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:		P2P MMOG design issues:
• Managing players' positions	→	• Interest Management
• Processing game events	→	• Event Dissemination
• Controlling NPCs	→	• NPC Host Allocation
• Maintaining the game world	→	• State Persistency
• Security reinforcement	→	• Cheating Mitigation
• Accounting	→	• 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. ***Voronoi '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

P2P MMOG Architectures	Interest Management	Event Dissemination	NPC Host Allocation	State Persistency	Incentive Mechanism	Overall Evaluation
[43] P2P Support '04	Region-based	ALM	Region-based	None	None	Simple
[16] Distributed '04	Region-based	Unicast	Distance-based	Distributed	None	Moderate
[18] OPeN '05	Aura-Nimbus	Unicast	None	Centralised	None	Moderate
[28] P2P Arch '06	Region-based	ALM	None	PAST	None	Simple
[30] VAST '07	Voronoi	Unicast	Distance-based	Centralised	REPS	Complete
[20] Mediator '07	Hybrid	Unicast	Task Sharing	PAST	DCRC	Complete

- **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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