Networked Virtual Spaces and Clouds

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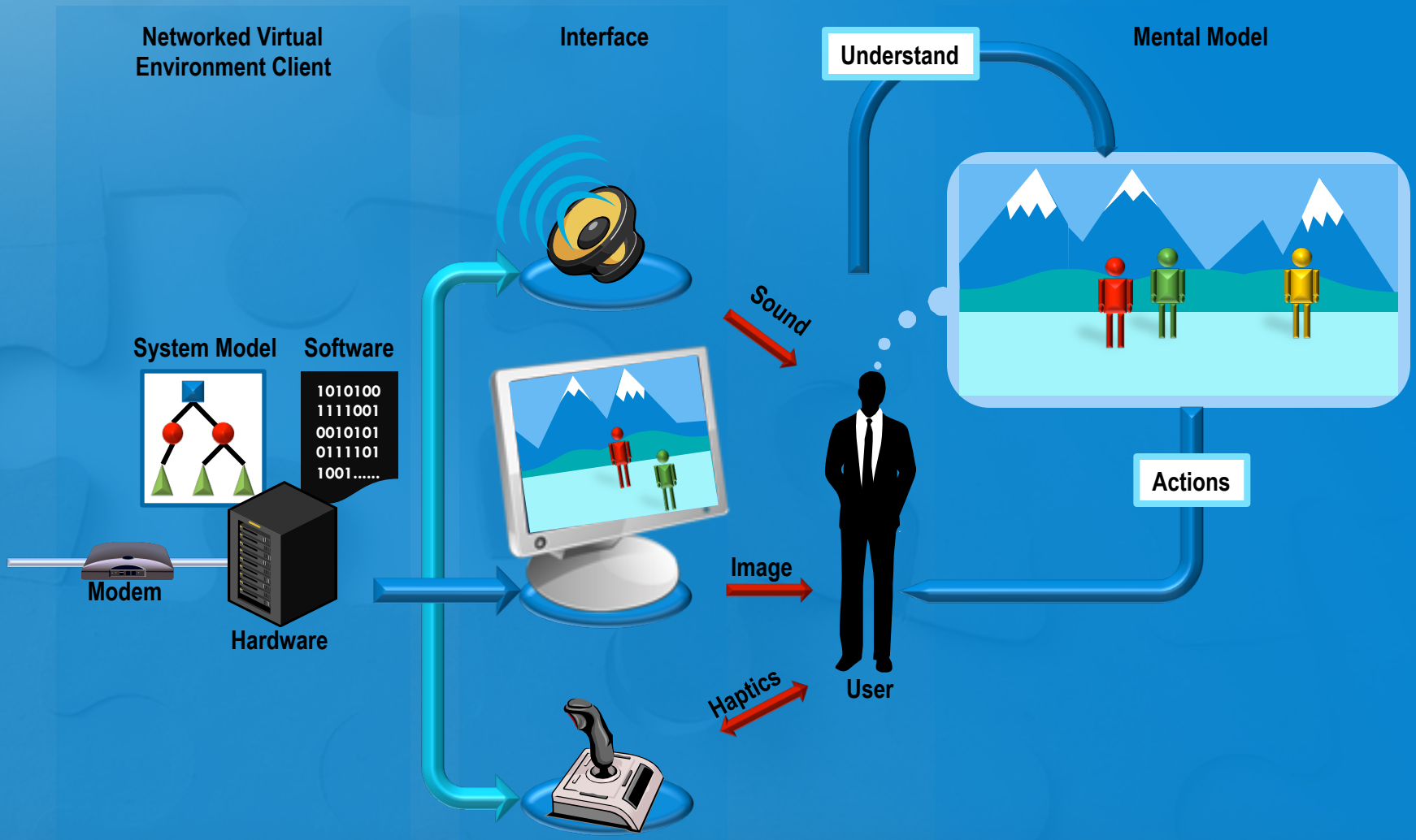
Outline

- Introduction to Networked Virtual Environments (NVE)
- Networked Virtual Environment Architectures
- Quality of Experience
- Clouds and real time interactions in NVE
- NVE as a Service
- Design issues for NVEs in the Cloud

Networked Virtual Environment



Networked Virtual Environments

- A shared (space, time, presence) 3D virtual environment
- All have Real-time changes
- Collaboration with other users
  - Representation of users in the world (typically as human-like avatars)
  - Objects that users interact with – cars, planes, etc.
  - Text and voice communication

Universal Campus

Immersive Exercising

Broad Definition of NVE

- By definition an online/network virtual space must involve a **network**
- Multi-user virtual spaces are not necessarily networked.

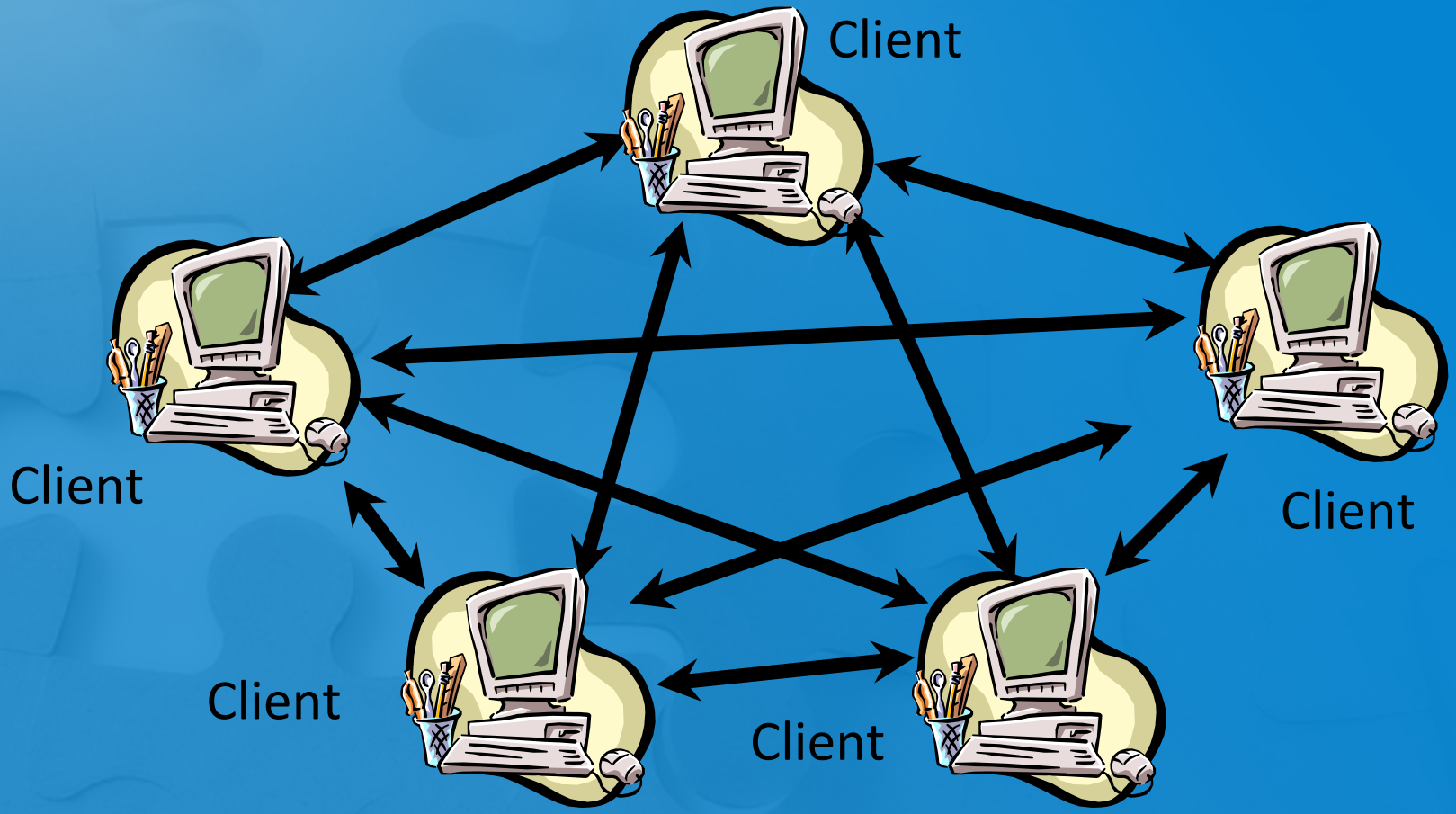
And…..

