

# Augmented Reality and Internet2 for Advanced Collaborative Environments

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# Outline



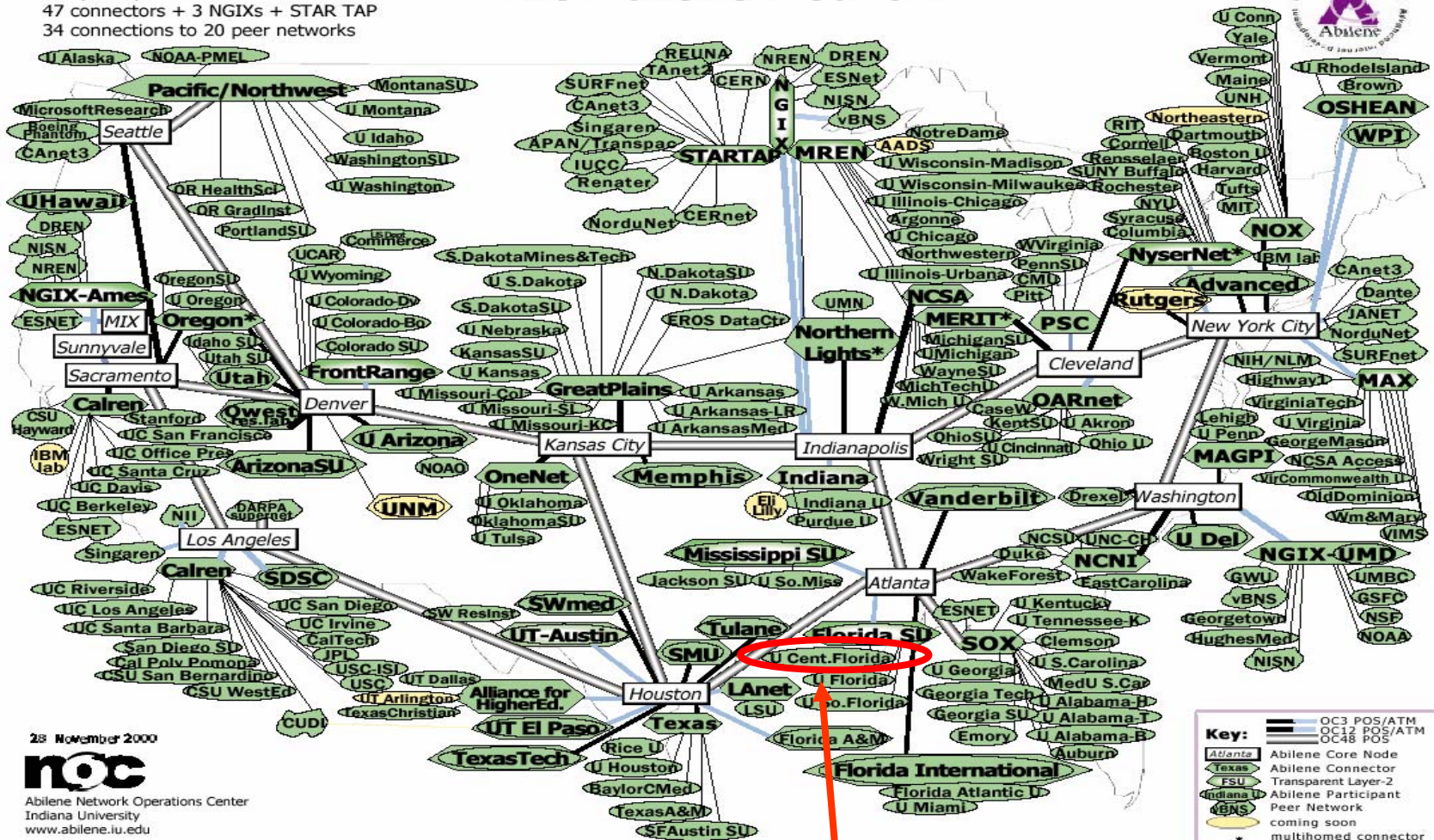
- Introduction: I2 and FLR
- The Augmented Reality Paradigm
- Application Domains; Distributed Collaborative Environments
- AR Collaborative Environments @ ODALab
  - VRDA Tool
  - AR Training Tool
  - 3D Video Conferencing
- AR System Components
  - Position Tracking Sensors
  - 3D Visualization Devices
- Consistency in Distributed Environments
- Concluding Remarks

# Logical map of Internet2 core topology



completed connections:  
 183 participants  
 47 connectors + 3 NGIX + STAR TAP  
 34 connections to 20 peer networks

## The Abilene Network



28 November 2000



Abilene Network Operations Center  
 Indiana University  
[www.abilene.uiu.edu](http://www.abilene.uiu.edu)

We are here

# Florida Lambda-Rail (FLR)



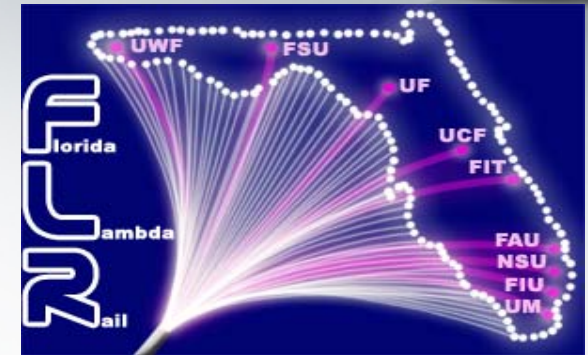
- Part of a larger national fiber optic network, the National LambdaRail (NLR)
- Linking research institutions around the country with connectivity to international research networks
- Foundation for the next-generation networks needed to support large-scale research, education outreach, public/private partnerships.
- Participating universities are: FAU, FIT, FIU, FSU, NSU, **UCF**, UF, UM, and UWF
  - November 2002 – Formed consortium
  - May 2003 – Incorporated as the Florida LambdaRail, LLC (non-profit limited liability corporation)
  - February 2004 - Applied for 501(c)(3) tax-exempt recognition



# Florida Lambda-Rail



- Future Services:
  - IP connectivity to NLR
  - IP connectivity to Internet
  - IP connectivity to Internet2
  - Share IP transport between member institutions
  - Dedicated wavelengths between FLR members and other FLR or NLR institutions
- Prospects
  - Collaborative Environments
  - Video teleconferencing
  - Interactive distributed simulations
  - Access to digitized databases
  - Processing and visualization of large data sets
  - Distance Learning



<http://www.flrnet.org>

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# What is Augmented Reality (AR)?



