

# Remote Software Service for Mobile Clients leveraging Cloud Computing

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# Background

## ■ Beihang University

- ◆ Founded in 1952
- ◆ Located in Haidian District, Beijing, China
- ◆ Research oriented University
- ◆ Strengthens: Aeronautics, Astronautics, and Information Technologies

## ■ Institute of Advanced Computing Technologies (ACT)

- ◆ Focusing the internet software platform and developing method
- ◆ NC Group: Grid, Virtualization, Client-Cloud Computing, Security/FT
- ◆ SDP Group: Service-oriented application production
- ◆ WS Group: Web-service based middleware and applications
- ◆ Data Management Group: Large-scale data mngt, graph modal and graph data processing

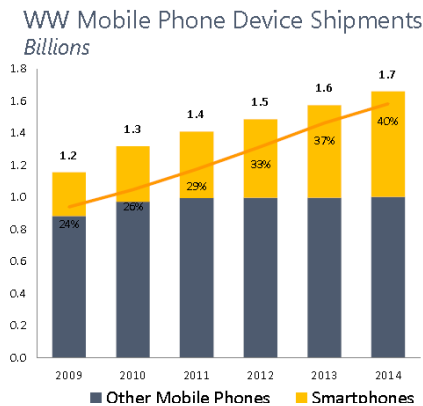
# Background

## Smart Phones and other Mobile clients

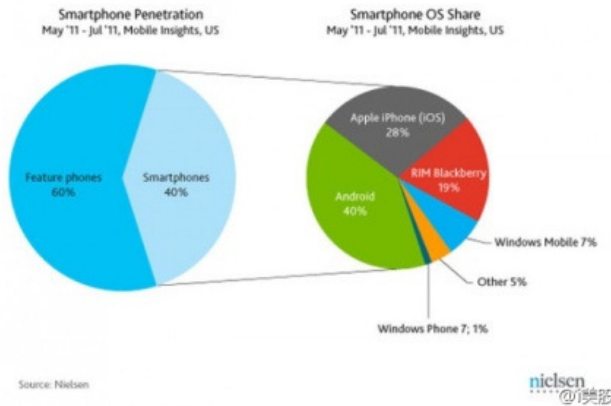
- ◆ More smartphones shipped than PCs in FY 11 Q2 ( from Victor Bahl, MSR Faculty Summit 2011)
- ◆ Smartphone make up more than 40% of US phone market. (40% A, 28% I, 19% B, 7% M)

IDC FY12 forecast 518 million SmartPhones sold world-wide

- More smartphones shipped than PCs in FY11 Q2 (101M vs. 92M)



Smartphones now make up 40% of all mobile phones in the US



- ◆ Limited capability of mobile phone (compute, storage, and battery)

# Background

- Information at your finger tip anywhere anytime
  - ◆ Driving vision of Mobile Computing in past 2 decades

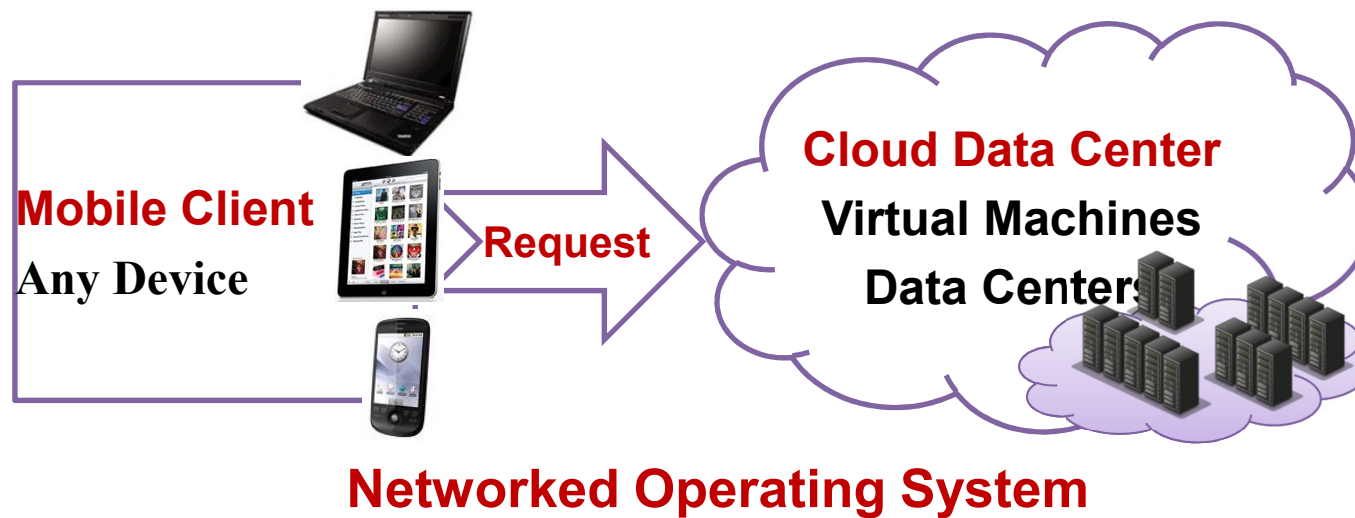


- Performance disadvantage of mobile devices
  - ◆ Computation, Storage, Battery -> less powerful Software Service



# Basic Idea

- Leveraging Cloud Capabilities to enhance the Mobile Clients



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- Leveraging Cloud Capabilities to enhance the Mobile Clients
- Some examples
  - ◆ Apple iCloud: Storages and data sync crossing devices



iCloud stores your music, photos, documents, and more and wirelessly pushes them to all your devices. Automatic, effortless, and seamless — it just works.

