An Implementation of a First-Person Game on a Hybrid Network

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The 1st International Workshop on
Massively Multiuser Virtual Environments
at IEEE Virtual Reality 2008

March 8th, 2008, Reno, Nevada, USA

Outline

1. Introduction and Background
2. Frontier Sets and their Use
3. Hybrid Networking & Latency Impact
4. Live Test on Modified Quake 3 Arena
5. Conclusions and Future Work

1. Introduction

- MMVEs need to exploit awareness relationships between players in order to scale
- MMVEs need to delegate “local” communication to peers
  - Mitigates congestion
  - Provides lower latency
- However awareness is difficult to compute over peer-peer networks, as it must be constantly re-evaluated

Goals

- Support awareness management on a peer-peer network
  - Uses a hybrid networking mechanism
  - No assumptions about peer-peer reliability
  - Fault tolerant
- Practical implementation, not a simulation

- Utilises the fact that for awareness management

  “Negotiated ignorance is bliss”

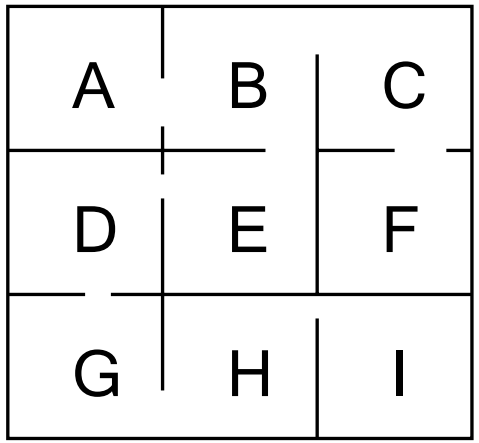
Previous Work

- Networks CVE and games have received a lot of attention (Singhal and Zyda, 1999)
- Peer to peer is fairly uncommon, but e.g. SIMNET, Age of Empires
- Most research work has focussed on partitioning the world into separate locales
  - E.G. NPSNET, Spline
  - Algorithms tend not to deal well with rapid changes in areas that are congested

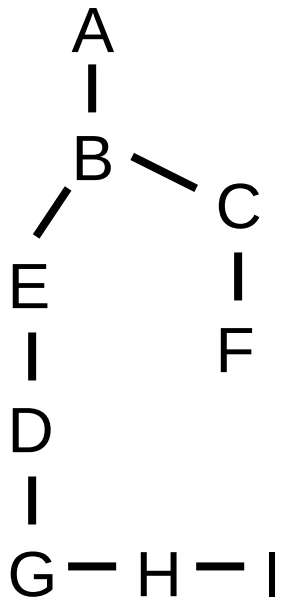
Previous Work

- Can use the geometry of the space itself to partition users
  - E.G. Funkhouser's RING systems exploited a potentially visible set to perform message filtering on a central server network
- Alternatively can make partitions of the plane to create *update free regions*
  - Y. Makbili, C. Gotsman and R. Bar-Yehuda. *Geometric Algorithms for Message Filtering in Decentralized Virtual Environments*. Proceedings of the ACM Symposium on Interactive 3D Graphics, 1999.

Cells and Portals



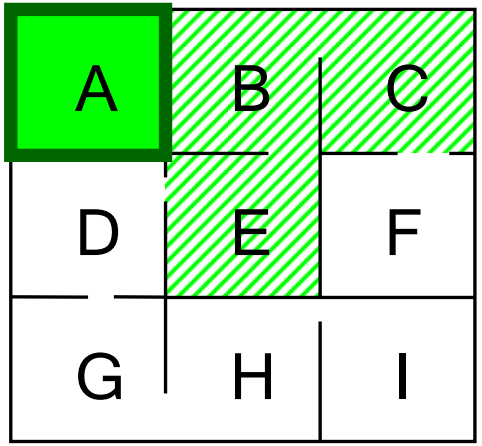
Cells



Portals

Airey, Rohlf and Brooks, 1991, Teller and Sequin, 1991

Potentially Visible Set (PVS)



PVS_A

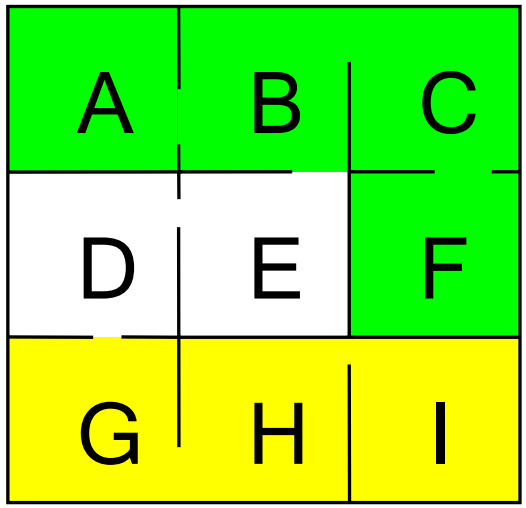
A	B	C	D	E	F	G	H	I	
-	1	1	0	1	0	0	0	0	A
	-	1	1	1	1	0	0	0	B
		-	0	1	1	0	0	0	C
			-	1	0	1	1	0	D
				-	0	1	0	0	E
					-	0	0	0	F
						-	1	1	G
							-	1	H
								-	I