- Augmented Reality (AR) is a growing area in Virtual Environment research
- AR 3D Environment is a *computer generated (partially), interactive*, three-dimensional environment in which a person is *immersed*
  - *Computer generated*: who else could do it ?
  - *Partially*: only some of the objects in the scene are computer generated
  - *Interactive*: needs real time computation
  - *Immersed*: needs a device and proper content to give this impression (ex. Head Mounted Display)
- Augmented Reality Environments generally include
  - calibration procedure
  - dynamic superimposition procedure to bring virtual objects *in register* with real objects.

# Virtual Environment Taxonomy



Argotti, Y., L. Davis, V. Outters, and J.P. Rolland, "Dynamic superimposition of synthetic objects on rigid and simple-deformable objects," *Computers and Graphics*, 26(6), pp.919-930 (2002).

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# Application Domains



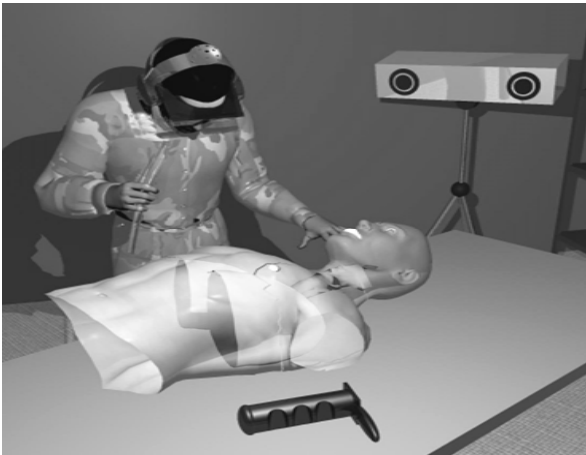
- Training (*Medical, Technical, Military etc*)
- Entertainment
- Engineering Design
- Consumer Design (*Magic Book, M.Billinghurst*)
- Robotics and Tele-robotics
- Manufacturing, Maintenance and Repair
- more to come...

# AR Applications in Medicine



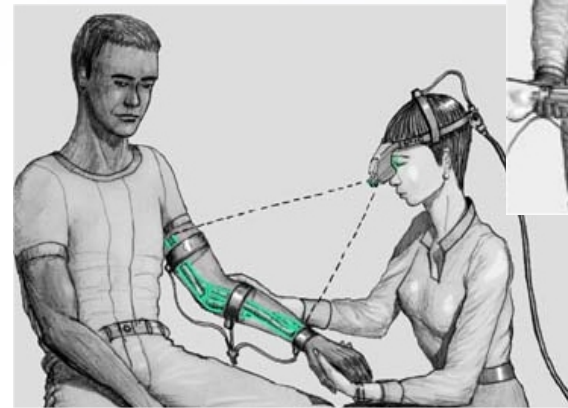
- AR Diagnostics/Prognostics
- Medical Procedure Training

## AR Medical Training Concept



Courtesy of S. Johnson

## AR Diagnostics Concept



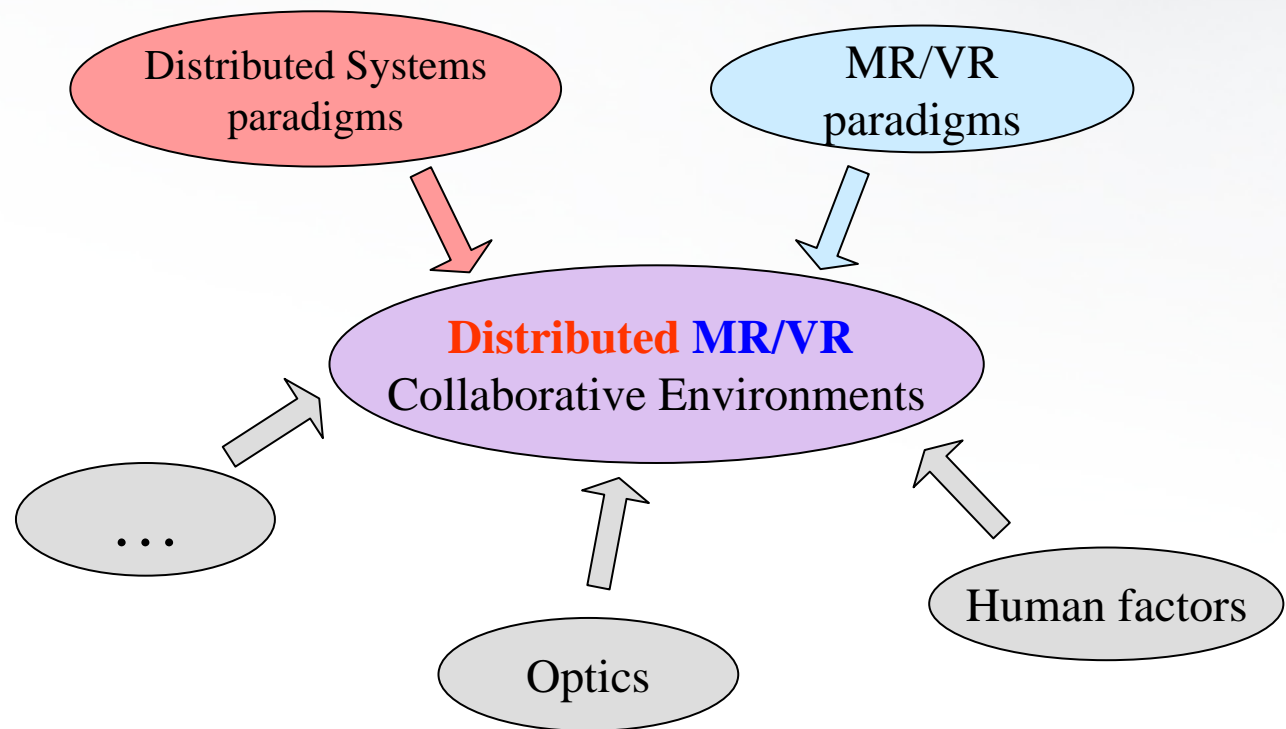
Courtesy of A. State



# Distributed Collaborative AR Environments



- Distributed Collaborative Environments
  - still in their infancy
  - require interdisciplinary research



# Distributed Collaborative AR Environments



- DCE useful for
  - Information/knowledge dissemination
  - Reduced costs, time and risks
  - Increased efficiency through team work
- Examples & Trend
  - Industry
    - Military simulations: (VR) SIMNET, NPSNET, (MR) MOUT ...
    - Entertainment: (VR) networked games, (MR) Project (ISMR'99) ...
    - Medicine: (AR) training tools (MMVR'03) ...
  - Academia: (VR) MASSIVE, DIVE, DEVA, (AR) Studierstube, Coterie...
  - Trend toward Mixed Reality (focus on AR)

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# **AR Collaborative Environments at Optical Diagnostics & Applications Laboratory**

***- past, present & future -***

# One Goal



- Use Internet 2 and available tools for development of distributed AR applications.

