Distributed Scene Graph to Enable Thousands of Interacting Users in a Virtual Environment

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Outline

- Scalability barriers
- Current server architecture
- Distributed Scene Graph
- Client Manger prototype
- Experimental setup & Results
- Conclusions & Future work

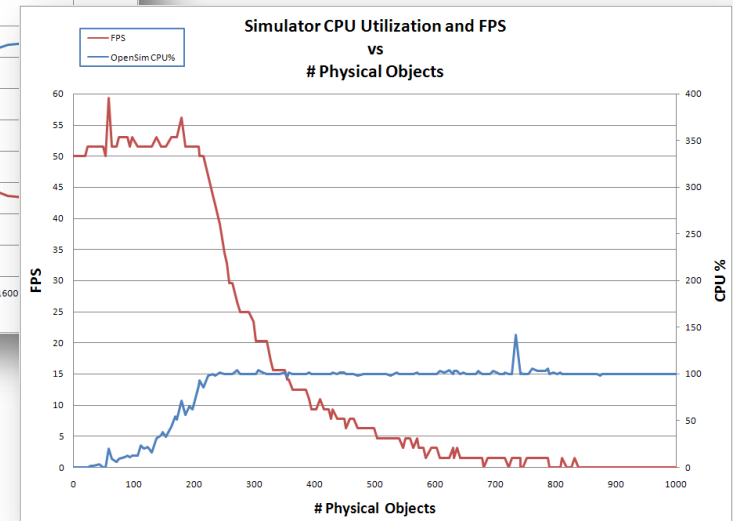# Grand Challenge: Scalability

50,000 Avatars

500 Avatars
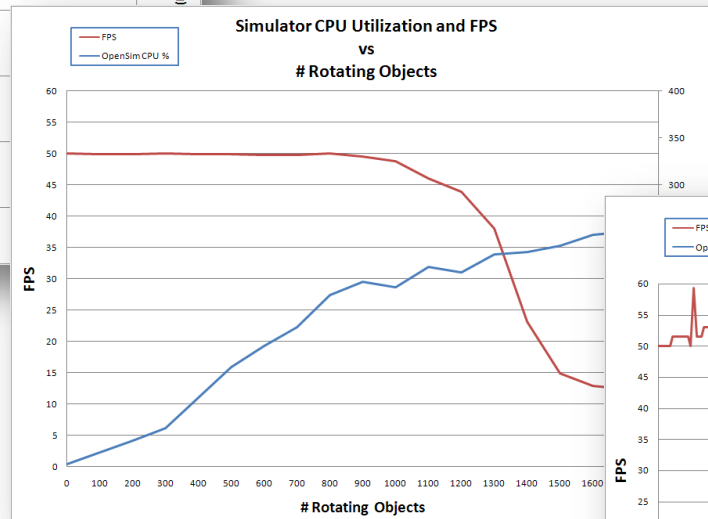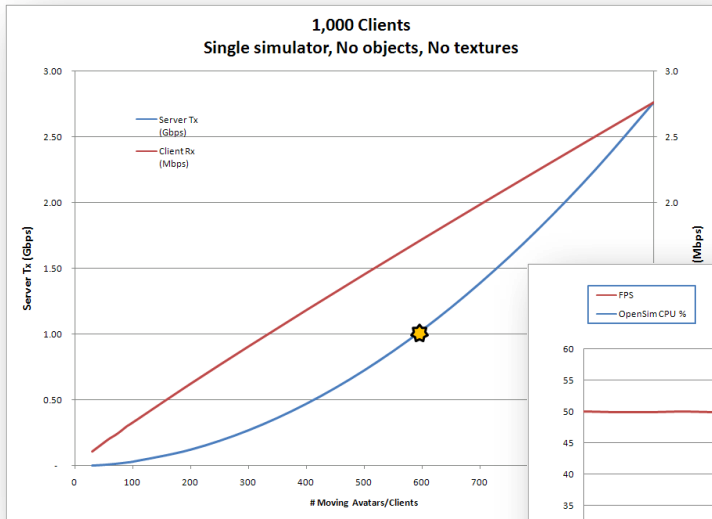
50 Avatars