# Basic Idea

- Leveraging Cloud Capabilities to enhance the Mobile Clients
- Some examples
  - ◆ Apple iCloud: Storages and data sync crossing devices
  - ◆ Cloud Mobile Phones:
    - Aliyun/K-Touch W700 Phone and OS
    - Huawei's cloud phone and Cloud+ platform in 2011 (in China)

【天语官方旗舰店】K-Touch/天语 W700 云智能 8G存储 多种颜色



价 格: **¥2680.00**

运 费: 卖家承担运费

月 销 量: 16 件

评 价: ★★★★★ 4.4分 (已有2)

送 积 分: 单件送 1340 商城积分

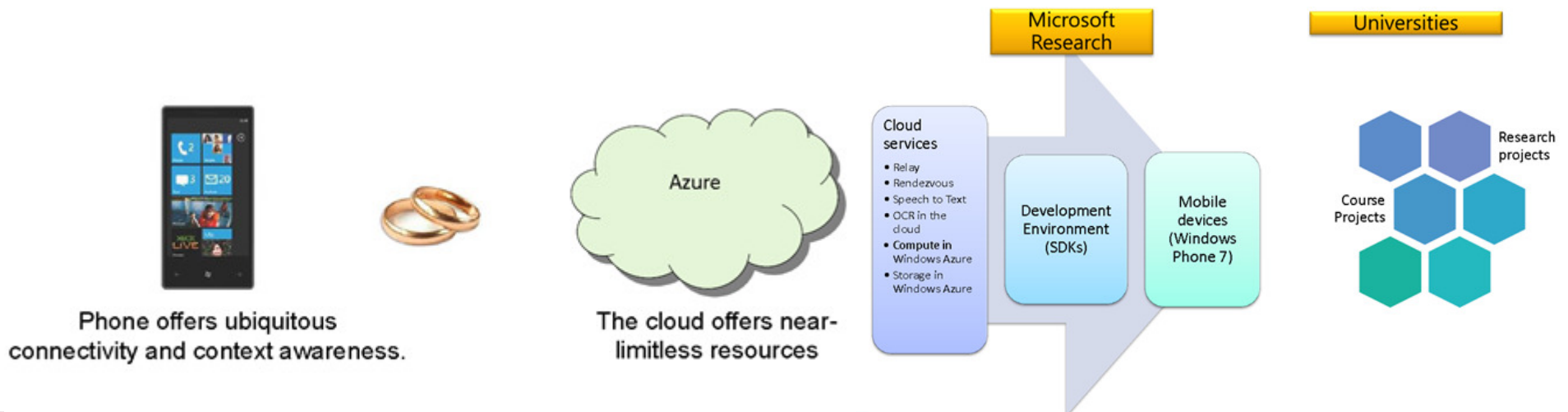
特色服务:

付款方式: 支持信用卡付款



# Basic Idea

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  - ◆ Apple iCloud: Storages and data sync crossing devices
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  - ◆ Microsoft WP and MSR Hawaii Project





# Basic Idea: Applications

- Two types of software services for mobile devices

- ◆ Download & Install

- ◆ Web Application



- Software remote execution leveraging Cloud Computing

- ◆ Separate software presentation and execution

Modern vs. Traditional



+



## > VM-based Software Remote Execution

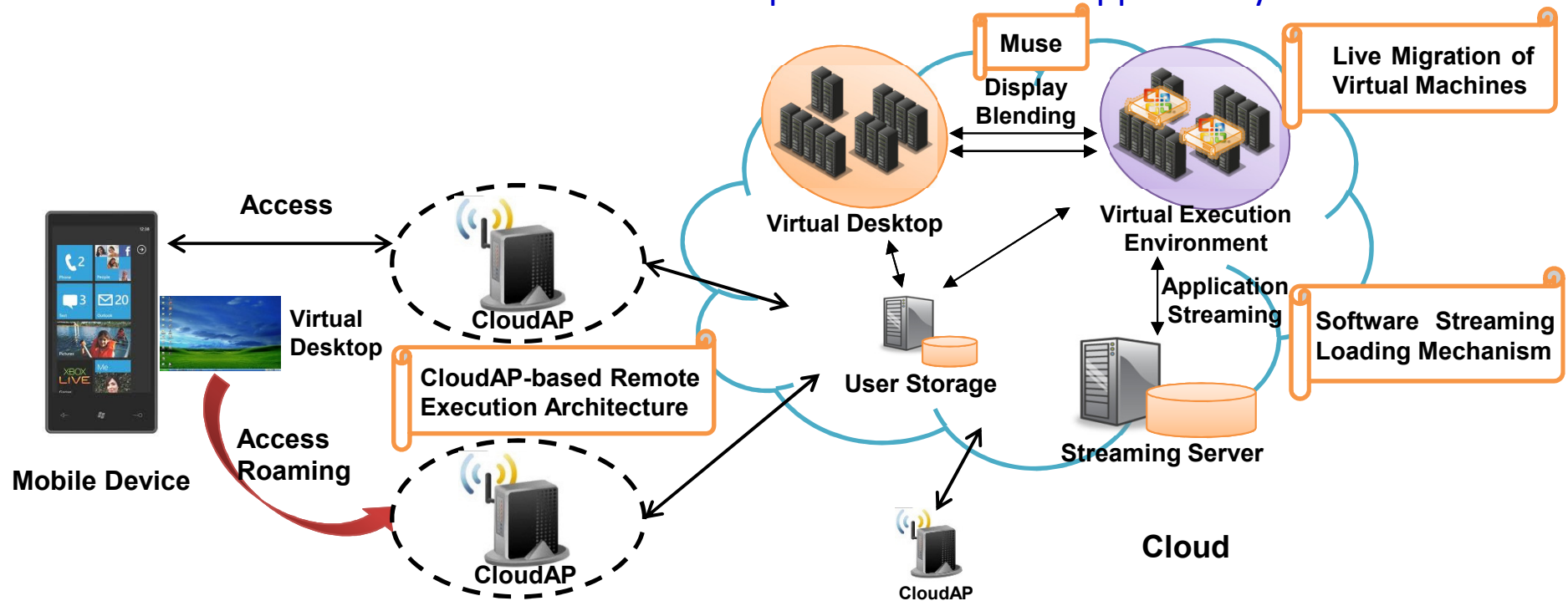
- Provide a virtual software execution method for browser and mobile client
- Create the software execution environment on demand
- Create an software marketplace for remote execution software

	Presentation & Interaction	Execution	Executable/App Storage
<b>Native App</b>	Client	Client	Install first
<b>Web App</b>	Mobile Client Unified Client (Browser - based)	Server	Server
<b>VM-based Local Execution</b>	Client	Client	Install first VA (VM-Instance)
<b>VM-based Remote Exec.</b>	Client Unified Client (Frame-based)	Server	Server



