Immersive 3D over Enhanced Access Grid

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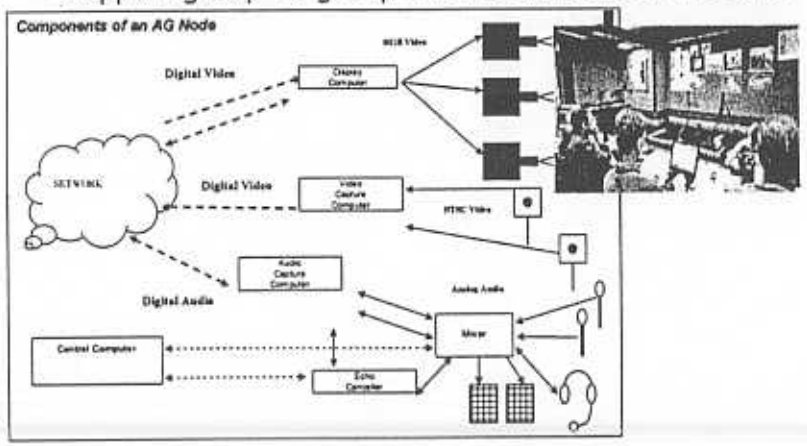
Outline

- Introduction
  - Motivation: Immersive Media
  - Why (enhanced) Access Grid?
  - Applications: Net VR
- 3D AG project
  - Testbed: system configuration
  - KJIST testbed: M-Class room
- Lessons & Demo
  - 3D delivery & display between KJIST & KISTI

What's Access Grid?

- Access GRID
  - Support group-to-group interaction across the Grid

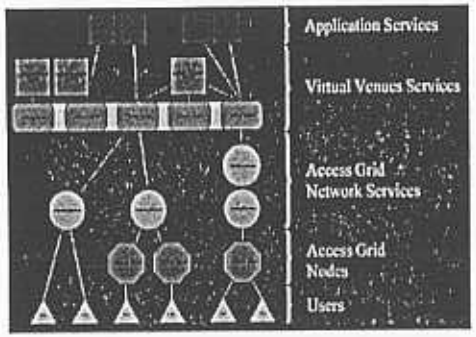


What's Access Grid?

- Aim of Access GRID
  - Enable group-to-group interactions at a distance
  - Improve the user experience
    - Provide an increased sense of presence
    - Support natural human and instrument interaction
    - Eliminate the boundaries of the monitor and the location
  - Enable multi-site visual & collaborative experiences
    - Integrate with high-end visualization environments
    - ActiveMural, Powerwall, CAVE, Flatland, Workbenches
  - Build on integrated GRID services architecture
  - Use quality but affordable digital IP based AV

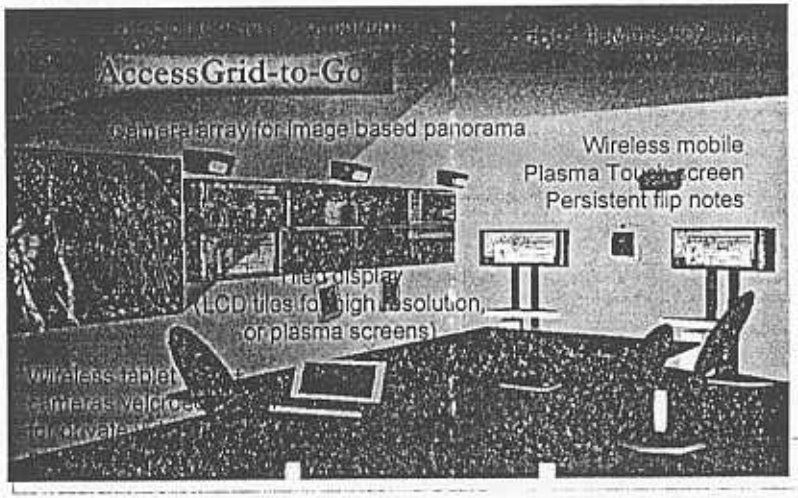
What's Access Grid?

- Access Grid Evolution
  - Network Support
  - Improved Audio
  - Enhanced Video (HD, Stereo/3D Video, ...)
  - Usability
  - Inter-operability
  - Security



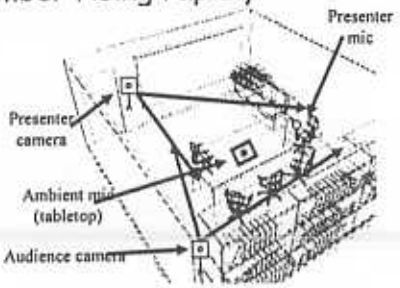
Why enhanced AG?