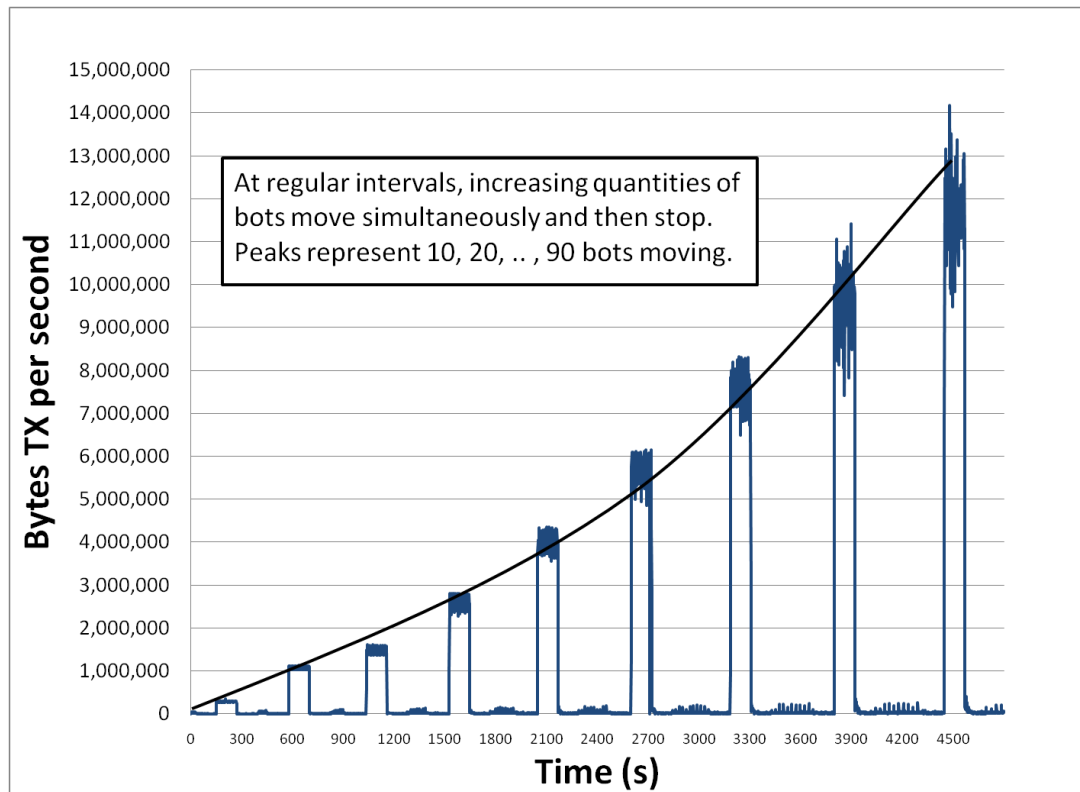Scene Complexity, Concurrent Users & Interactions

Scalability Barriers
## Concurrent users, Script execution, Physics simulation

Scaling Concurrent Users

- Interactions critical for an immersive experience
- Communication grows exponentially with interactions

At regular intervals, increasing quantities of bots move simultaneously and then stop. Peaks represent 10, 20, .. , 90 bots moving.

Current Server Architecture

- Scene and actors are combined
  - Scene defines space and stores objects
  - Script engine, physics and client stack acts on it

