CSc 165
Computer Game Architecture

8 - Multi-Player Games & Networking

Overview

Application side:

- Game Network Architectures
- Networked Virtual Environments
- Game Communication Protocols

Game Engine side:

- Networking support in RAGE
- Protocol Stacks
- Java Sockets
- UDP / TCP client and server tasks

Game Network Architectures

type	advantage	disadvantage
Peer-to-peer *(all talk to each other)*	sometimes simpler, no server needed	limited by slowest machine, easier to cheat/hack
Client/Server *(one server per game)*	more secure, centralized control	powerful server needed, single point of failure

Floating Server:

peer-to-peer, but one "peer" is the server

Distributed Server:

multiple services for managing a very large world

Networked Virtual Environments (NVE)

"A computer-based artificial world of 3D spaces and objects visited by geographically dispersed users who interact and collaborate with each other and with objects/entities local to the world" [1]

Common terms: **NVE, MMG, MMOG, MMORPG, Virtual World**

Many different types:

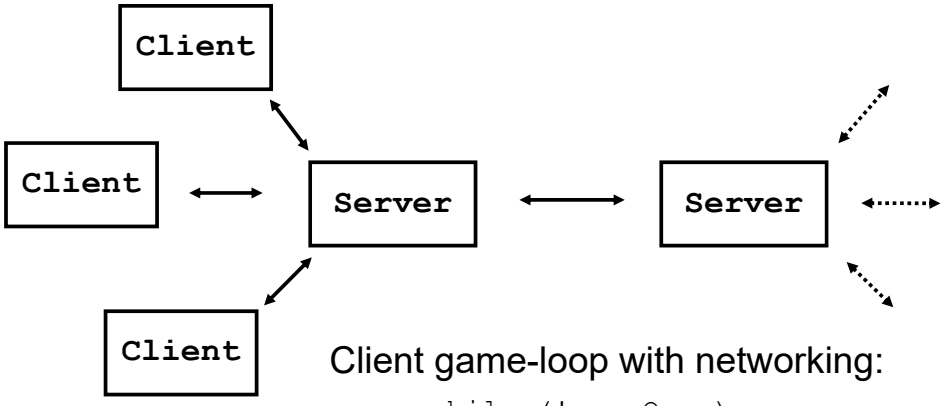
- Gaming
- Military
- Business / Training ("Serious Games", "performance engineering")
- Education

Examples: Overwatch, Counter-Strike, World of Warcraft, League of Legends, etc…

mmorpg.com (multi-player online game directory) lists thousands of MMO's.

[1] Davison, *Killer Game Programming in Java,* O'Reilly

Client-Server Organization



Client game-loop with networking:

```
while (!gameOver)
{  handleNetworkInput();
   handlePlayerInput();
   update();
   render();
   sendStateToNetwork();
}
```

(or send changes on the fly)

Game Communication

What to send?

- Entire world state is usually too much
- Can usually just send *user actions*
- also impacted by NPCs (we will see later)

"Fat Client"
(each client runs world simulation)

Advantages:

- Fast local updates
- Server handles message-switching

Drawbacks:

- Code/data duplicated on each client
- Need to *synchronize* client worlds
- Clients must be *deterministic*

"Thin Client"
(server runs world simulation)