- Access Grid Collaboration



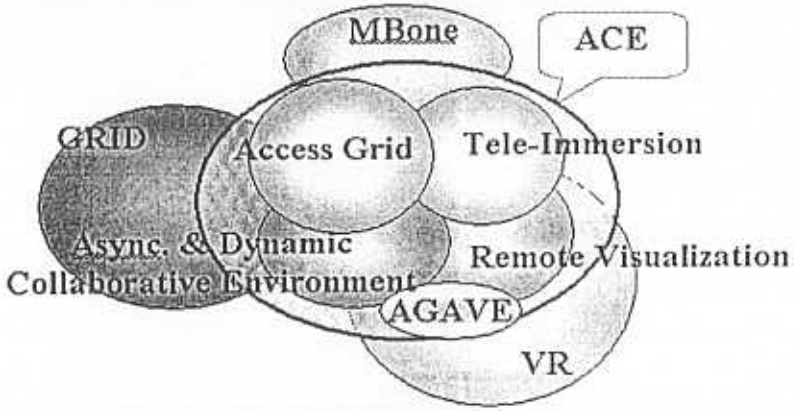
Why enhanced AG?

- Access Grid Collaboration
  - Enable collaborative work at dozens of sites worldwide, with strong sense of shared presence
  - Combination of commodity audio/video tech + Grid technologies for security, discovery, etc.
  - 130+ sites worldwide, number rising rapidly



Why enhanced AG?

- Advanced Collaboration Environment



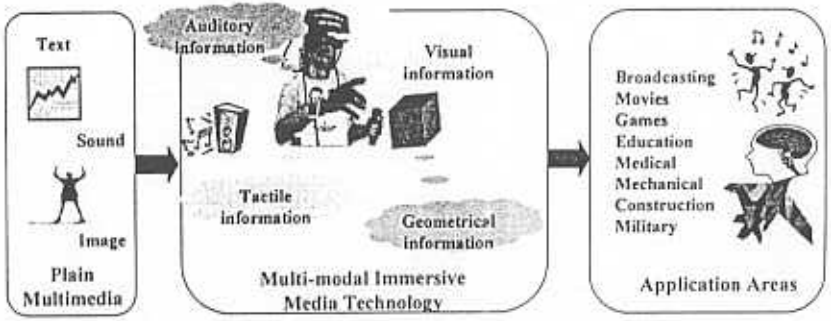
ACE : Advanced Collaborative Environment
AGAVE : Access Grid Augmented Virtual Environment

Why enhanced AG?

- Realization of Advanced Collaboration Env. via Immersive Media

Immersive Media

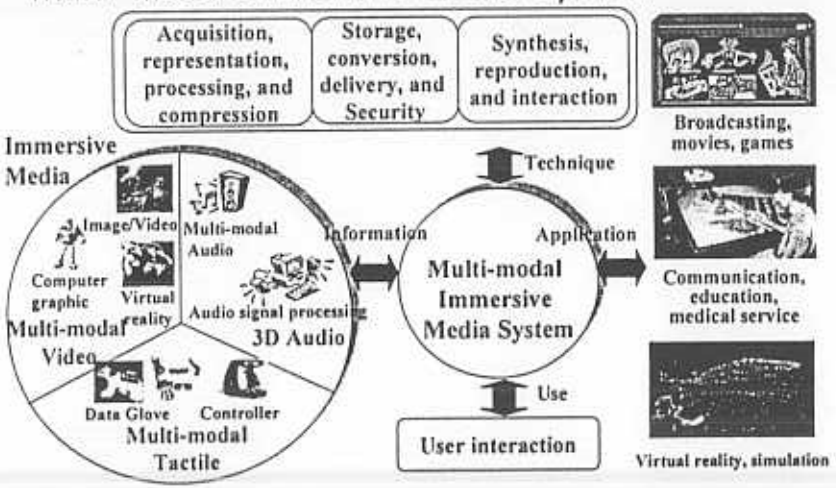
- Multi-modal Immersive Media Technology



- Increasing demand for user-centered multi-modal immersive media
- Growing needs for multi-modal interaction with users over the network
- Expected to serve as the core technology for next-generation IT industry
- Enables diverse application areas to provide add-on services