# Our Research

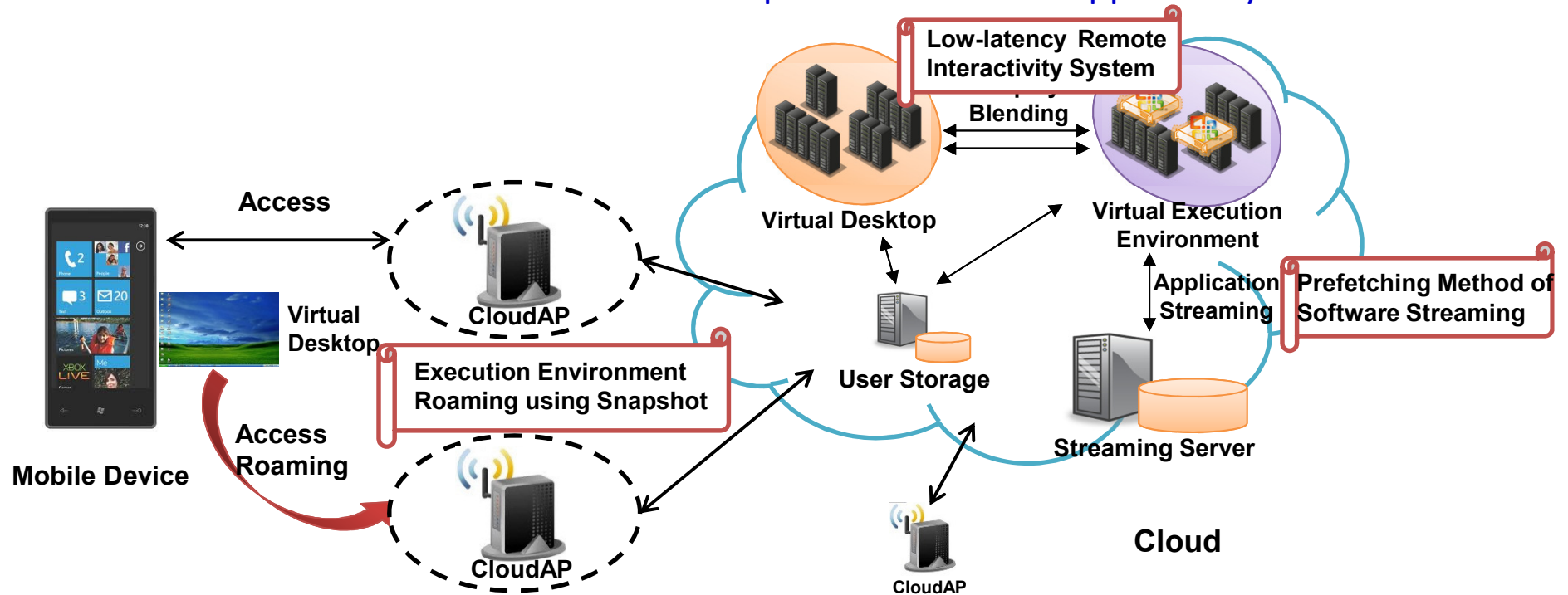
- Remote Software Service for Mobile Clients leveraging Cloud Computing
  - ◆ Cloud + Client model to enhance device capabilities
  - ◆ Legacy software on PC extended to mobile device
  - ◆ Software distribution solution with potential business opportunity





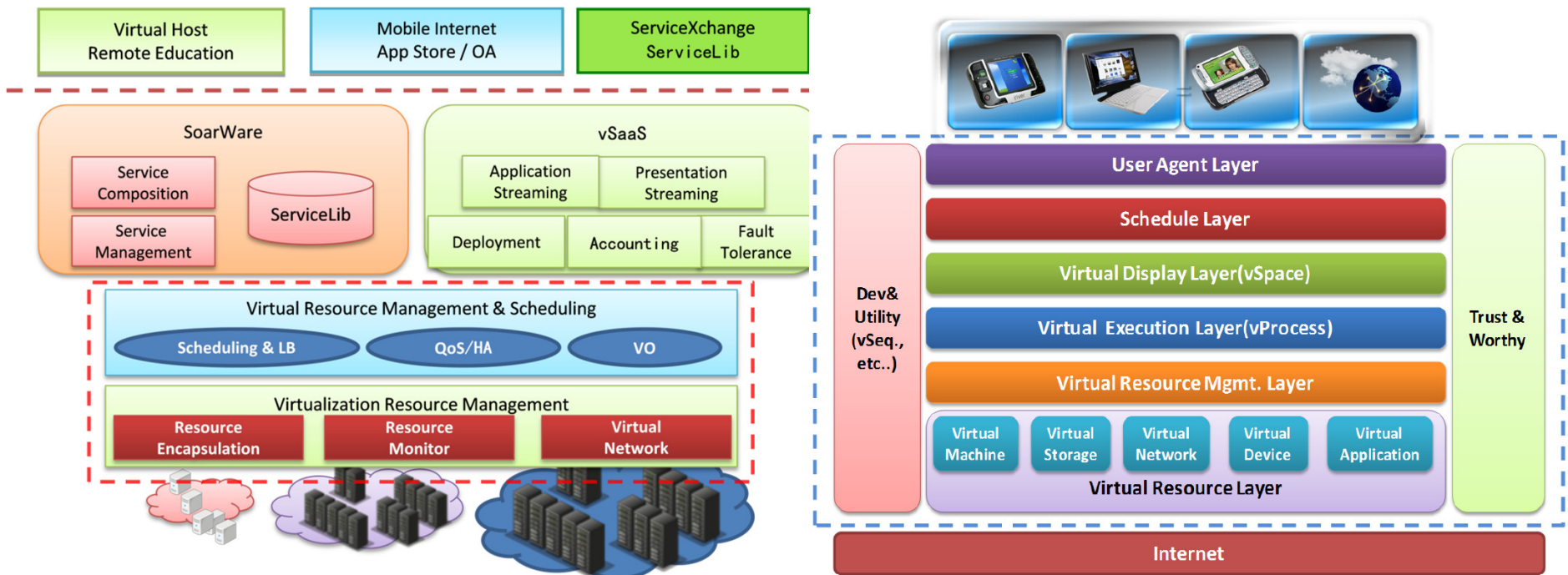
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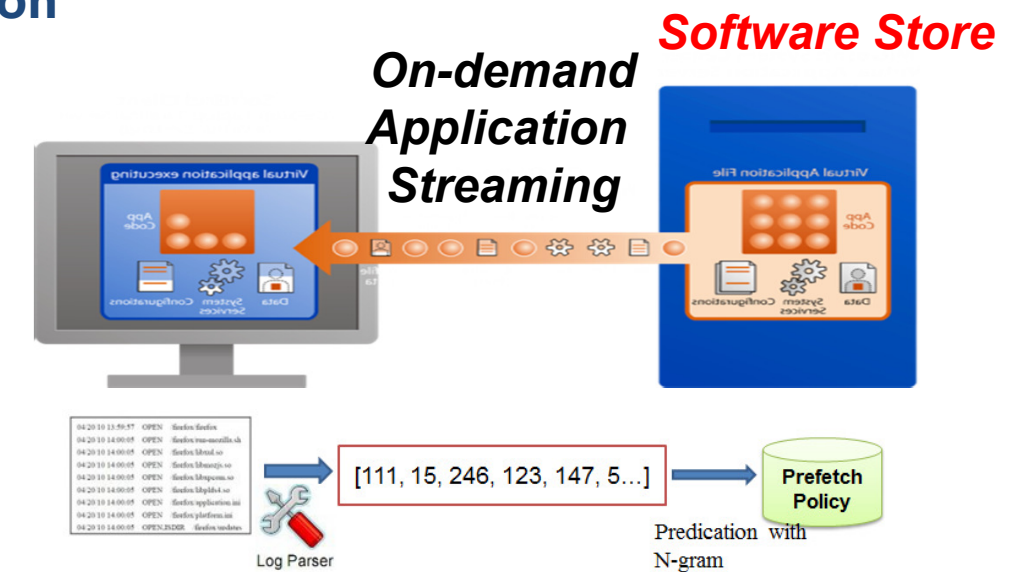
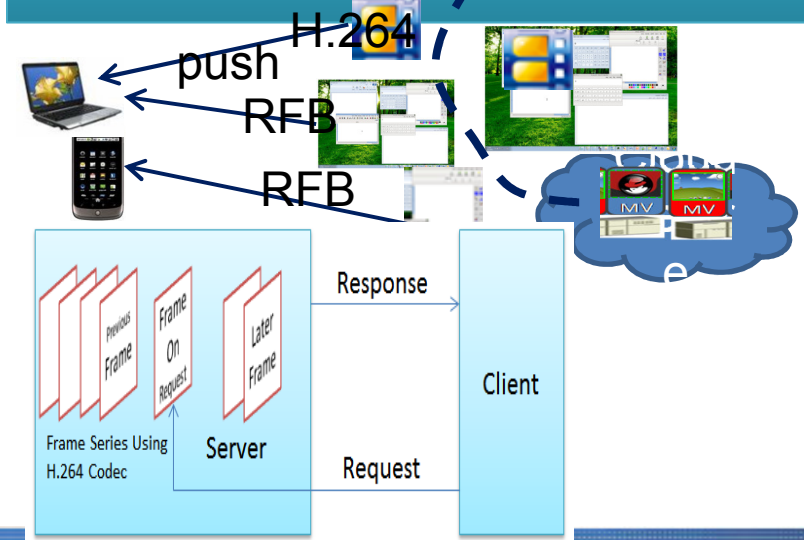
# System Architecture