# Technology



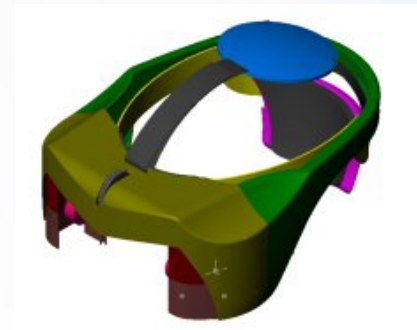
- Head Mounted Projective Displays



2000



2003



2004

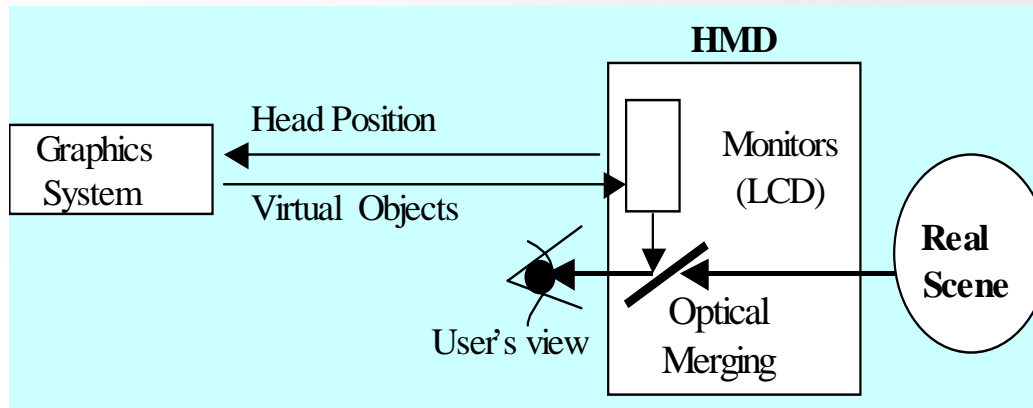
# Technology



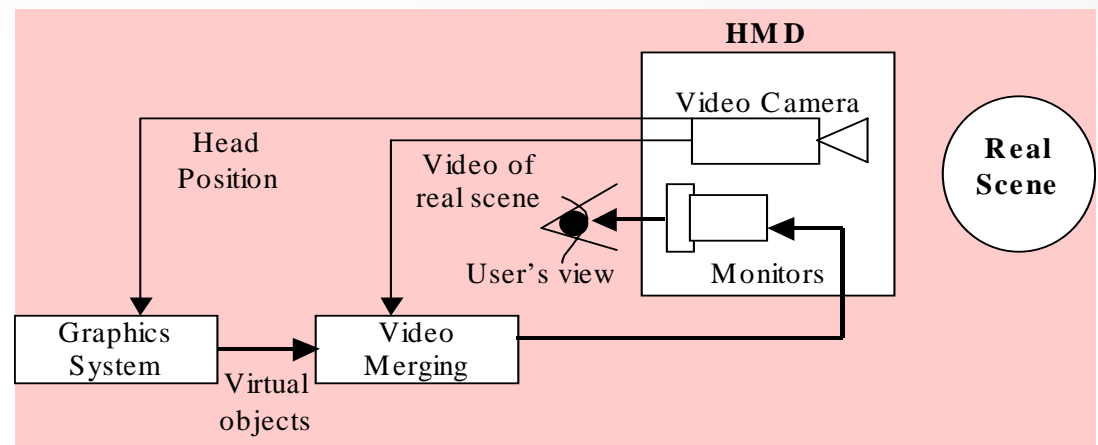
## HMPD History

- 1996 Fisher, US Patent for monocular projection display
- 1997 Kijima and Ojika, First demonstration of implementation
- 1997 Ferguson, US Patent conceptually generalized to binocular
- 1999 Rolland and al., First ultra compact optics
- Biocca and Rolland, US Patent Filed (pending)
- 2002 Hua and Rolland, US Patent filed (pending)
- 2003 Rolland et al., US Patent filed on fabric free wearable projection display (pending)

