Design Issues for Peer-to-Peer Massively Multiplayer Online Games

MMVE’09

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Overview

- Background
- Design Issues for P2P MMOGs
  - Interest Management
  - Event Dissemination
  - NPC Host Allocation
  - State Persistency
  - Cheating Mitigation
  - Incentives
- Classification of P2P MMOG Designs
- Discussion
Background

- Conventional MMOG architectures
  - Client/Server, e.g.
    - Sony’s EverQuest 2
    - Blizzard’s World of Warcraft
  - Middleware & Service Platforms, e.g.
    - IBM’s Butterfly Grid
    - Sun’s Game Server technology
  - In nature
    - Either dedicated game servers
    - Or shared game server clusters
Background

- **C/S or Middleware**
  - **Advantages**
    - Relatively easy to implement
    - Relatively easy to secure
  - **Disadvantages**
    - Reliability – single failure points
  - **Cost**
    - Server hardware
    - Network bandwidth
    - Housing & Cooling
    - Electricity & UPS
    - Maintenance staff
Background

❖ Engineering Peer-to-Peer MMOGs

Game server functions:
• Managing players’ positions
• Processing game events
• Controlling NPCs
• Maintaining the game world
• Security reinforcement
• Accounting

P2P MMOG design issues:
• Interest Management
• Event Dissemination
• NPC Host Allocation
• State Persistency
• Cheating Mitigation
• Incentives
Design Issues 1: Interest Management

- Objective: avoid broadcasting game events to all players
- Approaches:
  - Spatial models
    - Players communicate with nearby objects
    - Objects outside a player’s vicinity are ignored
    - E.g. *Voronoi ’04, Scalable & Low Delay ’05*
  - Region-based models
    - A game world is partitioned into multiple regions
    - A player subscribes to all game events from appropriate regions
    - E.g. *Distributed ’04, IM Middleware ’05*
  - Hybrid models
    - Partition the game world into regions
    - Select a super-peer in each region to facilitate a spatial model
    - E.g. *MOPAR ’05, Meta-Model ’06*
Design Issues 1: Interest Management

- IM Discussion
  - Spatial Models
    - Advantages: fine-grained
    - Drawbacks: communication overhead may be high
    - Suitable for unicast
  - Region-based Models
    - Advantages: simple, bandwidth efficient
    - Drawbacks: coarse-grained
    - Suitable for multicast
  - Hybrid Models
    - Combines the first two approaches
    - Current implementations ignore load-balancing & fault-tolerance
Design Issues 2: Event Dissemination

- **Objective:** deliver game events quickly and efficiently

- **Approaches:**
  - **Unicast**
    - A player distributes game events to all recipients directly
    - E.g. *Voronoï ’04, Scalable & Low Delay ’05*
  - **Application-Level Multicast (ALM)**
    - A player distributes game events to a small number of forwarders
    - Forwarders relay events to other peers recursively
    - E.g. *P2P Support ’04, P2P Architecture ’06*
  - **Locality-aware ALM**
    - Players in the vicinity are used as forwarders
    - Players closer to the source receive events faster
    - E.g. *N-Tree ’05, pSense ‘08*
Design Issues 2: Event Dissemination

Event Dissemination Discussion

- **Unicast**
  - Advantages: lower communication latency
  - Drawbacks: consumes more bandwidth
  - Can be ameliorated by using fine-grained IM

- **General ALM**
  - Advantages: bandwidth efficient
  - Drawbacks: typically induce longer latency

- **Locality-aware ALM**
  - Advantages: bandwidth efficient, exploits tolerance of weak synchronisation
  - Drawbacks: complex, higher computation overhead
Design Issues 3: NPC Host Allocation

- **Objective:** host non-player characters (NPCs) on peers
- **Approaches:**
  - **Region-based**
    - Game world is partitioned into regions
    - Each region selects a super-peer to host all NPCs
    - E.g. *Zoned Federation ’04, P2P Support ’04*
  - **Virtual-Distance-based**
    - An NPC is hosted by the closest player
    - E.g. *AtoZ ’04, Colysues ’06, Voronoi State ’08*
  - **Heterogeneous Task Sharing**
    - Share multiplayer NPCs among ‘nearby’ peers
    - Resource availability & QoS are considered during task allocation
    - E.g. *Deadline-Driven Auctions (DDA) ’09*
Design Issues 3: NPC Host Allocation

NPC Host Allocation Discussion

- Region-based
  - Early means of NPC hosting
  - A number of issues: super-peer selection, load-balancing, QoS…

- Virtual-Distance-based
  - Advantages: minimises communication latency & overhead for 1:1 interactions
  - Drawbacks: QoS for 1:N interactions, NPC host switching

- Heterogeneous Task Sharing
  - Advantages: maximises resource utility, reduces latency for 1:N interactions, less NPC host switching
  - Drawbacks: complex, must be combined with 1:1 NPC hosting
Design Issues 4: State Persistence

Objective: store players' profiles between game sessions

Approaches:
- General Storage Infrastructures
  - Large scale persistent data store utilities
  - Mostly designed for P2P file sharing application
  - E.g. *OceanStore ’00, PAST ’01*
- Special Persistency Mechanisms
  - Classify the data to be stored into multiple categories, e.g. ephemeral & permanent, deal with each category in separate ways
  - Expedite data read/write with caching mechanisms
  - E.g. *Zoned Federation ’04, P2P Architecture ’06*
Design Issues 4: State Persistence

