Gaming as a Service

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Outline

- **Introduction to Mobile Cloud Computing**
- **Gaming as a Service (GaaS)**
  - Commercial Cloud Gaming System
  - A Cloudlet-assisted Cloud Video Gaming System
  - Cognitive GaaS Platform
    - Design of Cognitive GaaS Platform
    - Environment Perception Design
    - Resource Management
- **Research Opportunities: Mobile Gaming as a Service**

Mobile Cloud Computing

Cloud Computing

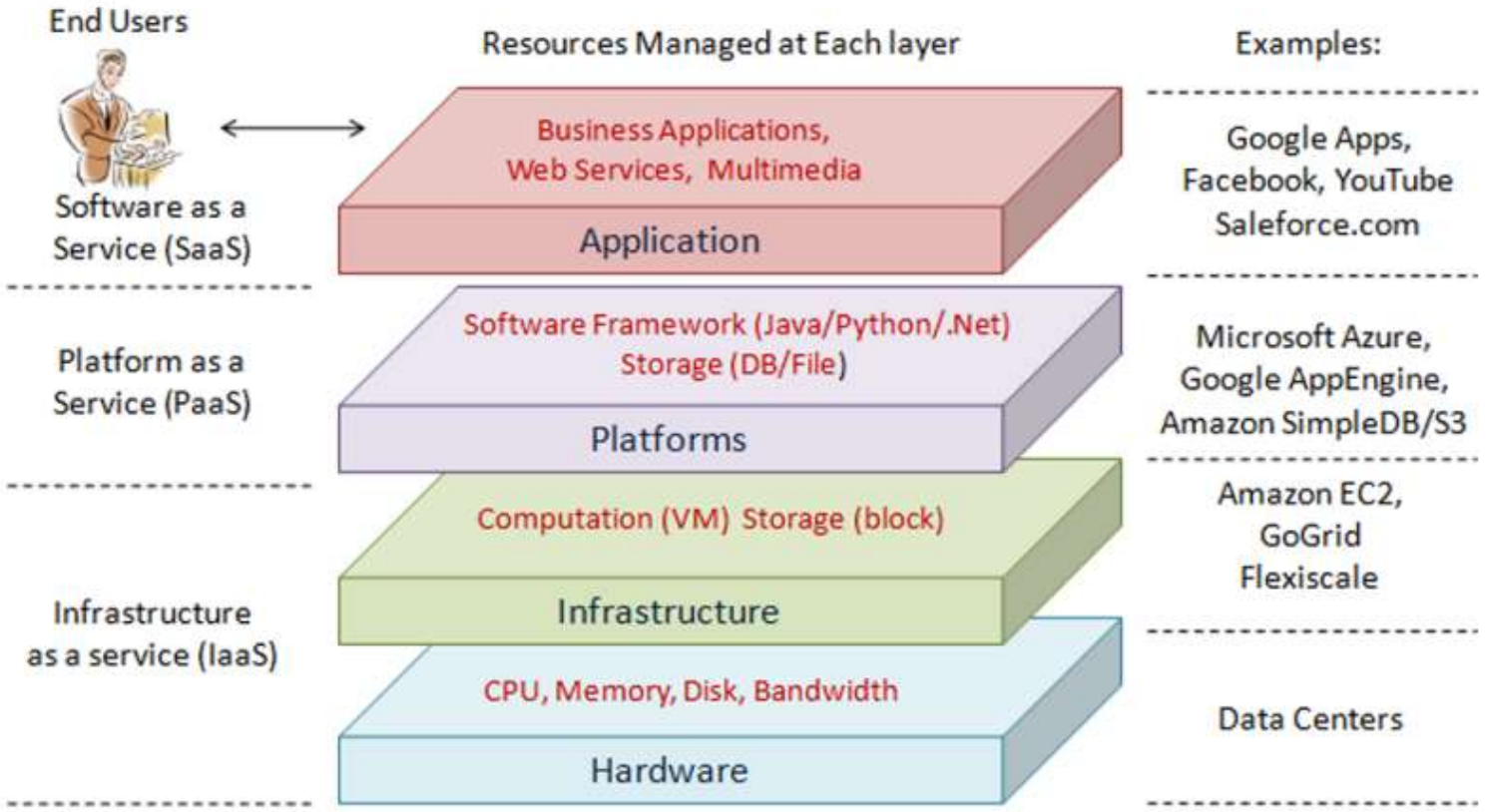
- Definition from NIST: “Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” $\Rightarrow$ virtualization of computing resources
- Providing Everything as a Service (XaaS)
- Types of Cloud Computing
  - Public clouds
  - Private clouds
  - Hybrid clouds
  - Virtual private clouds

Cloud Computing (Cont.)

- Evolution of cloud computing concept
  - Distributed computing (pure academic concept)
  - Grid computing (academic-leading application: SETI@home)
  - Cloud computing (commercial concept: reuse computing resources)
- Advantages
  - Multi-tenancy
  - Shared resource pooling
  - Geo-distribution and ubiquitous network access
  - Service oriented
  - Dynamic resource provisioning
  - Self-organization
  - Utility-base pricing

Cloud Computing Services

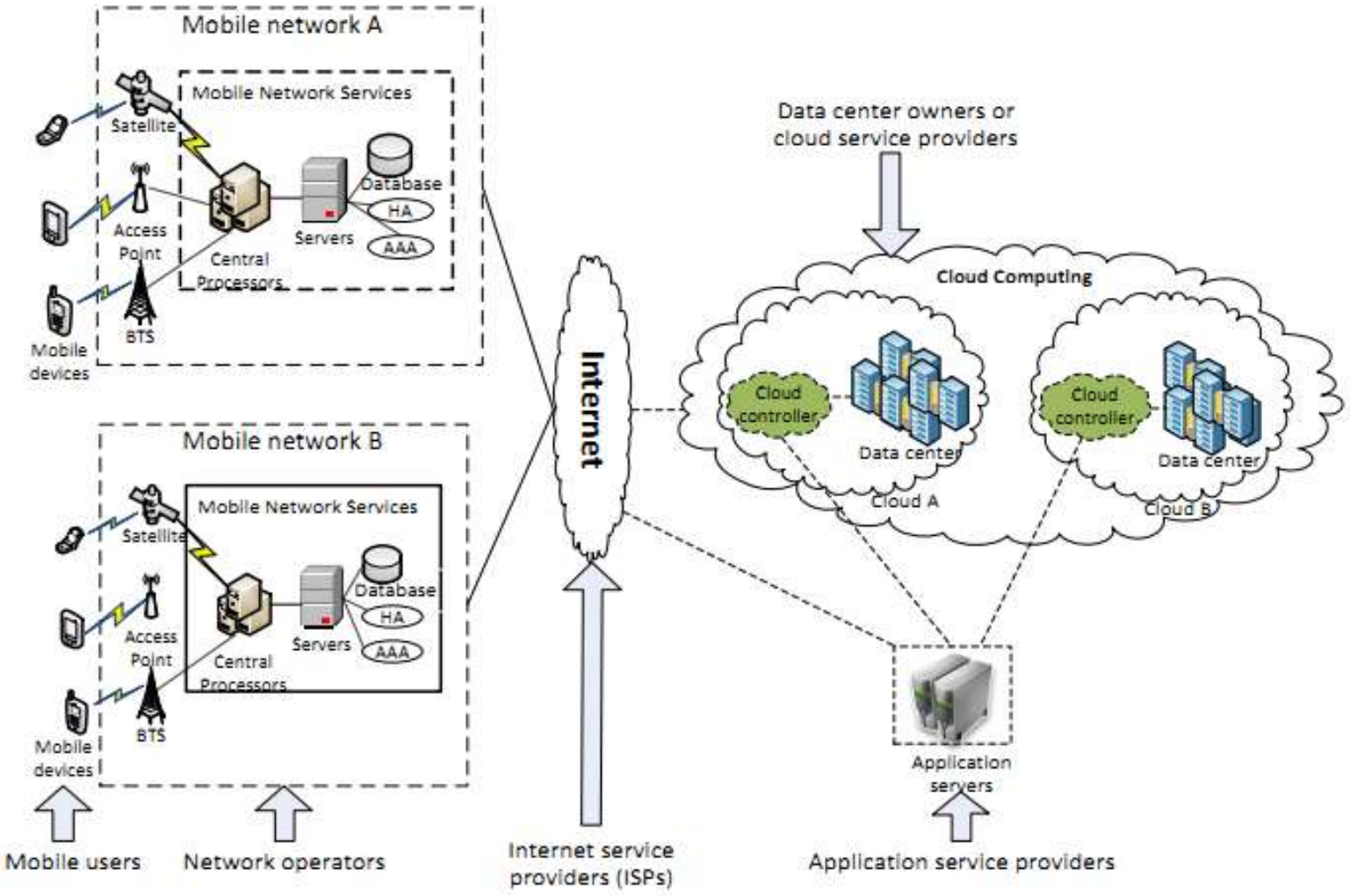
- Virtualized services at different levels



Mobile Cloud Computing

- Mobile cloud computing (MCC) $\Rightarrow$ mobile applications are built, powered and/or hosted using cloud computing technologies
- Motivated by:
  - ✓ Resource constraints in mobile devices
    - Processing
    - Data storage / memory
    - Energy storage / battery
  - ✓ Diversity of mobile devices (smart phones, tablets, etc.)
  - ✓ Contemporary mobile devices are (almost) always connected
  - ✓ Desire of mobile device users to interact with other mobile device users (e.g., via social networking)

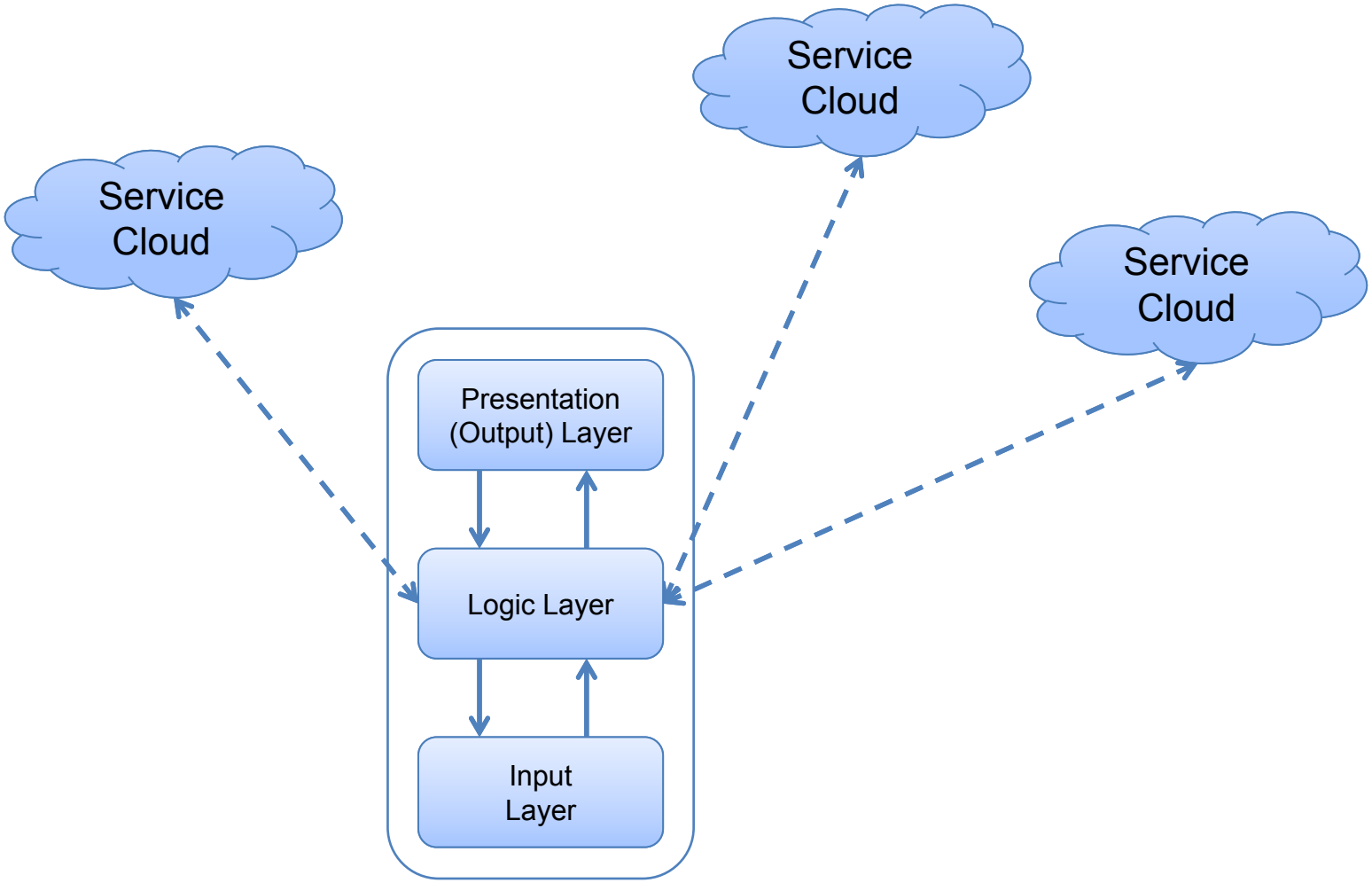
Mobile Cloud Computing (MCC): Architecture