- iVIC: Internet based Virtual Computing Infrastructure
  - ◆ Unified operating platform
  - ◆ Aggregation of heterogeneous and autonomous resources
  - ◆ Two sub-systems: vHaaS + vSaaS



## Key Issues for Remote Execution

- On-demand Software Execution Environment  
VM-based, Application Streaming and Prefetching
- Clouddlet-based distributed execution
- Cloud-Client Protocols  
H.264/AVC based Multi-channel



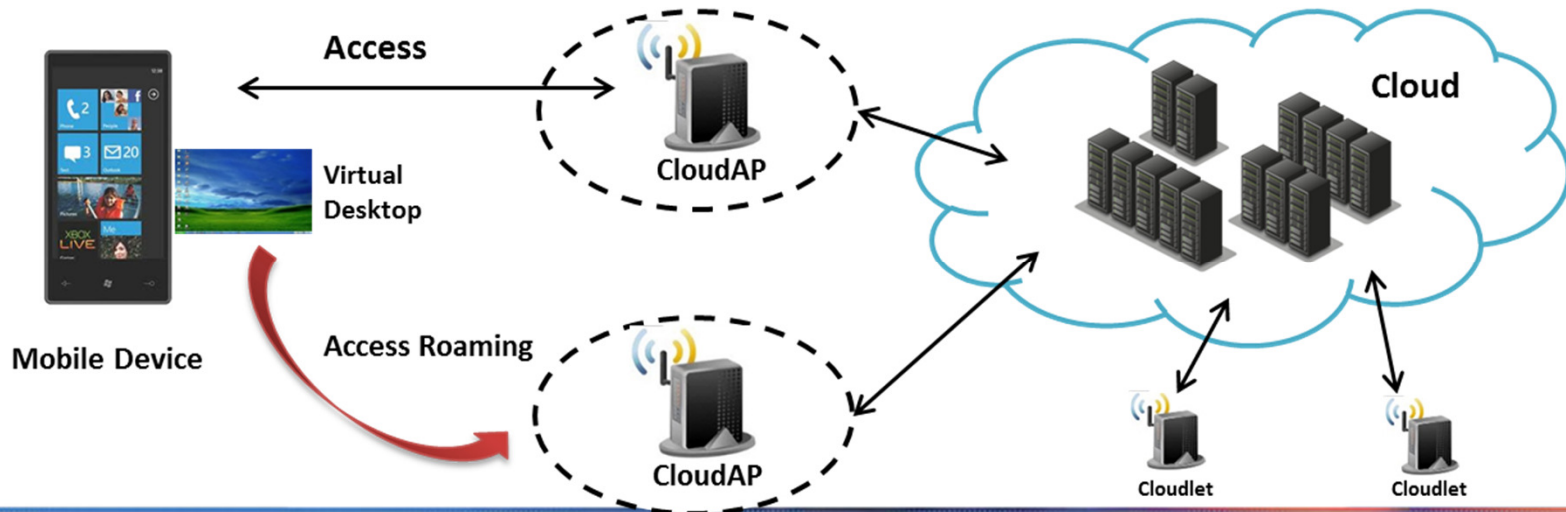
## Enhanced User Experience Application Framework for Remote app





# Key Issues - CloudAP

- CloudAP-based Remote Execution Architecture
  - ◆ CloudAP as Access Point vs. independent remote cloud solution
  - ◆ Architecture of CloudAP based System
    - CloudAP as small-scale cloud station with better network connection
    - Application delivery network based on user location
  - ◆ CloudAP switch based on location and network condition
    - Environment migration and resource planning