Frame Rate vs. Interacting Clients
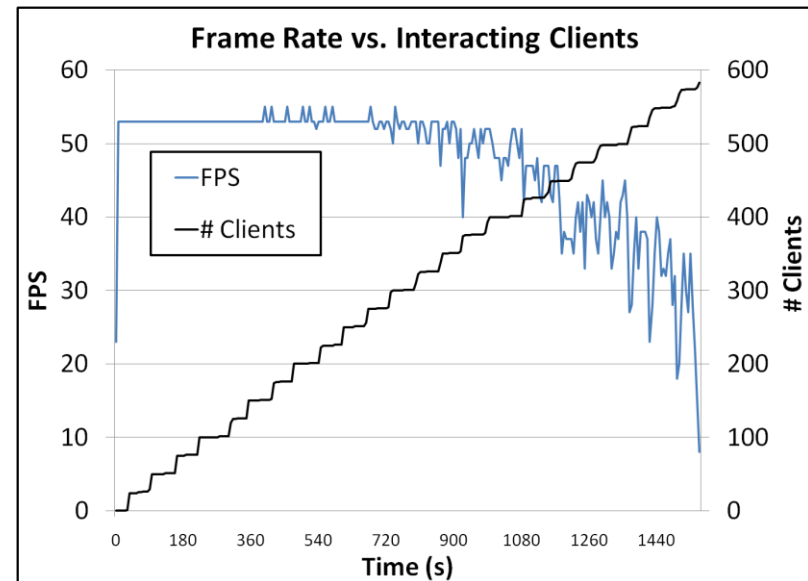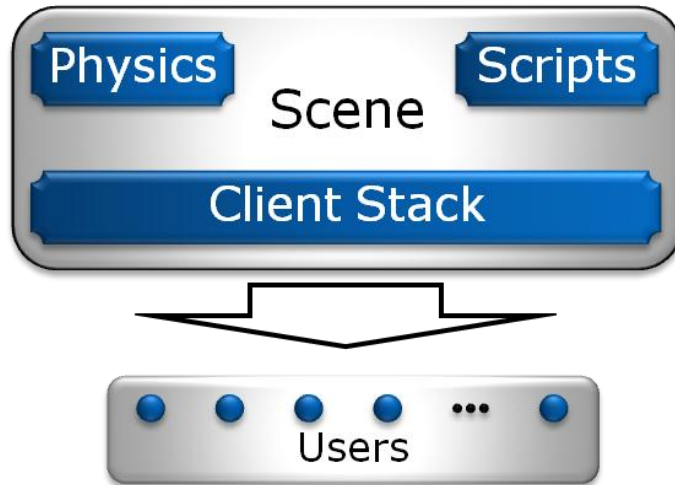
- Does not scale up with additional hardware
- Sharding and partitioning scale by limiting interactions

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Our Approach: Distributed Scene Graph

- Scene and actors distributed across multiple servers

- Performance of a scene scales up with hardware

- Scene
  - Spatially partitioned
  - Provides interface to actors

- Actors
  - Operate independently and asynchronously
 - Use heterogeneous hardware best suited for workload
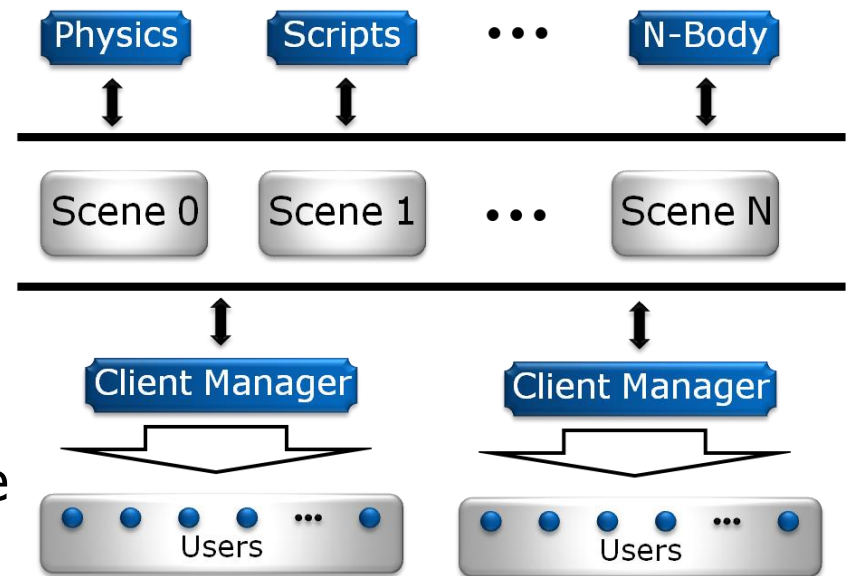
Winter Simulation Conference
Scaling Virtual Worlds: Simulation Requirements and Challenges
Huaiyu Liu, Mic Bowman, Robert Adams, John Hurliman and Dan Lake (Intel)

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Proof Point: Client Management