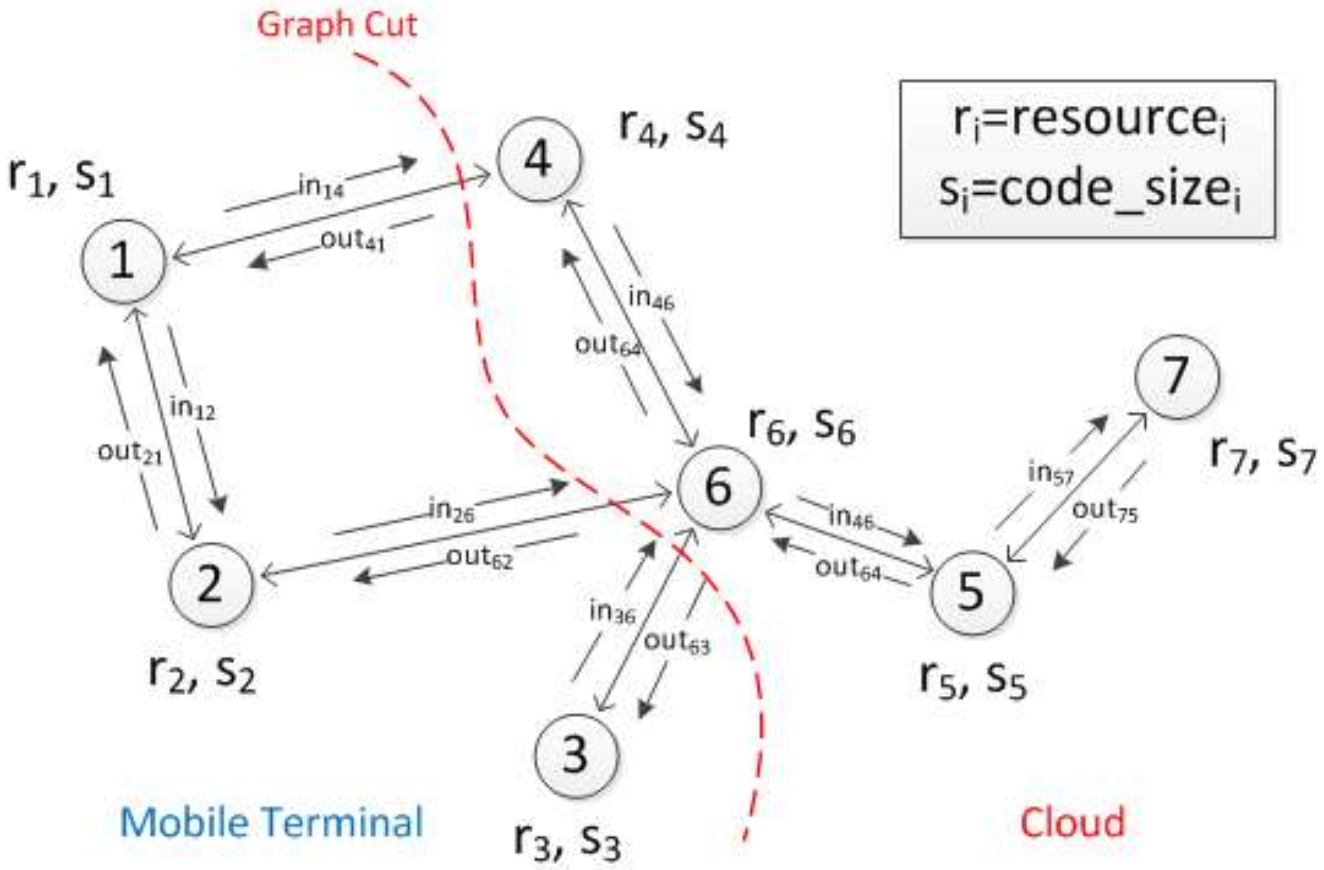
Advantages of MCC

- For users
  - Overcome limits of mobile hardware
    - ✓ Extending battery life
    - ✓ Improving data storage capacity
    - ✓ Improving processing power
  - Improving reliability
- For developers
  - Reusing existing, matured services – quick to market
  - Overcome design limitations of mobile systems
- For service providers
  - Continuous revenue from service providing model
  - Unified service regardless of platform

An Application Model of MCC

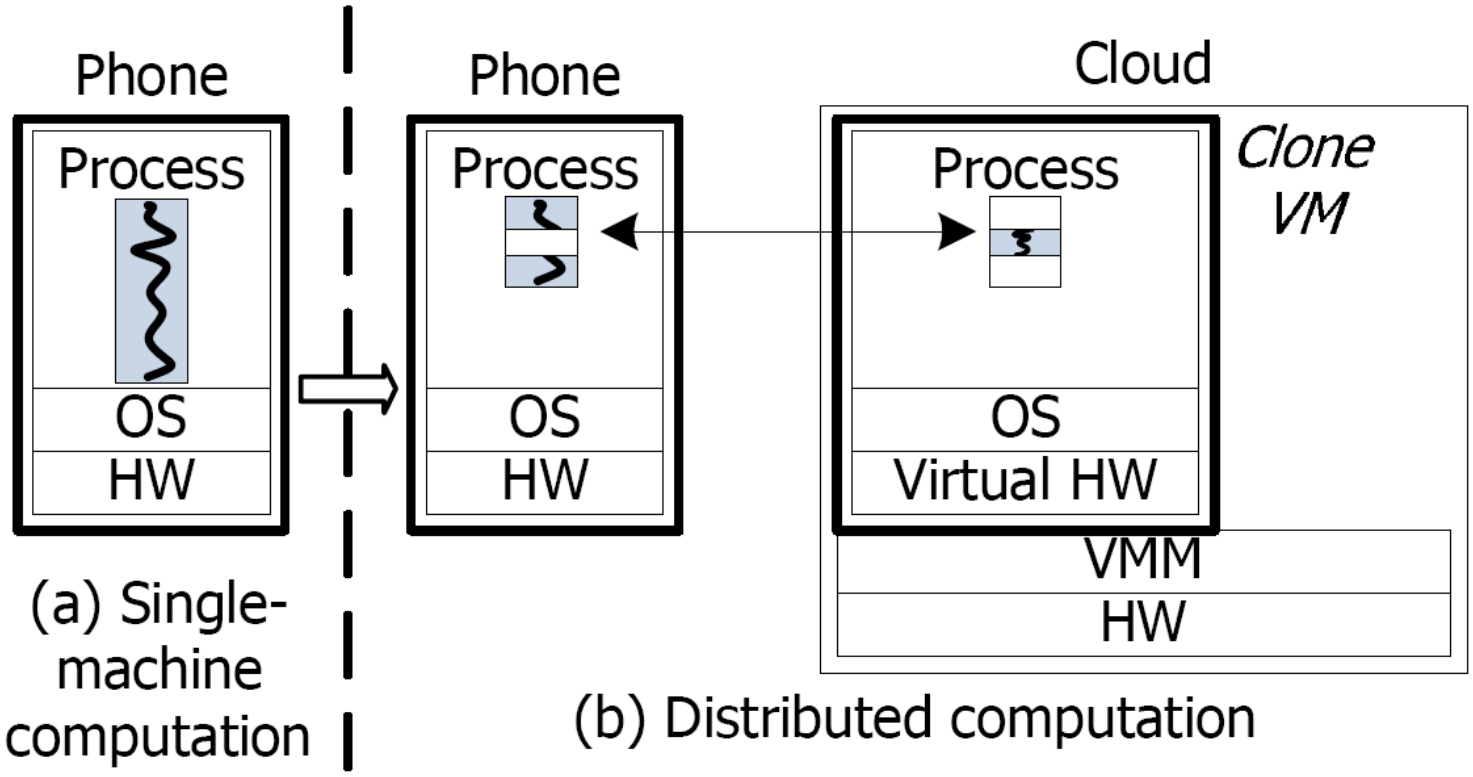


Program Aspect of MCC



Nodes represent program modules of a mobile cloud applications

Offloading Model of MCC Design



From “CloneCloud” (Intel Research Berkeley 2011)

Application of MCC

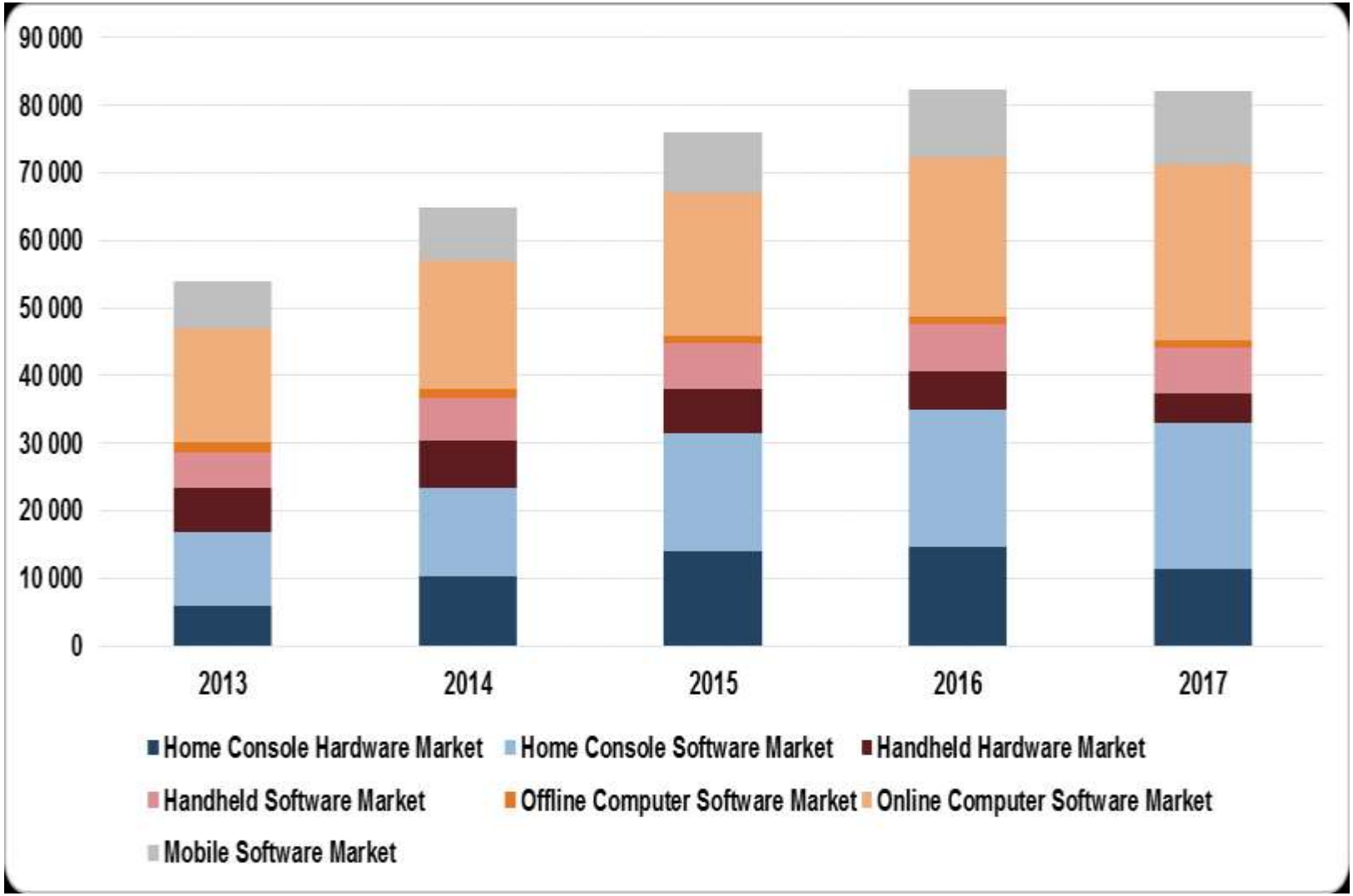
- Mobile Commerce
- Mobile Learning
- Mobile Healthcare
- Mobile Sensor Surveillance System
- Mobile Vehicular Networks
- Mobile Social Network
- Mobile Gaming

Research Topics of MCC

- Research Issues
  - Bandwidth requirements
  - Network availability
  - Network heterogeneity
  - Offloading
  - Security
  - etc.
- Associated with other topics
  - Vehicular networks
  - Social networks
  - Wireless sensor networks
  - etc.