# Key Issues - Prefetching

## ■ Prefetching Framework for the Streaming Loading of Virtual Software

### ◆ Problem of software streaming execution in SaaS

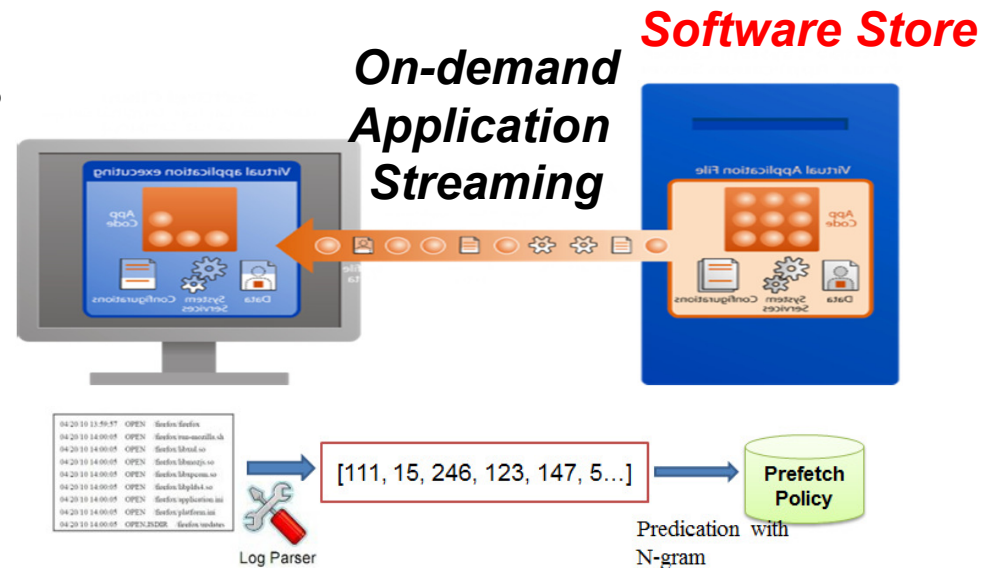
- ▶ missing data block downloading delay

### ◆ Strategy

- ▶ Block-level prefetching framework based on N-Gram prediction model
- ▶ Incremental data mining algorithm: updates and polishes the prefetching rules

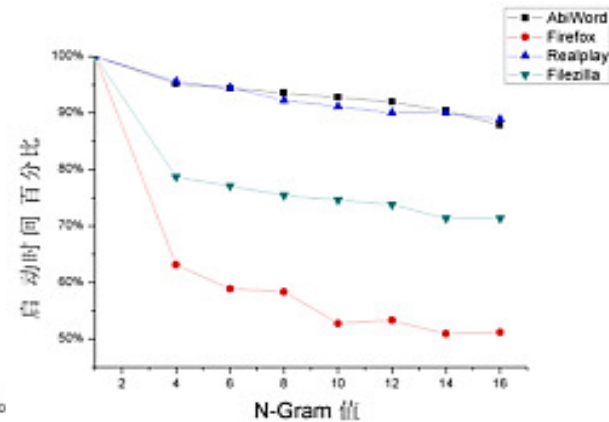
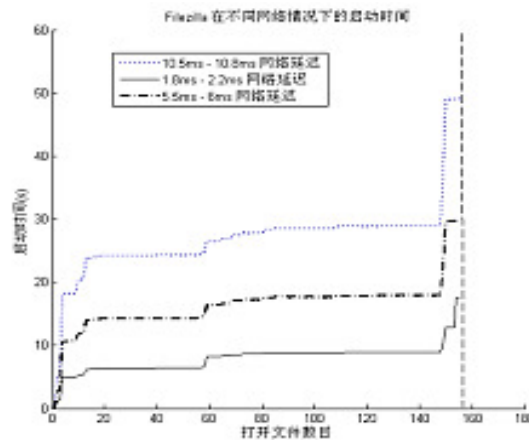
### ◆ Performance Gain