❖ State Persistence Discussion
  - General Storage Infrastructures
    - Advantages: well distributed, highly consistent, secure, scalable, available, and durable.
    - Drawbacks: high redundancy, slow reading & writing
  - Special Persistence Mechanisms
    - Advantages: customised for MMOGs, fast reading & writing
    - Drawbacks: complex, immature, less secure
  - A major challenge, and potential for further research
Design Issues 5: Cheating Mitigation

Objective: prevent cheating, or detect & remedy suspicious game sessions

Approaches:

Proactive Mechanisms

- Advanced information exposure protocols that prevent unfair knowledge acquisition, e.g. *Mitigating Information Exposure ’05*
- Advanced event ordering protocols that prevent fixed-delay, suppressed update and other cheating, e.g. *NEO ’04, SEA ’06, EASES ’08*

Reactive Mechanisms

- Referee-based monitoring & log audit, e.g. *LA ’05, Cheat Detection ’06*
- Mutual monitoring among all the players, e.g. *FreeMMG ’04, DaCAP ’08*
- Behavioural monitoring for indications of cheating play, e.g. *Detection of Cheating ’07*
Design Issues 5: Cheating Mitigation

Cheating Mitigation Discussion

- **Proactive Mechanisms**
  - Advantages: effective and forceful
  - Drawbacks: applies to specific vulnerabilities, needs to know method of exploitation in advance.

- **Reactive Mechanisms**
  - Advantages: broad-spectrum
  - Drawbacks: not so rigorous

- Crucial for justifying P2P MMOGs’ practicality
- An active research field starting to bear fruit – many new mechanisms proposed in the last couple of years!
Design Issues 6: Incentive Mechanism

✎ Objective: persuade participants to contribute resources to the MMOG

✎ Approaches:

- Accounting Systems
  - Credit – record players historical contribution
  - Debit – entitle all player to roughly equivalent resources, e.g. DCRC ’03, DDA Incentive Model ’09

- Reputation Systems
  - Mutual-rating-based trustworthiness aggregation algorithms
  - Anonymous-request-based honesty measurement algorithms
  - e.g. Local Reputation ’07, Proactive Reputation ’08, REPS ‘08
Design Issues 6: Incentive Mechanism

❖ Incentive Discussion

- P2P systems are voluntary resource sharing systems.
- Individual concerns vs. collective welfare
- Require both:
  - Accounting
    - To quantify resource contribution & consumption
    - To identify selfish participants
    - To facilitate reciprocity
  - Reputation
    - To evaluate participants’ honesty & dependability
    - To discourage disadvantageous behaviours
    - To reinforce the accounting mechanism
## Classification of P2P MMOG Designs

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### P2P Support ’04

- Partitions game world into large regions to apply coarse-grained IM
- Disseminates game events using Scribe ALM
- Hosts all NPCs in a region using a single super-peer
- No game state persistence
- No incentive mechanisms
- A prototype application “SimMud” has been implemented
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- **Distributed ’04**
  - ☺ Partitions game world into small regions & applies a hierarchical IM
  - ☺ Disseminates game events via unicast
  - ☺ Supports a simple distance-based NPC host allocation mechanism
  - ☺ Suggests a special game state persistency mechanism
  - ☹ No incentive mechanisms
  - ☹ No demonstration application
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**OPeN ’05**

- ☺ Supports fine-grained IM using a novel spatial data index service
- ☺ Disseminates game events via unicast
- ☹ NPC host allocation is undefined
- ☺ Stores players’ profiles using a centralised database
- ☹ No incentive mechanisms
- ☺ A simple P2P MMOG application has been implemented
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### P2P Arch ’06

- Partitions game world into large regions to apply coarse-grained IM
- Disseminates game events using Scribe ALM
- No NPC host allocation
- Stores players’ data in a distributed way using PAST
- No incentive mechanism
- No demonstration application
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### VAST ’07

😊 Proposes a remarkable Voronoi assisted fine-grained IM mechanism
😊 Disseminates game events via unicast
😊 Proposes a good distance-based NPC host allocation mechanism
😊 Suggests storing players’ data using centralised game servers
😊 Proposes a novel mutual-rating-based reputation system
😊 A prototype application “ASCEND” has been implemented
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### Mediator ’07

- 🎈 Adopts a MOPAR-like hybrid IM scheme
- 🎈 Disseminates game events via unicast
- 🎈 Proposes a novel heterogeneous task sharing infrastructure
- 🎈 Supports game state persistency with PAST
- 🎈 Supports a native accounting mechanism that is similar to DCRC
- 🎈 Key components & a test-bed application have been implemented
Discussion

❖ Conclusions
  ▪ Classical C/S architectures suffer from various drawbacks
  ▪ We articulate a set of six design issues for P2P MMOGs
  ▪ We present design alternatives & discuss their implications
  ▪ We classify & compare representative P2P MMOG designs
  ▪ P2P MMOG architecture are improving rapidly

❖ Future Work
  ▪ To refine the Mediator framework & DDA infrastructure
  ▪ To evaluate Mediator MMOG prototype
Thank you for your attention!

Q & A

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