Gaming as a Service (GaaS)

World Video Game Market (Million €)



Source: IDATE, November 2013

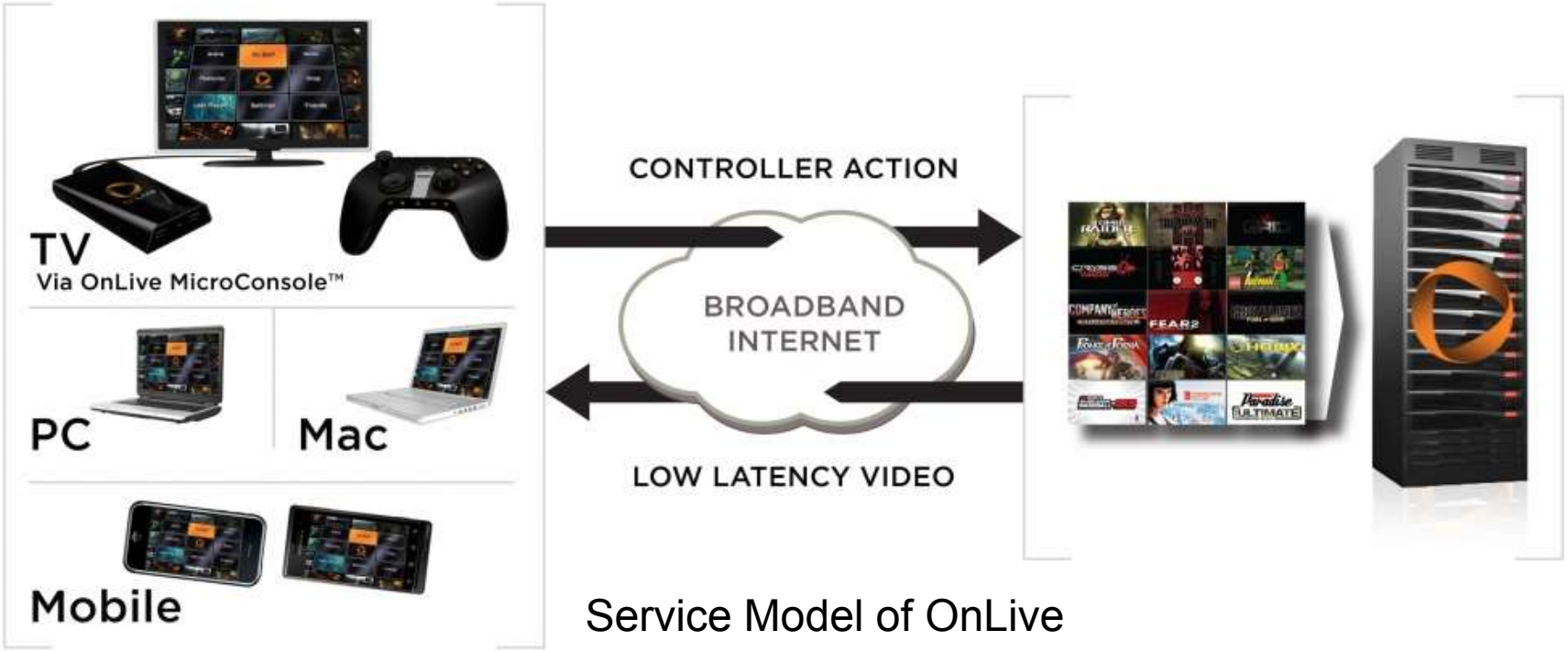
Gaming as a Service

- Games are built, powered and/or hosted using cloud computing technologies
- Additional Features:
  - Anti-Piracy
  - Click-and-Play
    - most games are seldom if ever played after downloading
  - Enhanced Gaming Experience
    - Gaming Anywhere
    - Gaming Anytime
    - Seamless Gaming

Commercial Cloud Gaming

Commercial Cloud Gaming

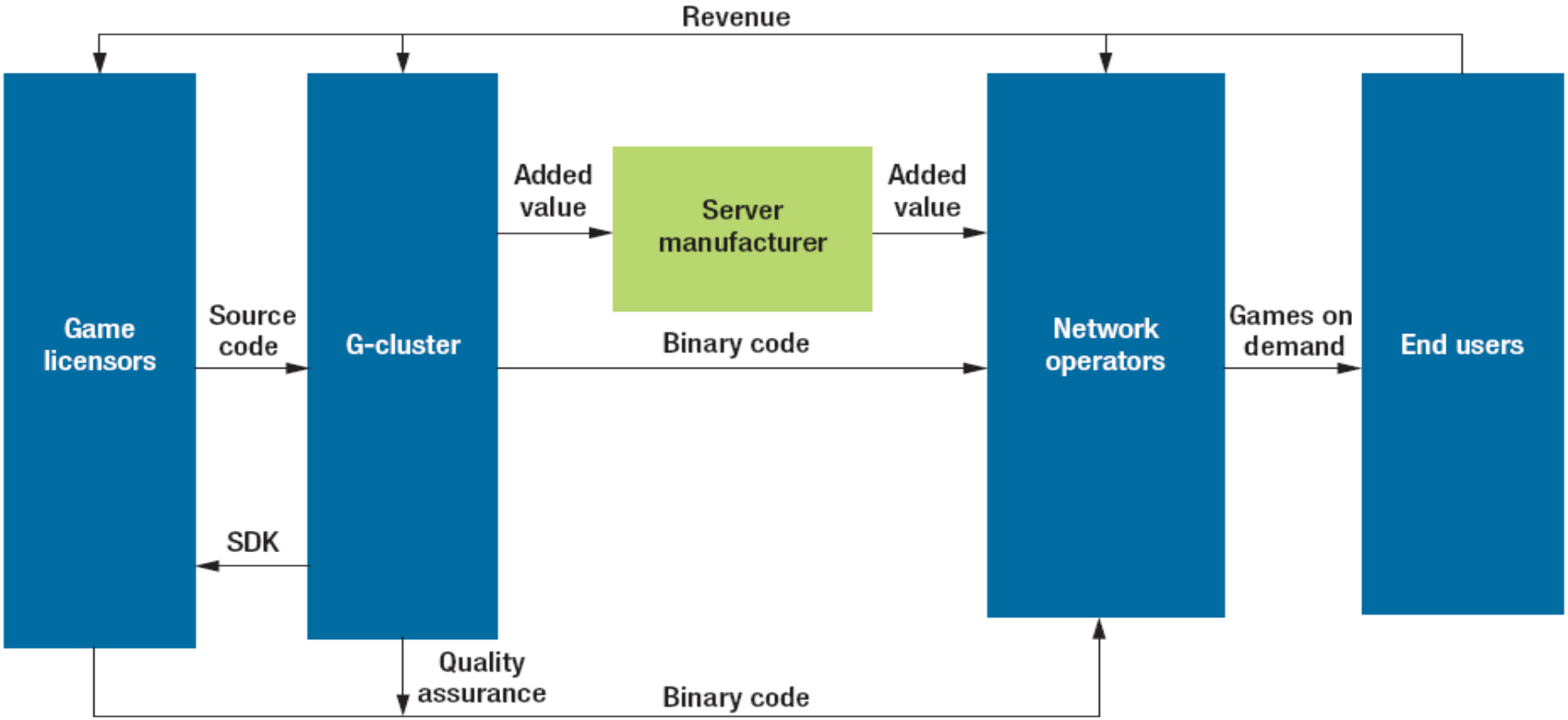
- Existing commercial cloud gaming service providers
  - OnLive, Gaikai, G-Cluster



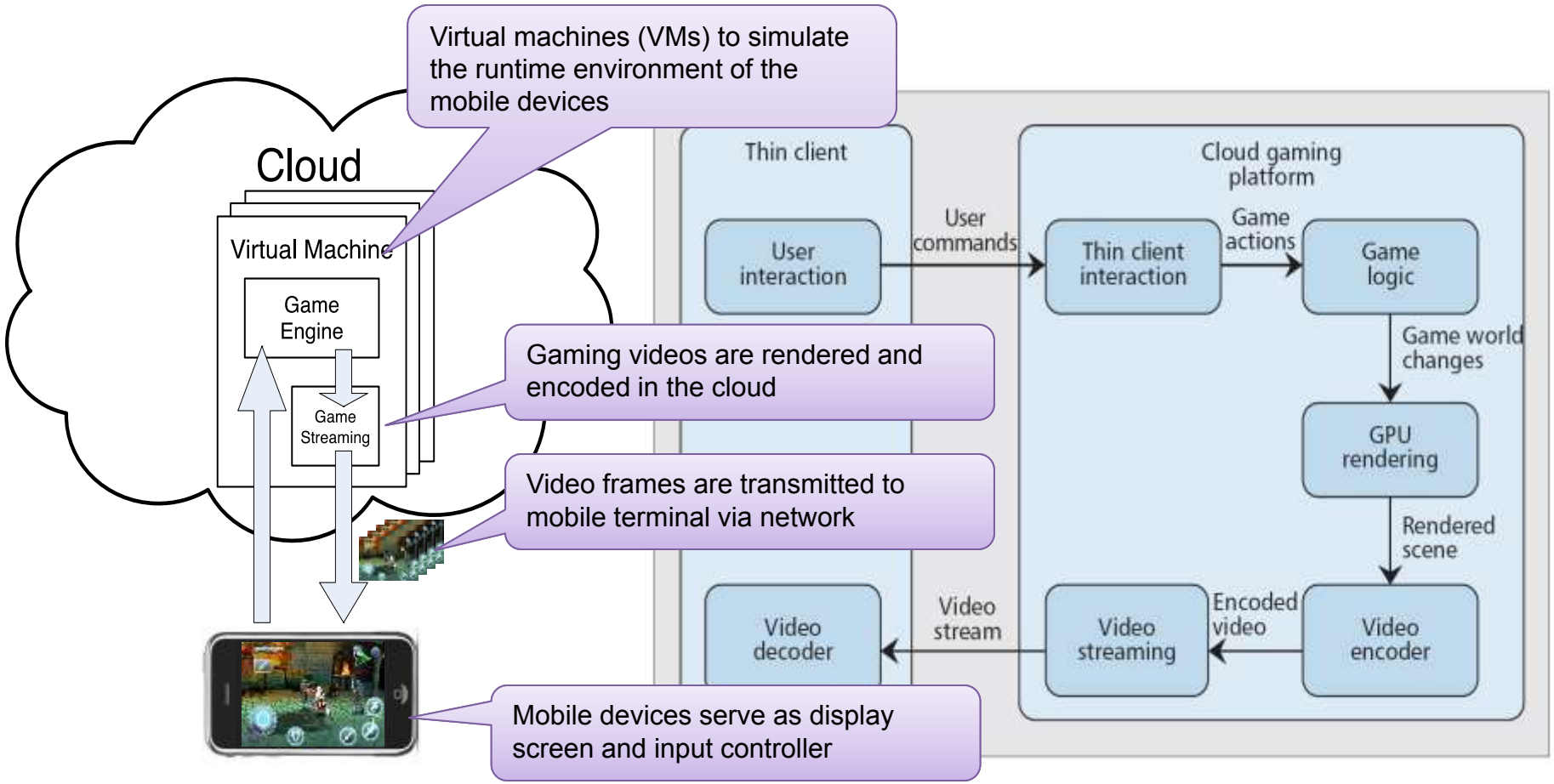
Service Model of OnLive

Cloud Gaming

- Business Model （from G-Cluster）

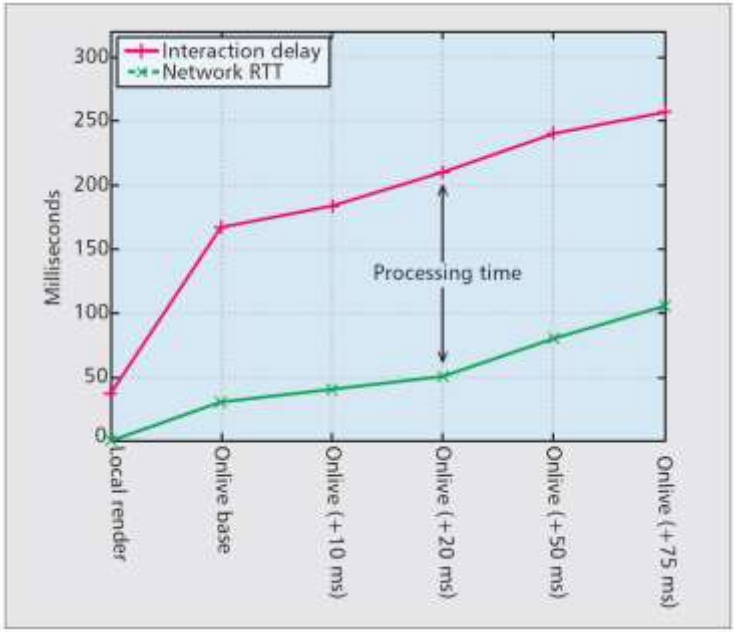


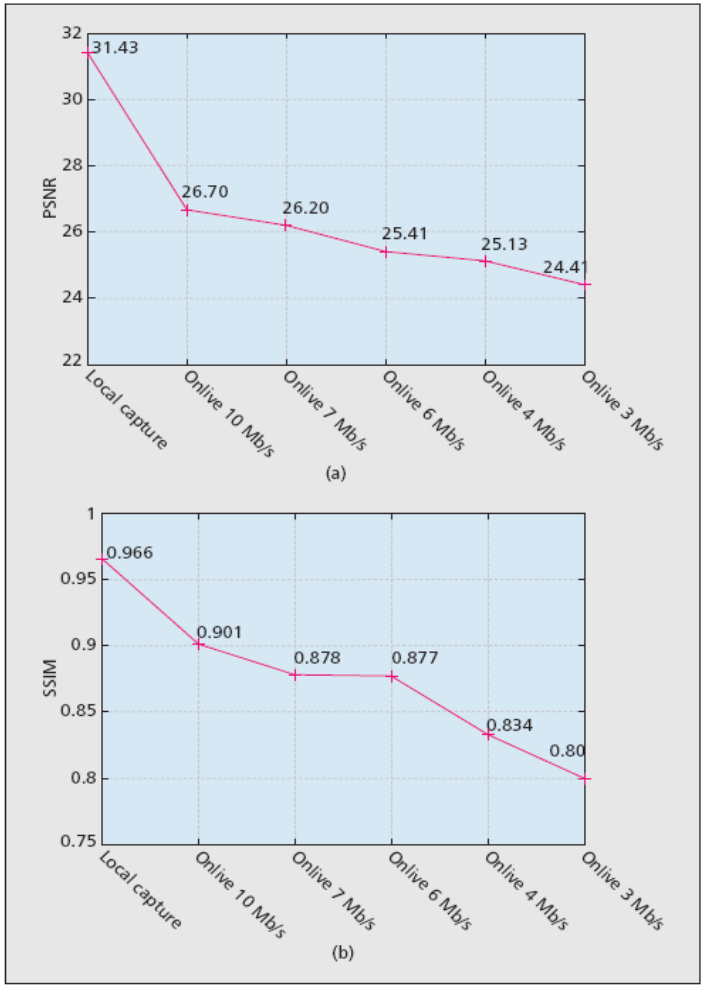
Architecture of Cloud Gaming



Measurement of OnLive

- Research Issues and Challenges
  - Interaction delay tolerance
  - Video streaming and encoding





Measurement of OnLive (Simon Fraser Univ. 2013)