- ▶ launch time reduced by 10% to 50%
- ▶ hit rate between 81% and 97%



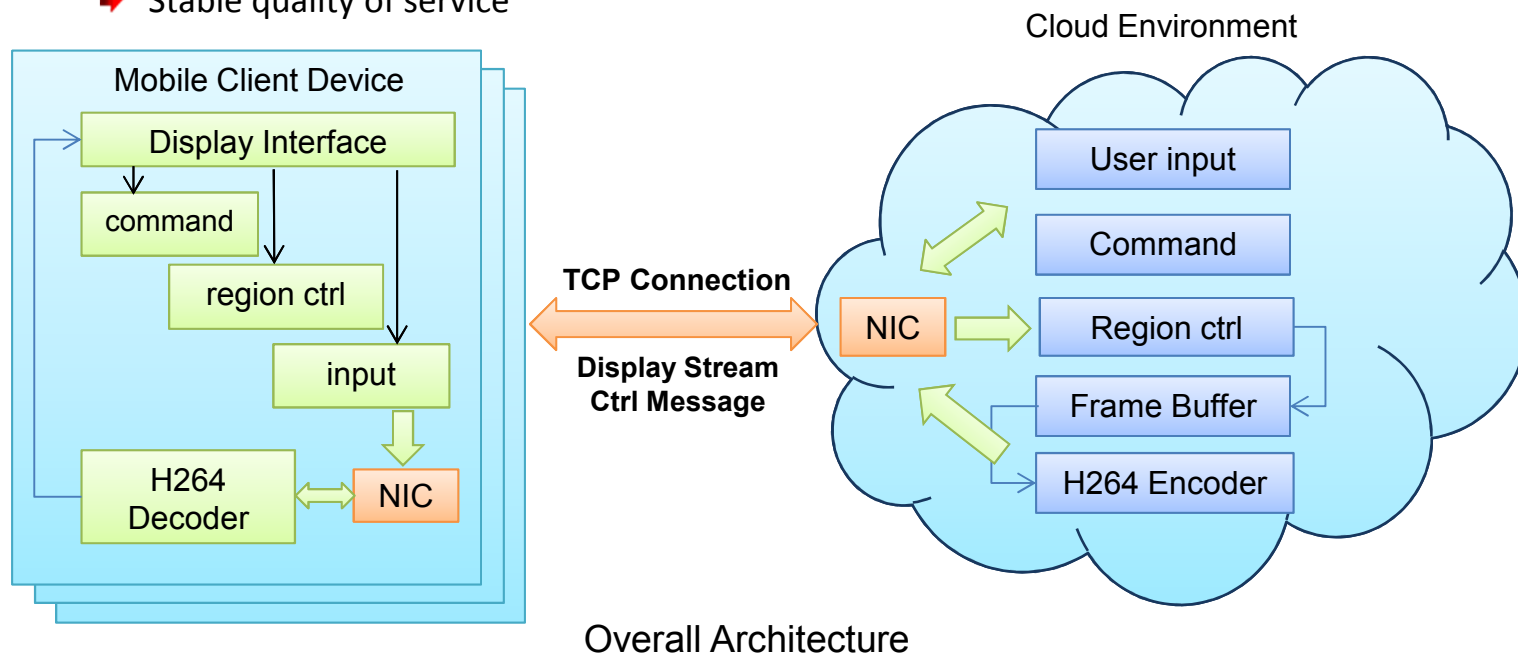
# Application Streaming

- Block based software streaming loading and prefetching mechanism
  - ◆ Prefetching strategies, pre-take algorithms developed by analyzing historical data of access to software blocks to dynamically adapt to user behavior
  - ◆ Achieve real-time on-demand deployment and minimum number of required software initialization blocks



# Key Issues - MUSE

- Muse - Multimedia Streaming Enabled remote interactivity system
  - ◆ Windowed display: Optimize data traffic cost and interactivity latency
  - ◆ H.264 based codec: Better video performance and lower bandwidth
  - ◆ Interactive performance : 1Mb/s Angry Birds @ 1024\*768
    - ◆ In common desktop scenarios & Game scenarios
    - ◆ Stable quality of service



# Evaluation

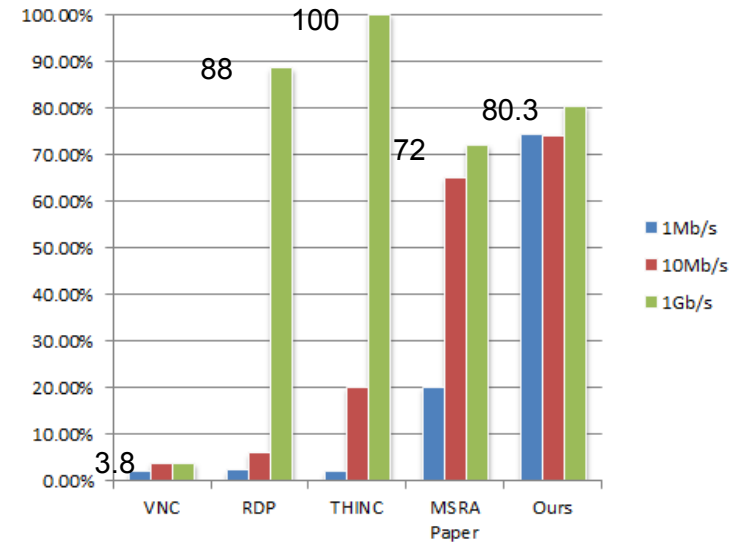
## ■ Video Playback Performance

### ◆ Video Quality Benchmark

$$V.Q. = \frac{DataTransferred(24fps)}{DataTransferred(1fps)} = \frac{\frac{DataTransferred(24fps)}{Total\ Frame\ Numbers}}{\frac{DataTransferred(1fps)}{Total\ Frame\ Numbers}} \quad \text{reference formula}$$

$$V.Q. = \begin{cases} \text{reference formula} & RDP, VNC \text{ etc.} \\ \frac{frameNums(24fps)}{Total\ Frame\ Num} & Ours \end{cases}$$

- ◆ Bandwidth: 1Mb/s, 10Mb/s, 1Gb/s
- ◆ Latency: 1ms
- ◆ Video Quality Result



# Evaluation

## Encoder Efficiency

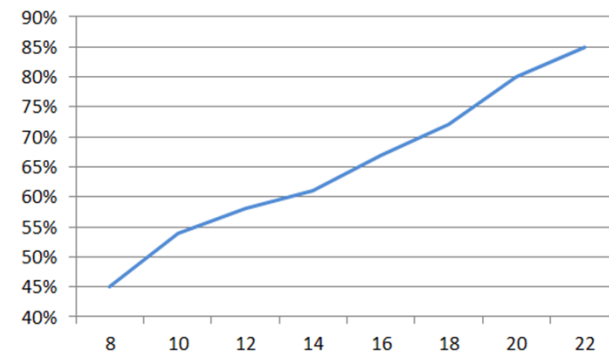
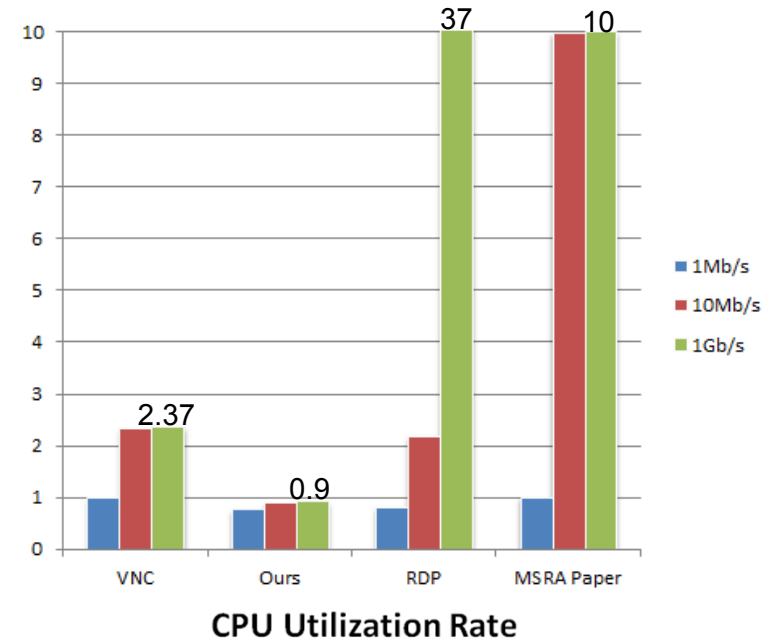
### Network Traffic Load Comparison

Bandwidth: 1Mb/s, 10Mb/s, 1Gb/s

Latency: 1ms.