# Technology



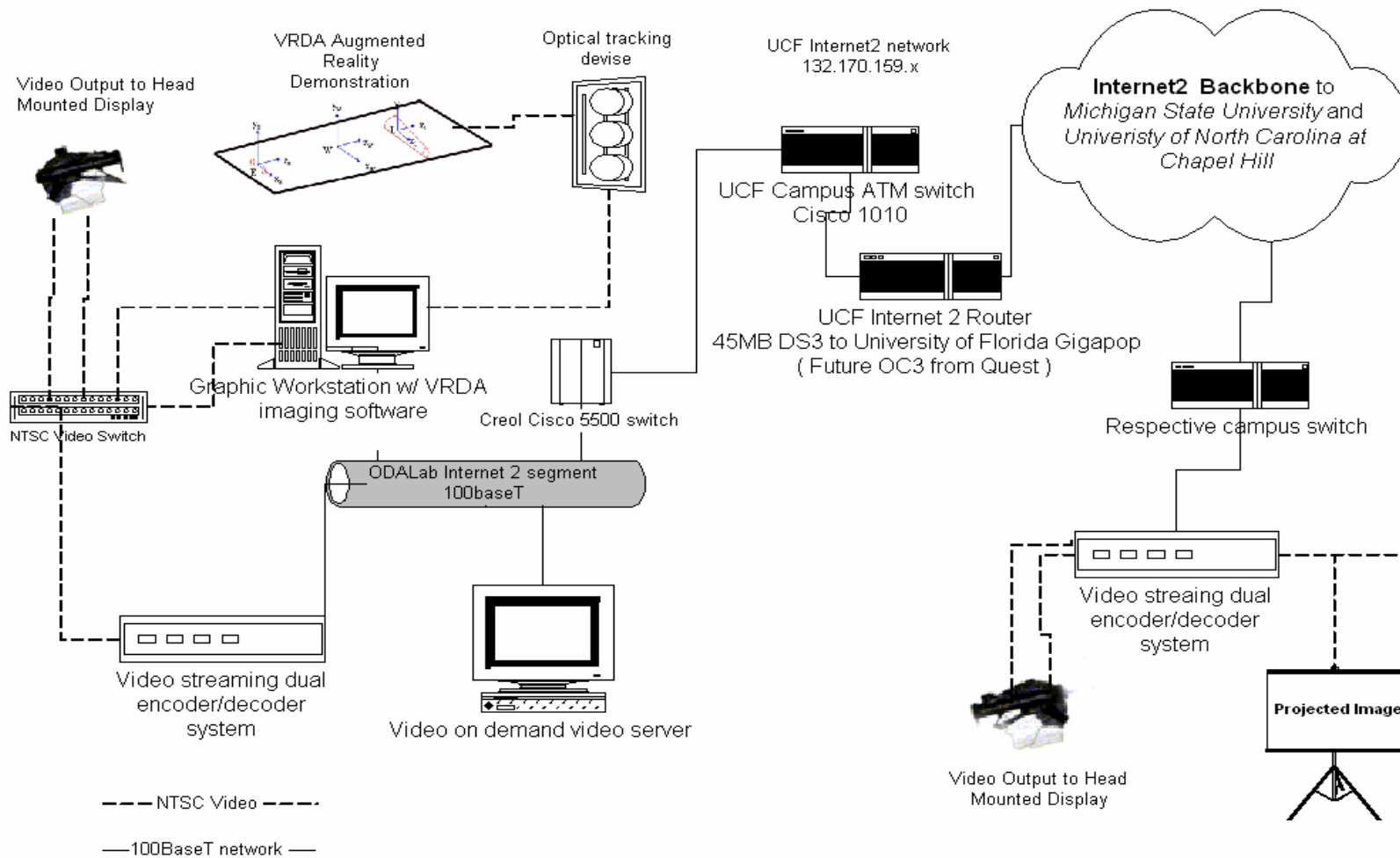
## Optical See-through vs. Video See-through HMDs