Adaptive Rendering for Cloud Gaming

- Adapt rendering parameters to network environment

Full quality

Reduced depth

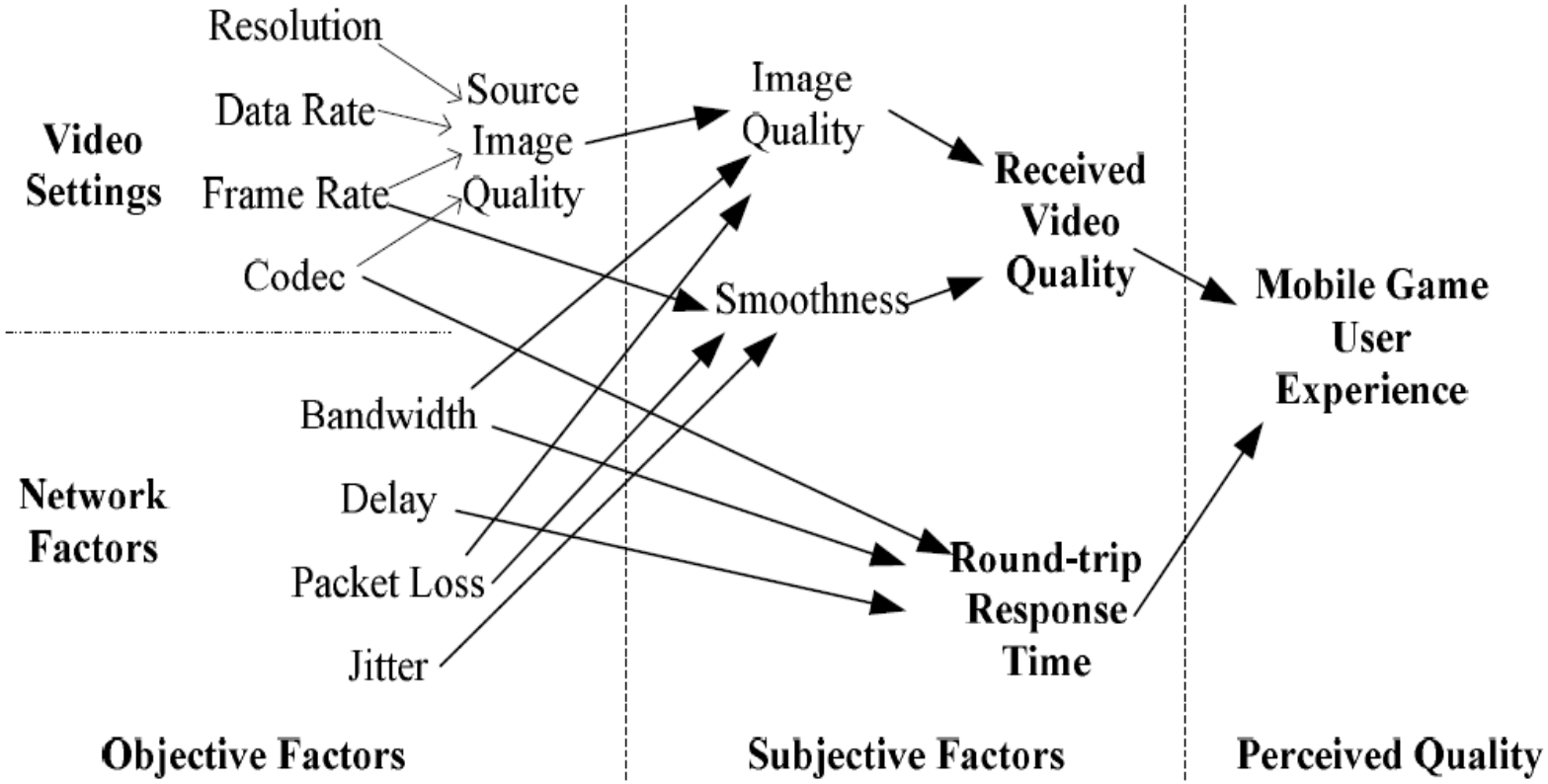
Reduced details

Reduced details

Adaptive Rendering for MCG (Univ. of California San Diego 2011)

Quality of Experience (QoE) for Cloud Gaming

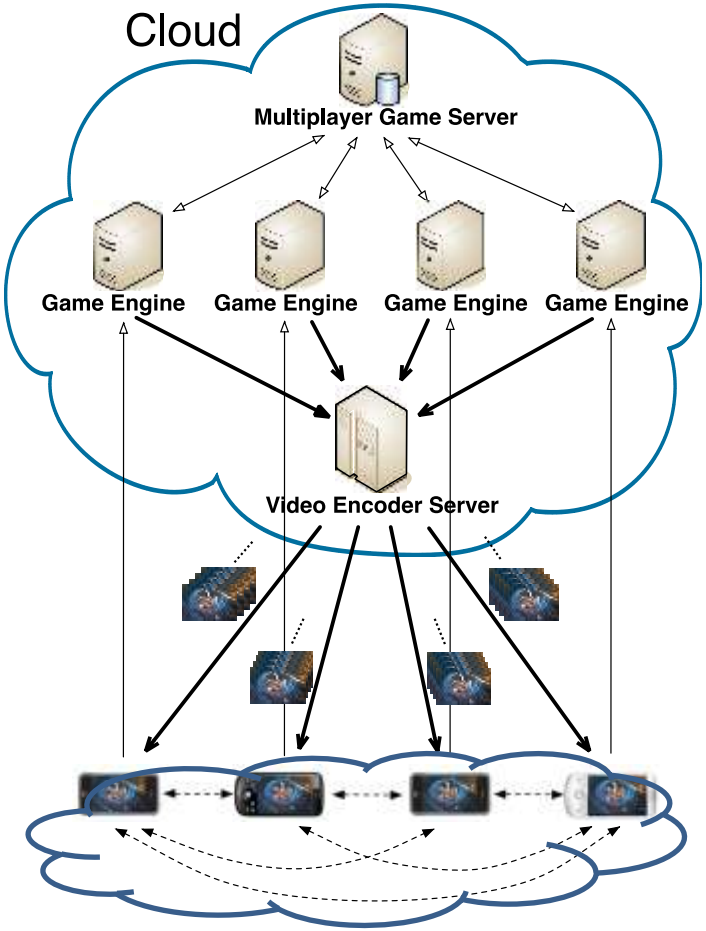
- Mapping user QoE to network Quality of Service(QoS)



A Cloudlet-Assisted Multiplayer Cloud Video Gaming System

Work published in ACM/Springer Mobile Networks and Applications (MONET)

System Model

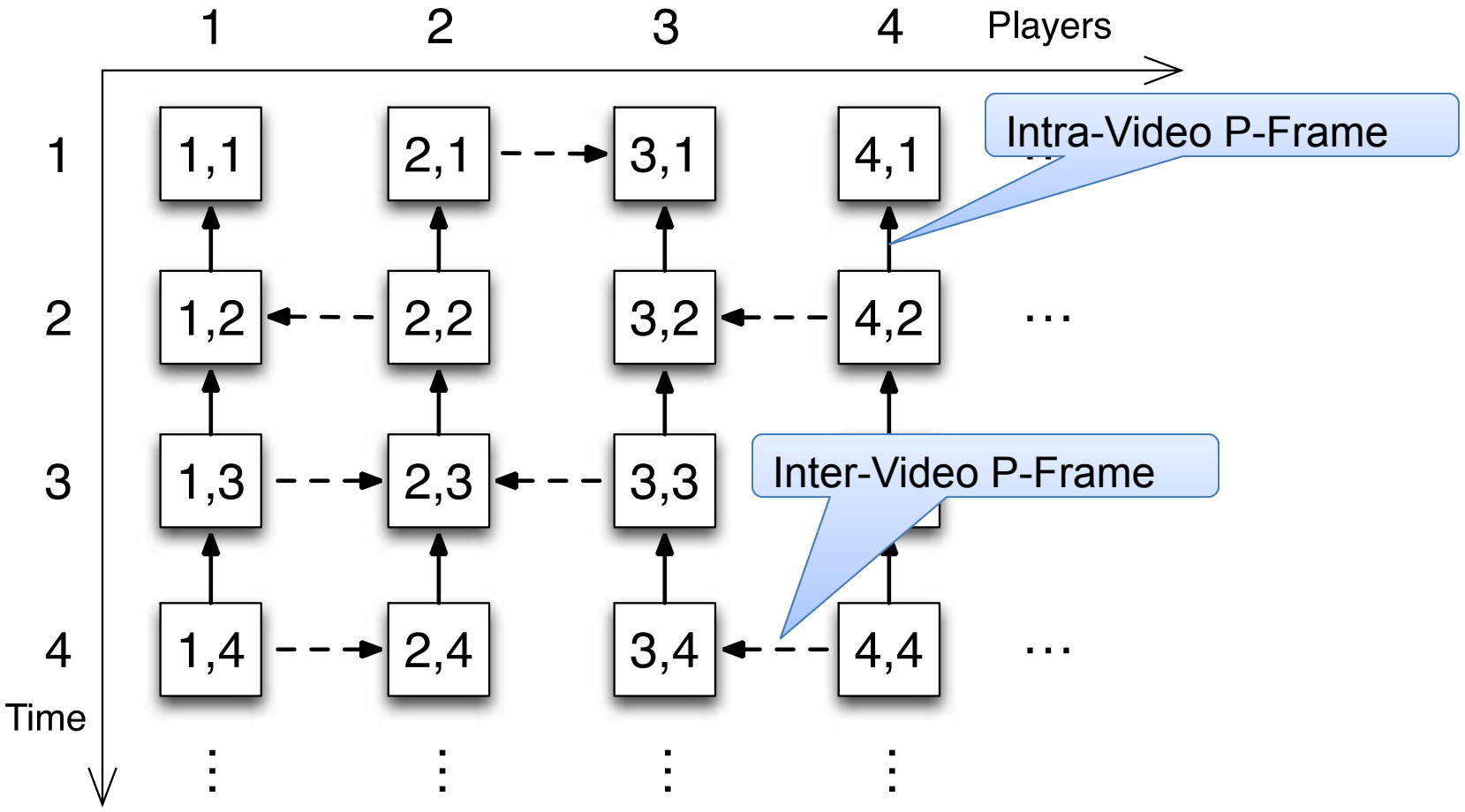


Ad-hoc Cloudlet

➢ Motivations

- Multiple game players in a same game scene would receive similar game videos
- Mobile clients are able to share their received gaming videos with the help of ad-hoc cloudlet constructed by a secondary local ad hoc network
- Potentially, the sharing of gaming video frames is able to reduce the server transmission rate