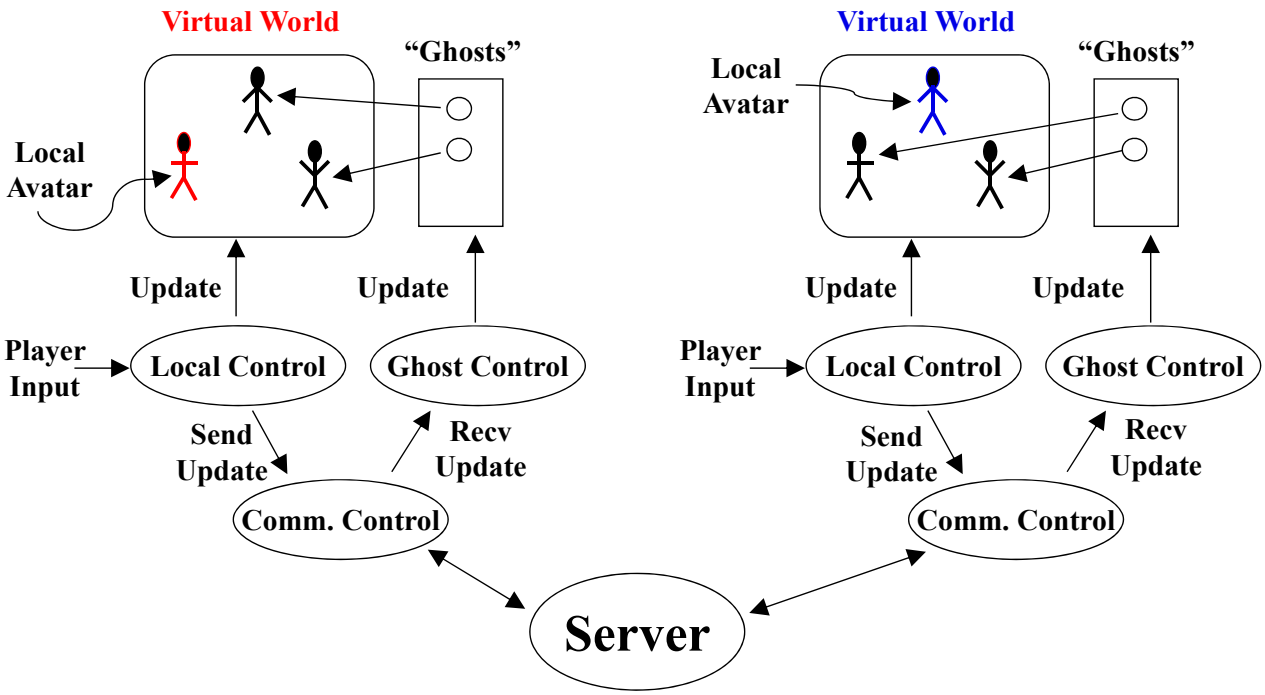
Advantages:

- Client can be *non-deterministic*
- Synchronization easier

Drawbacks:

- More network traffic
- Server bottleneck for all activity

NVE Fat-client Organization



Davison, Killer Game Programming in Java, O'Reilly

Example Game Protocol

Messages from Client to Server :

- **`CREATE (name, position)`**
  Informs server of a new world participant
- **`MOVE/ROTATE (amount)`**
  Informs server about a change in a client avatar
- **`DETAILSFOR (addr,port,position,orient)`**
  Informs server of local avatar position/orientation
  (intended for forwarding to another client)
- **`BYE (name)`**
  Informs server that client is leaving

Davison, Killer Game Programming in Java, O'Reilly

Messages from Server to Client :

- **`CREATE (name, position)`**
  Informs client that a new remote avatar exists
- **`MOVE/ROTATE (senderName,amount)`**
  Informs client of a change in status of a remote avatar
- **`WANTSDETAILS (addr,port)`**
  Informs client that a remote client wants a local status update
- **`DETAILSFOR (senderName,pos,orient)`**
  Provides client with updated status of a remote avatar
- **`BYE (name)`**
  informs all clients with the name of a client who quit