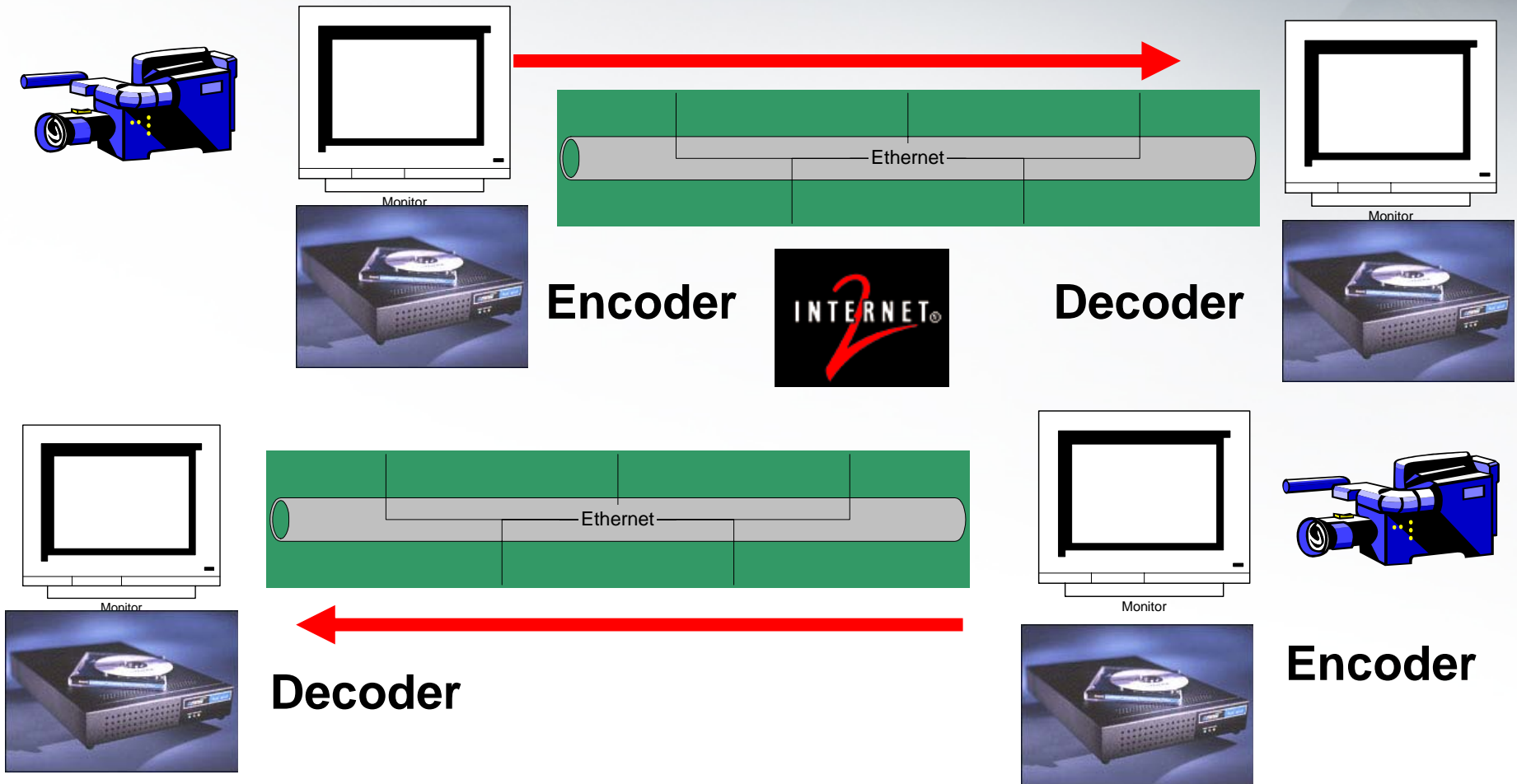
# Technology



## Optical Diagnostics and Applications Laboratory Internet2 Project



# Internet2 Connection for Video Streaming and other modalities (e.g. haptic)



# Distributed AR Applications

## VRDA TOOL

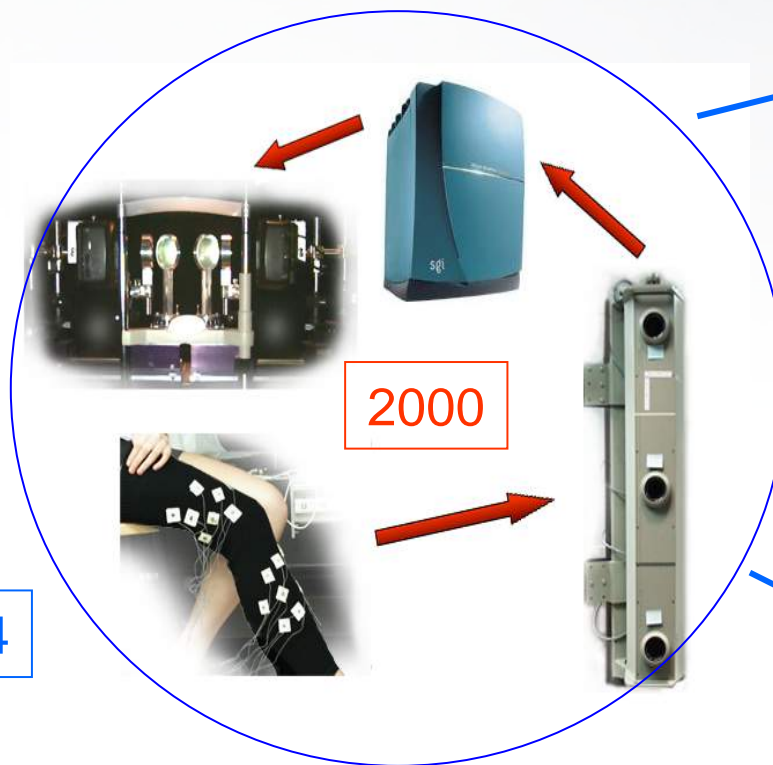


- Virtual Reality Dynamic Anatomy
- Dynamic 3D models superimposition
  - High frequency dynamic 6DOF tracking