Correlation of Video Frames



Correlation of Inter-video Frames

- Inter-Video P-frame

$R_{overlap}$ = ratio of frame overlap

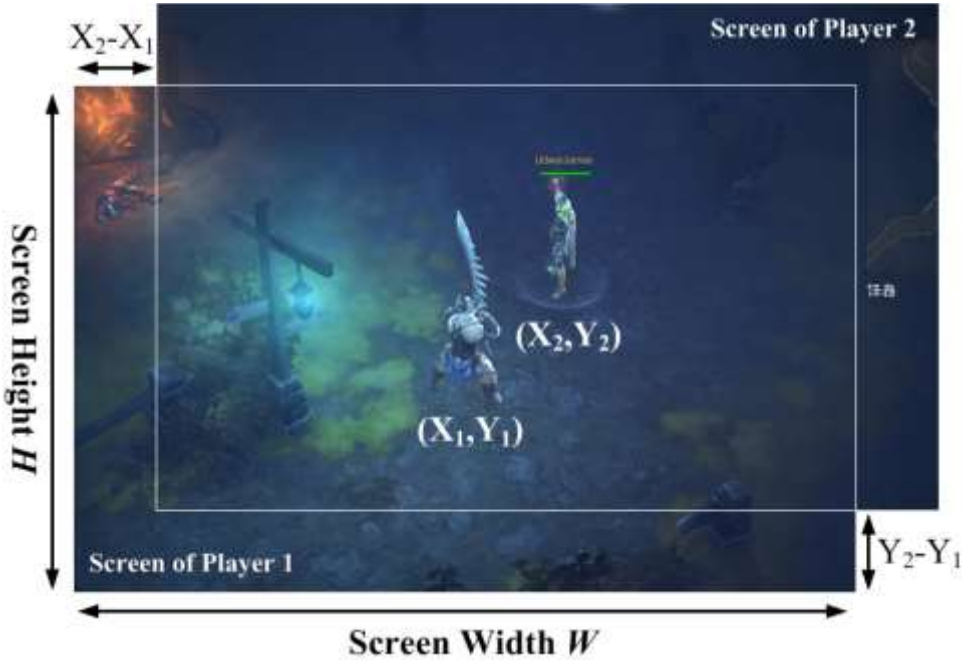
P_{inter} = size of inter-frame

I = size of intra-frame

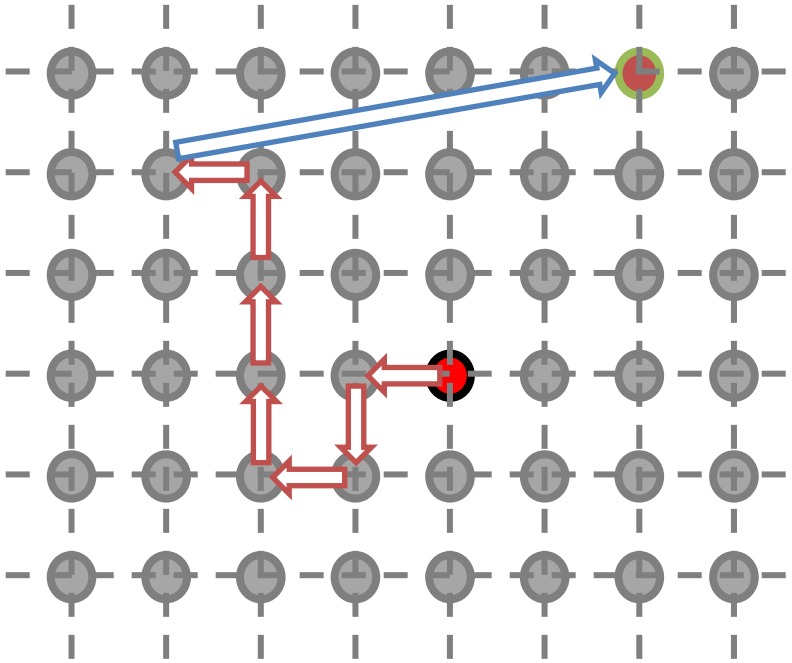
ρ = compression ratio

$$R_{overlap} = \frac{[W - (|X_2 - X_1|)][H - (|Y_2 - Y_1|)]}{WH}$$

$$P_{inter} = (1 - R_{overlap}) I \rho$$

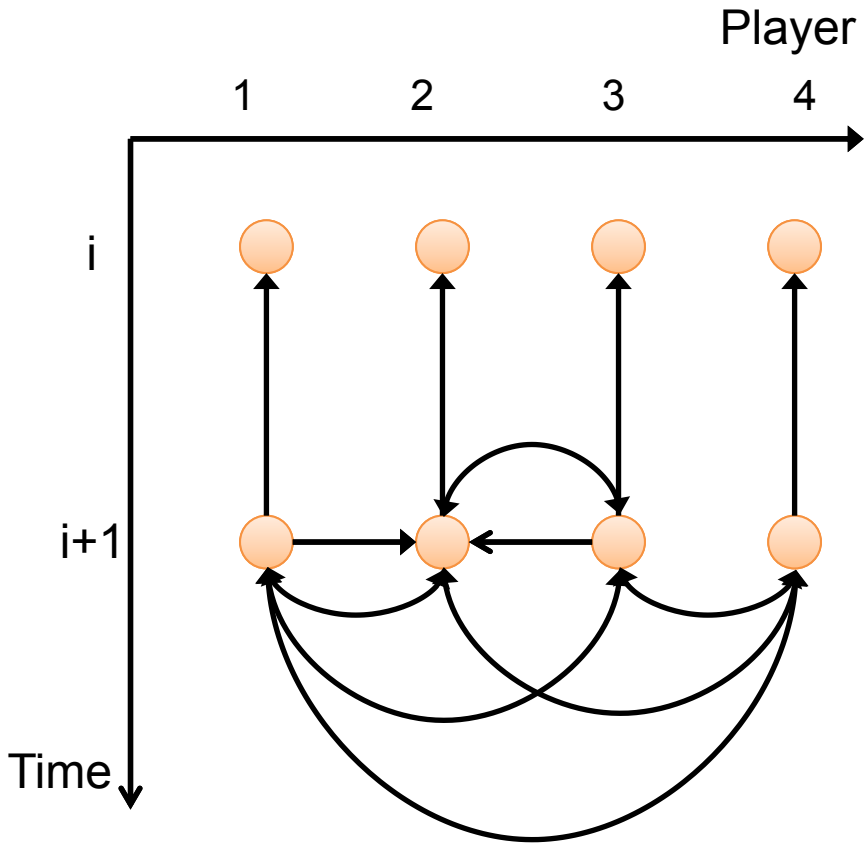


Player Interaction Models



- Random Walk –
  Choose a random direction to move
- Group Chase –
  Randomly choose a peer avatar, and chase it for a certain period of time

Design of Video Encoder

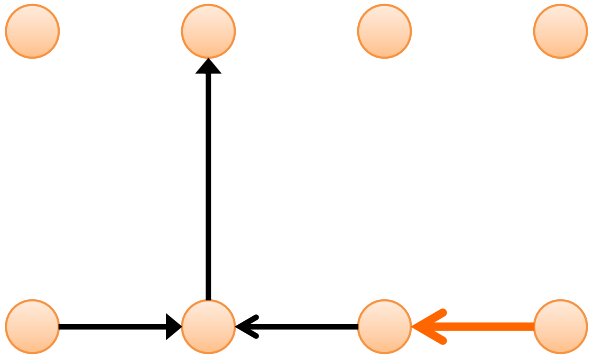


Encoding steps:

1. Frame Size Estimation
2. Grouping
3. Optimal Encoding

   Minimum Spanning Tree

Multi-hop Decoding Problem



- Drawbacks
  - Unacceptable Decoding Delay
- Solution to the problem
- To restrict the encoding in 1-hop
  - Search the F[x] with most $P_{inter}[y][x]$ frames which use F[x] as predictor
  - Encode F[x] as $P_{intra}[x]$
  - Encode all $P_{inter}[y][x]$
  - Continues until all F[x] is encoded

Experiments

Table 1. Player Interaction Model

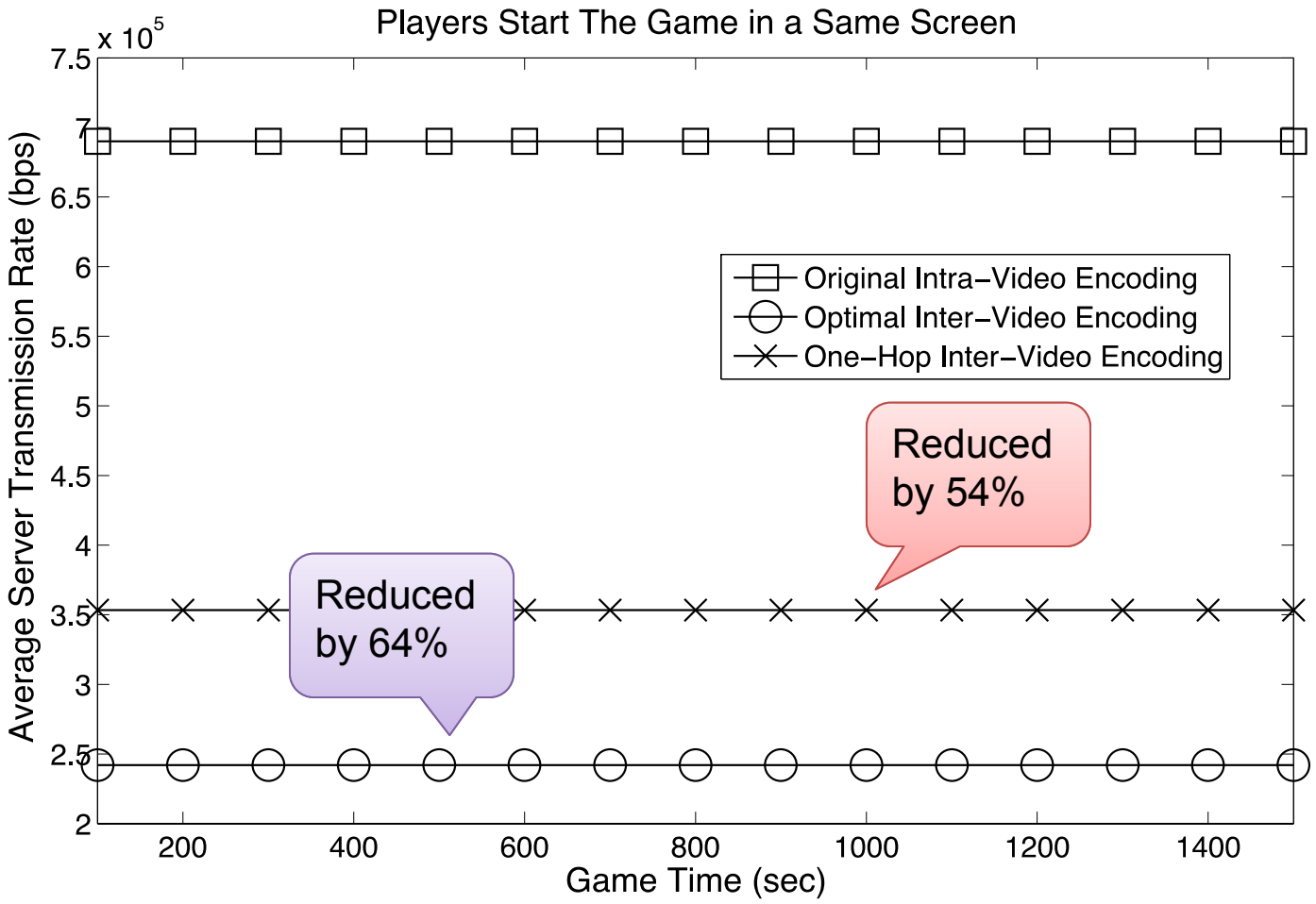
Number of Players	8
Average Game Time	1000s
Probability of Random Walk	0.7
Probability of Group Chase	0.3
Time of Each Chase	5s

Table 2. Video Encoding Parameters

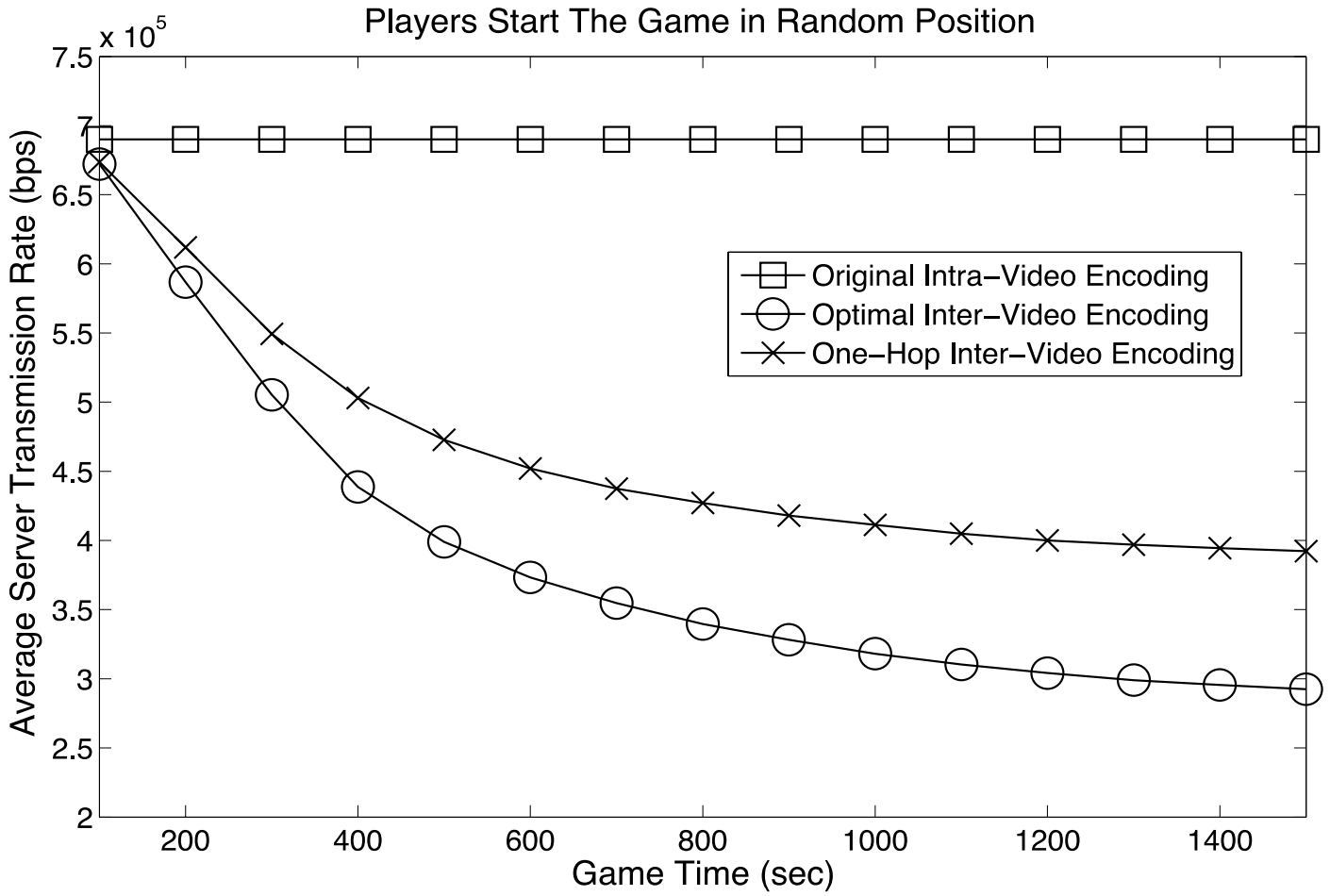
Screen Resolution	1024x1024
Game Map Size	4096x4096
Pixels of Each Move	32 pixels
FPS(Frame per Second)	24
GoP (Group of Pictures)	Infinite
PSNR (Peak Signal to Noise Ratio)	32dB

- Video Frames
  - Stanford Bunny Light Field
  - H.236 Encoder
- Evaluation
  - Server Transmission Rate
- Comparison
  - Original Intra-Video Encoding
  - Optimal Inter-Video Encoding
  - One-Hop Inter-Video Encoding