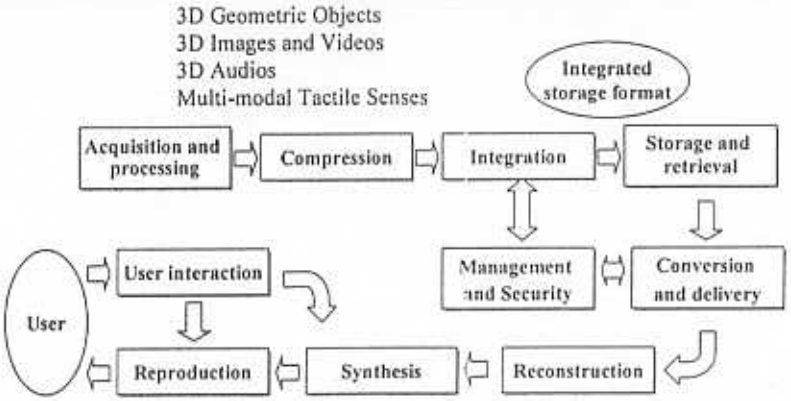
Immersive Media

- Multi-modal Immersive Media System



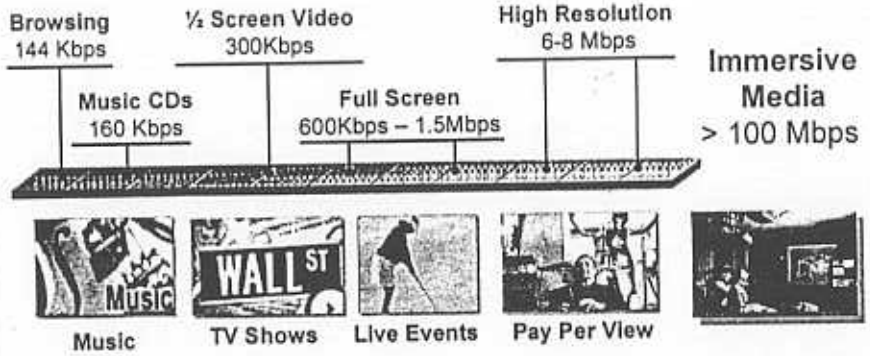
Immersive Media

- Life Cycle of Multi-modal I-Media



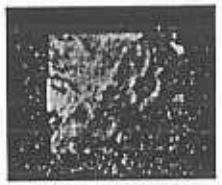
Immersive Media

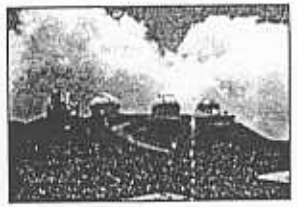
- Broadband Content Requires More...



Applications: e-AG

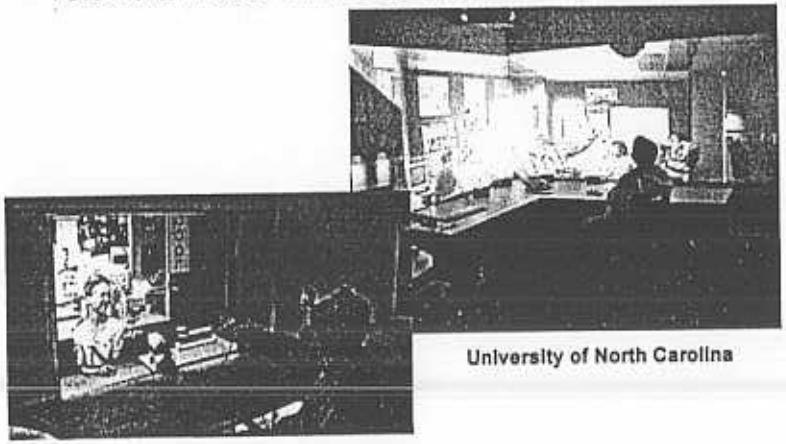
- Applications Cases
  - Interactive collaboration
  - Real-time access to remote resources
  - Shared virtual reality
  - Large-scale, multi-site computation and data mining
  - Any combination of the above





Applications: e-AG

- Applications Cases
  - Tele-immersive "Office of the Future"