### VRDA IMAGING PROCESS



2004

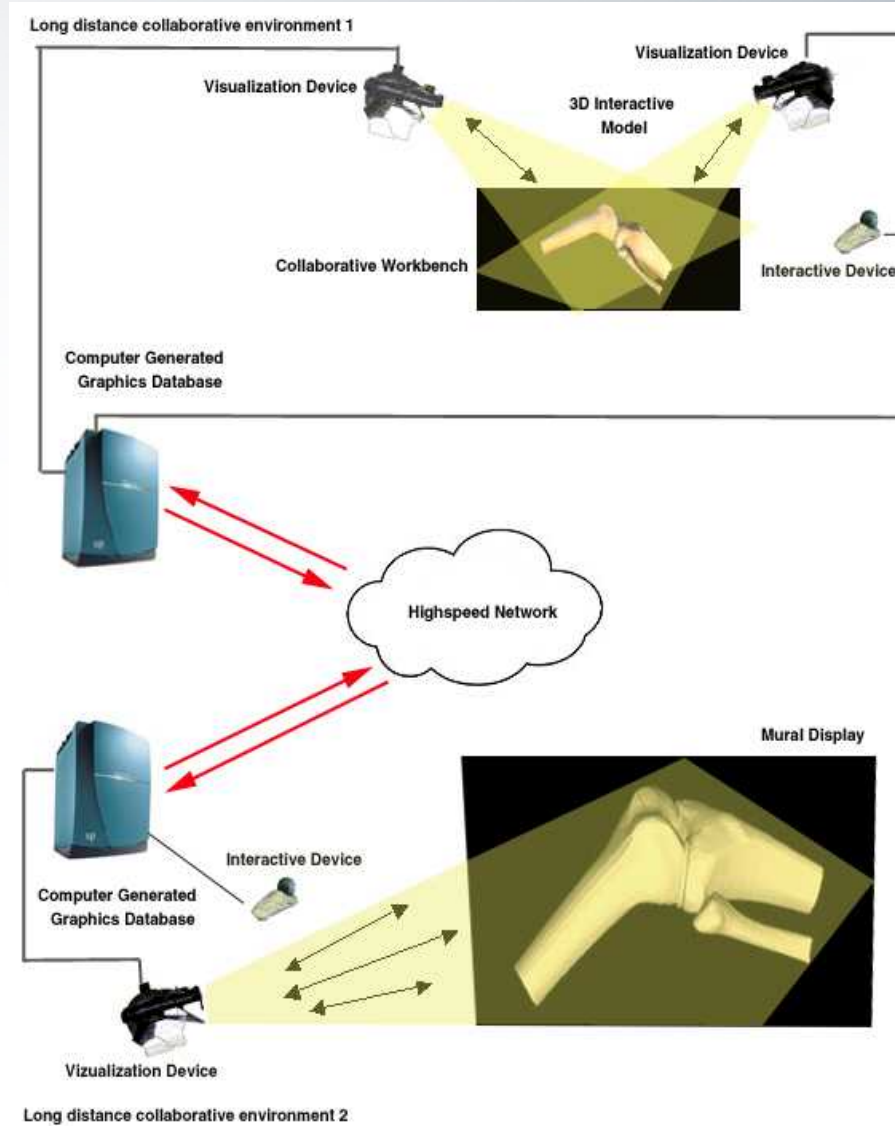


Desktop  
Laptop

2004

Deployable  
Tracking  
System

# Distributed VRDA



# Real-time Remote Demonstration from ODA Lab, Orlando to Networld Interop, in Atlanta Fall 2000 using Internet2

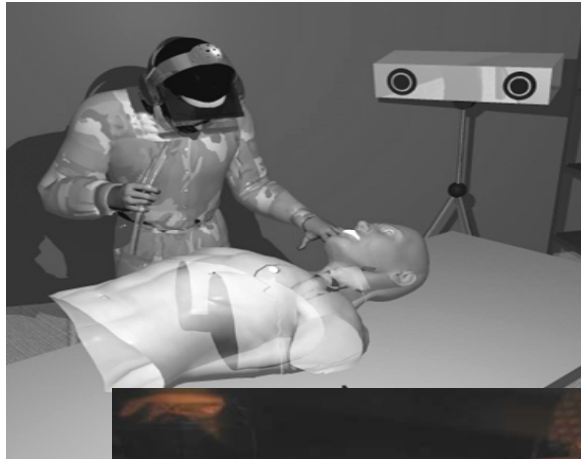


<http://www.cnn.com/2000/HEALTH/10/02/inet2.demo.story/index.html>

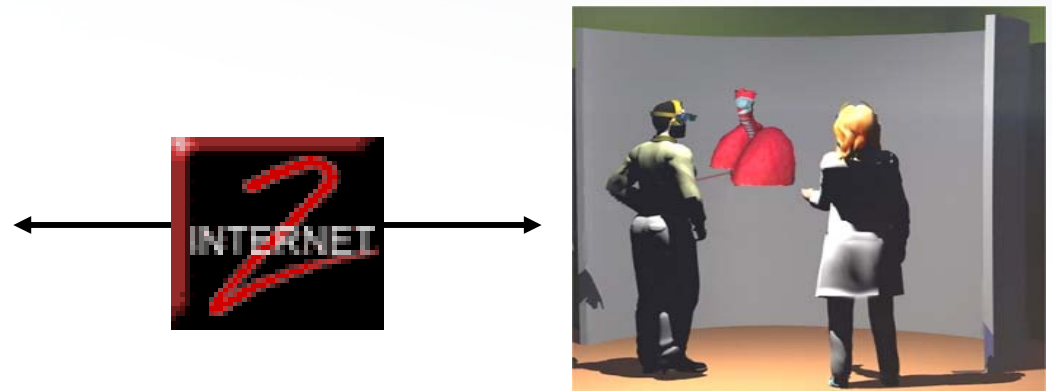
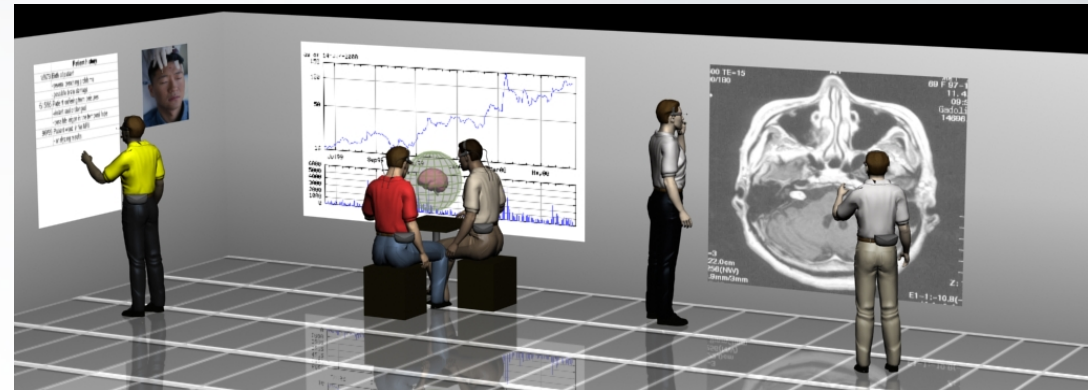
# AR Endotracheal Intubations Medical Training Tool



## AR Local Medical Training



## Teleportal Visualization designed for Telemedicine



Rolland, J., L. Davis , F. Hamza-Lup et. al.:  
“Development of a training tool for endotracheal  
intubation: Distributed Augmented Reality”, Medicine  
Meets Virtual Reality, Vol. 11, 2003, pp.288-294.

# 3D Video Conferencing



Stereoscopic Rendered Images and Video Streaming with Real-Time compression methods using Internet2 network infrastructure



