Remote Software Service for Mobile Clients leveraging Cloud Computing

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08 May 2012, MSR CloudFuture 2012, UC Berkeley
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)

■ 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

Mobile Client
Any Device

Request

Cloud Data Center
Virtual Machines
Data Centers

Networked Operating System
Basic Idea

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

2011.10 苹果发布iCloud

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)
Basic Idea

- Leveraging Cloud Capabilities to enhance the Mobile Clients
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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

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<tr>
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<td>VM-based Local Execution</td>
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<td>Unified Client (Frame-based)</td>
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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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![Diagram of CloudAP-based Remote Execution Architecture]

- Access to Virtual Desktop
- CloudAP-based Remote Execution Architecture
- CloudAP
- Cloud
- Mobile Device
- Access Roaming
- Virtual Desktop
- User Storage
- Streaming Server
- Application Streaming
- Virtual Machine Migration
- Software Streaming Loading Mechanism
- Live Migration of Virtual Machines
- Virtual Execution Environment
- Display Blending
- Muse

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Our Research

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Diagram:
- CloudAP-based Remote Execution Architecture
- Access Roaming
- Virtual Desktop
- CloudAP
- User Storage
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- Live Migration of Virtual Machines
- Software Streaming Loading Mechanism
- Cloud
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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 Prefecting

- Cloudlet-based distributed execution

- Cloud-Client Protocols
  H.264/AVC based Multi-channel

On-demand Application Streaming

Software Store

Cloudlet-based distributed execution

Enhanced User Experience
  Application Framework for Remote app

On-demand Software Store

Android 客户端

服务端

Client

Response

Request

Frame Series Using H.264 Codec

Server

H.264

push

RFB

RFB

push H.264

Log Parser

[111, 15, 246, 123, 147, 5...]

Prefetch Policy

Predication with N-gram

Android 客户端

VNC Client

服务端

VNC Server

IE内核浏览器
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

Cloud Environment

Overall Architecture
Evaluation

- **Video Playback Performance**
  - **Video Quality Benchmark**
    \[
    V.Q. = \frac{\text{DataTransfered}(24\text{fps})}{\text{DataTransfered}(1\text{fps})} = \frac{\text{DataTransfered}(24\text{fps})}{\text{Total Frame Numbers}} = \frac{\text{DataTransfered}(1\text{fps})}{\text{Total Frame Numbers}}
    \]
  - Reference formula

- **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**

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<td>10%</td>
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<td>THINC</td>
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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

![Graphs showing CPU and Mem utilization over time]
# TMail Performance - Bandwidth

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# TMail Performance – Response Time

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## Attachment Open（First Frame Displayed）

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

In corporate with aliyun.com
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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Acknowledges:
Thanks goes to Jianxin Li, and Weiren Yu. Thanks the vSaaS team in Beihang University (Tianyu Wo, Junbin Kang, Liang Zhong, ...). Part of the work are supported by NSFC (61170294), MOST of China (under grant 2011AA01A202).
References