- Not all networked virtual spaces are multi-user.
- In a nutshell: a networked multi-user virtual space is a software system that allows multiple users to interact with each other in real-time from different locations, usually remote, and preferably with immersive graphics

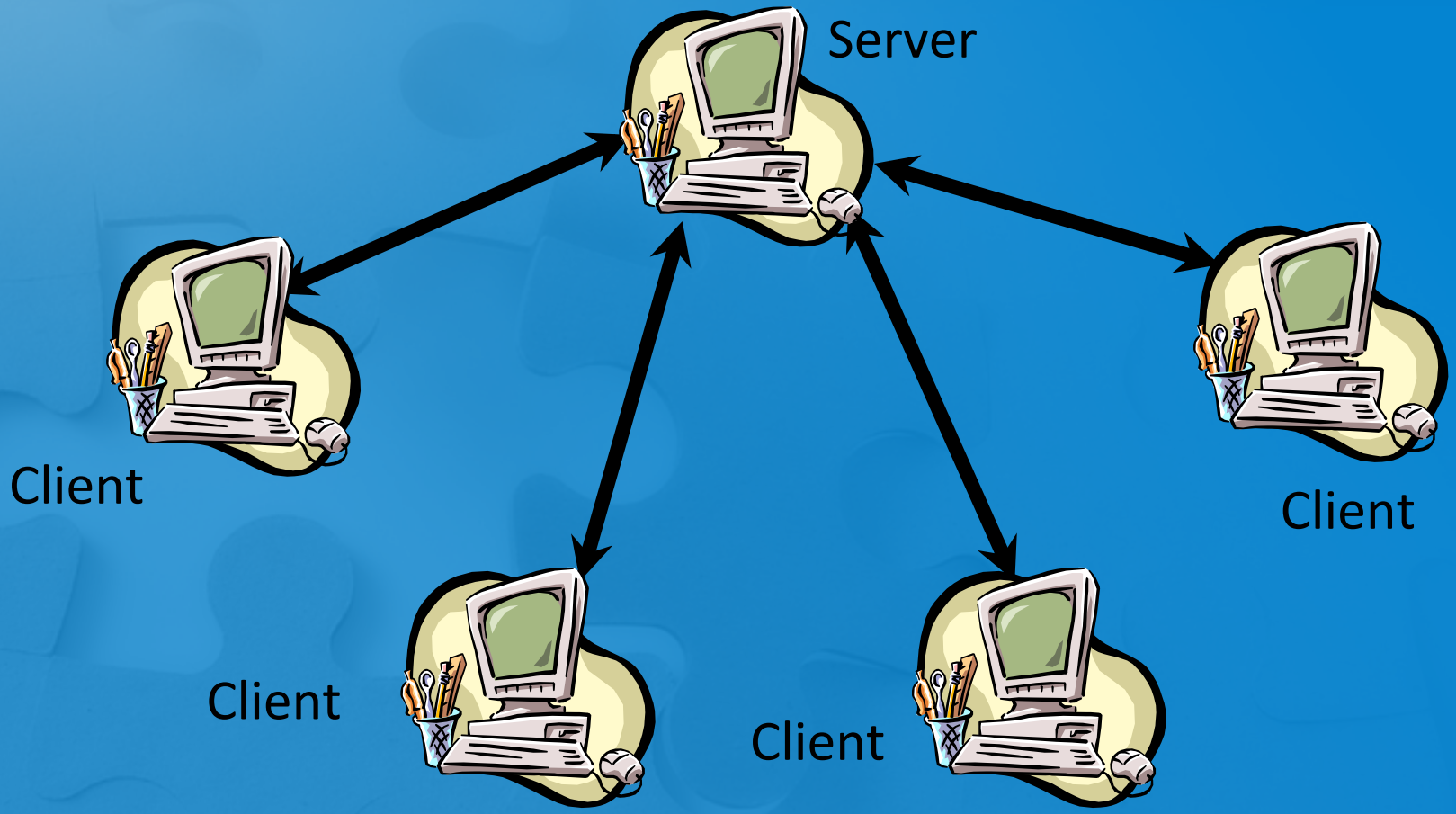
NVE by Definition MUST

Have a Network and Involve Multiple users

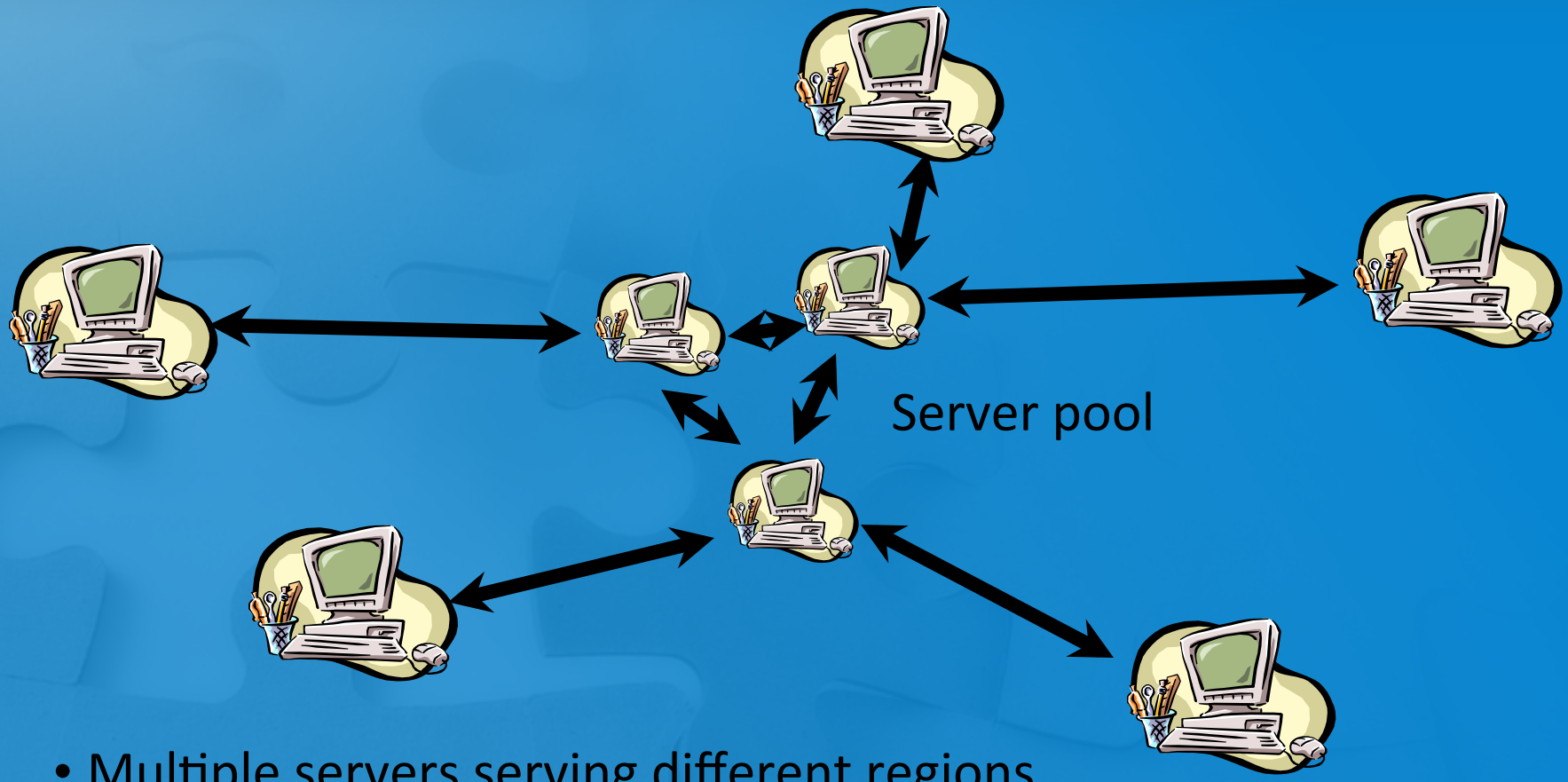
Network Architectures
Peer to Peer



Network Architectures
Client-Server



Network Architectures
Hybrid



- Multiple servers serving different regions
- Multiple service types & service layers

Latency/Delay in NVEs

- Most NVEs today run on the client-server (C-S) architecture:
  - the server handles the NVE logic
  - every request made by a user in the NVE is processed at the server
