

Distributed Virtual Reality

Networked Virtual Environments

- Introduction
- History
- Networking issues
- VE state distribution
- Other systems
- Our Effort

Networked Virtual Environments

- Multiple users interact in real-time (although located around the world)
- A shared sense of space
- A shared sense of presence
- A shared sense of time
- A way to communicate
- A way to share

Terminology

- **Networked**
- **Virtual Environments (VE)**
- Distributed
- Virtual Reality
- Multi-user, ...
- Virtual Worlds, ...

History

- Military applications: **SIM-NET** → **DIS**
- Academic research: **NPSNET**
- Networked games: **Doom**, **SGI Dogfight**

SIM-NET

- Simulator networking, 1983-1990
- Department of Defense (DoD)
- Low-cost VE for training small units (tanks, helicopters, ...)
- Networked simulators making up virtual battlefield (850 units, ~1Mbps traffic)
- Effort to formally generalize and extend the SIMNET protocol → DIS (Distributed Interactive Simulation) protocol

DIS [IEEE 1278]

Distributed Interactive Simulation

- **Object-event architecture:** the world is a collection of objects interacting with each other by events (27 PDU: entity state, fire, detonation, collision, data, ...)
- **Autonomous simulation nodes:** nodes are responsible for distributing the state of objects they maintain
- **Dead reckoning:** predictive modeling algorithms, less network traffic, ghosts

NPSNET

- DoD technology was undocumented, unpublished
- It had to be reinvented, extended, published
- Academic research (Naval Postgraduate School NET Research Group)
- Origins – fiber-optically-guided missile (1986)
- “Wouldn't it be nice if the tank could be driven, too.”
- NPSNET-IV: DIS-compliant, dead reckoning, spatial sound, 60 players (SIGGRAPH 1993)

DOOM

- Shareware game, id Software, 1993
- Archetypical shooter
- Doom2, 1994, 1.6 million copies sold
- Main point: **popularity**

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Networking issues

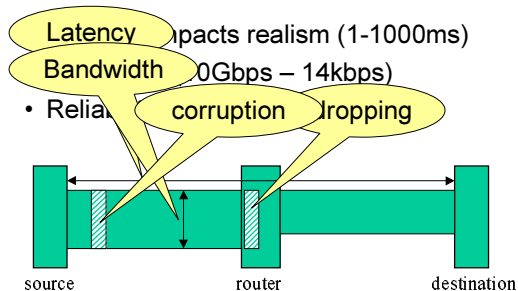
- Physical network
- Protocols
- Scale (LAN, WAN)

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Physical network



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Protocols - patterns

- 1:1 reliable connection
 - TCP/IP
- 1:1 unreliable best-effort delivery transmission
 - UDP
- 1:all best-effort delivery transmission
 - IP Broadcasting
- 1:many best-effort delivery transmission
 - IP Multicasting

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What the network distributes

Ideal situation:

all participants share the identical VE state

Static (fixed) Shared State – SSS

Initial Dynamic Shared State – initial DSS

Dynamic Shared State Updates – DSS updates

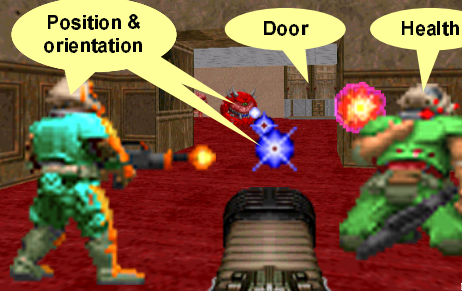
- Continuous
- Discrete

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Dynamic Shared State



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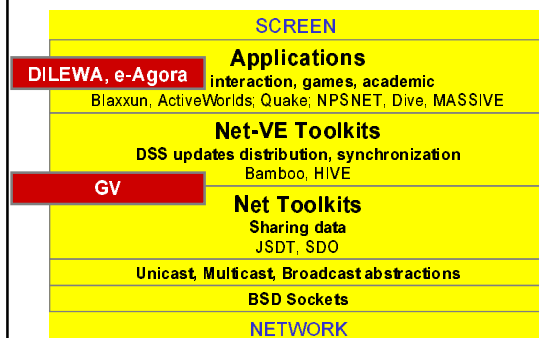
Continuous DSS updates

- o **Movement** of entities – changes of position and orientation (participants, vehicles driven by participants, objects manipulated by users, autonomous objects)
- o **Video and audio** streams
- **1:many best-effort delivery - multicasting**

Discrete DSS updates

- o Changes of entity **high-level state**. For example color of a table ($[R, G, B]$), state of a light bulb in the room (on/off), state of a door (opened/closed/locked), weather (shiny/raining), ownership of an entity
- o **Text** communication (chat)
- o **Introducing and removing** entities
- **1:1 reliable connection**

Hierarchy of net-VE solutions



Enhancing scalability and performance

- **Packet compression**
- **Packet aggregation**
- **Interest management (IM)**
- **Dead reckoning**
- **Level of detail (LOD)**
- **Additional servers**
- **Adaptive architecture**

Existing systems

- **Commercial**
 - Games and social interaction
 - Quake
 - Blaxxun
- **Academic**
 - Cooperation
 - NPSNET V
 - MASSIVE – 3
 - Dive

References

- **Study**
Postgraduate Study report DC-PSR-2001-16
Cooperation in multi-user virtual environments
Michal Máša
<http://www.cgg.cvut.cz/~xmasam/study.ps>
- **Book**
Networked Virtual Environments,
Sandeep Singhal, Michael Zyda.