MobiScud: A Fast Moving Personal Cloud in the Mobile Network

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Various Wearable Devices

Google Glass
- Takes photos and video
- Has a live video feed feature
- Gives directions
- Sends audio messages
- Answers questions
- Translates
- Keeps your schedule

Intelligent Cycling Jacket
by Wolfgang Langeder
- Features intelligent waterproofing, a flexible 64 RGB-LED display, and accelerometer and a 3D Gyroscope.
- The jacket can link to your smartphone to track your speed and location.

The Programmable T-shirt by CuteCircuit
- When combined with a smartphone app, this t-shirt lights up with tweets, facebook status' your favourite songs and pictures.
- It has 1,024 LEDs, a built in micro-camera, microphone, accelerometer and speakers.

UP Smart Fitness Wristband by Jawbone
- Tracks activity, sleep, and eating habits.
- Works with the MyFitnessPal app to track calories.
- Can be plugged into a smartphone to visualise data captured each day with the UP app.
With Wearable Device

• The Google glass keeps doing facial recognition or analysis.

• The smart wristband detects and records my heartbeats and blood pressure, giving me advices.

• More on the way...
Application Requirements

• Characteristics of these applications
  – Highly responsive: should get results in real-time (AR, face recognition)
  – Intensive computation: hard to run only on mobile
  – Need storage to keep and analyze user-related information

However, the first priority of wearable devices is not computation and storage, but better portability

Need computation offloading to cloud server everywhere and anytime
With Cloud & Mobile Network

• Cloud server
  – Provide computing resource & storage for wearable & mobile devices

• Stable connectivity
  – LTE is everywhere and always-on (Macro, small cells)
  – LTE is more stable than WiFi since it runs on license spectrum

However, cloud server far from users and centralized GWs (hierarchical routing) in Core network result in unpredictable and long delay

Offset benefit from computation offloading due to network delay

Cloudlet* approach on mobile network

2/6/16

Cloudlet* - The case for vm-based cloudlets in mobile computing, Satyanarayanan et al.
In Cloudlet, they designed Cloudlet based on WiFi network.

*We tried to use this Cloudlet approach in mobile network.*

Source: The case for vm-based cloudlets in mobile computing, Satyanarayanan, et al.
Challenges of Cloudlet on Mobile Network for Low Latency

• Deployment
  – Put cloudlets with or close to eNodeB
  – Modification of existing mobile network is difficult
    • Rigid architecture and complex protocol in mobile network

• Mobility
  – As an user moves, initial cloudlet for the user can be gradually far from the user (e.g., Handover)
  – Considering target applications are highly latency-sensitive, increasing small latency drops user’s QoS a lot
Design Requirements

• Highly distributed cloudlet platform

• Deploy cloudlet approach without modification of current protocol or mobile network

• Guarantee constantly short latency regardless of mobility
Proposed Architecture: MobiScud

• Highiy distributed cloudlet platform
  – Cloudlet with or close to Radio Access Network (RAN)

• Apply cloudlet approach without modification of current protocol or mobile network
  – Software-Define Networking (SDN)

• Guarantee constantly short latency regardless of mobility
  – Personal cloudlet keeps following the owner
  – Combine handover procedure & cloudlet migrations
MobiScud Architecture

LTE/EPC Architecture

MobiScud components

Internet

Cloud

SDN

MobiScud

SGW

PGW

MME

eNB

Cloud

MobiScud components
• **MobiScud Monitor**
  – Monitor the control plane messages (e.g., attachment and handover event)
  – Extract necessary information from them for future flow rules
• MobiScud Controller - Orchestrate SDN substrate and Cloud platform
  – Construct flow rules with extracted information from Monitor
  – Manage cloud platform to create and migrate the personal VMs
  – Exchange control message between MobiScud controllers to support handover
SMORE*: software-defined networking mobile offloading architecture, J Cho et al.
MobiScud Workflow for Handover

After user attachment

Traffic for Cloud

Traffic for Internet

MobiScud1

Cloud1

eNB1

SDN1

SGW

PGW

MME

Internet

1

Traffic for Cloud

Traffic for Internet
MobiScud Workflow for Handover

User start moving, Handover procedure starts

Cloud2

MobiScud2

Internet

Cloud1

MobiScud1

SDN1

eNB1

SDN2

eNB2

SGW

PGW

MME
MobiScud Workflow for Handover

Cloud2

MobiScud2

SDN2

eNB2

Cloud1

MobiScud1

SDN1

eNB1

Internet

SGW

PGW

MME
MobiScud Workflow for Handover

Cloud1

Cloud2

SDN1

SDN2

eNB1

eNB2

MobiScud1

MobiScud2

SGW

PGW

MME

Internet

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MobiScud Workflow for Handover

Request VM migration

Cloud2

SDN2

MobiScud2

SGW

PGW

MME

Internet

Cloud1

SDN1

MobiScud1

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eNB2

eNB1

Cloud1

Cloud2

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MobiScud Workflow for Handover

Cloud2
 SDN2
  eNB2
  SDN1
  eNB1
 Cloud1
 MobiScud1
 MobiScud2
 Start VM migration

SDN2
 SGW
 PGW
 MME
 Internet

2/6/16
MobiScud Workflow for Handover

Handover completes

Cloud2
SDN2
MobiScud2
SGW
PGW

Cloud1
SDN1
MobiScud1
SGW
PGW
MME

Internet

eNB1
SDN1

eNB2
SDN2

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MobiScud Workflow for Handover

Still use VM in cloud 1

LDN2

Cloud2

MobiScud2

Internet

SDN2

eNB2

Cloud1

MobiScud1

SGW

PGW

MME

SDN1

eNB1

Cloud1

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MobiScud Workflow for Handover

Still use VM in cloud 1
MobiScud Workflow for Handover

After finishing VM migration Modify flow rules

Cloud2

MobiScud2

7

Internet

eNB2

SDN2

MME

SGW

PGW

SDN1

MobiScud1

Cloud1

eNB1

Cloud2

MobiScud1

Cloud1

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MobiScud Workflow for Handover

Use VM in Cloud2
MobiScud Workflow for Handover
Implementation

• PhantomNet testbed
  – OpenEPC LTE/EPC software

• MobiScud SDN & Controller
  – SMORE SDN & Ryu controller

• Personal cloudlet
  – Xen
• End-to-End RTT improvement according to the level of cloud distribution
  – Cloud in Internet
  – Cloud in intermediate location between eNB and Core network (MTSO)
  – MobiScud without VM Migration
  – MobiScud with VM Migration

• We use ping for evaluation
Evaluation

- End-to-End RTT improvement according to the level of cloud distribution
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**Evaluation**

- **End-to-End RTT improvement according to the level of cloud distribution**
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  - MobiScud without VM Migration
  - **MobiScud with VM Migration**

- We use ping for evaluation
RTT of Different Cases

Constant ~80 ms latency

Constant ~20 ms latency
RTT of Different Cases

- Google(8.8.8.8)
- SMORE(MTSO)
- Mobiscud without VM Migration
- Mobiscud with VM Migration

First Handover
Second Handover
RTT of Different Cases

- Google(8.8.8.8)
- SMORE(MTSO)
- Mobiscud without VM Migration
- Mobiscud with VM Migration

First Handover

Second Handover
Conclusion

• We presented MobiScud architecture to realize cloudlet in mobile network for low latency applications
  – No modification of existing LTE/EPC mobile network.
  – Keep following personal cloudlet even handover

• Prototype realization of MobiScud architecture in PhantomNet LTE/EPC testbed.
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