- When a request is made by a user, it travels from the client to the server and back to client, and this transmission introduces possible unacceptable latency in the NVE.

Responsiveness, Consistency and Plausability

- The system needs to be responsive (or locally plausible) – react to a user's input/local actions and give appearance of consistency
- The system needs to have a consistent view across all clients/users (shared plausibility):
  - Network delay means that all received information is out-of-date. Messages are delayed, incur different delays, arrive out of order, lost –> inconsistent views -> conflicts
  - Conflicts – An NVE must provide accurate collision detection, agreement on actions/events, and resolution among participants when states are out of sync

Categorizing User Actions

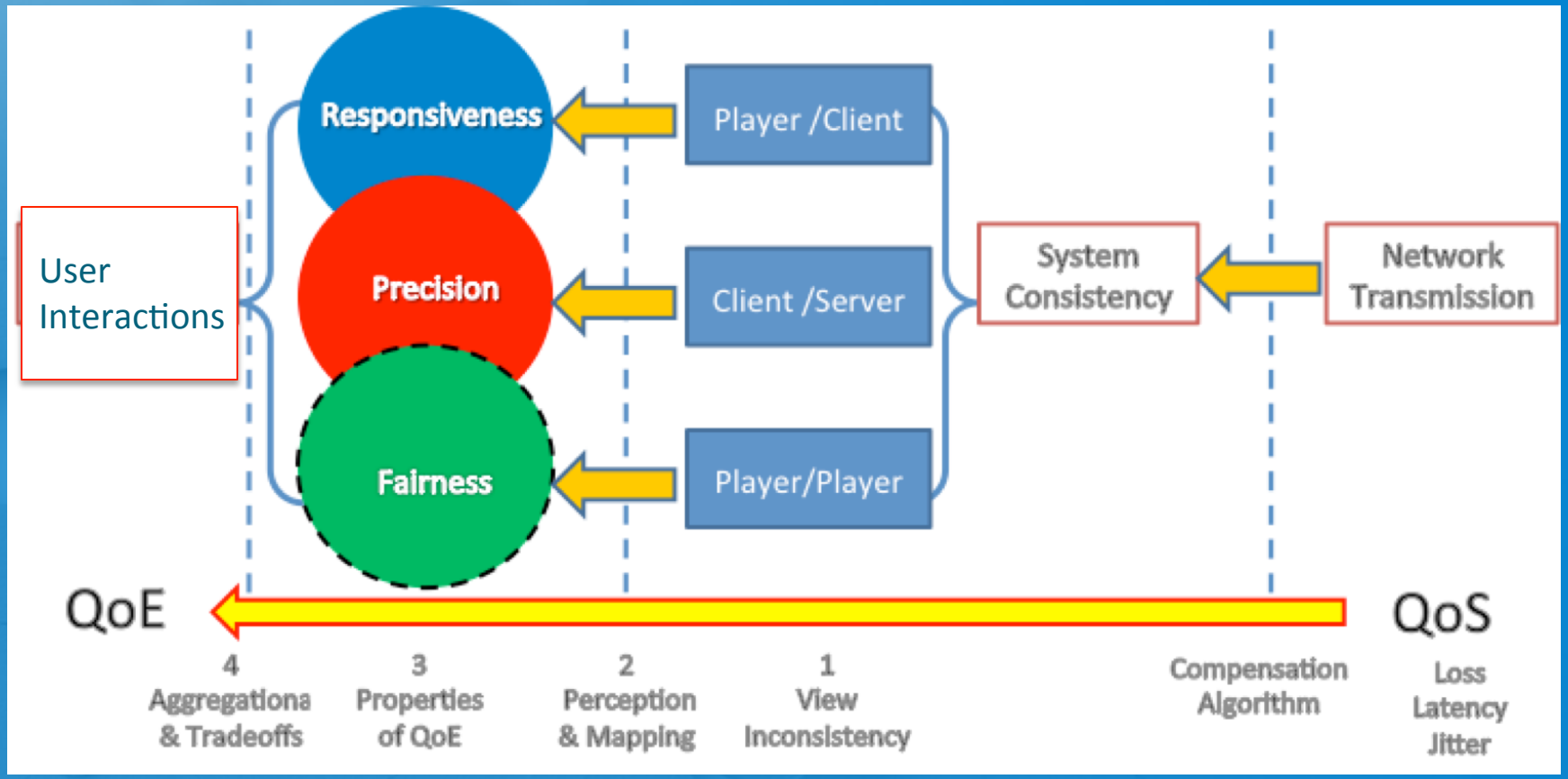
- Precision
- Deadline

The precision and deadline requirements for a user action determine the effects of latency on that action.