Full PVS

Airey, Rohlf and Brooks, 1991, Teller and Sequin, 1991

2. Frontier Sets

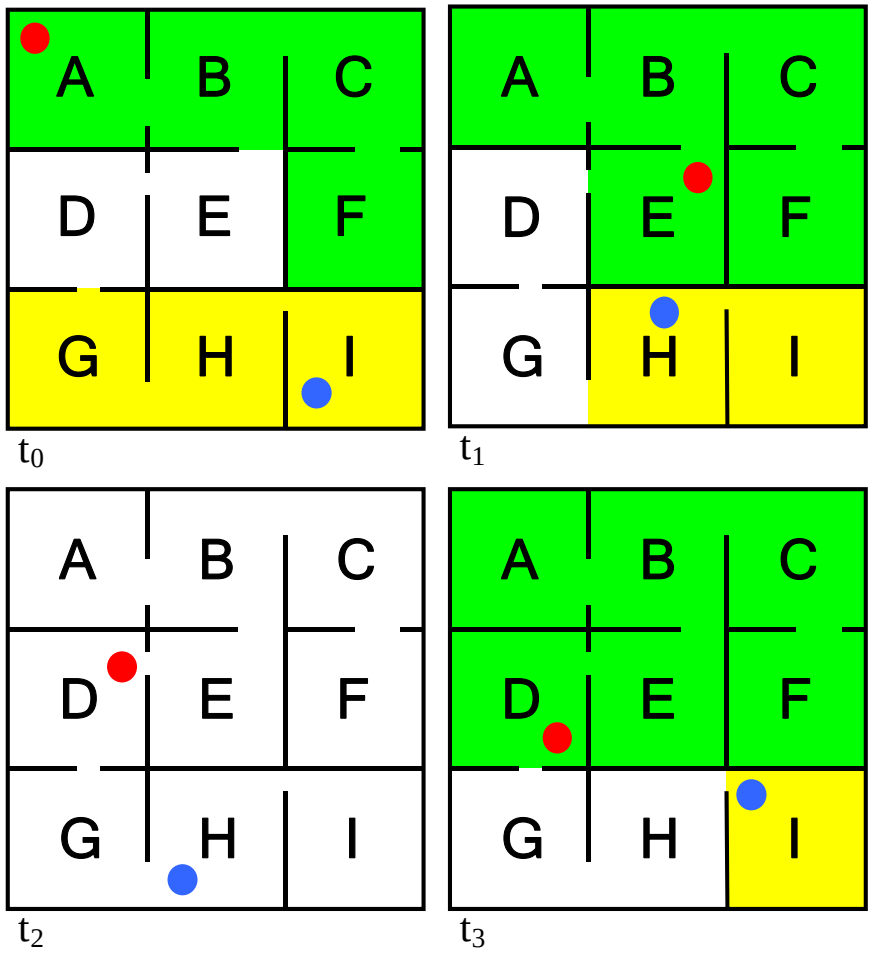
- For a pair of cells, a frontier comprises two sets of cells, such that no cell in one set can see any cell the other
  - If the two cells see each other, there is no frontier
  - We assume that a symmetric PVS has been pre-calculated
  - There are many possible frontiers for a pair of cells



$F_{AI} = \{A,B,C,F\}$

$F_{IA} = \{G,H,I\}$

Using Frontiers for a CVE

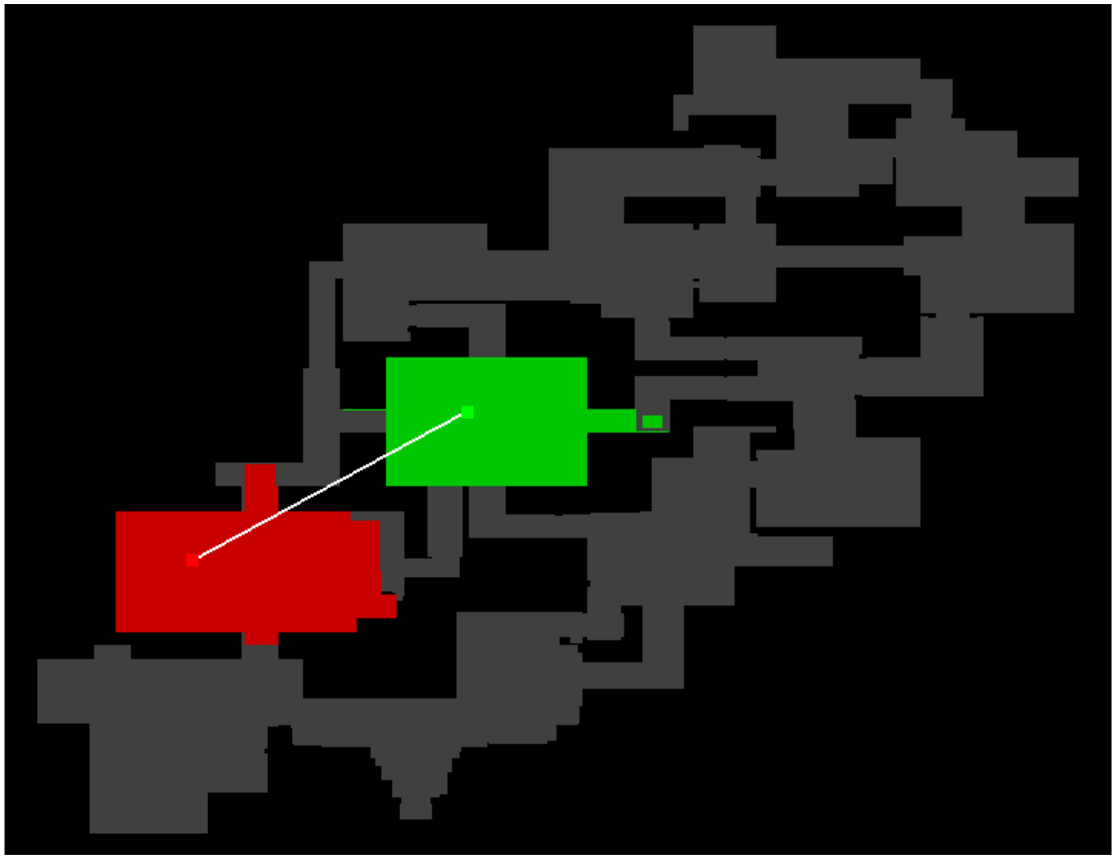


- t_0 Red and Blue are mutually invisible, a frontier exists
- t_1 A new frontier exists
- t_2 No frontier exists
- t_3 A new frontier exists