Example Protocol Processing

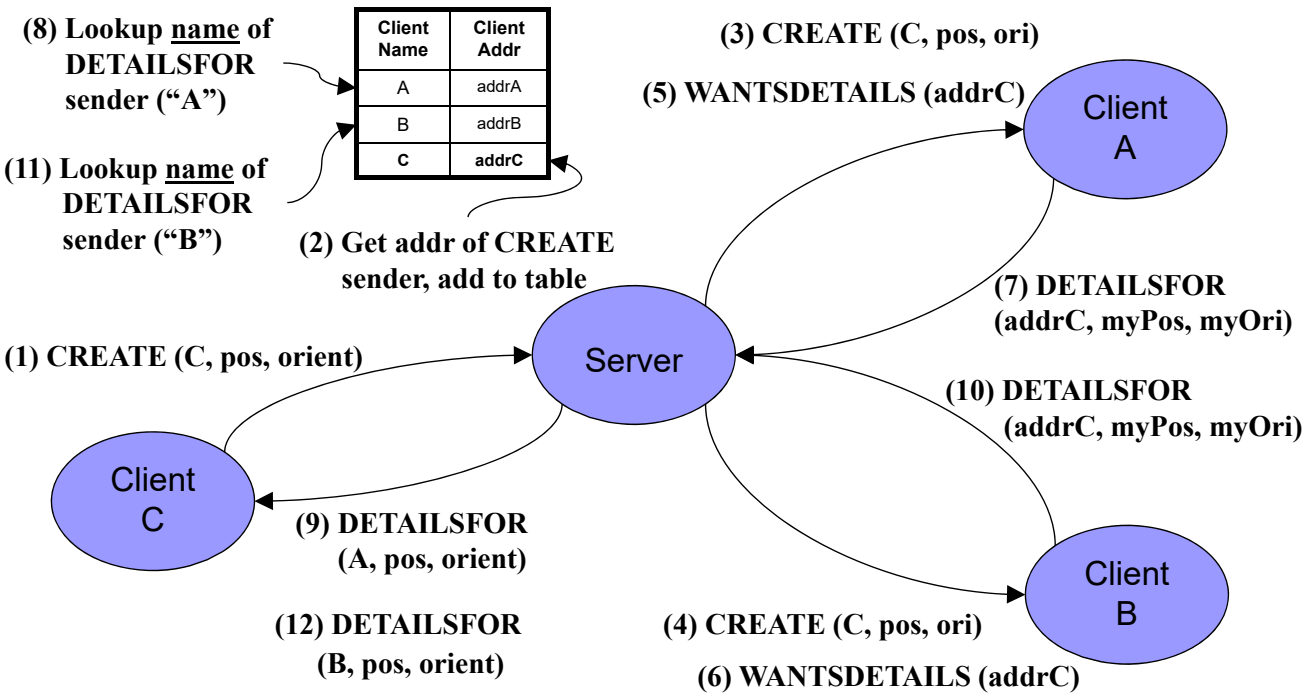
Server Handling:

- **`CREATE (name,position)`**
  - Save name and corresponding IP/port
  - Forward **`CREATE`** message to all other clients
  - Send **`WANTSDETAILS(addr,port)`** to all other clients
- **`MOVE/ROTATE (name,amount)`**
  - Look up sender name
  - Send **`MOVE/ROTATE`** message to all other clients
- **`DETAILSFOR (addr,port,position,orientation)`**
  - Look up sender name
  - Send **`DETAILSFOR(sender,pos,orient)`** to <addr,port>