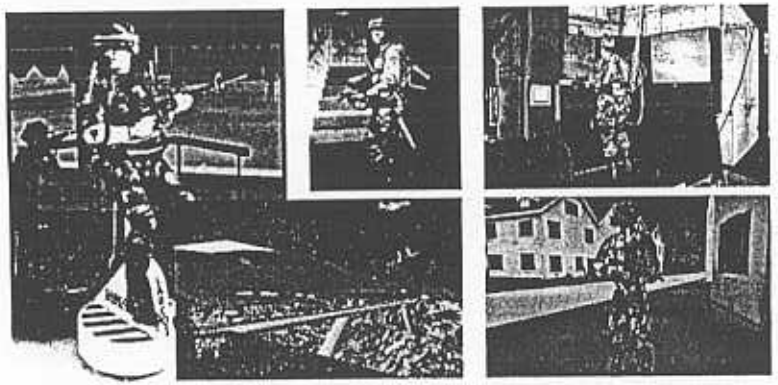
University of North Carolina

Applications: e-AG

- Application Cases
  - Collaborative design and engineering
    - airplane - wing, engine
  - Multiplayer games
  - Virtual shopping malls (e-commerce)
  - Online tradeshows and conferences
  - Remote customer support
  - Distance learning
  - Virtual Heritage

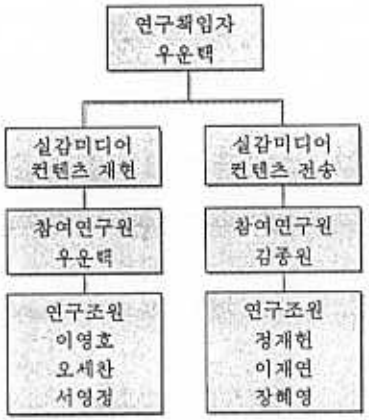
Applications: e-AG

- Application Cases
  - Military and industrial team training/simulation
    - military campaign - tank, plane, infantry



3D AG Project

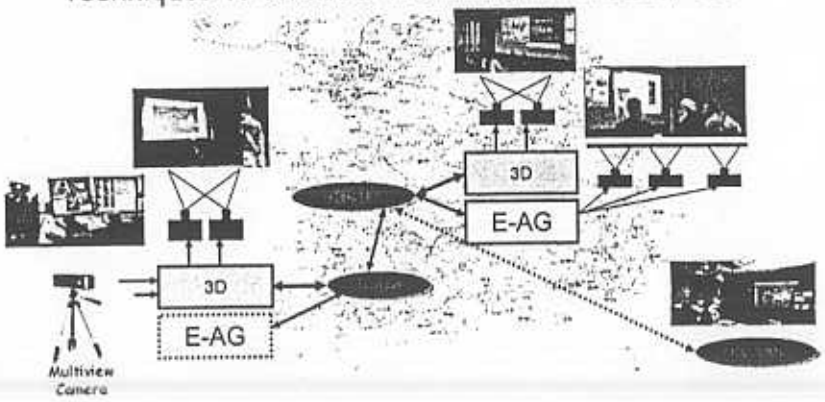
- 3D AG Project
  - Joint project btw KJIST U-VR Lab & NetMedia Lab



- 기존 AG 시스템의 화질 한계를 극복하도록 고화질 대용량 비디오 전달을 위한 요소기술 개선
  - 고화질 비디오 획득 및 처리, 압축 및 전송, 복원 및 재현 과정에 걸친 전체적인 효율성 개선에 의한 대용량 비디오 전송기술
  - 초고속 선도시험망의 전송 환경(155Mbps)를 극복하면서 실감형 비디오를 전송하는 AG 기술
- 실감형 상호작용 환경을 위한 고화질 3차원 영상 미디어 전송 및 재현 기술 개발
  - 디지털 (Stereoscopic) 3D 또는 마노리미 비디오 전송 및 재현을 위한 AG 구현 기술
  - AGAVE 시스템 기반 3차원 실감영상 재현 시스템 구축