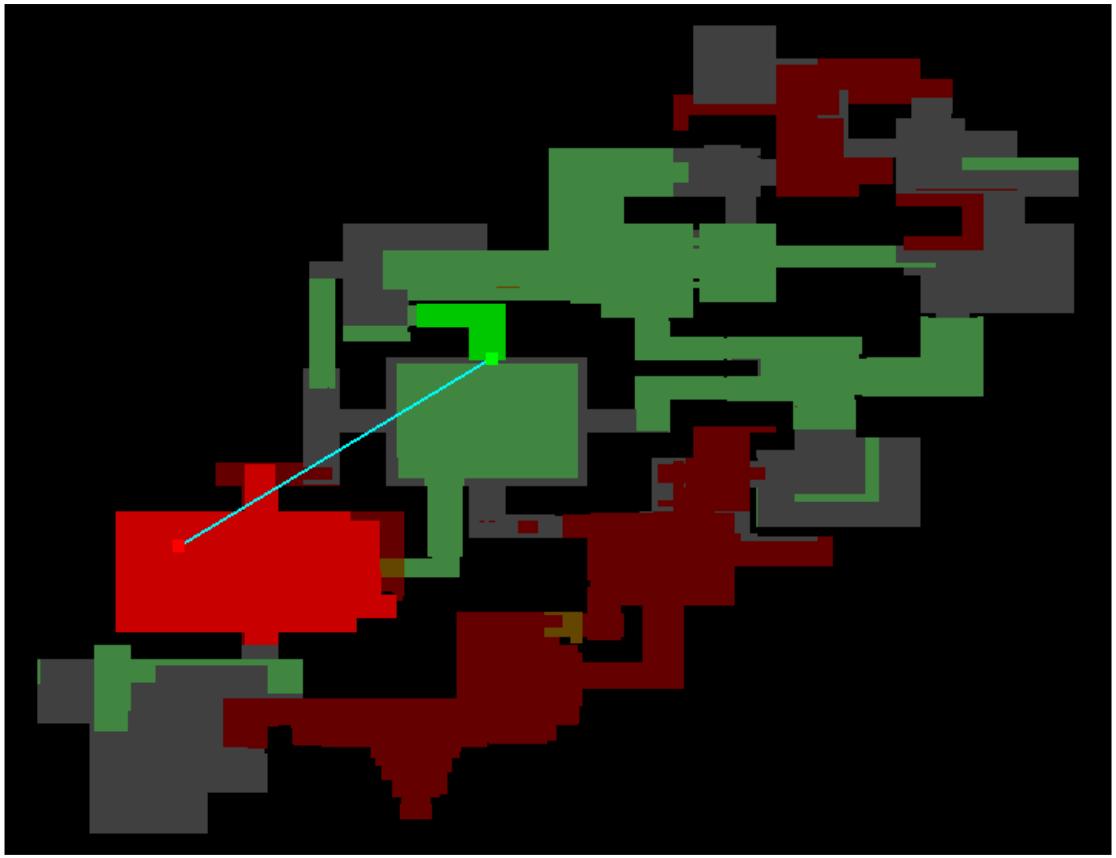
Using Frontiers for a CVE

- Frontiers can be used in a peer-to-peer CVE networking protocol
  - Trivial overhead on a normal “position update” packet
- Frontiers are independently verifiable at either site
  - No central server is required to manage area of interest
  - More robust than 3rd party negotiation strategies

Frontiers in Use



Frontiers in Use



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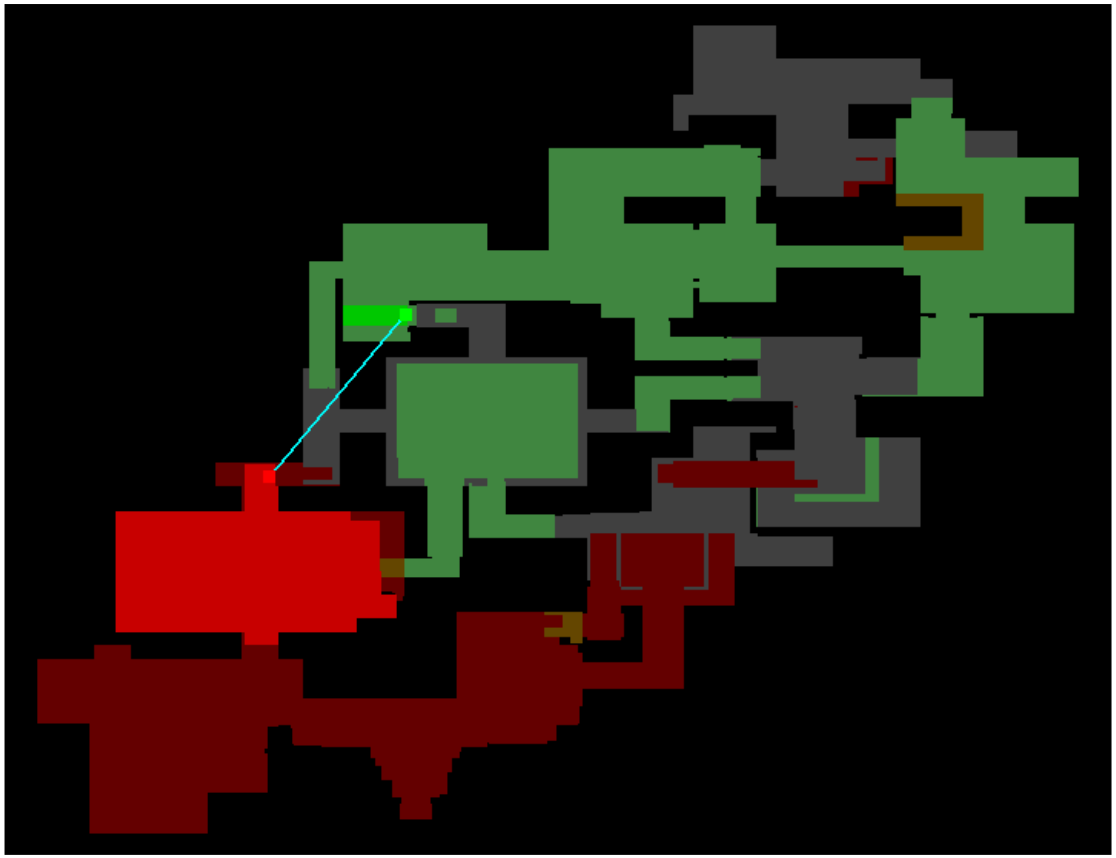