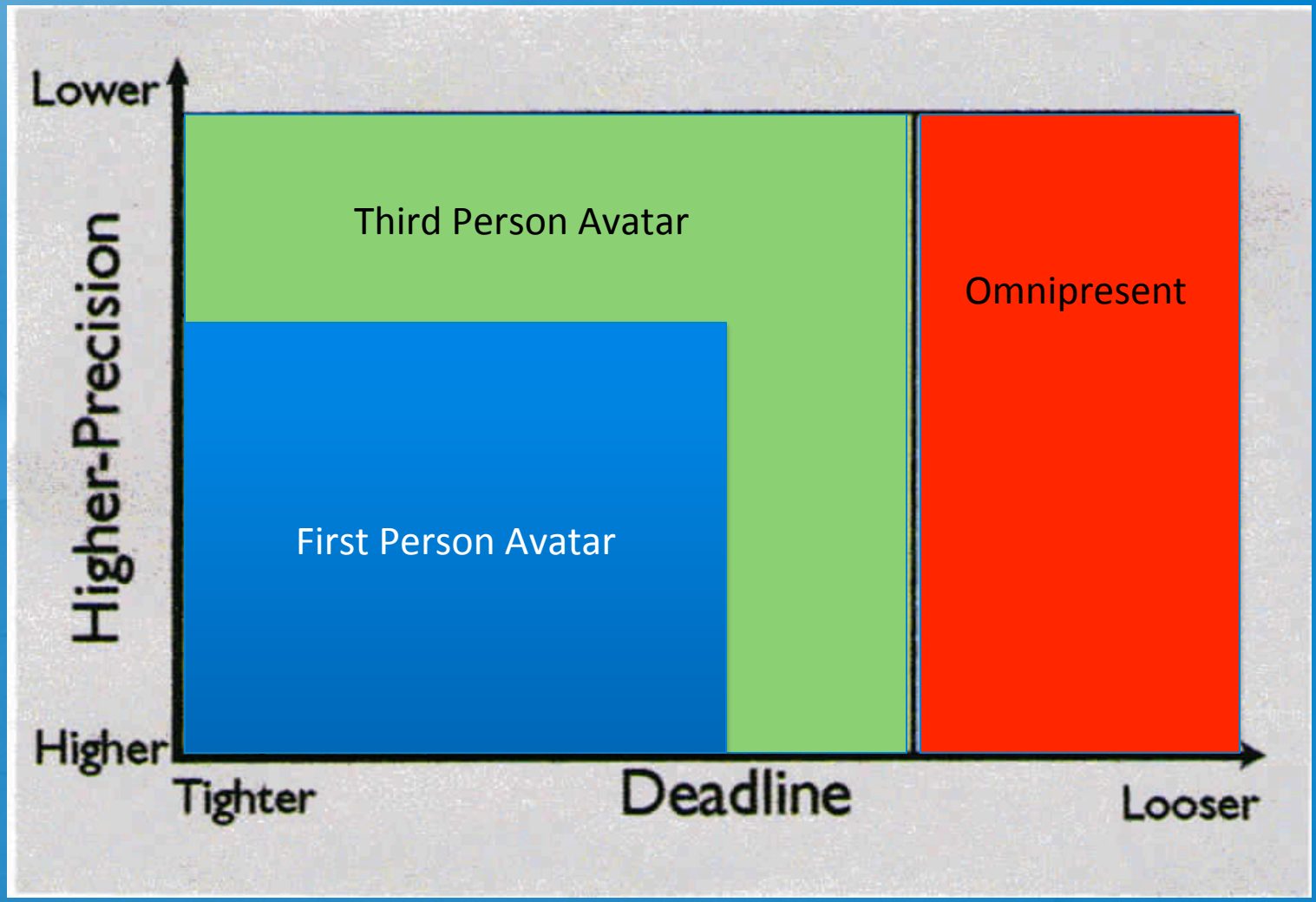
QoS vs QoE

- **QoS – Quality of Service**:
  - network characteristics/behavior
  - Network performance guarantees given by network provider based on measurements taken over time
- **QoE – Quality of Experience**:
  - impact of network performance on end user
    - some imperfections may go unnoticed
    - some imperfections may render application/service useless
  - impact not always captured by network measurements
    - a 5% packet loss could be invisible if it affects background
    - A late action due to a 100ms delay can affect the user interaction

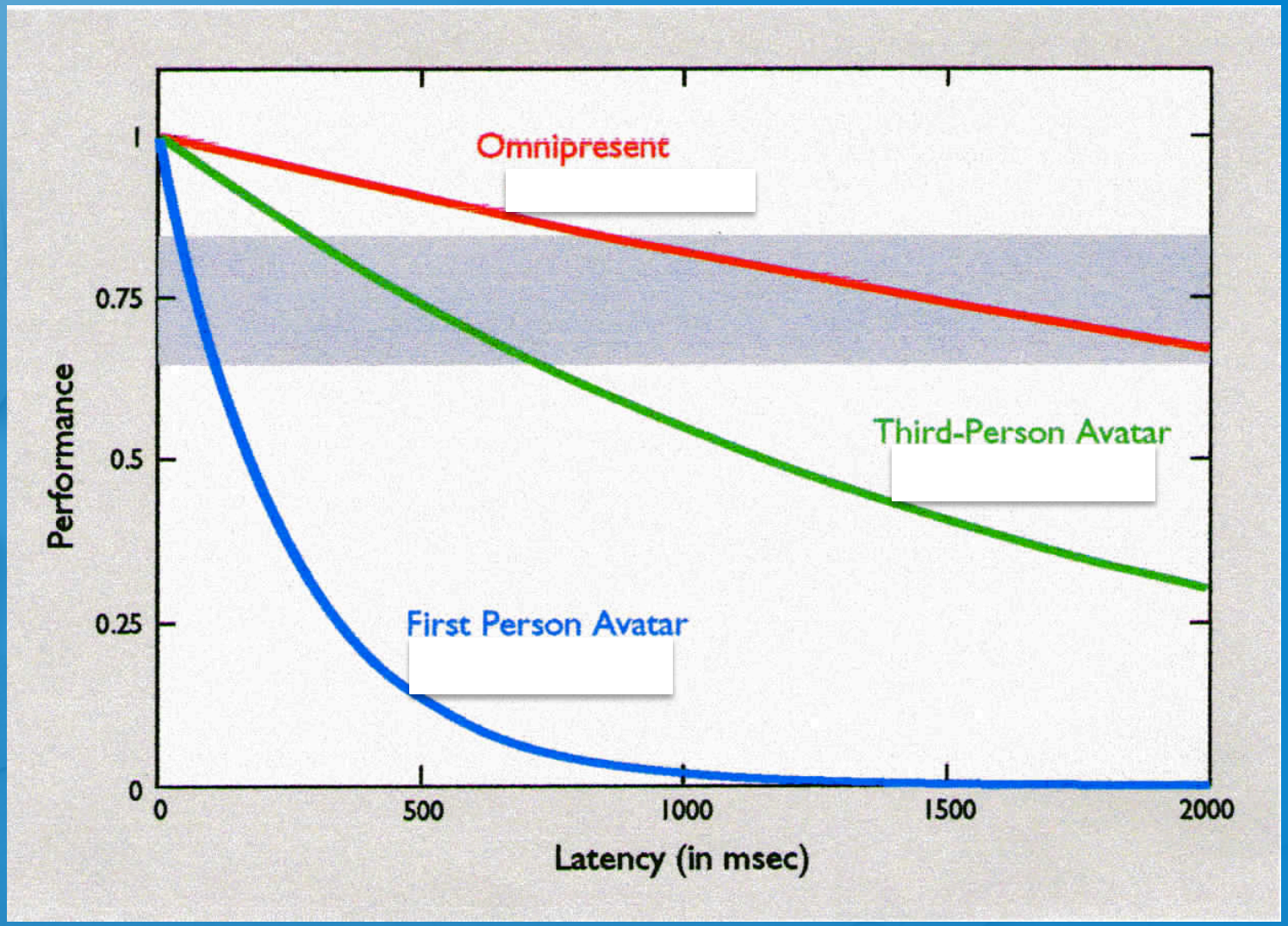
Quality of Service (QoS) vs Quality of Experience (QoE)



