ public\ cloud$

check network interface state

check network interface state

if only cell network is available **then**

check cloud availability

if cloud is available **then**

$decision \leftarrow minCost(local, cloud)$

return $decision$

else

return $decision(local_execution, null)$

else if only WIFI is available **then**

check cloud, cloudlet and manet availability

$decision \leftarrow minCost(local, cloud, manet, cloudlet)$

return $decision$

else if only Bluetooth is available **then**

check manet availability

if manet is available **then**

$decision \leftarrow minCost(local, manet)$

return $decision$

else

return $decision(local_execution, null)$

Future Work

- Having access to a variety of task offloading traces for different cloud instances
- Different user mobility models on system performance
- Cloud failure recovery
- Cloud resource intercommunication

Conclusion

- Mobile Cloud Computing currently faces many challenges due to heterogeneity of the mobile devices and public cloud services
- With mCloud, an offloading framework, we can solve this heterogeneity issue and take advantage of the changing context of smartphones to provide seamless offloading service

References

https://ieeexplore-ieee-org.csulb.idm.oclc.org/document/7362223

https://ieeexplore-ieee-org.csulb.idm.oclc.org/stamp/stamp.jsp?tp=&arnumber=6517049

https://ieeexplore-ieee-org.csulb.idm.oclc.org/document/7474411

https://ieeexplore-ieee-org.csulb.idm.oclc.org/document/8081998

https://dl.acm.org/citation.cfm?doid=1814433.1814441

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6195845