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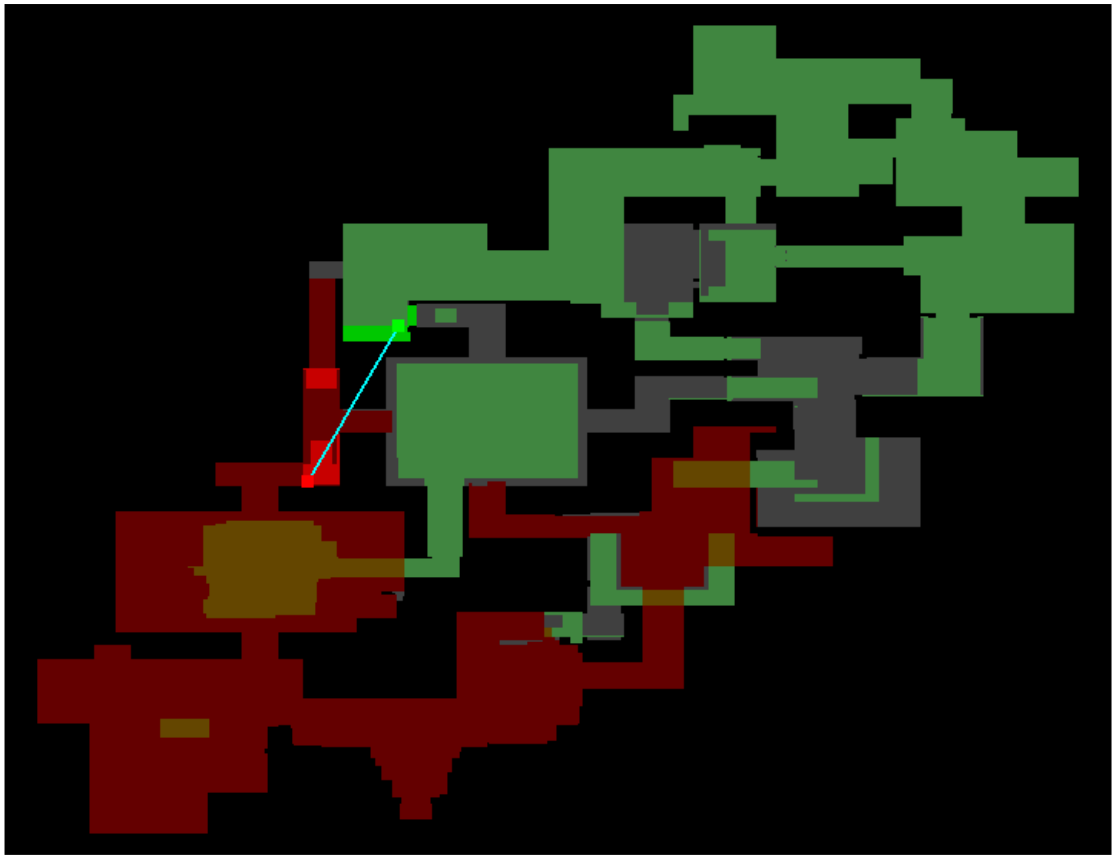