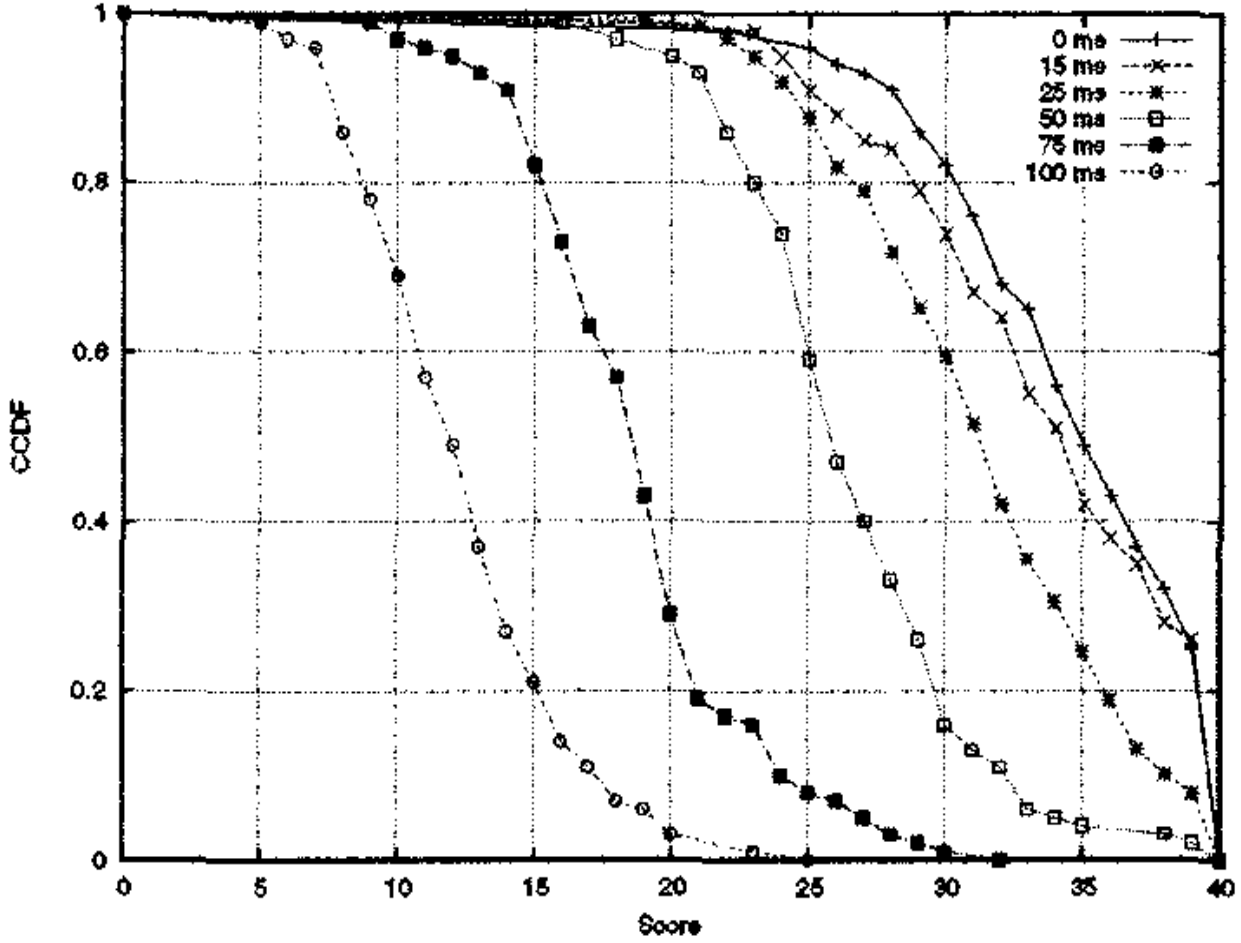
Precision – Deadline Requirements



Performance vs Latency for different classes of online NVEs



Impact of Delay on User Performance

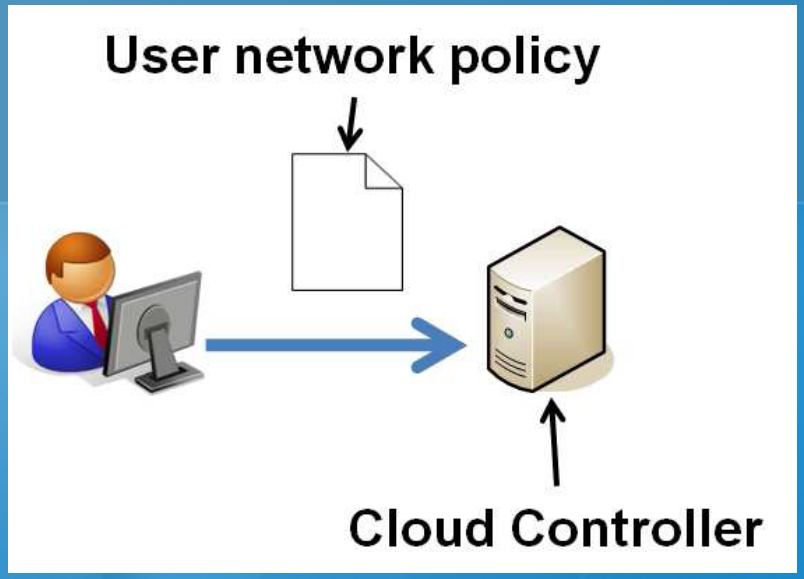


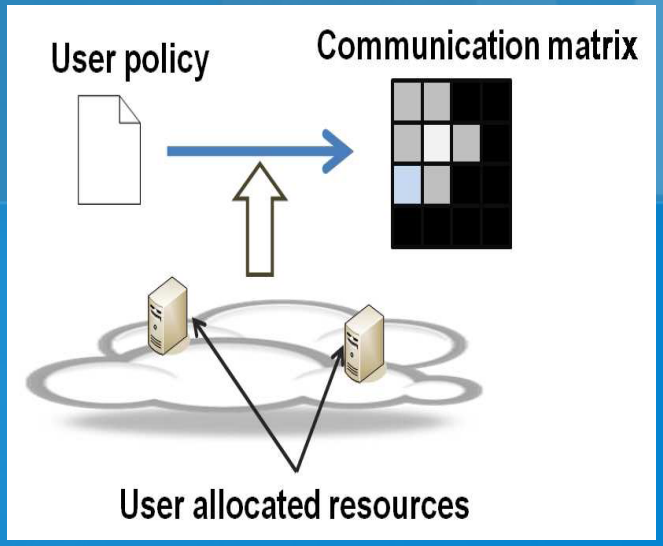
Ball Park Numbers for Designers

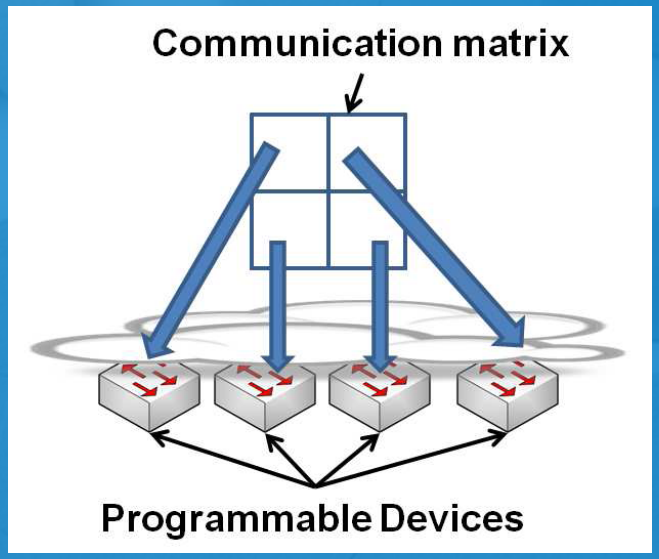
Model	Perspective		Sensitivity	Thresholds
Avatar	First person		High	100msec
	Third person		Medium	500msec
Omnipresent	Several		Low	1,000msec

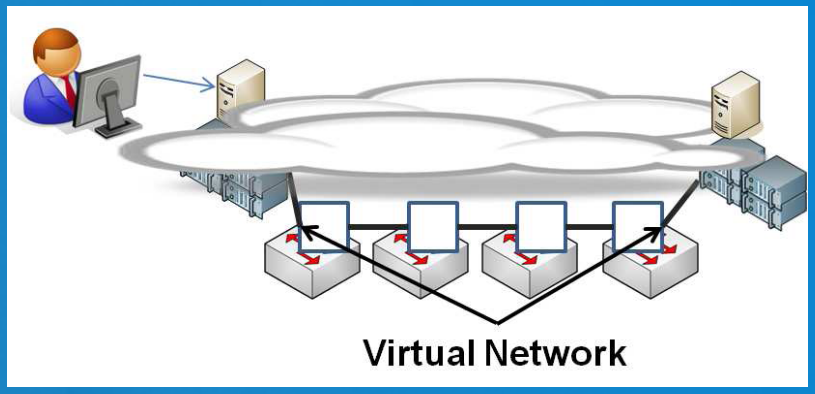
Cloud Networking

- **Network as a Service – NaaS**