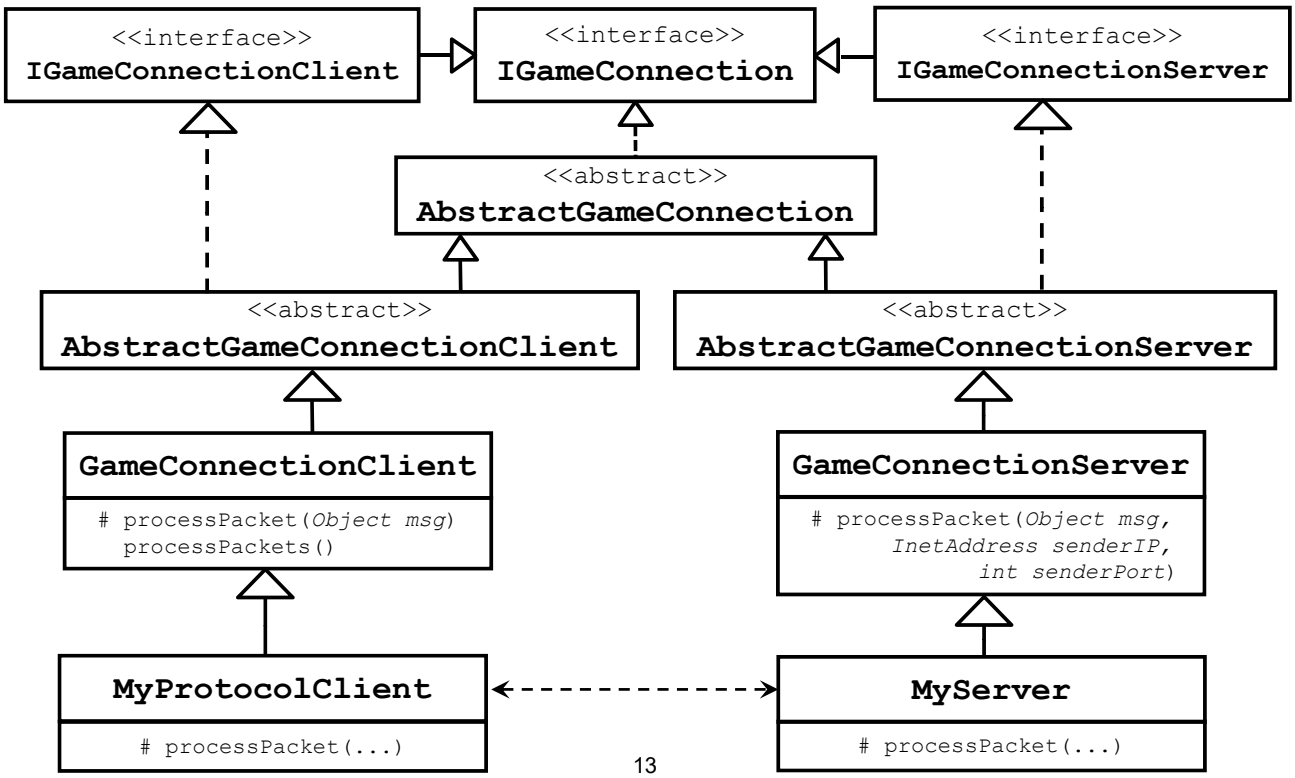
Client Handling:

- **`CREATE (name, position)`**
  - Create Ghost avatar
- **`MOVE/ROTATE (senderName, amount)`**
  - Update Ghost avatar for sender
- **`WANTSDETAILS (addr, port)`**
  - Get local avatar position/orientation
  - Send **`DETAILSFOR(addr,port,mypos,myorientation)`**
- **`DETAILSFOR (senderName, position, orientation)`**
  - Update Ghost avatar for sender

Sample Protocol Sequence



Networking Support in RAGE



Networking in RAGE (continued)

server side:

- extend **`GameConnectionServer`**
- override constructor, calling parent class constructor with port and type (typically UDP)
- override **`processPacket`**(…), implementing desired protocol
- if the message represents a first message from a new client, use **`addClient`**(…), getting the client's info using **`createClientInfo`**(…)
- To send messages to clients, use **`sendPacket`**(), or **`sendPacketToAll`**(), etc.

client side:

- extend **`GameConnectionClient`**
- override constructor, calling parent class constructor with address, port and type.
- override **`processPacket`**(…), implementing desired protocol. This method is called each time another node (typically the server) sends it a message. The message is contained in a java Object passed as a parameter (typically a string).
- The game's update() method should call **`client.processPackets`**()

NVE issues

Naming

- Need some way to identify clients uniquely

Server Discovery

- Clients need a way of finding servers

Synchronization

- Need to keep the various simulations “in step”

Creating Unique Names

Class **`UID`** (“Unique ID”)