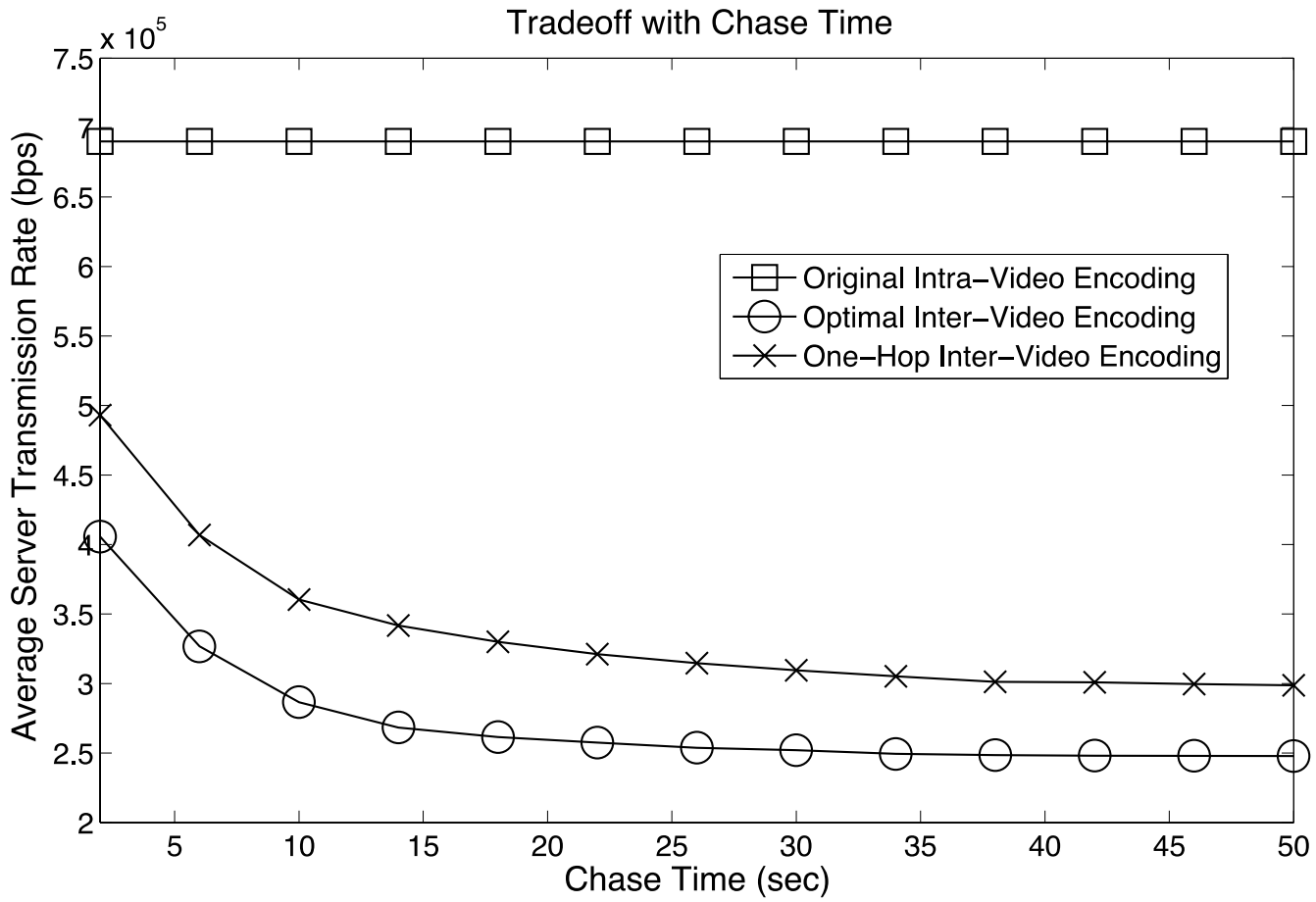
Transmission Rate vs. Game Time



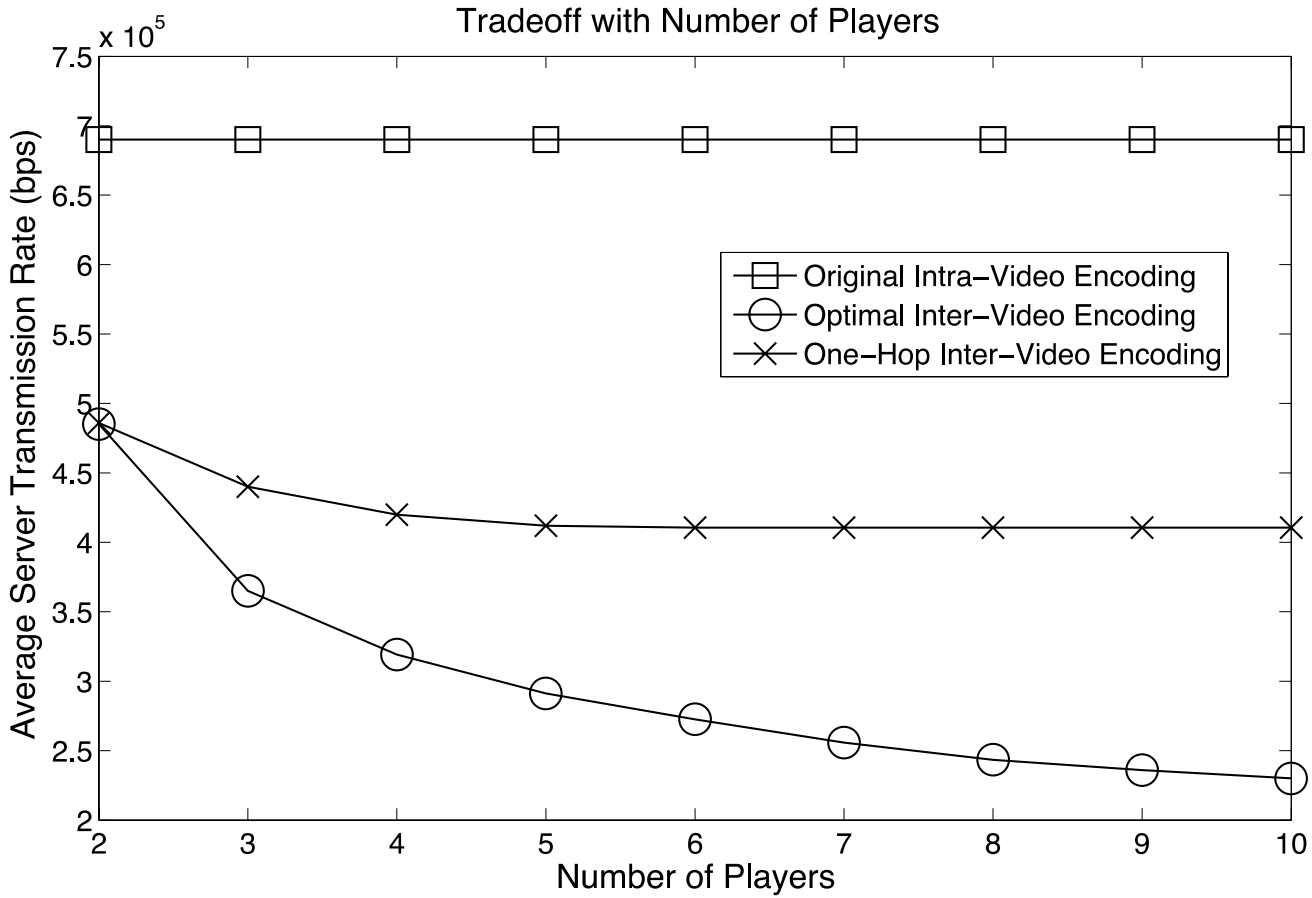
Transmission Rate vs. Game Time



Transmission Rate vs. Chase Time



Transmission Rate vs. No. of Players

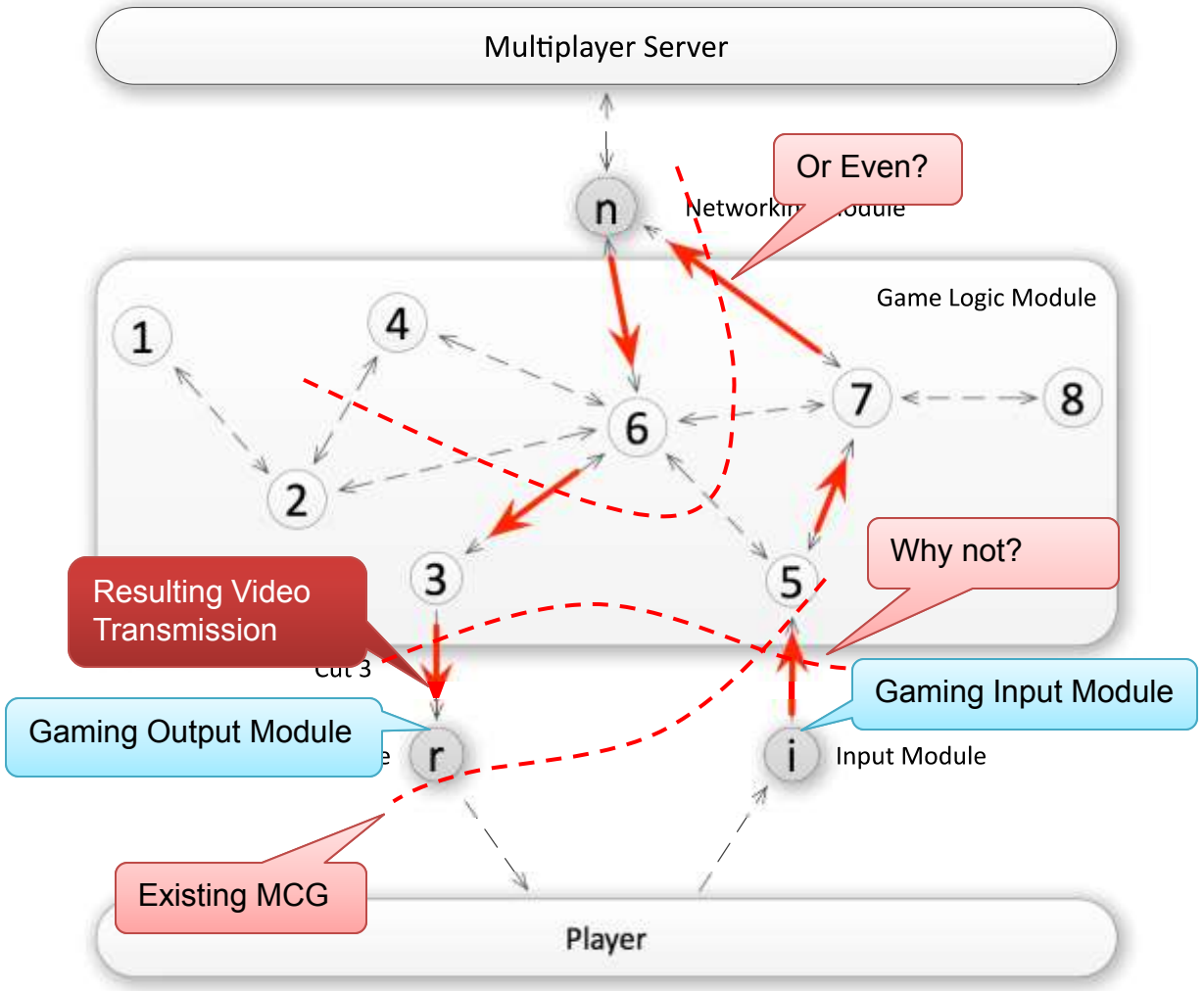


Cognitive Gaming as a Service

Problems of Existing Cloud Gaming Systems

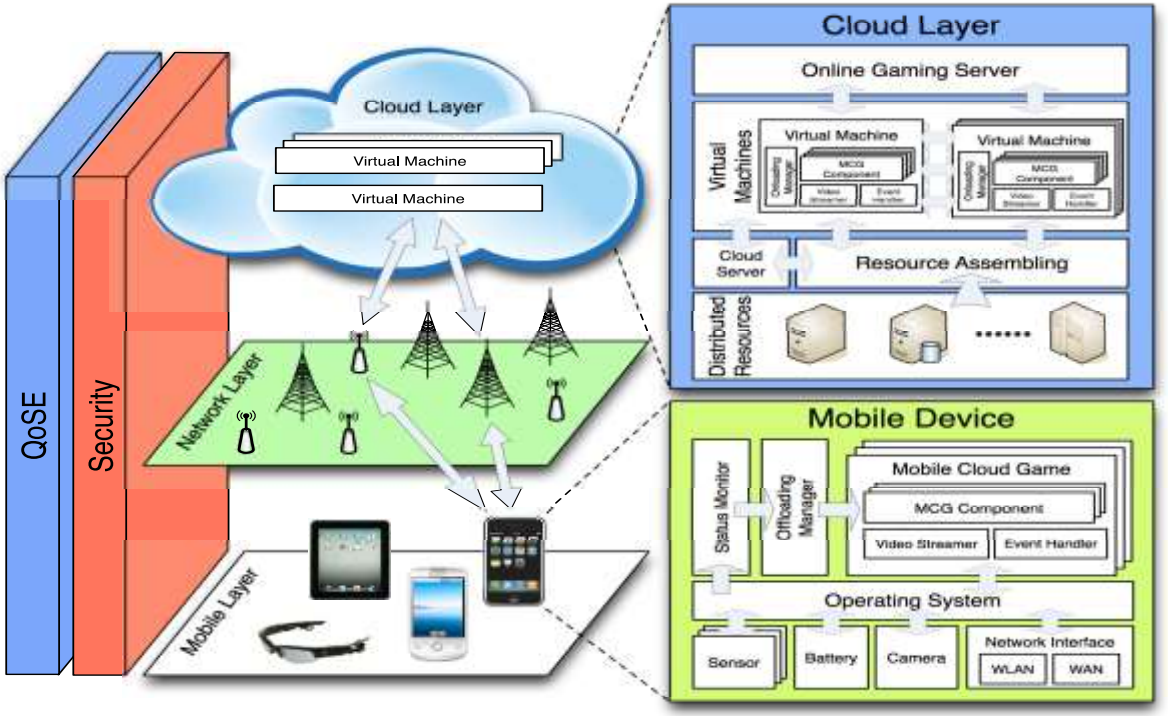
- Transmission of gaming video
  - High bandwidth requirement
    - Infeasible: unstable in mobile network
    - Irrational: too expensive in paid network
  - Hard to extend battery life
    - Screen display consumes lots of battery
    - Decoding of gaming video frames consumes power as well
- Need flexible scheme that is situation-aware and capable of adapting to the situation