  - A framework that integrates current cloud computing offerings with direct, secure, user access to the network infrastructure - **SDN**
- **Software Defined Networking (SDN)**
  - Users can easily deploy custom routing and multicast protocols
  - Users can efficiently implement advanced network services (aggregation, duplication, redundancy) -> Users create their own private network that conforms to their desired specs.


User network policy
Cloud Controller


User policy
Communication matrix
User allocated resources


Communication matrix
Programmable Devices


Virtual Network

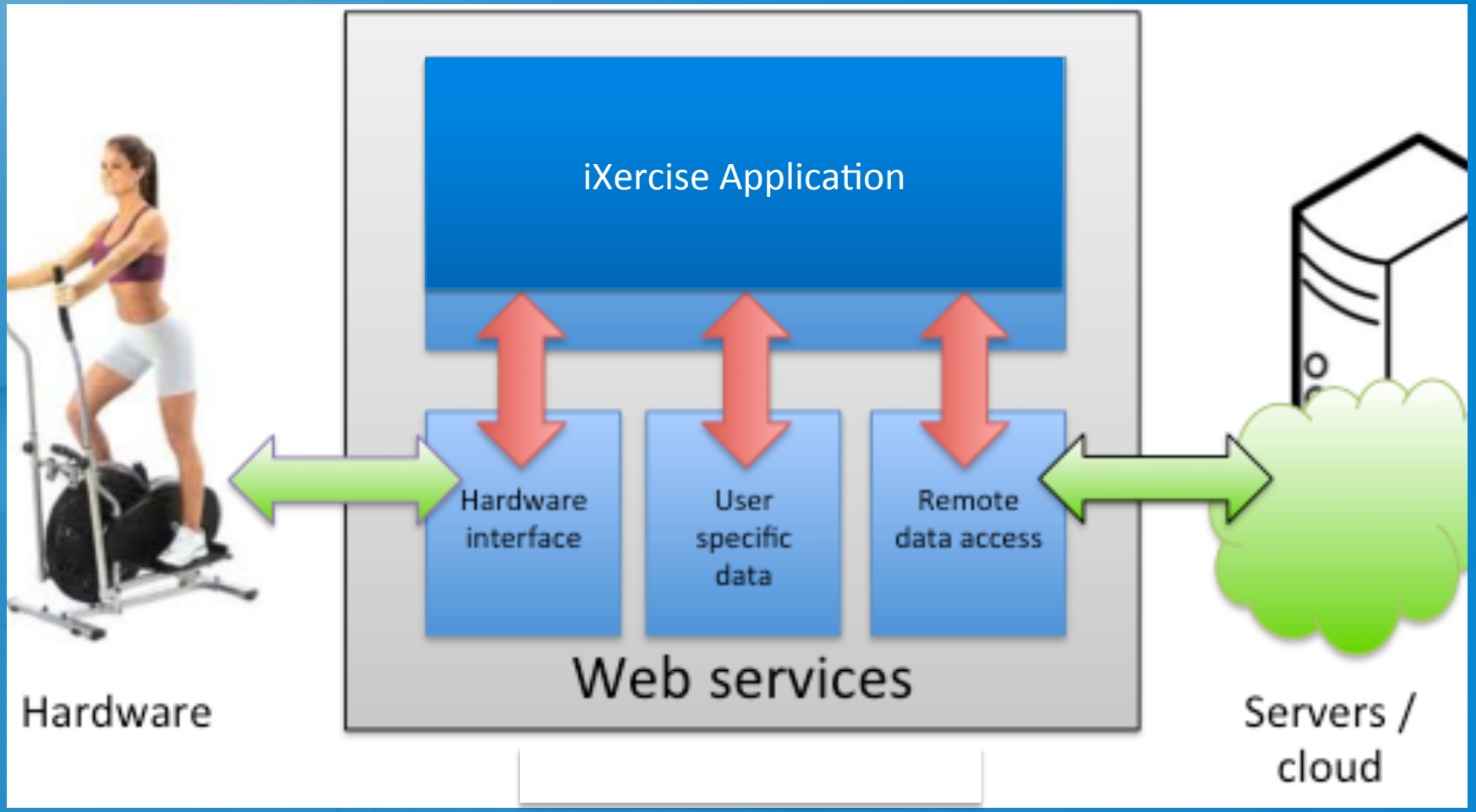
Cloud NVE- Why?