- Servers provisioned for networking
- Pushes client inputs into scene through interface
- Subscribes to scene updates and passes to clients
- Could implement reduction or filtering
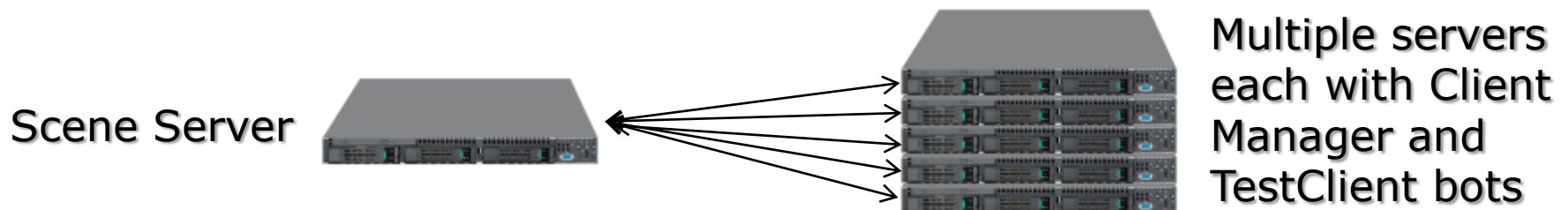- Geographically distributed
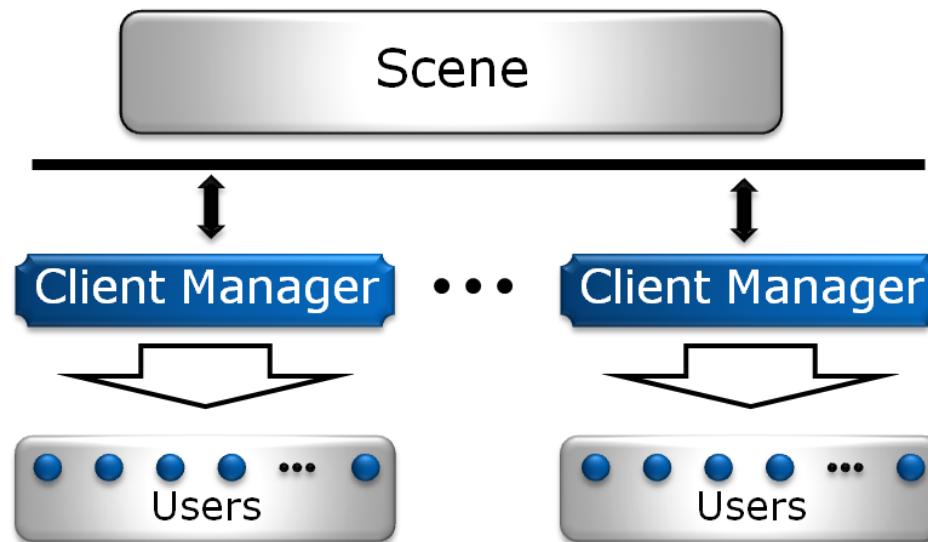
Client Manager Prototype

- Uses OpenSimulator server software
- Region modules implements scene interface
  - Add, delete and update avatars and objects
  - Same binary is configurable as different DSG components
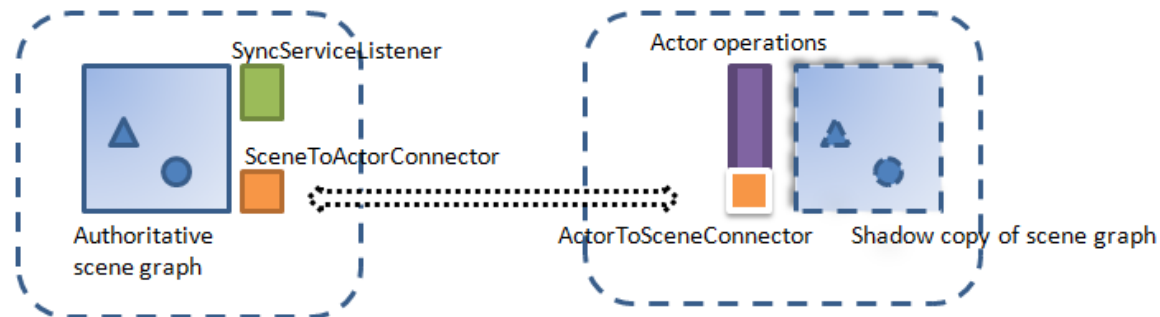
Experimental Setup

- Single scene server with a region of virtual space
- Multiple client managers in different configurations
  - 10 client managers
  - 3 client managers in different geographies
  - Connected 100-250 bots to each client manager
- Bots connect to client manager and wander about
- Testclients on same machine w/few remote clients