# 3D Imaging through the HMPD

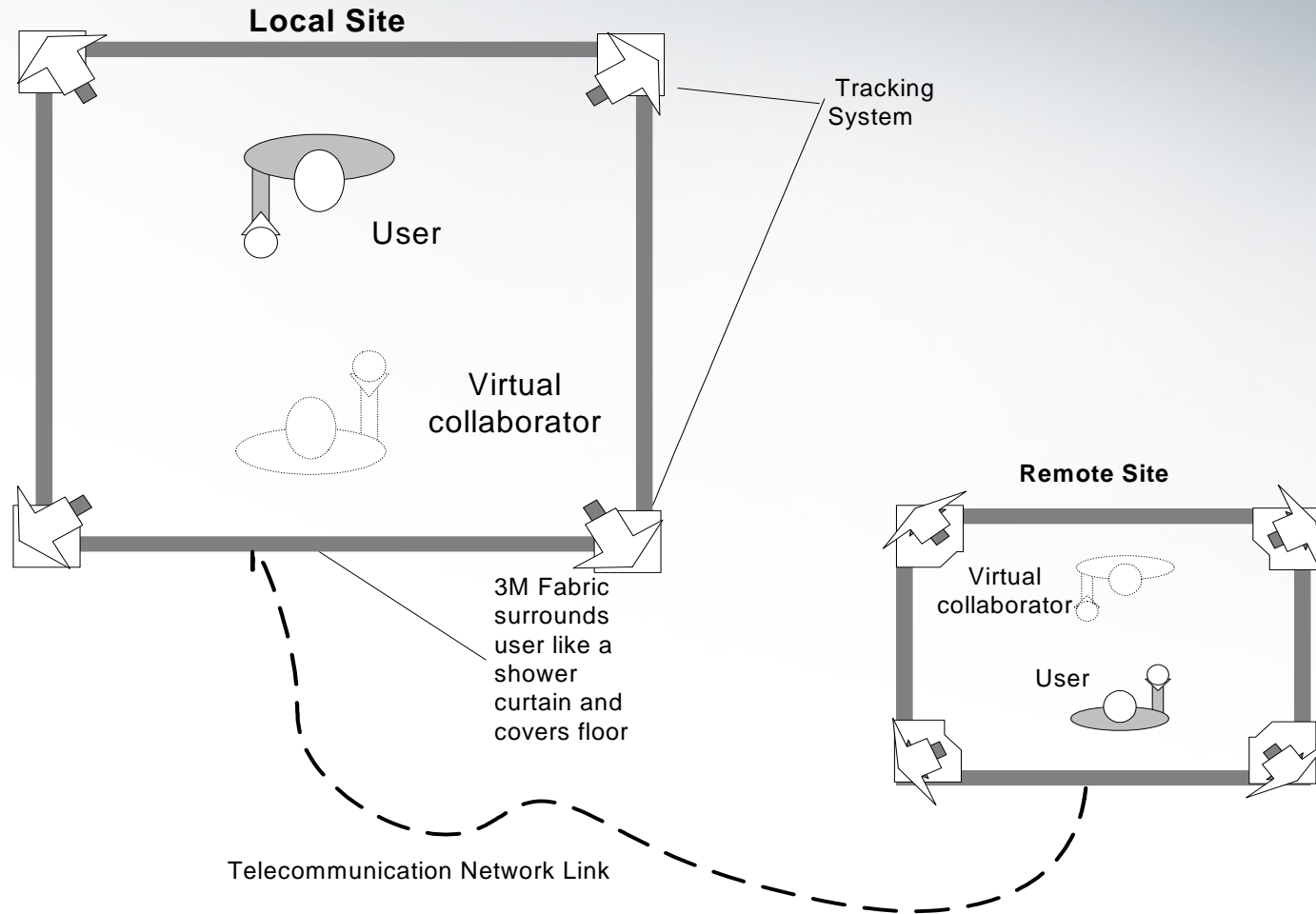


A 6 ft- 3D human skeleton appears to float inside a retro-reflective cylindrical display

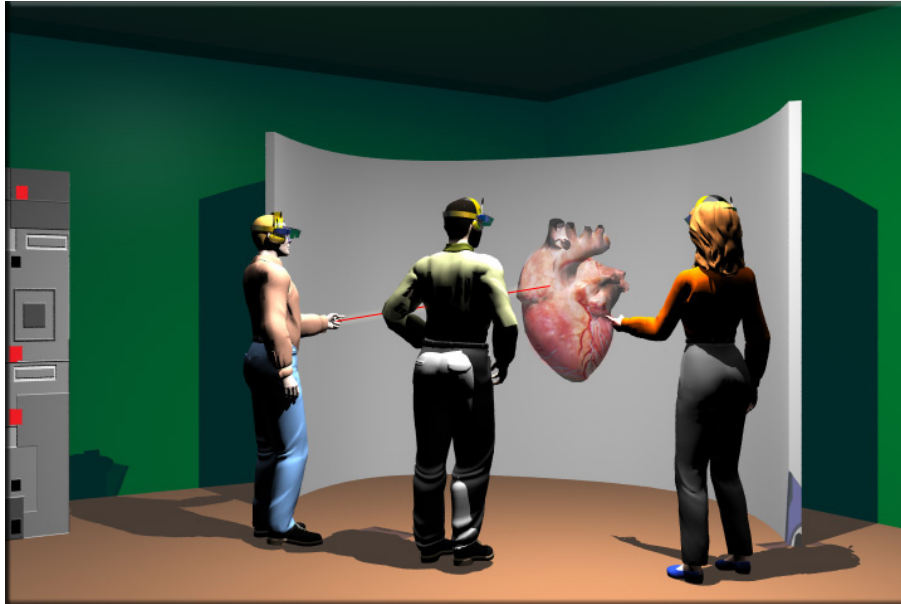
Rolland, J.P., Davis, Felix Hamza-Lup, Frank Biocca et. al. "Head-mounted projective displays for creating collaborative environments Larry in Proceedings of Aerosense'02, Vol. 4711, 399 April1-5th, Orlando FL, (2002).

# Identical Networked Rooms link

## Physical Local Collaborators and Remote Virtual Collaborators



# Extensions to other Distributed AR applications



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# AR Components - Sensors



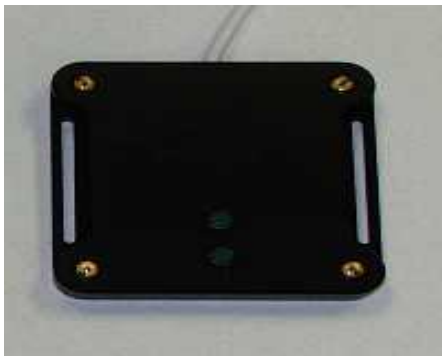
- 6DOF sensors (tracking sensors)
  - Give the position and orientation of the real objects in the environment.
  - Types:
    - mechanical, magnetic, optical, acoustic, inertial
    - hybrid - combinations

# AR Components – Sensors

## - an example – optical tracking sensors -



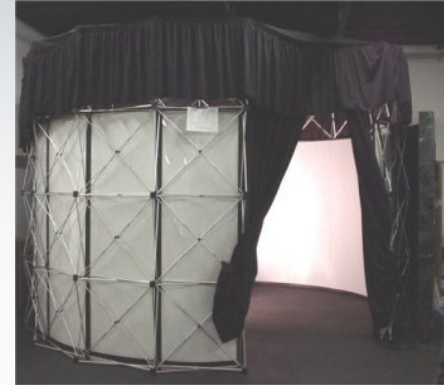
- Polaris™ Tracking System: used to determine the position and orientation of the user's head, HPS and Intubation Tube.
- Probe = rigid configuration of IREDs
- IRED probes:
  - HMD probe - tracks the HMD position
  - HPS probe - gives the manequin's chin position
  - Digitizing probe - gives the 3D position of the probe tip



# 3D Visualization System

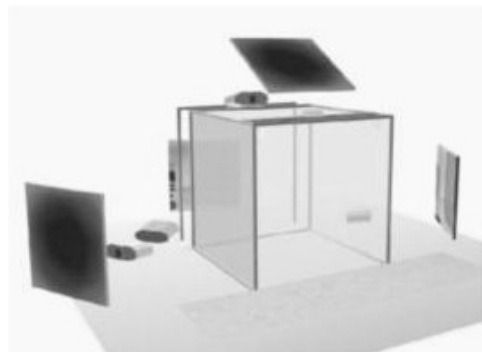


Head Mounted Projective Displays in  
the A.R.C. (Artificial Reality Center)



Hamza-Lup,F., L.Davis, and J.P. Rolland, "The Arc Display: An Augmented Reality Visualization Center", Proceedings of IEEE International Augmented reality Toolkit Workshop, Darmstadt Germany(29september 2002).

