Promises and Challenges of Networked Virtual Environments

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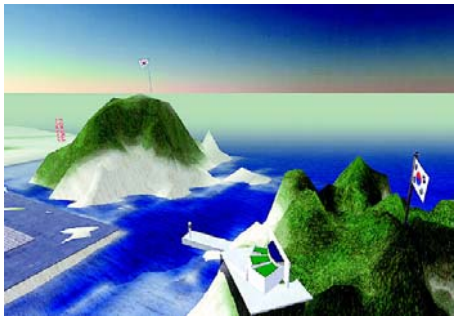
Metaverse

- Second Life by Linden Lab
  - http://www.serakorea.com/
  - UCC-based 3D networked virtual environment

Second Life on Mars



Dokdo

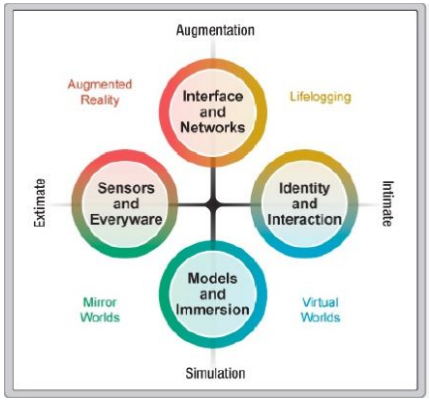
Metaverse

- War of Warcraft
  - http://www.worldofwarcraft.com/
  - Most popular MMORPG

South Park Episode 1008 "Make Love Not Warcraft"

Metaverse

- Spectrum of Technologies
  - Augmentation
  - Simulation
  - Intimate (identity-focused)
  - External (world-focused)
- Metaverse Space
  - Virtual Worlds
  - Mirror Worlds
  - Augmented Reality
  - Lifelogging



Metaverse Roadmap

What is a Networked VE (NVE)?

- A networked virtual environment (NVE) is 'a software system in which multiple users interact with each other in real-time, even though those users may be physically located around the world.' – Singhal & Zyda, 1999
- Typically, each user accesses his/her own computer workstation or console, using it to provide a user interface to the content of a virtual environment.
- These environments usually aim to provide users with a sense of realism by incorporating realistic 3D graphics, spatial sound & other modalities to create an immersive experience.

NVE Applications

- Military and industrial team training
- Collaborative design and engineering
- Multiplayer games
- Mobile entertainment
- Virtual shopping malls
- Online tradeshows and conferences
- Remote customer support
- Distance learning

Synonyms, Keywords, and Abbreviations

- Collaborative Virtual Environment (CVE)
- Computer-Supported Cooperative Work (CSCW)
- Distributed Interactive Simulation (DIS)
- Distributed Virtual Environment (DVE)
- Shared Virtual Environment (SVE)
- Media-Space, Shared-Spaces

Benford's Taxonomy of Shared-Space

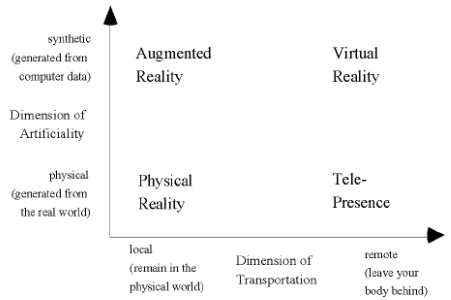


Figure 1: Broad classification of spatial technologies according to transportation and artificiality

- Physical reality
  - Resides in the local, physical world
  - Here and now
- Tele-presence
  - A real world location remote from the participant's physical location
  - A remote-controlled robot

Benford's Taxonomy of Shared-Space

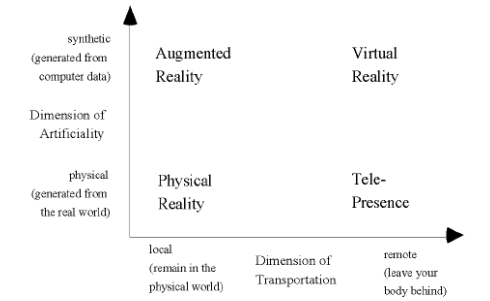


Figure 1: Broad classification of spatial technologies according to transportation and artificiality

- Augmented reality
  - Synthetic objects are overlaid on the local environment
  - A head-up display (HUD)
- Virtual reality
  - The participants are immersed in a remote, synthetic world
  - A networked virtual environment

NVE Features

- A networked virtual environment is distinguished by five common features
  - A shared sense of space
  - A shared sense of presence
  - A shared sense of time
  - A way to communicate
  - A way to share

CAVERNsoft

NVE Features

- A shared sense of space
  - Illusion of being located in the same place
  - Same characteristics for all participants
    - Time of day, weather, acoustics, haptics
- A shared sense of presence
  - A participant has a virtual persona, an avatar
  - Entering and leaving is visible for other participants
  - All participants do not have to be human-controlled

NVE Features

- A shared sense of time
  - See other participants' actions when they occur
    - Enables real-time interaction
- A way to communicate
  - By gesture, by typed text, by voice
- A way to share
  - Interact realistically not only with each other but also with the virtual environment itself

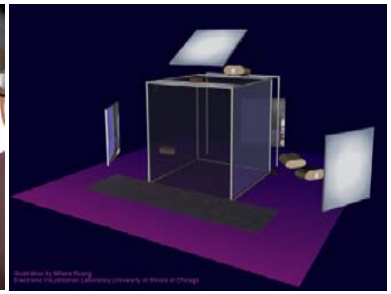
NVE Components

- Graphics Engines and Displays
- Control and Communication Devices
- Processing Systems
- Data Network