- Unique with respect to the current host
- Components:
  - Time, VM ID, Counter

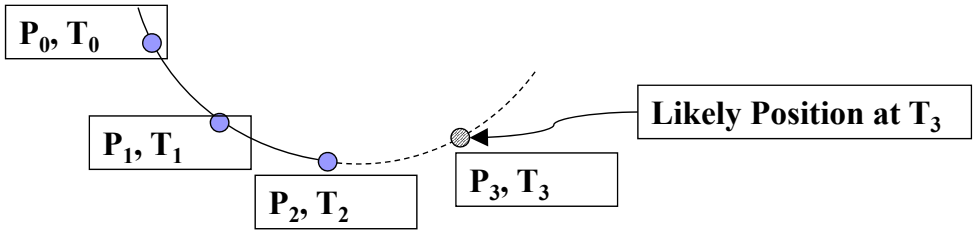
Class **`UUID`** (“Universally Unique ID”)

- 128-bit value, guaranteed unique world-wide
- Components:
  - Time, VM ID, Counter, MAC address
- Potential security issue: publishing MAC addresses
  - Partial solution: random UUIDs

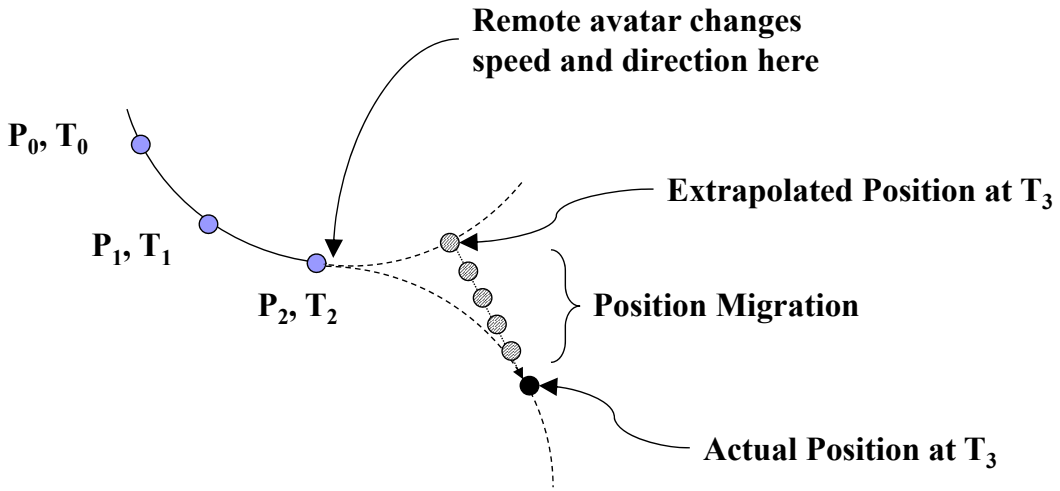
```
UUID newID = UUID.randomUUID();
```

Synchronization issues

- Latency can cause “freezing”
- Solution: *data prediction*
  - Clients retain position “history” for ghosts
  - Extrapolate “likely next position” from history (typically use a quadratic polynomial)



Correcting Prediction Errors



Additional Synchronization Issues

Potential inconsistencies in code

- Different handling of user actions
- Different (pseudo-) random sequences

Divergence in worlds

- Small errors can lead to *big* divergence

Game protocol should allow for this

(or assume the code is "perfect"…)

- Example: "resynchronize" protocol
  Causes "jumps", uses "smoothing algorithm"