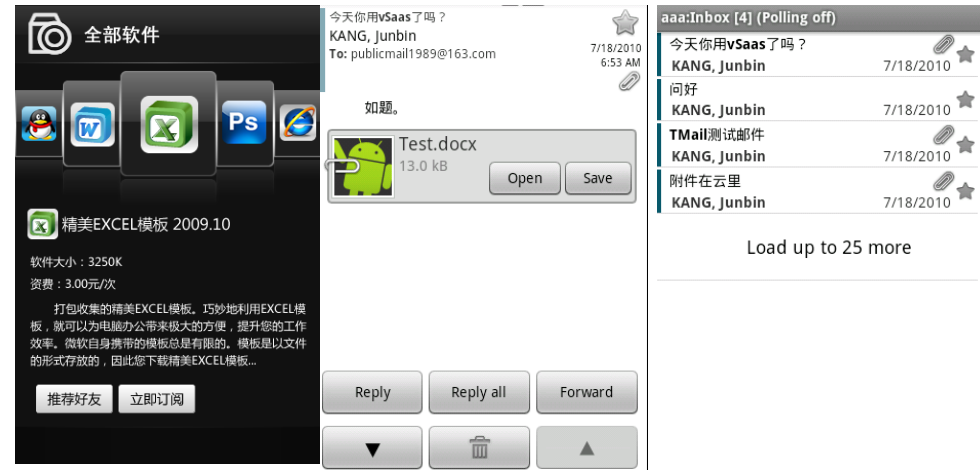
### CPU Utilization

	Server	Client	FPS
VNC	12%	Near 100%	0.95
Muse	80%	60%	20
RDP	10%	1%	22
THINC	10%	10%	25