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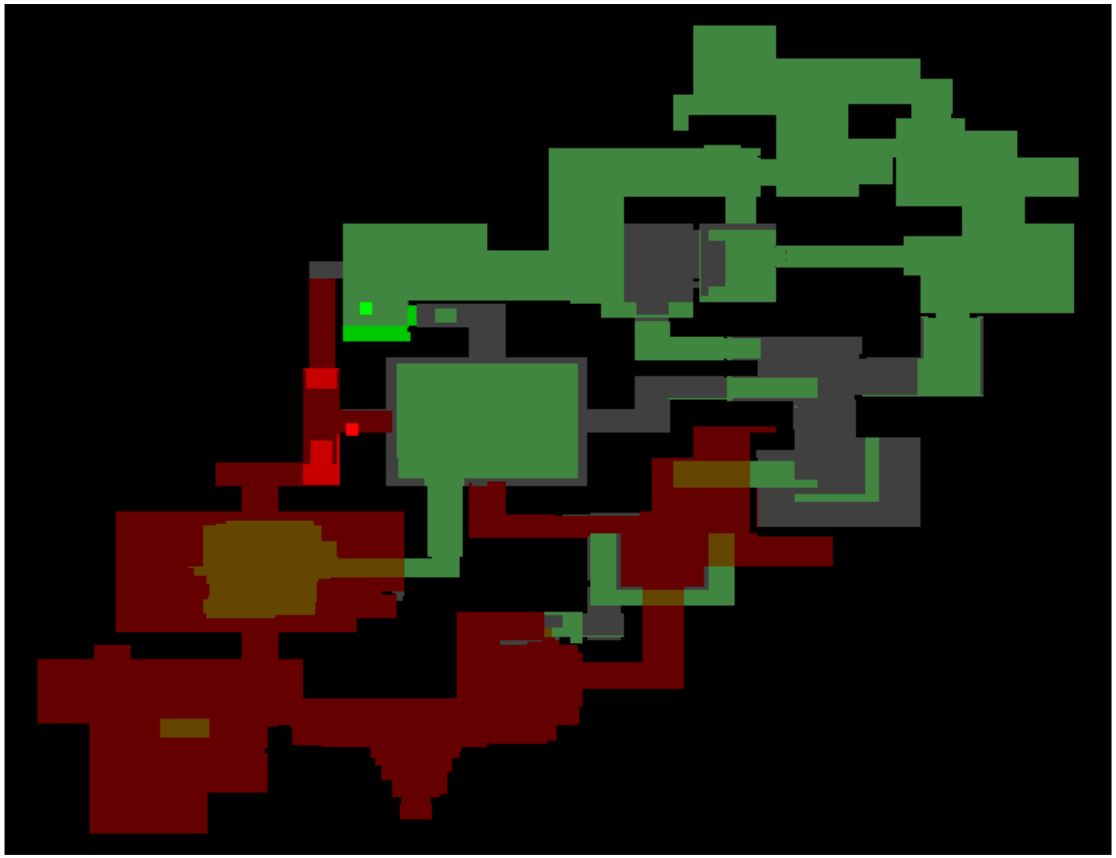

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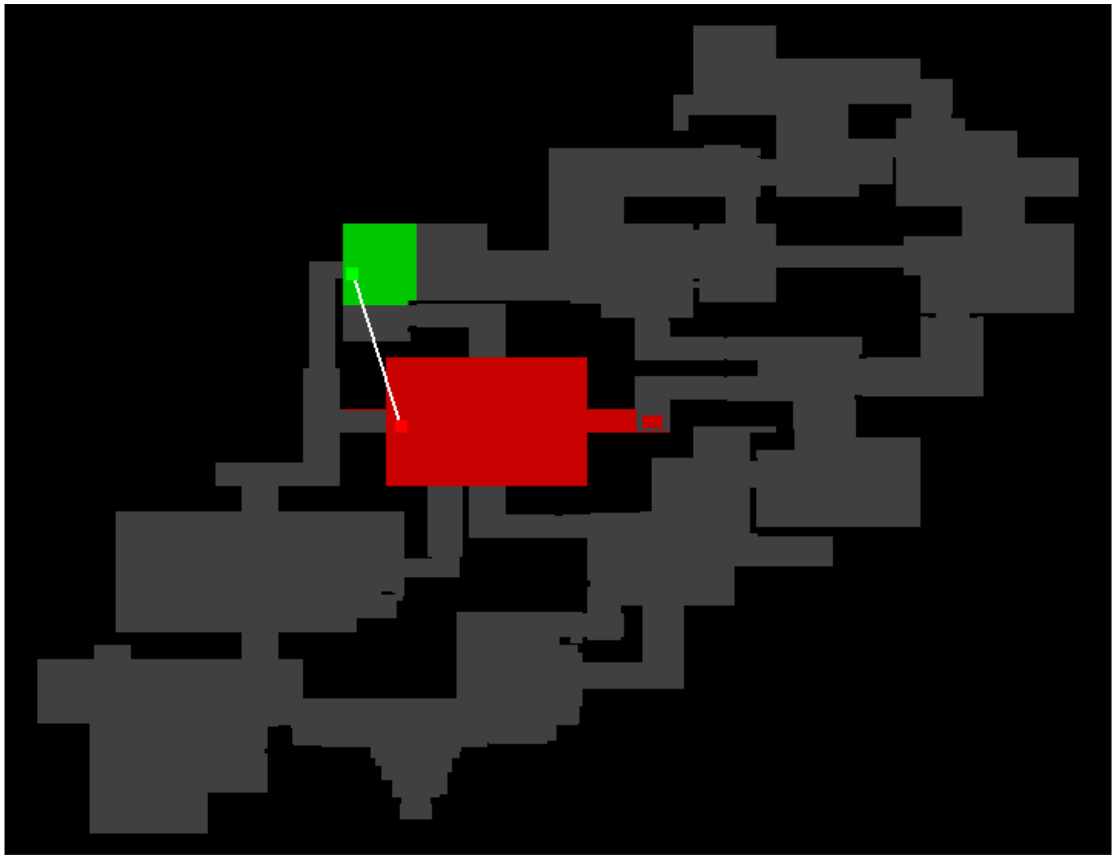