NVE Components

- Graphics Engines and Displays
  - The cornerstone of the NVE user interface
  - Head-mounted displays (HMD)
  - Cave Automatic Virtual Environment (CAVE)

HMD



CAVE

ImmersaDesk

NVE Components

- Control and Communication Devices
  - Keyboard/Mouse
  - Joystick
  - Dataglove
  - Motion detectors in full-body immersive environments
  - Microphone

Cyberglove

Ascension Flock of Birds motion tracker

Phantom Desktop

Intersense IS900

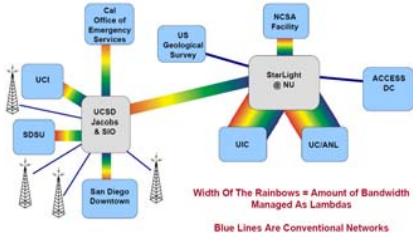
NVE Components

- Processing Systems
  - NVEs demand a considerable amount of processing capacity
  - Computes the effects of the user's actions
  - Determines when to notify other users
  - Receives information from other users
  - Controls autonomous objects
  - Computes a visualization of the virtual environment

SGI Onyx

NVE Components

- Data Network
  - Exchange information
  - Notify about environment changes
  - Synchronize the shared state
  - Communication among users



StarLight: 40-Gbps Optical Network

Challenges in Design and Development

- Network Bandwidth
- Heterogeneity
- Distributed Interaction
- Real-Time System Design and Resource Management
- Failure Management
- Scalability
- Deployment and Configuration

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Challenges in Design and Development

- Difficult to implement correctly and effectively
- Include multiple traditional software types
- NVEs are
  - Distributed systems
    - Contend with managing network resources, data loss, network failure, concurrency
  - Graphical applications
    - Maintain real-time display frame rate
    - Allocate the CPU among several tasks
  - Interactive applications
    - Process real-time input
    - Users should see the virtual environment as if it exists locally

Challenges in Design and Development

- NVEs must work with other applications
  - Typically integrate with database systems
  - Need to support user authentication and may interact with commerce and other transaction systems
  - To support reproducible systems, must be able to log events in real-time to a persistent storage
    - The complete state of the NVE may not be known at any single host
- Optimizing one element of the NVE is hazardous
- Consider as a unified system

Challenges in Design and Development

- NVE development is a difficult balancing act of trade-offs
  - Network bandwidth
  - Heterogeneity
  - Distributed interaction
  - Real-time system design and resource management
  - Failure management
  - Scalability
  - Deployment and configuration

Challenges in Design and Development

- Network Bandwidth
  - Amount of desired information varies
  - Amount of users varies
  - How to allocate a limited network capacity?

Challenges in Design and Development

- Heterogeneity
  - Users do not have equipment with the same quality
  - Weather to expose or hide the differences between participants
    - Connection speed, processing capacity,…
  - Hide by reducing the system to the lowest common denominator
    - A single 'bad' participant causes problems for everybody else
  - Take a full advance of the available resources
    - User receive different levels of information
    - Fair play
  - Graphical display, computational, and audio capabilities

Challenges in Design and Development

- Distributed Interaction
  - One of the defining qualities of an NVE system
  - NVE system must provide each user with the illusion that
    - The entire environment is located on the local machine
    - The actions of the users have a direct and immediate impact on the environment
  - Difficult because of the messaging required
  - Each host attempts to
    - Present a consistent real-time view
    - Cope with out-of-date information
  - Problems when multiple users or components interact
    - Collision detection, agreement, and resolution among participants

Challenges in Design and Development

- Real-time System Design and Resource Management
  - Real-time interaction defines the process and thread architecture
    - Many tasks have hard real-time constraints
  - Support quick detection and processing of user action
    - Graphical image generation at fixed rate
    - Network packets arrive asynchronously, process them soon
    - Perform physics modeling and collision detection
  - Everything in a single thread, use round-robin
  - Segment into multiple threads, balance them
    - Shared data structures on each host
    - Shared locks

Challenges in Design and Development

- Failure Management
  - One ore more of the connected hosts can crash at any time
  - Network connections can fail
  - Categories of failure handling
    - System stop : entire NVE terminates due to a missing resource
    - System closure : no impact on the existing users but new ones are unable to login
    - System hindrance : a required service becomes unavailable; degrades the experience
    - System continuance : a non-critical service becomes unavailable; no noticeable effect

Challenges in Design and Development

- Scalability
  - Can be measured with the number of entities that may simultaneously participate in the system
    - May include human- and computer-controlled vehicles, a terrain, and even logical objects
  - Also, the number of hosts, and physical distance between the hosts
  - Depends on a variety of factors
    - Network capacity, processor capabilities, rendering speeds,..
  - The complexity of an NVE increases exponentially with the number of entities because of the number possible interactions between them
  - Expensive to achieve because it requires enhancements to virtually all aspects of the NVE system

Challenges in Design and Development

- Deployment and Configuration
  - Deploying the software to participants
    - If the software is large, it is inappropriate for downloading
    - A small core library with dynamically downloaded components
  - Implications to the software design, implementation language, and supported platforms
  - In the case of web browsers or light-weight platforms, ensure that the environment
    - Can be easily downloaded
    - Conforms the security bounds
    - Executes and displays correctly across different platforms
  - Participants need an access to the configuration information
    - Network addresses, encryption keys, access codes, images, computational modes, ..

References

- http://www.metaverseroadmap.org/MetaverseRoadmapOverview.pdf Metaverse Roadmap: Pathways to the 3D Web
- http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.3.9070 Understanding and Constructing Shared Spaces with Mixed Reality