Personal Clouds: Sharing and Integrating Networked Resources to Enhance End User Experiences

MINSUNG JANG, KARSTEN SCHWAN, KETAN BHARDWAJ, AND ADA GAVRILOVSKA
GEORGIA INSTITUTE OF TECHNOLOGY

ADHYAS AVASTHI
CISCO SYSTEMS

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Motivation

Watching a movie, @bus → @Home;
Dynamic changes of environment

Dynamically select screen and decoding quality based on where user is and what she is watching.
CHALLENGES
Challenges: The status quo

• High overhead for management & use of increased devices
  – App installations for a multiple-device owner

• Smooth and seamless user experience
  – Watching video clips

• Sharing resources
  – Family reunion

Limitation of an individual and isolated single device
Challenges: Main causes

• Extreme heterogeneity of networked resources
  – From wearable devices to home servers
  – Management of distributed resources

• Inter-operability
  – Vendor-specific (Vertical) or peer-to-peer (Horizontal) manners
    • Sometimes, closed ecosystem (e.g., Control4Home)
    • pre-determined roles for each device: Not flexible
    • Composing Capabilities

• Permission and access control
  – Who (or what application) is allowed to use my resources?
  – What kind of resources can they use?
PERSONAL CLOUDS
INFRASTRUCTURE
Approach

- Provide a new system-level abstract (Virtual platform) composed of user-accessible resources to applications & users

Local device

Remote Clouds

nearby devices

SNS

Friend’s Resources

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Design Considerations for System-level Infrastructure

• Providing Mechanism and Control to manage a resource pool and construct a virtual platform per application needs

• Using system virtualization to logically decouple resources from a device

• Instantiating an abstract looking like a single device from application’s point of view

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Operations

Application1

Application2

Application3

Application4

VP1

VP2

VP3

VP4

Computation

Storage

I/O

control

mechanism

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Software Components

- **Applications** is a set of services running on a PCloud instance (e.g., a media player)
- **PCloud Instance** presents an illusion of a single machine. (i.e. implementation of a VP)
- **PCloud Runtime** brings up a PCloud instance complied with application’s needs
- **Cirrostratus** is the extension of the Stratus framework
- **System Services** are used to authorize applications to run and to access a data storage with global scope
Implementations

Application

Camera Service
Screen Service
Face Recognition

Composition
Intent
Access Control

Service Management

Resource Mgmt & System Service

M-CH v2

PCloud Instance

M-CH v2

Friends Resources

Hardware Resources
USB Cam
KBD
Screen
CPU/Mem

Storage
Laptop
Smart phone
Drop box

SNS
Facebook
Friends list
Contributions

• Resource management and dynamic composition of distributed networked resources
  – Local, Nearby, and Cloud resources
• Runtime environment for applications to seamlessly access such resources
• SNS guides permissions for resource sharing
EVALUATION
Screen Sharing

Access Control Service on EC2

Certificate Authority

“JOIN” and request screen

Owner Group

Guest Group

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Results: Quick Deployment

<table>
<thead>
<tr>
<th>Task (message)</th>
<th>From</th>
<th>To</th>
<th>Time taken</th>
<th>Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiate a certificate</td>
<td>MO</td>
<td>S</td>
<td>88.2</td>
<td>27.6</td>
</tr>
<tr>
<td>Return the certificate and key pairs</td>
<td>S</td>
<td>MO</td>
<td>213</td>
<td>35.3</td>
</tr>
<tr>
<td>Authentication</td>
<td>All</td>
<td>All</td>
<td>405</td>
<td>41</td>
</tr>
<tr>
<td>Send a display sharing request</td>
<td>MO</td>
<td>SM</td>
<td>140</td>
<td>66.3</td>
</tr>
<tr>
<td>Return a list of available capabilities</td>
<td>SM</td>
<td>MO</td>
<td>293</td>
<td>117.3</td>
</tr>
<tr>
<td>Notify a selection of a display that wants to use</td>
<td>MO</td>
<td>SM</td>
<td>179</td>
<td>55.8</td>
</tr>
<tr>
<td>Initiate a VNC connection</td>
<td>SM</td>
<td>MO</td>
<td>153.3</td>
<td>80</td>
</tr>
</tbody>
</table>

Total Elapsed time: 1471.5 ms

MO: a mobile device, S: the authentication service, SM: a Cirrostratus master

The unit for time is milliseconds

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Neighborhood Watch

Camera Service ➔ Face Service

Face Database

Local storage

Face Service

Public Clouds

Aggregated storage

Home Devices

Friends' albums (faces, tag)

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Results: Impact on Response Time and Battery Life

Figure 4. User-experienced total response times in milliseconds for face recognition requests sent every 3 seconds for a 5 minute duration. face service: Config. (i) local, Config.(ii) nearby@Home, Config.(iii) EC2

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ADDITIONAL USE CASES
Basic Operations - Discovery

PCloud Discovery Service

Query with the current location

Available PCloud Master Node

List of available resources under control

PCloud Agent for Android

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Use cases (1)

• Project sound/screen to remote resources
  – Remote Screen

• Issues:
  – Our VNC-based solution does not perform well with applications that highly update a screen like Youtube
  – Some devices block accessing to their framebuffer
  – Remote Sound
Use cases (2)

• Slide sharing in a classroom or coffee shop
  – Use case for Multiple devices participation
Use cases (3)

• Collaboration
  – Use case for Multiple devices participation with a virtual white board
  – A (large) touch screen monitor turns into a tool to exchange opinions and record all ideas during a meeting
  – It also updates all participants’ device screen.
Next Step

• Sensors/Cameras
  – Use case in consideration: Home surveillance and security

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THE ROLE OF THE MIDDLE TIER
Better support *and* leverage richness of services, device types, users and data…

Maintain focus on dynamic, decentralized nature of the environment, and on importance of service quality

Offer additional capabilities through increased flexibility of middle-tier infrastructure

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Strapp: App streaming from eBoxes

User installs apps on devices

Apps appear automatically on end user devices

Apps submitted by developers

Existing

Strapp

Apps streamed from eBoxes

eBox stores apps for multiple users

App stores pre-populates apps on eBoxes based on user’s app-profile
Benefits and Next Steps

• Benefits -> performance, resource usage (including battery), richer services
• Ability to integrate virtualized and non-virtualized devices (Android and Meego support)
• Increased importance of edgeBox role – context cache, last-mile content distribution, to-cloud bandwidth…