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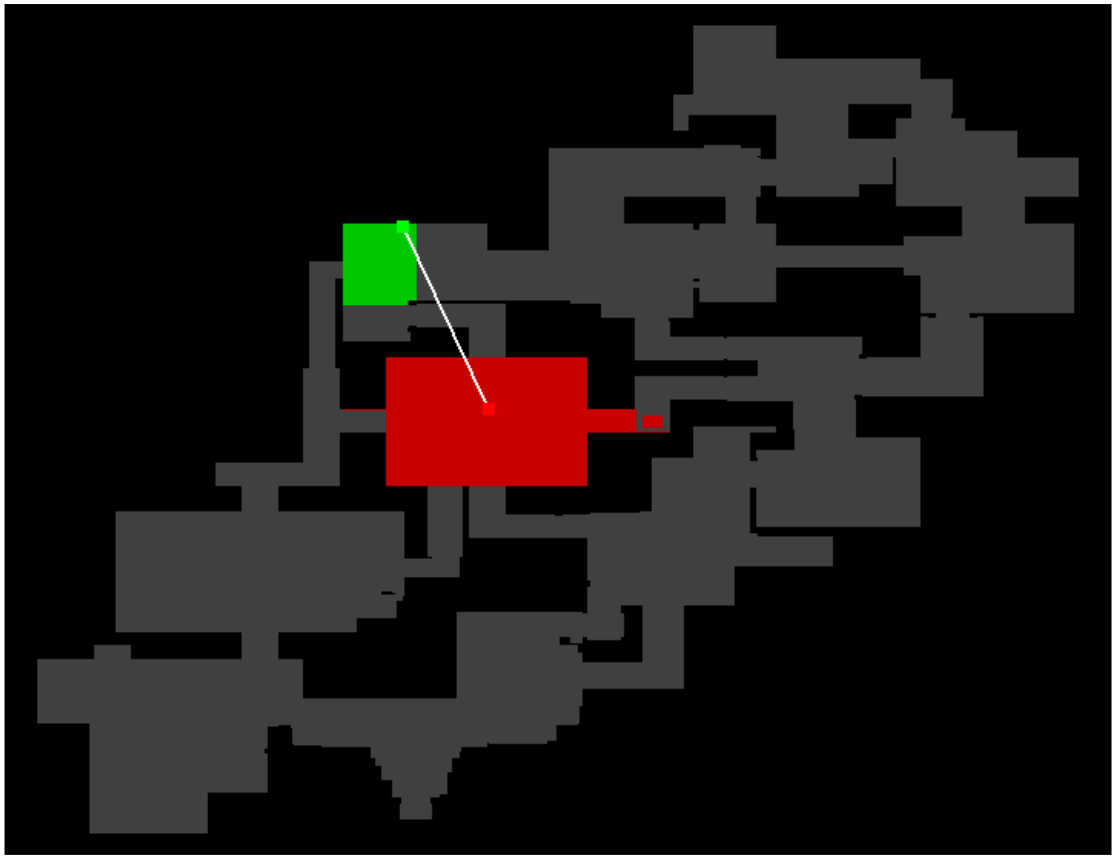

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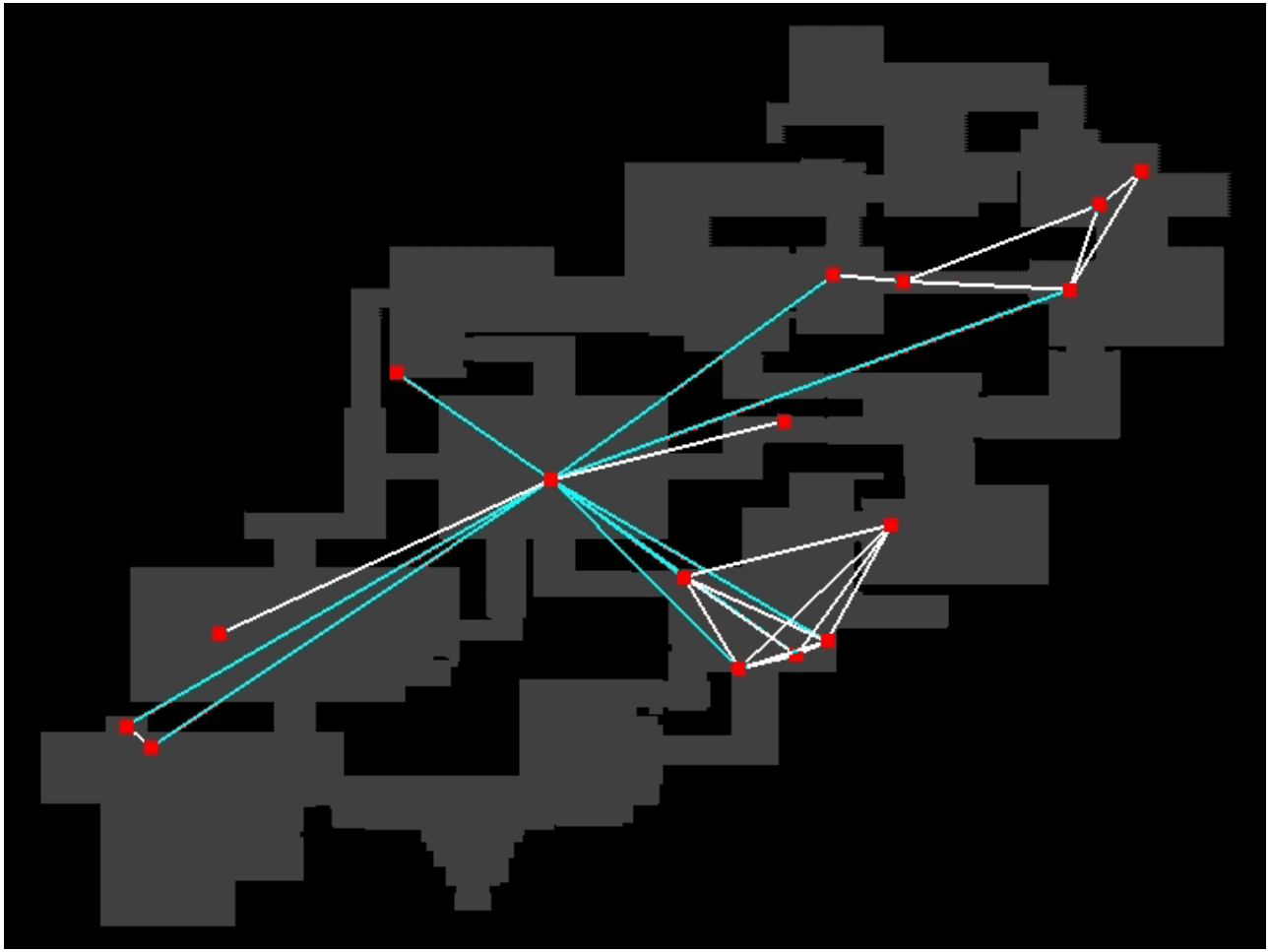
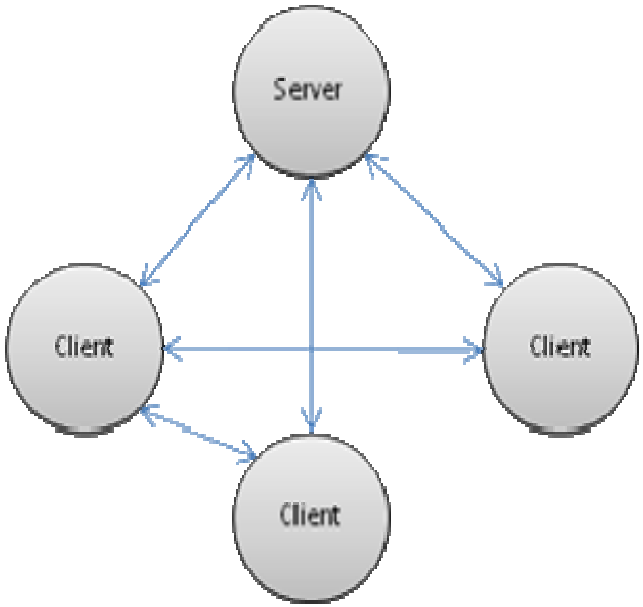