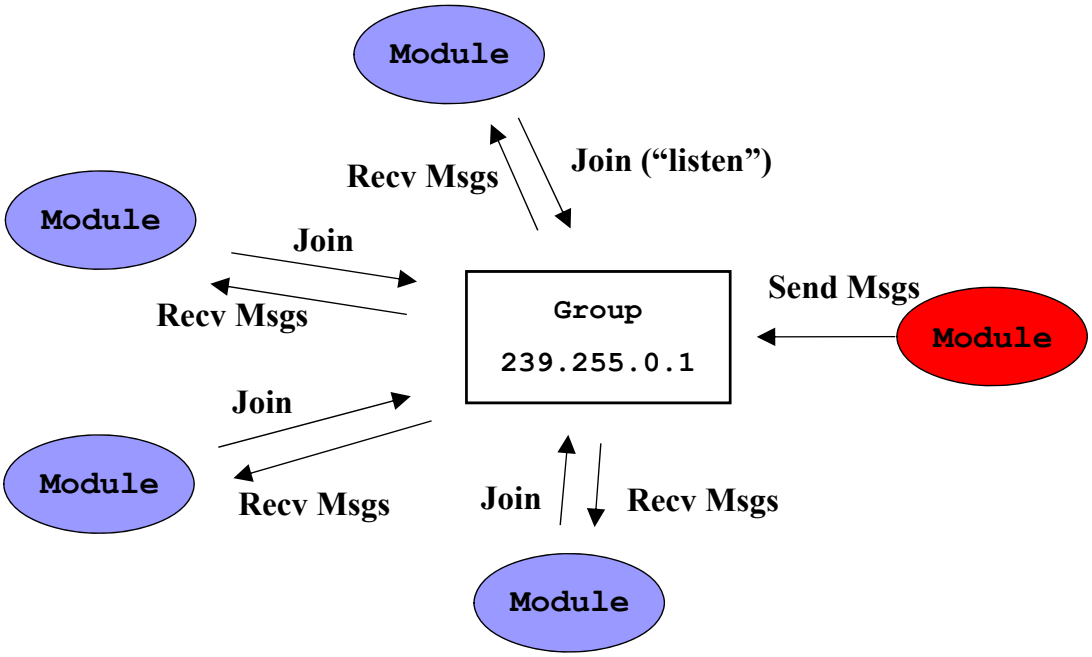
Server Discovery

Client must know how to contact server

Various approaches:

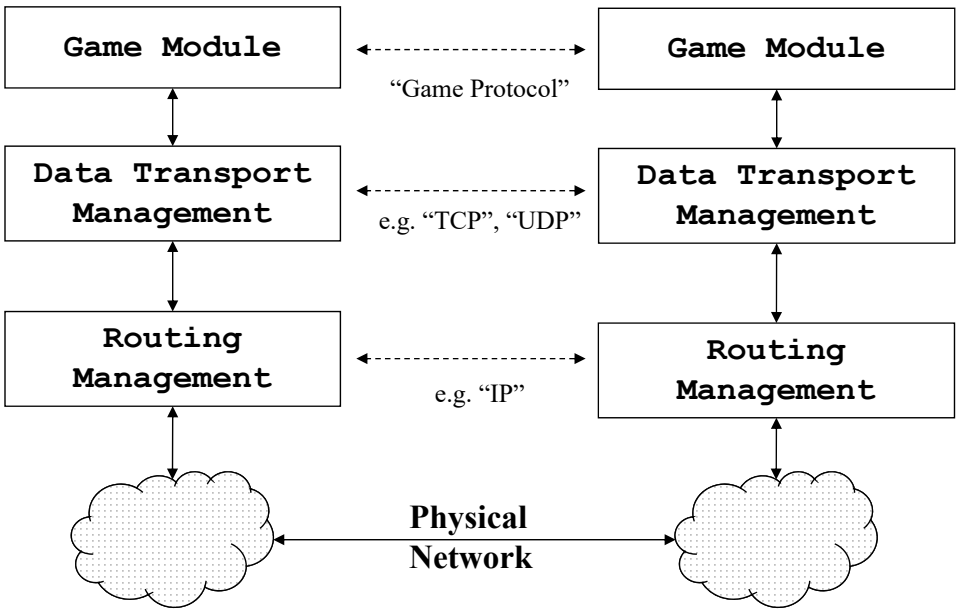
- "Hard-coded" in client
- Player-provided to client at startup
  - Command line
  - Interactive prompt
- "Multicast" groups

Multicast Groups



Networking Internals

Protocol Stacks



TCP vs. UDP

- **TCP** – sender verifies packet is received
  - more reliability
  - good for file transfers
- **UDP** – sender just sends; no verification of receipt
  - faster speed
  - good for real-time broadcasts, or games

Connection Abstraction: SOCKETS

- Socket: end-to-end connection
  - Can operate in either TCP or UDP mode
- Programs read/write socket
  - Can ignore underlying mechanism