# Demo

- Transparent Mail on Mobile Client



- Integrate with China Mobile Pad T71

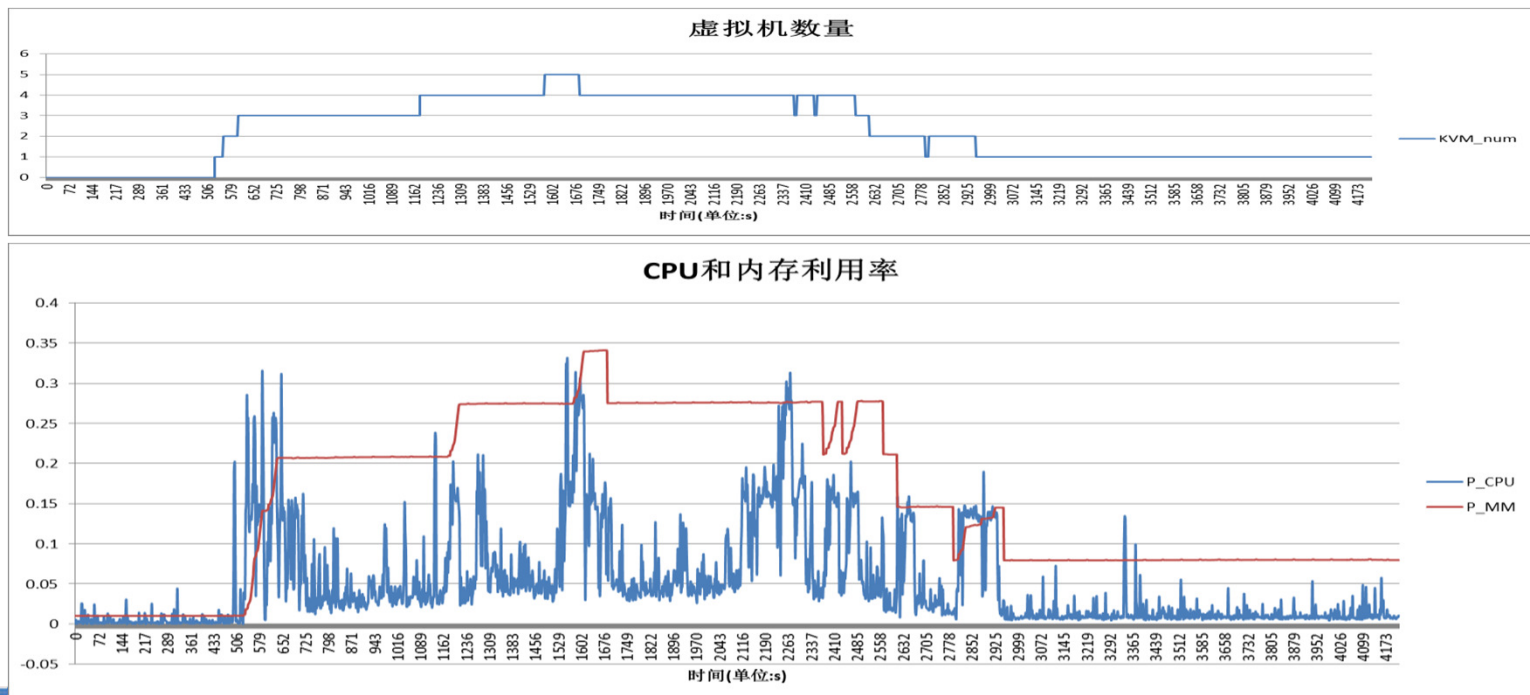


MobileCloud Pad

# TMail Performance

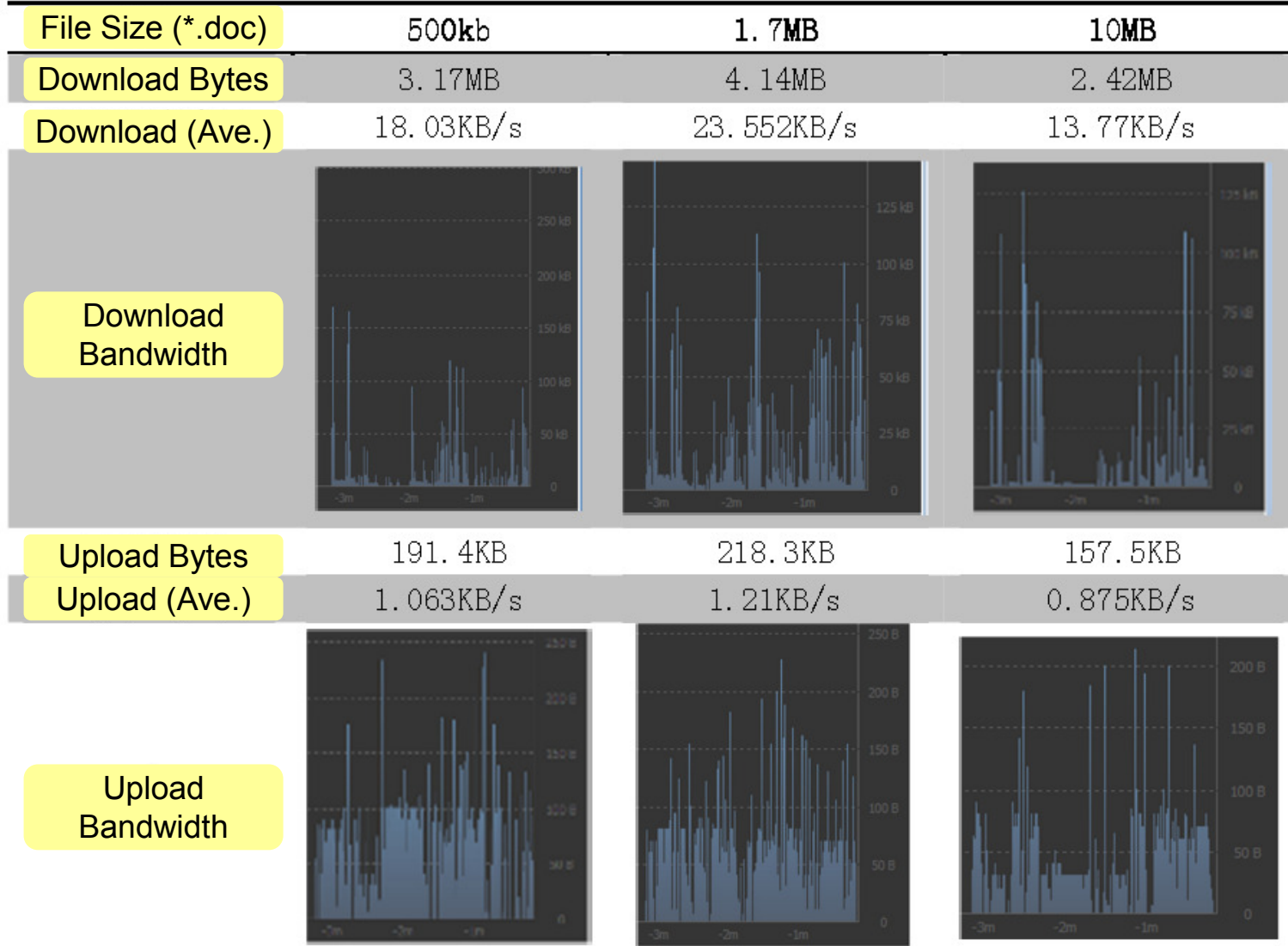
## Server Configuration

- ◆ Intel Core2 CPU, 8G RAM, 150G SCSCI HD (\$1,500)
- ◆ Supported VM Numbers: 5-10
- ◆ CPU & Mem utilization





# TMail Performance - Bandwidth



# TMail Performance – Response Time

## Microsoft Word (\*.doc)

File Size	500KB	1.7MB	10MB
Screen Scroll	0.5s	0.3s	0.3s
Text Input	<0.1s	<0.1s	<0.1s
Text Selection	<0.1s	<0.1s	<0.1s
Modify Font	<0.1s	<0.1s	<0.1s
Modify Color	<0.1s	<0.1s	<0.1s
Insert Table	<0.1s	<0.1s	<0.1s
Drag Text	0.3s	0.1s	0.3s
Text Center	<0.1s	<0.1s	<0.1s

## Microsoft Powerpoint (\*.ppt)

File Size	350KB	2MB	9.8MB
Screen Scroll	0.5s	0.3s	0.3s
Start Present.	0.5s	0.5s	0.5s
Page Change	0.5s	0.5s	0.3s
Stop Present.	0.8s	1s	0.5s
New slide	1s	0.8s	1s
Slide Selection	0.3s	0.5s	0.6s
Delete slide	0.8s	0.5s	0.5s
Text input	<0.1s	<0.1s	<0.1s
Text Selection	<0.1s	<0.1s	<0.1s

## PDF File (\*.pdf)

File Size	623KB	2MB	11MB
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Zoom in	0.6s	0.8s	0.8s
Next Page	0.6s	0.5s	0.5s
Zoom out	0.3s	0.8s	0.8s
Text Selection	<0.1s	<0.1s	<0.1s

## Attachment Open (First Frame Displayed)

File Type	Doc	PPT	PDF
Size	1.7M	2MB	2M
First Frame Display	<b>4.99s</b>	7.66s	4.38s

## Remote Execution in Browser (<http://ivic.aliyun.net>)

### In corporate with aliyun.com



The screenshot shows the iVIC website interface. At the top, there is a navigation bar with links for '首页', '手机云空间', '创业者云计算', '开发者云计算', 'OS', '论坛', and '更多'. The user is logged in as 'codyhu@aliyun.com'. The main header features the iVIC logo and the text '凌聚软件 beta'. Below this is a secondary navigation bar with 'iVIC首页', '所有软件', '管理中心', and '论坛', along with a '关注我们' button. The main content area has a large banner with the text '无需安装 直接运行' and '怀凌云之志，聚八方软件'. Below the banner, there are sections for '所有软件' and '管理中心'. The '所有软件' section lists several applications: xjump (a jumping game), scite (a text editor), gpaint (a drawing tool), gimp (an image editor), evince (a document viewer), and gnumeric (a spreadsheet). Each application has a description, an icon, and buttons for '收藏' and '运行'. The '管理中心' section has a '进入管理中心' button and a '客户端下载' button. A '新手入门' section provides instructions on how to use the service, starting with '客户端下载安装'.

# Future Work

- Cloudlet architecture and platform
- Software execution environment migration and distributed snapshot technique
  - ◆ Problem of live VM and virtual network migration in WAN environment
  - ◆ Snapshot technology enables software recovery from the recent checkpoint rapidly after the failure
  - ◆ Algorithm to ensure application state and messages consistency during migration and sharing
  - ◆ Collaboration among VMs: VM Cloning and redirection of presentation stream
- Light-weight VM in Server side
- Moving to Microsoft Platform (Azure + WP)



# Thanks!

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