3. Hybrid Networking & Latency Impact

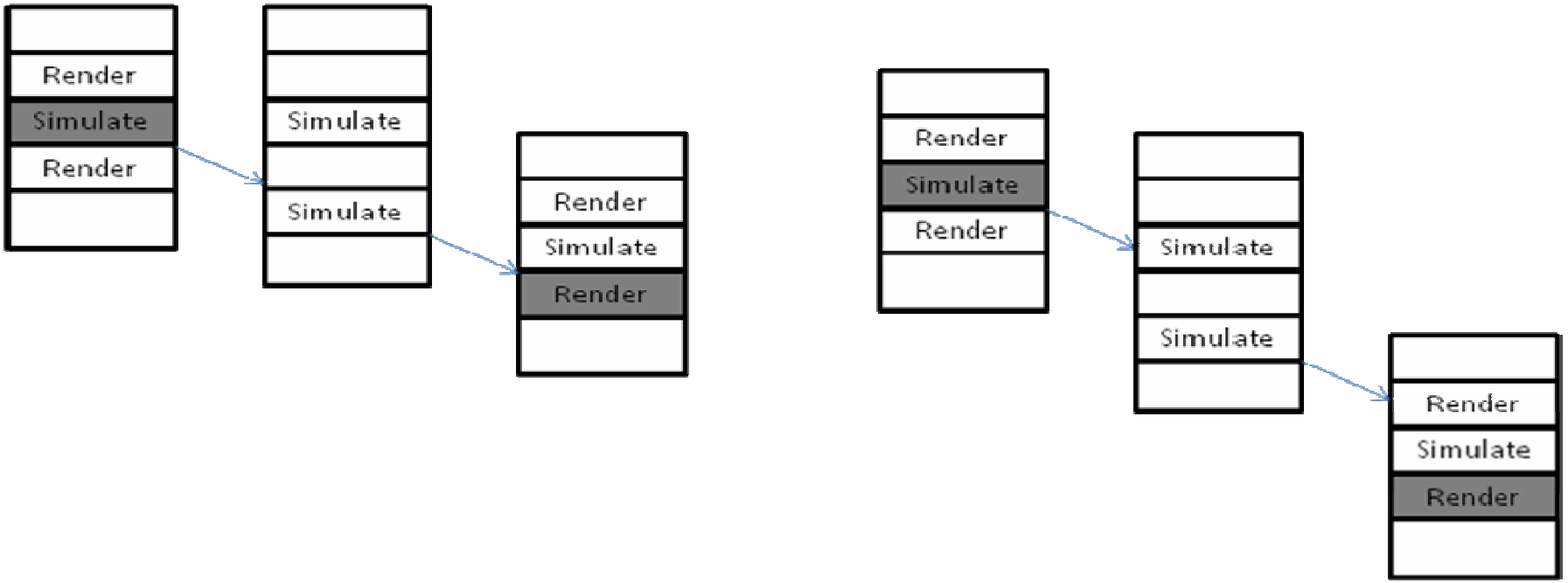
- Hybrid networking involves client processes bypassing the server for certain operations
- In FPS games
  - C-S for score, arbitration over kills, weapon event
  - P2P for position updates