- Elasticity property – ability to accommodate a very “variable” user population
  - Popularity of a NVE hard to gauge – users can increase overnight, population can go into the hundreds of thousands
  - Users not very loyal – new NVE released, lose users overnight
- User accessibility - global reach
- NVE Distribution – software and patches

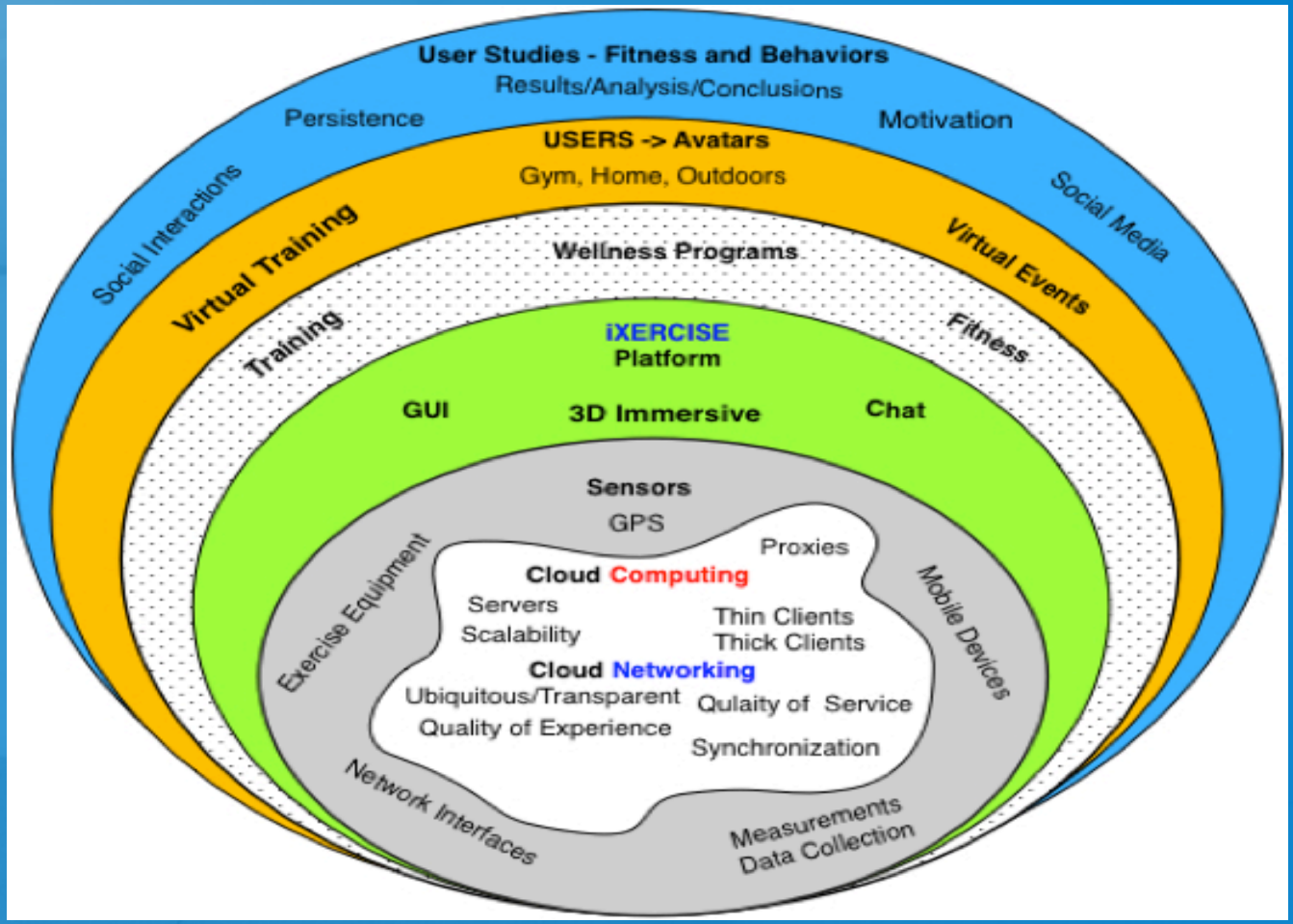
Cloud NVEs

- Classic NVE - all the logic is executed at clients, and the servers are only responsible for maintaining consistent space states among multiple clients
- Cloud NVE - run on cloud servers and users interact with virtual space over the Internet, via thin/thick clients, which run on commodity PCs, TVs with set-top boxes, and mobile devices.
- Usually implemented as IaaS

iXercise – Immersive Socially Inspired Exercising



iXercise: A Cloud Based NVE Project



Group Real-Time Exercising

Cloud NVE Models

- AAAS –NVE as an application service
  - Streaming – most popular model
  - Graphics – current online NVE model
  - Hybrid –
    - Streaming and Graphics – a blend of the two
    - Local and remote graphics processing
    - Layered graphics rendering
- Tiered Clouds
  - Remote public cloud, servers handle large number of users:
    - update state and create new view
    - sends graphics instructions to local cloud servers
  - Local regional cloud, servers render and stream view data to clients

Video Traffic vs Cloud NVE Traffic

- Answer Q1: The characteristics of NVE traffic are similar for all genres, but total bitrates for downstream and upstream traffic can vary by as much as 50%.
  - First and Third person avatar 50% > omnipresent