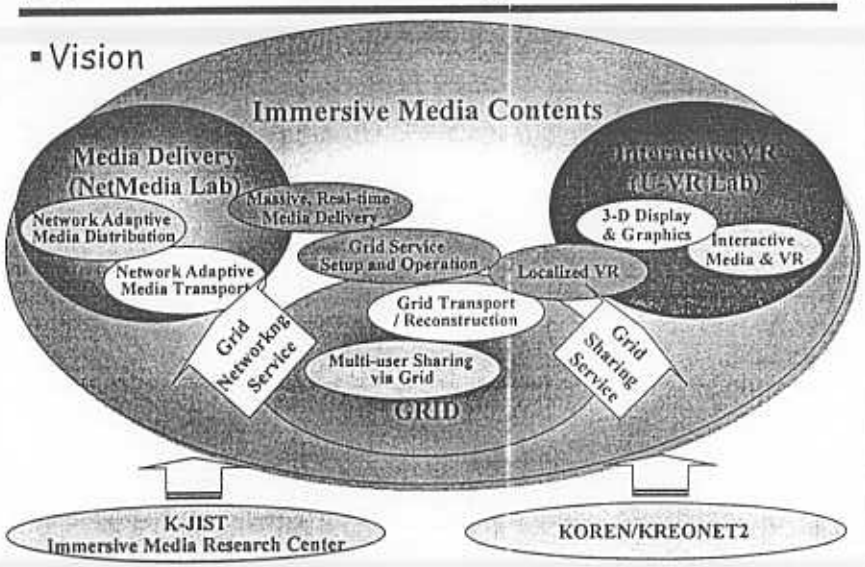
3D AG Project

- Goal of 3D AG Project
  - Realization of immersive media delivery/display
  - Development of 3D video delivery/display techniques to enhance the immersiveness of AG



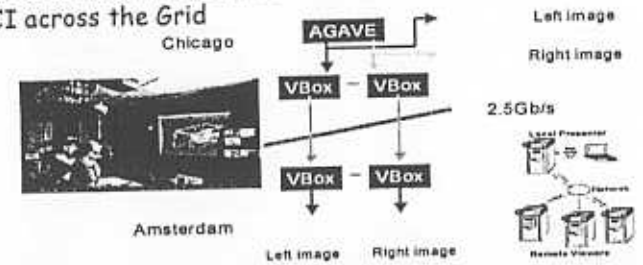
3D AG Project

- Vision



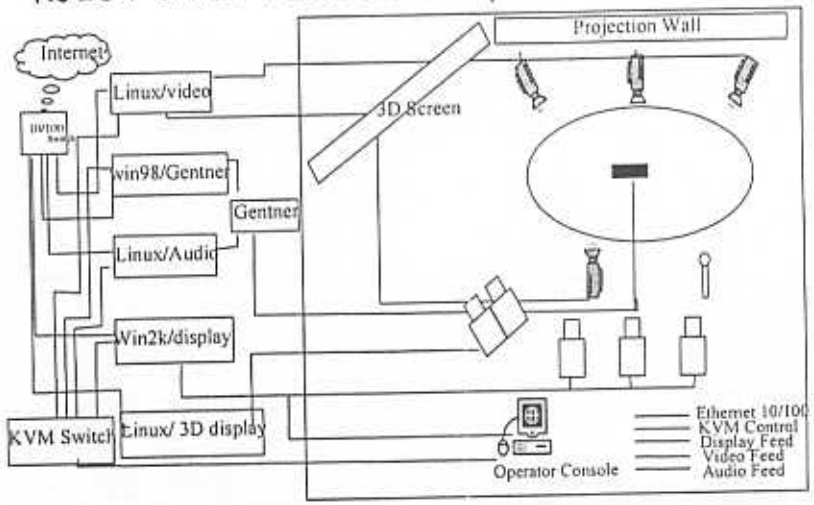
3D AG Project

- Previous research: AGAVE (UIC EVL)
  - Access Grid Augmented Virtual Environment
    - to augment the AG to allow collaborators to immersively share 3D contents
    - A low cost passive stereo-graphics projection system and accompanying networked PC
    - The ensemble of resources that can be used to support HCI across the Grid