Other 3D Visualization Systems  
(e.g. CAVE™)



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# Distributed AR



## Data to be distributed:

- 3D Virtual Components of the scene
- Position and orientation of the real components (e.g. head position) for registration of Virtual components at specific locations (collect and distribute data from real-time sensors) - 6 DOF tracking devices.
- Audio, haptic information (for multimodal distributed AR)
- Video Streams

# Consistency in Distributed AR

## - *Inconsistency Factors* -



- Network infrastructure latency
  - Propagation, transmission, buffering delays etc.
  - Influenced by: bandwidth, error rate, congestion.
- System (Node) latency
  - Processing, rendering, buffering delays etc.
  - Influenced by: system complexity

# Consistency in Distributed AR

## - *Maintenance Techniques* -



- Humans, perceptual abilities =>
  - tradeoff between *ideal* and *perceived consistency*
- Shared State Consistency Maintenance in VE
  - centralized information repositories (pull/push architectures)
  - dead-reckoning algorithms (convergence & prediction)
  - frequent state regeneration (blind broadcasts, applications that do not require strong consistency)
- Resource management for scalability in VE
  - Communication protocol optimization (e.g. compression/aggregation)
  - Visibility of data (e.g. Area Of Interest)
  - Human perceptual limitations (e.g. LOD, Temporal Contour)
  - System Architecture (e.g. centralized vs. distributed)

# Consistency in Distributed AR

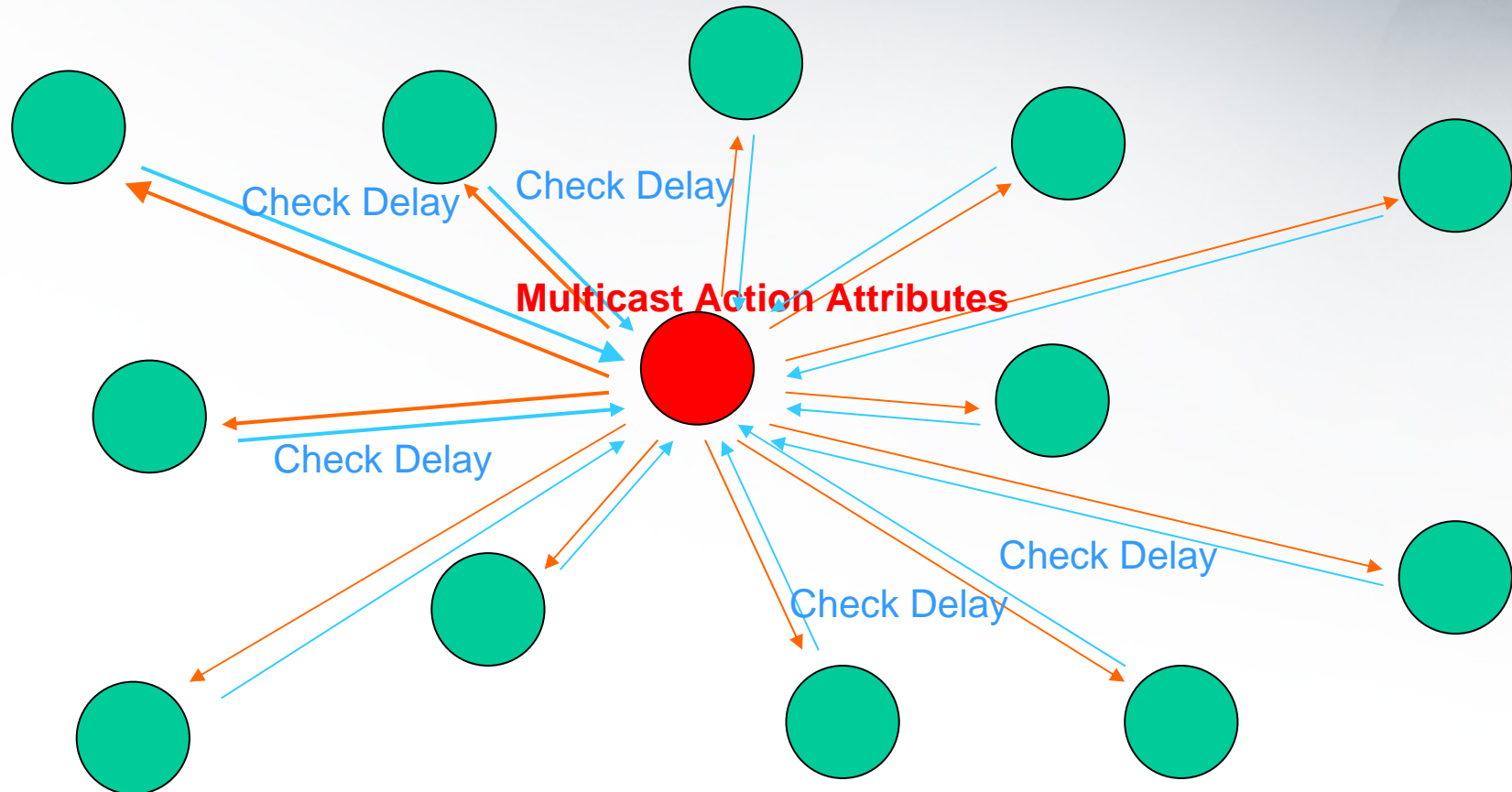
## - *Adaptive Synchronization Algorithm* -



- *Delay & Delay Variation compensation in distributed AR.*
- Each node:
  - runs a set of threads, rendering, interaction, monitoring...
  - has access to a local library of 3D models
  - interaction data is exchanged through messages
- Participants
  - “*active*” - nodes produce/broadcast/consume interaction data
  - “*passive*” - nodes consume interaction data, compute delay
- Each node independently adjusts its local scene based on
  - Communication delay
  - Participant’s actions attributes (e.g. velocity)

# Consistency in Distributed AR

- *Adaptive Synchronization Algorithm* -



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# Concluding Remarks



- We need applications to make best use of the increasing available bandwidth.
- Augmented Reality has a large set of application domains that wait to be discovered.
- Ease distributed application deployment over different administrative domains.
  - Transparent QoS management

# Internet2 ODALab Team



## Contacts:

- Jannick Rolland, PhD

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# Collaborators



Frank Biocca, PhD

M.I.N.D. Lab Director, Michigan State University

Ricardo Martins, Vasein Shaulov

Adastra Labs LLC.



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