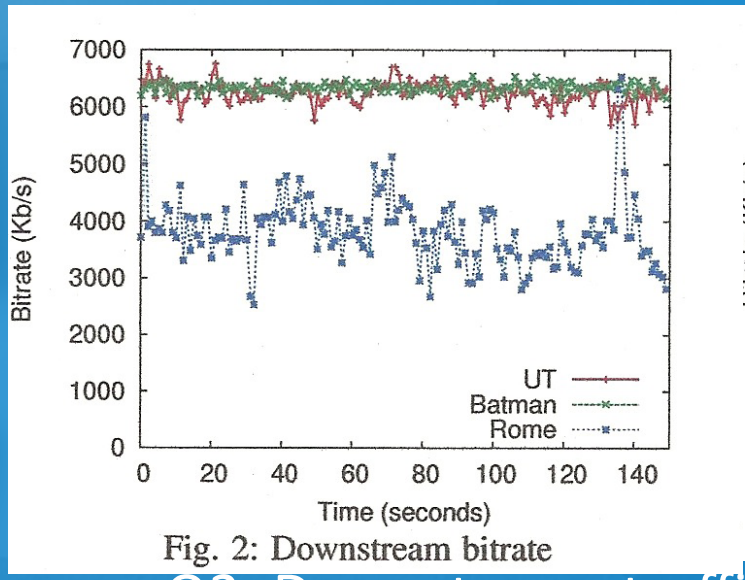


Fig. 2: Downstream bitrate

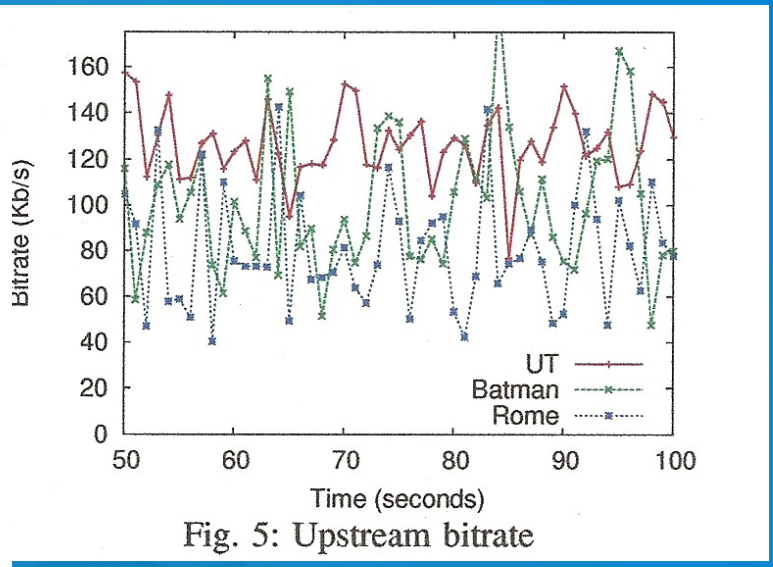


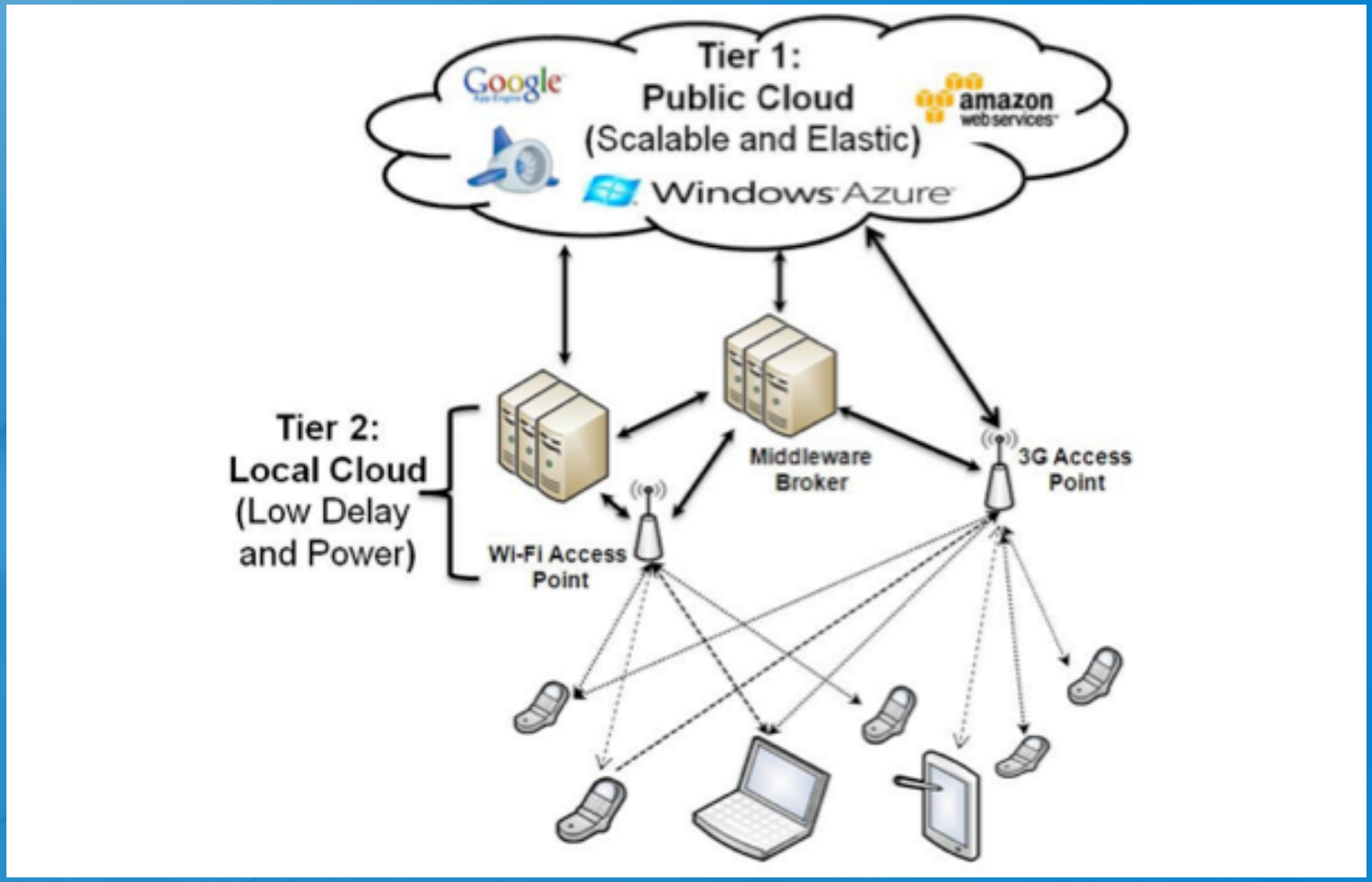
Fig. 5: Upstream bitrate

- Answer Q2: Downstream traffic is more similar to downstream live video, while upstream traffic is only somewhat similar to upstream traditional NVE traffic.

Comparison of Bit Rates

Application	Bitrate (Kbps)	Packet Size (bytes)	InterPkt Arr. (msec)
Trad. Game	67	75	45
Virtual Env.	775	1027	9
Live Video	2222	1314	0.1
Thin Client Cloud	6247	1203	0.7
Pre-recorded Video	43914	1514	0.1

Tiered Clouds



Open Issues

- Cloud Model
- Application QoE
  - Latency
  - Interactivity
  - Bit rates
- Application/Edge (fog network/computing) processing to accommodate cloud infrastructures and meet QoE

Questions

- Questions?