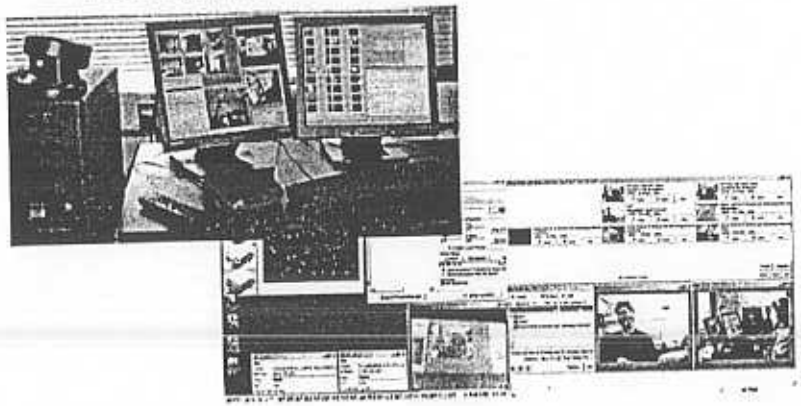
3D AG Project

- KJIST e-AG: Testbed Setup



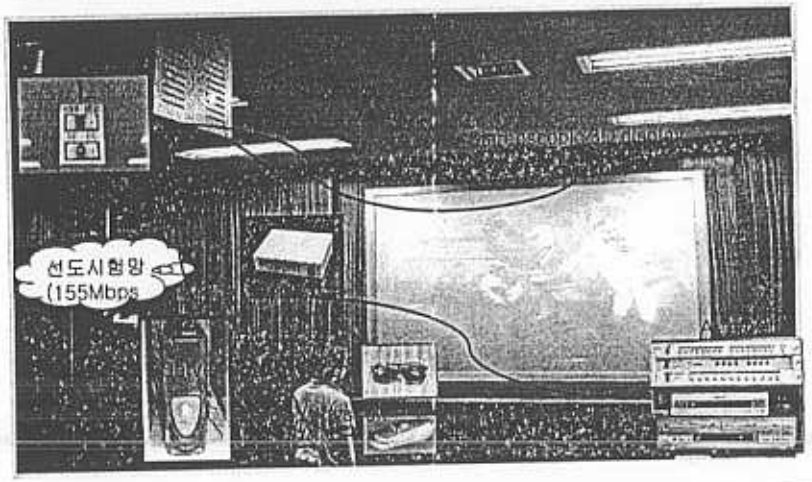
3D AG Project

- KJIST Mini AG (NetMedia Lab)
  - PIG: Personal Interface to AG (v.1.2, Oct. 2002)
    - Networking: KJIST - KISTI - KIST