Latency

- In a FPS latency leads to discrepancies
  - “Retrospective” kills
  - Appearance of firing weapons around corners
- Many sources of latency
  - Many games, inc. Quake 3 Arena have a fixed server tick rate
- Evidence that, other things being equal, players prefer low-latency servers

Best and Worst Case, Client-Server



Best and Worst Case, Peer-to-Peer

Note that latency is lower, but perhaps more importantly jitter is also much reduced

4. Live Tests in Quake 3 Arena

- Customised Quake 3 Arena to perform P2P in addition to C-S communication
  - Relatively easy to implement as uses UDP, so clients can send events directly to peer clients, once they know the UDP port.
  - Send position at frame rate ONLY to those participants who are known to be visible OR whose status with respect to frontiers is unknown
  - Some more CS packets to maintain peer lists, do statistics

Results

- The game continues to work

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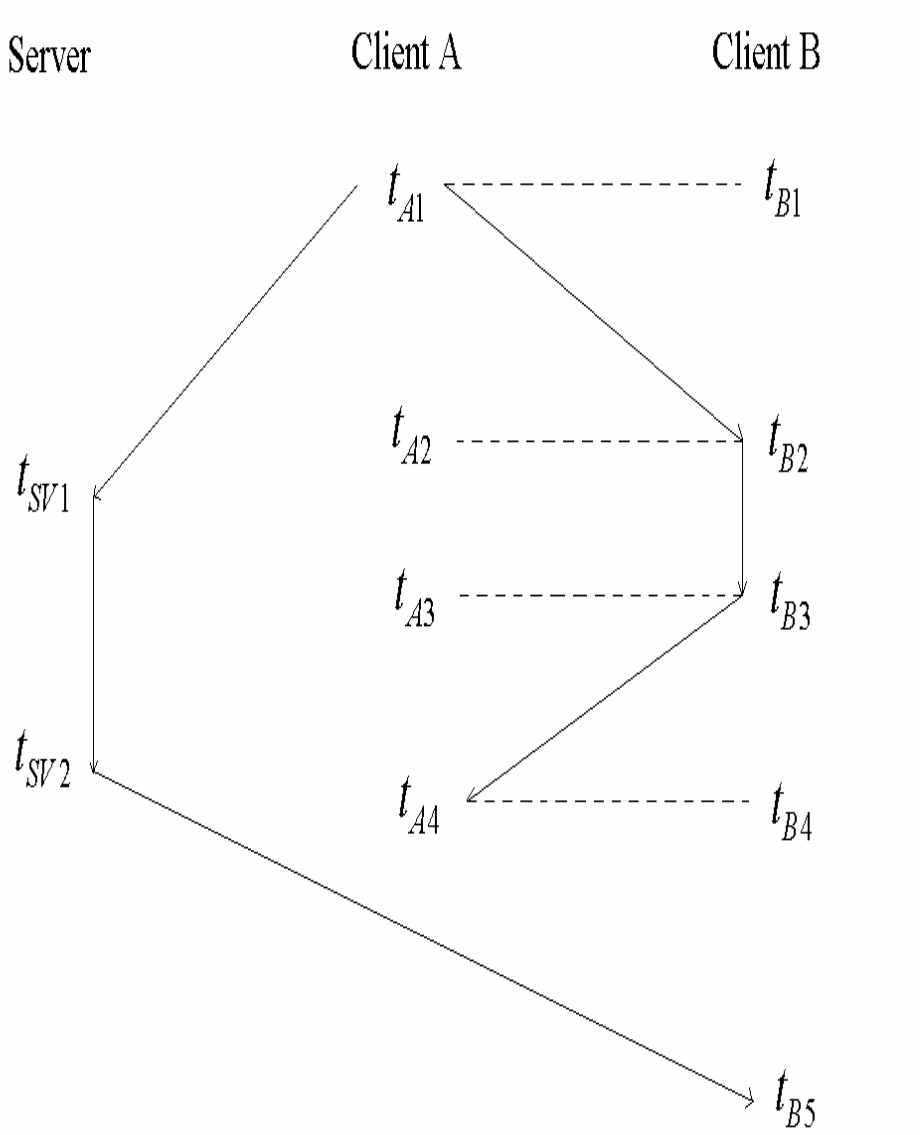
- The game continues to work
- At time of submission, a few tests had been done on the data throughput and latency for pairs
  - More trials being arranged

Latency

Timing	Δt_1	Δt_2	Δt_3
Mean	6.375	12.95	28.25
Std.dev.	2.804	5.633	11.77

Table 1 Timings of peer-to-peer single way, peer-to-peer two way, and client-server communication



Throughput

- Constantly, clients send about one packet every 4 frames to the server (this is rate limited)
- When the participants always share a frontier, there are is a single frame of P2P communication
- When the participants constantly see each other, they send one packet each frame to their peer.
- On average in a game they send about one packet every 4 frames to the peer
  - Note this wouldn’t scale linearly with number of players because the level is compact, and there is only one person to chase!

5. Conclusions

- One of very few practical hybrid networking implementations that would scale to large numbers of players
- Packet rates are low, and similar to that required to communicate to server
- Based on extrapolation from previous results on *simulations* with Quake 2 using log files of real games, the system should scale easily to large numbers
- We can use this to either support a better latency experience
  - OR by throttling the P2P traffic, and alleviating the server's requirement to relay packets, we could support more players on a single server

Further Work

- Will be setting up internal servers to support large numbers of players
  - Investigating mixed P2P aware & vanilla clients
  - Latency impact, and player experience
- Interested in extending this in to a awareness discovery mechanism
  - How do you find peers when you land in an area where there is no current communication?
- Potential for multi-server systems

Thank You

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Supported in part by the EU FET Project Presenccia