Dynamic Location of Gaming Program Modules



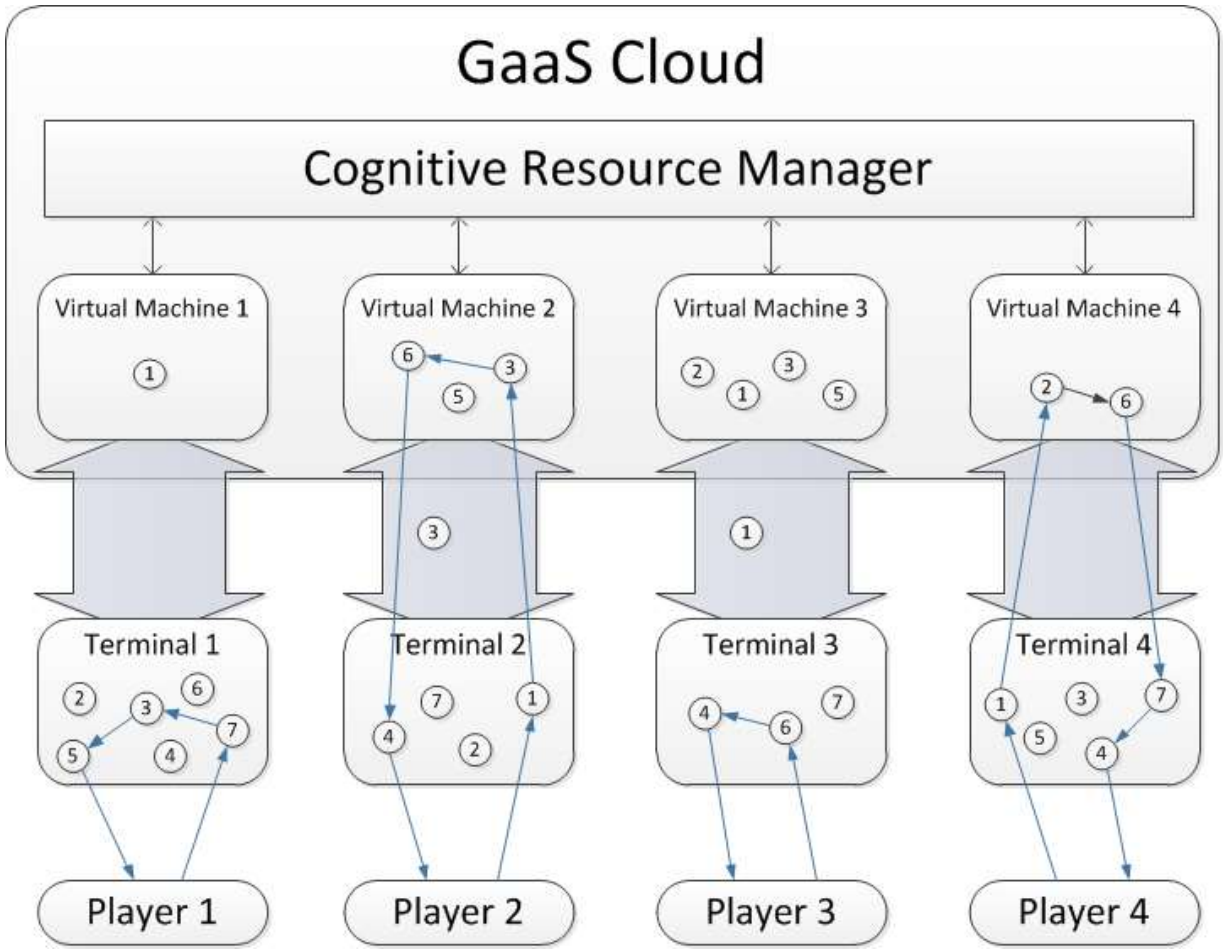
Architectural Framework of Future GaaS

- Cognitive cloud integration
  - Enabling component-based game design
  - Facilitating code migration from cloud to mobile terminal
  - Supporting cognitive resource allocation (dynamic partitioning)

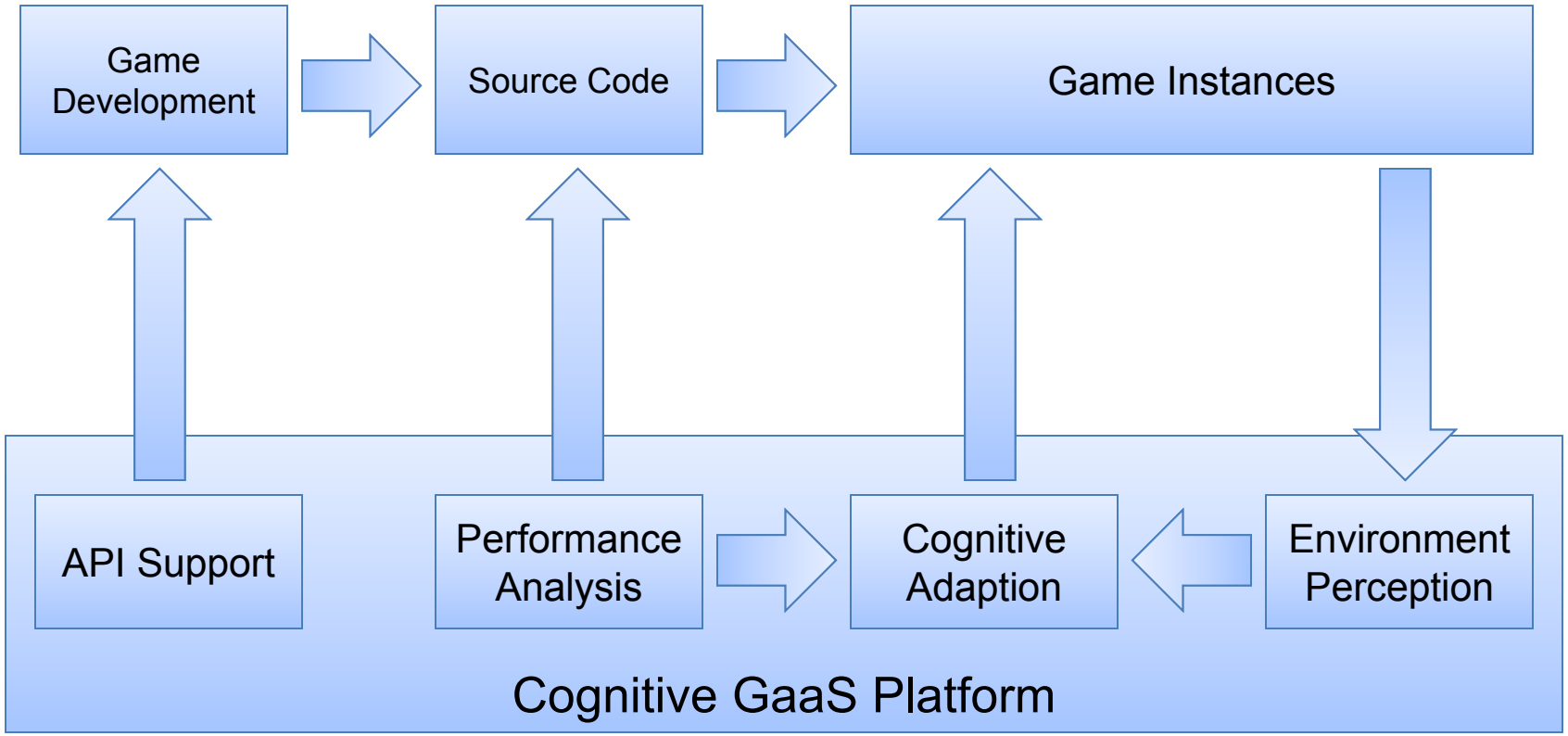


Work presented in MobileCloud 2013

A Running Cognitive GaaS Instance



Cognitive GaaS: Overview



Cognitive GaaS: Research Issues

- Cognitive GaaS Platform Design and Implementation
  - Enabling mechanisms and technologies
- Performance Prediction for Game Components
  - The reference for optimization algorithms
  - Unable to test performance in real-time
  - Prediction on code characteristics
- Environment Perception
  - The reason for adaptation
  - Efficient and accurate measurement, evaluation and prediction
- Intelligent Adaption Solution
  - Mapping system from QoE to QoS
  - Adaptive strategy: Level transitions and timing

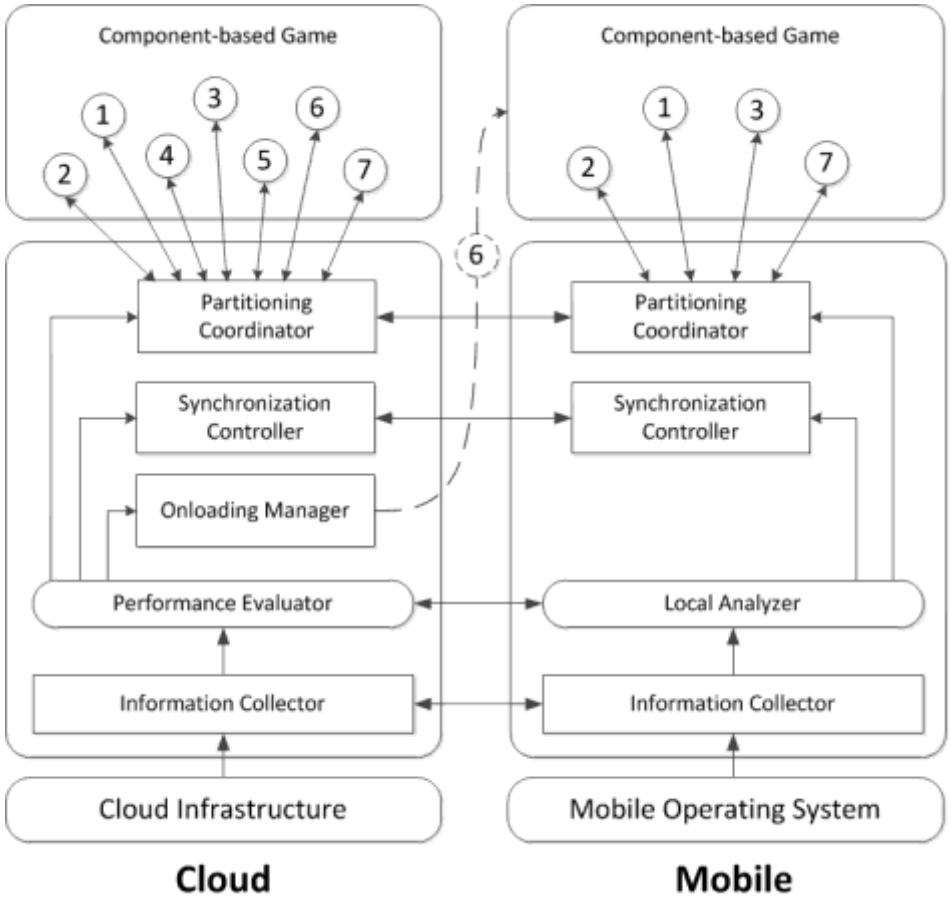
Cognitive Gaming as a Service

Design of Cognitive GaaS Platform

Work presented in CloudCom 2013

Design of Cognitive GaaS Platform

- Features
  - APIs for Game Developers
  - Click-and-Play
    - No installation required
  - Cognitive Adaptation
    - Environment Perception
    - Onloading Scheme
    - Dynamic Partitioning
  - Partial Offline Execution
    - For special scenarios



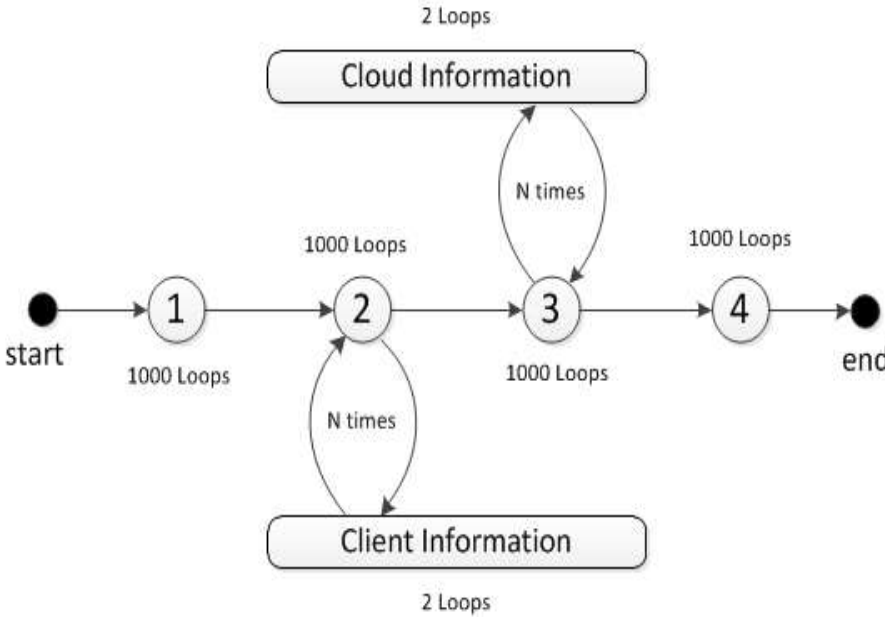
Design of Cognitive GaaS Platform

Configuration Center at Cloud End

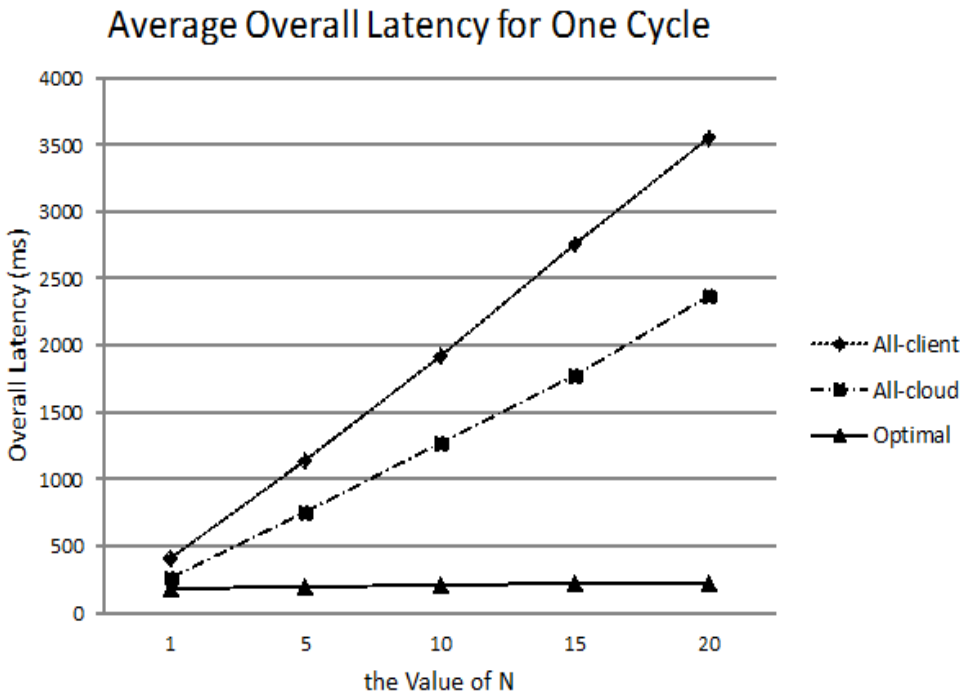
Figure 24. The Configure Center of Cognitive MCG Platform