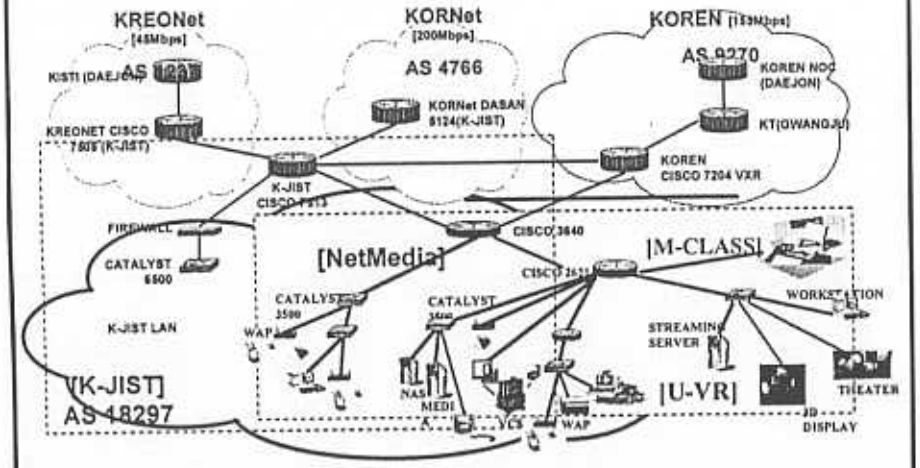
3D AG Project

- KJIST e-AG: Testbed Setup



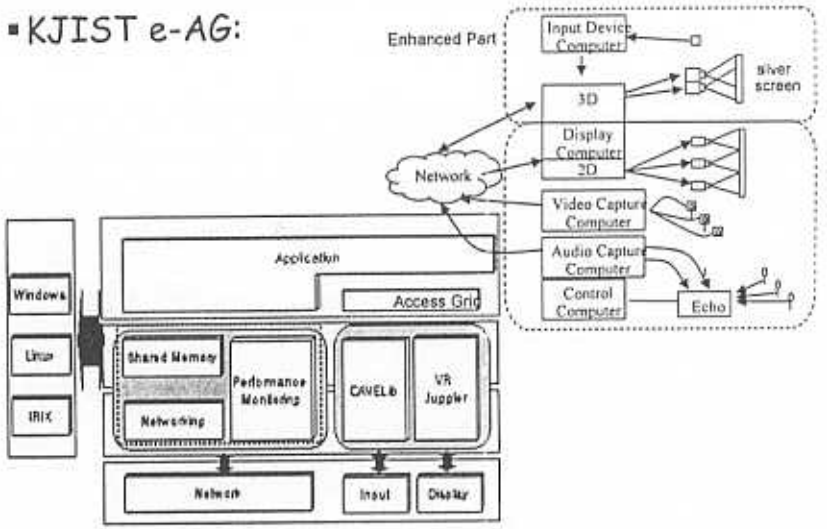
3D AG Project

- KJIST e-AG: Network Status



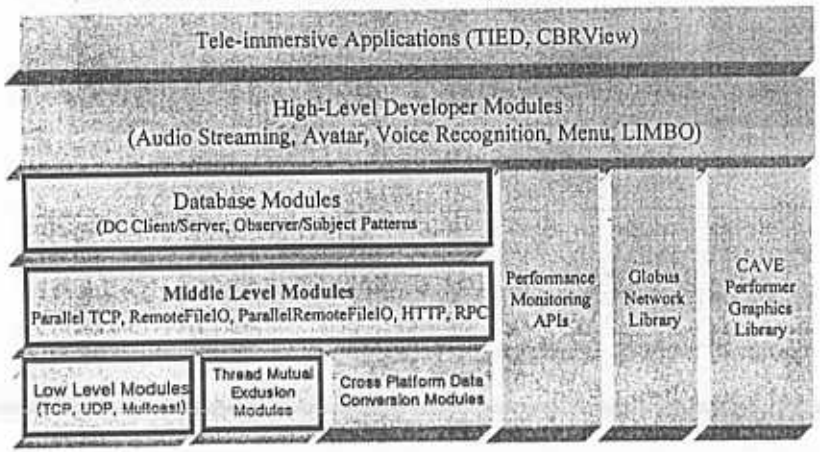
3D AG Project

- KJIST e-AG:



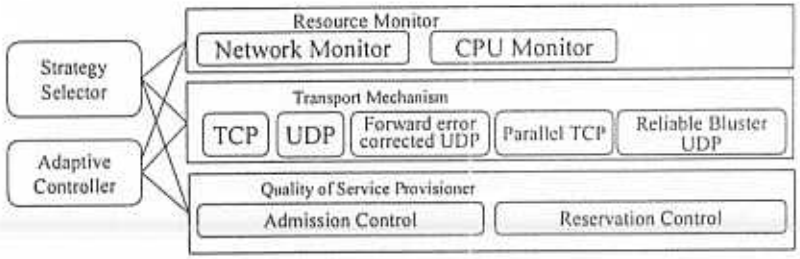
3D AG Project

- KJIST e-AG:
  - Networking: CAVERNSoft G2, Quanta



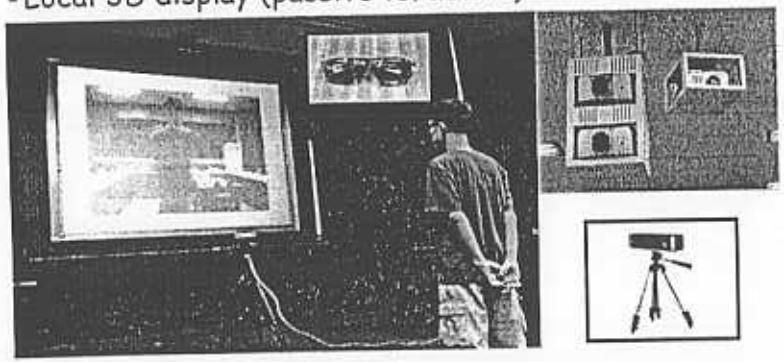
3D AG Project

- KJIST e-AG: Networking - QUANTA
  - Low-level modules: TCP, UDP, FEC+UDP, Parallel-TCP, Reliable Blast UDP
  - Thread/Mutual Exclusion modules: Thread management, mutual exclusion capabilities
  - Middle-level modules: Http, UDP and TCP reflector, Parallel socket TCP / Remote File I/O, RPC
  - Database modules: Distributed Shared Memory emulation



3D AG Project

- KJIST e-AG (3D Video Acquisition)
  - Capture using 3D camera
  - Formatting for efficient delivery & display
  - Local 3D display (passive vs. active)