Scene Server

Multiple servers each with Client Manager and TestClient bots

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Experimental Setup

Scene server

Client Managers

1000 TestClient bots

Oregon, USA

Utah, USA

California, USA

New York, USA

Real users

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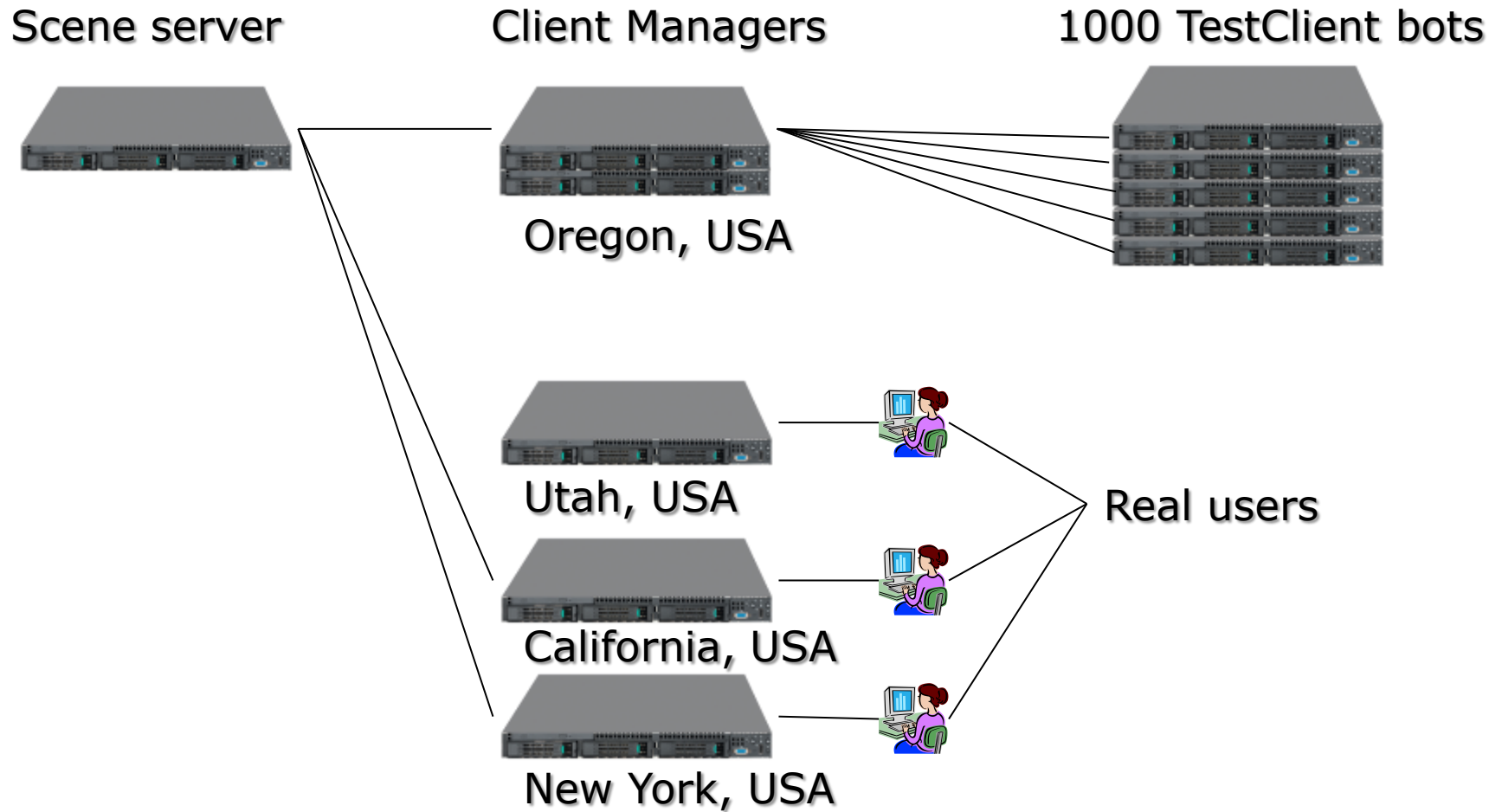
Experimental Environment

The 3rd International Workshop on Massively Multiuser Virtual Environments (MMVE 2010)

Results

- Demonstrated >1000 interacting clients
  - 13 client managers across multiple geographies
  - 1000 bots and 20 humans connected to client managers
- Network processing on scene reduced 99%
- Scaling of prototype limited by physics simulation

	Monolithic Server	Client Managers
Supported clients	400	750
Load on scene server	50%	12%
Client scaling Limit	800	>6000

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Conclusions

- DSG scales out scene with additional hardware
- Client managers enable thousands of interacting concurrent users

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Future Work

- Scaling physics simulations with DSG
- Continue research of robust scene interface
- Experiment with clients over Internet

The 3rd International Workshop on Massively Multiuser Virtual Environments (MMVE 2010)