Preliminary Experiment

- To validate the capacity of optimization
  - Latency-oriented optimization

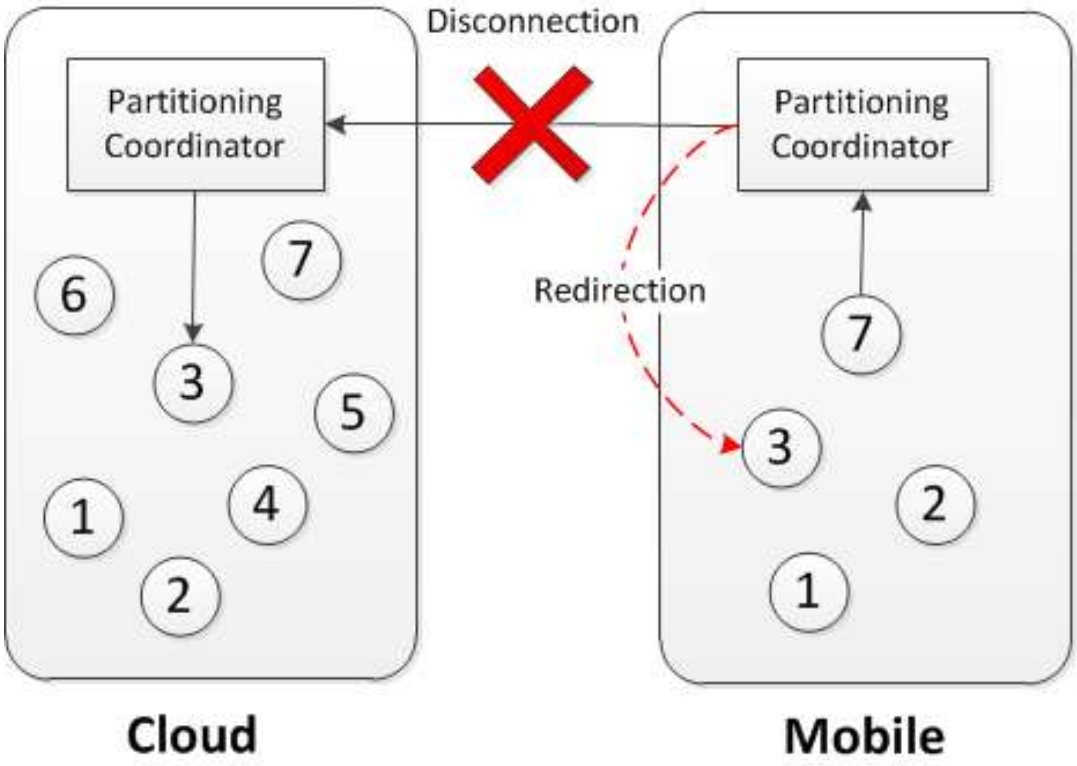


Experiment Setup



Experiment Result

Partial Offline Execution



Message Redirection or Offline Execution

Cognitive Gaming as a Service

Environment Perception

Work presented in CloudComp 2013

Mobile Agent (MA) Environment Perception

- Consider measurement, evaluation and prediction together!

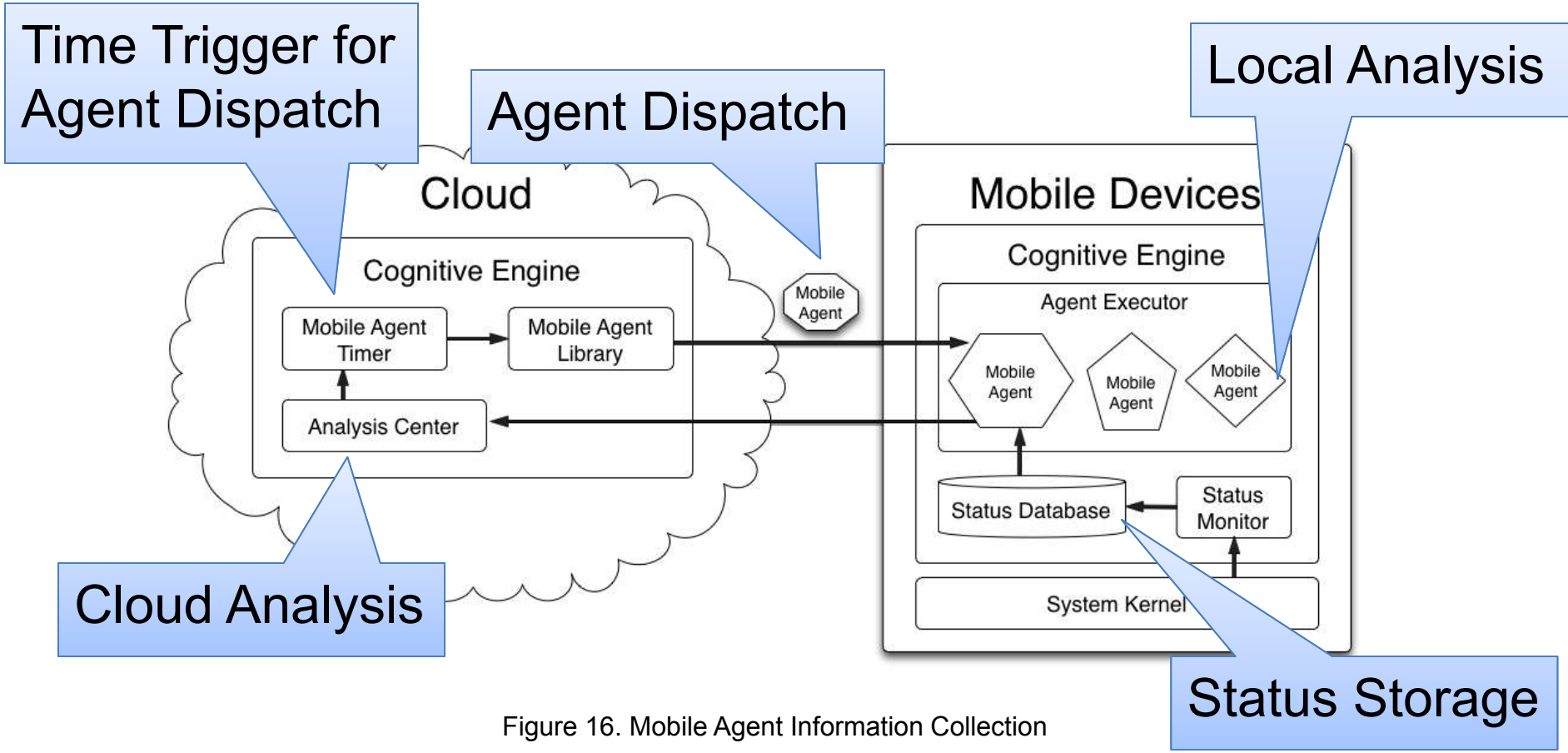


Figure 16. Mobile Agent Information Collection

MA Information Analysis

- Local Analysis
  - Extracting the features or characteristics of data
  - To increase the transmission efficiency of collected information
- Cloud Analysis
  - QoE level factor
  - System variance factor
  - Predict future information to increase the information collection efficiency

Benefits of MA Information Collection

- Intelligent Collection Interval
  - Determined by data variety
  - Predicted in the cloud with historic data
- Flexible Agent Design
  - Task-specific dispatching
  - Determined by data characteristics
- Efficient Information Transmission
  - Information retrieval, fusion and collection

Enabling Technologies

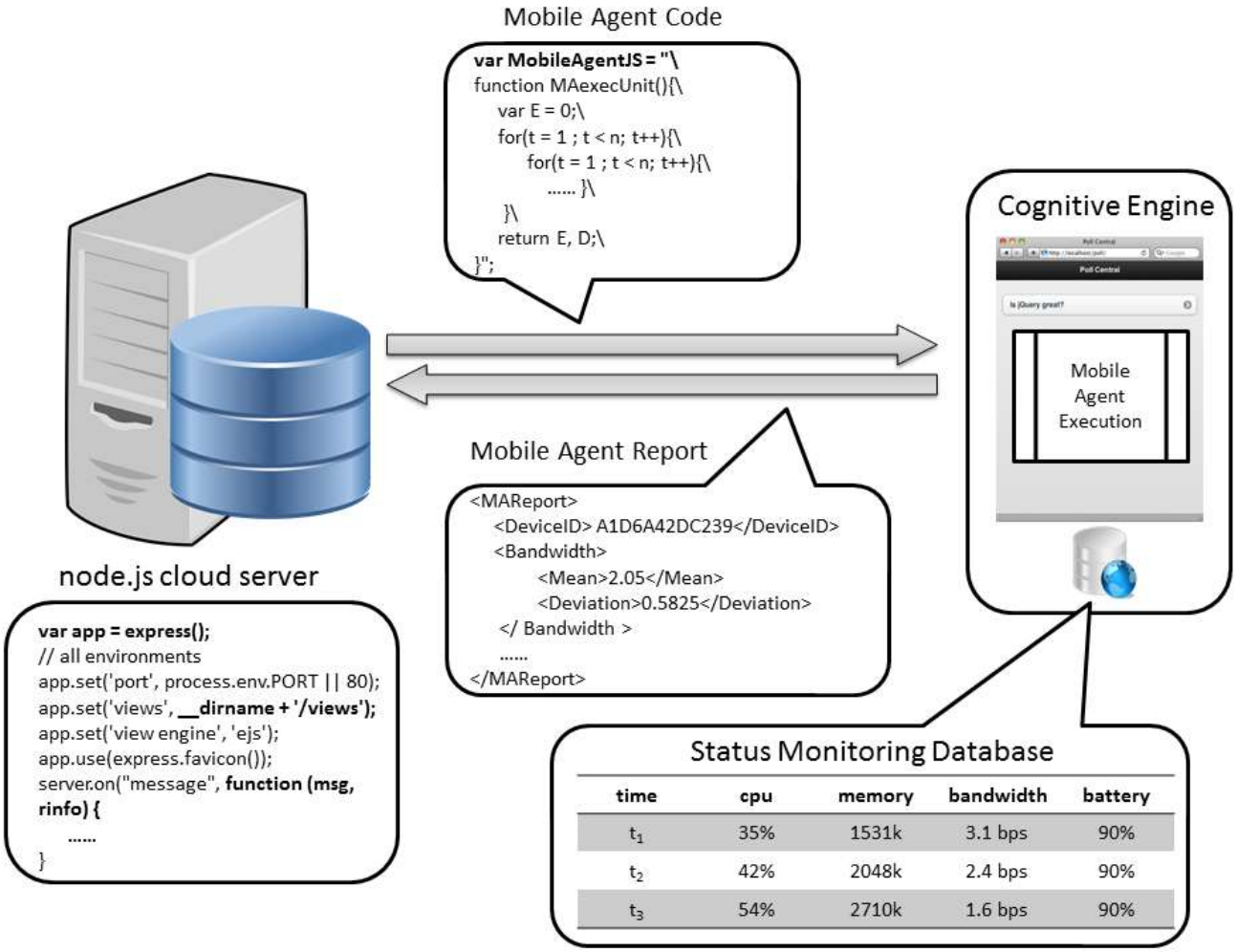


Figure 17. Implementation of Mobile Agent Information Collection

Cognitive Gaming as a Service

Resource Management

Work will be presented at IEEE ICC 2014

Our Future Work

- QoE testing involving different terminals under different network and cloud service conditions
- Further refine cognitive cloud-based gaming framework and platform development
- Develop demo games using platform
- Develop adaptive algorithms for situation-aware dynamic offloading of game components

The Opportunities of Mobile GaaS

- Make it MOBILE with novel I/O support

Sensor Games

Augmented-Reality Gaming (Google Glass)

Geographical Games(Ingress)



Thank You!

Wireless Networks and Mobile Systems Laboratory

http://winmos.ece.ubc.ca



This work was contributed by Wei Cai