3D AG Project

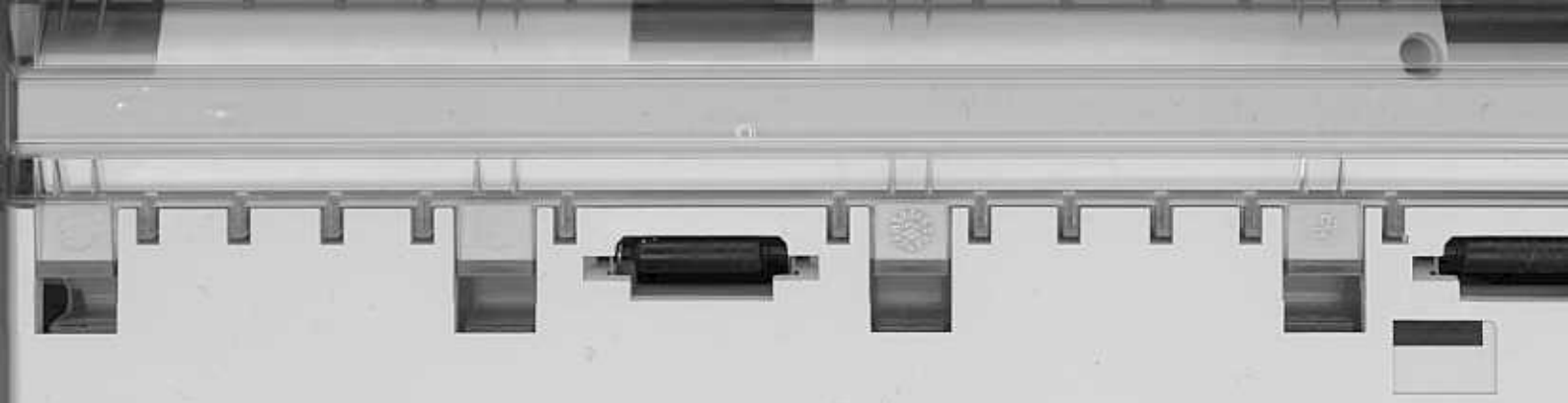
- KJIST e-AG: 3D Video Coding
  - Why 3D visual media delivery with multiview?
    - Immersive visual communication
    - (Object-based) functionality (interactivity)
  - Trade-offs: immersive vs. the amount of data
    - Channel BW, protocols, data amount

3D AG Project

- 3D Video Delivery: issues
  - Coding Efficiency
    - Occlusion detection and treatment
    - Joint motion/disparity estimation
  - Compatibility with Standards
    - MPEG-2: scalability
    - MPEG-4: object-based scalability
  - Functionality (interactivity)
    - Accurate & smooth disparity estimation
    - Segmentation or object-based coding

3D AG Project

- 3D Video Delivery: scalability
  - Why scalability?
    - Priority: error resilience on noisy channel
    - Multi-quality video services (VOD, HDTV, etc.)
    - Internetworking of standards or equipment
  - Basic Idea of Scalable Coding
    - Layered or hierarchical coding
    - Independent coding of the lowest layer
    - Dependent coding of each following layers
    - Coding complexity & quality scalability

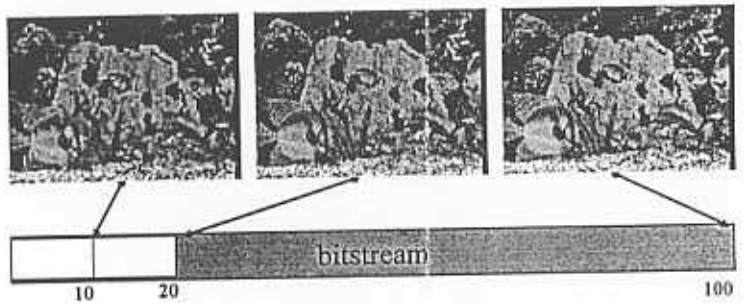


3D AG Project

- 3D Video Delivery: scalability
  - Why scalability?
  - Basic Idea of Scalable Coding
  - MPEG-2: Scalability Tools
    - Data Partitioning
      - Break a coded bit-stream into essential & additional parts
    - SNR (Quantization Noise) Scalability
    - Spatial (Resolution) Scalability
    - Temporal (Resolution) Scalability
    - Hybrid Scalability

3D AG Project

- MPEG-2: Scalability Tools
  - SNR Scalability: Control Quantization Step
    - Quantization Noise Scalability
    - Each layer coded at the same resolution w/ diff quality

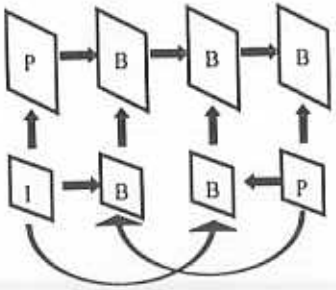


3D AG Project

- MPEG-2: Scalability Tools
  - Spatial Scalability: Extended Pyramid Coding
    - Base layer: coded at lower (sampling) resolution
    - Enhancement layer: upsampled and predicted from the BL
    - Backward compatibility: H.26x, MPEG-1.

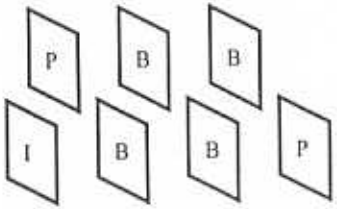
Enhancement layer

Base layer



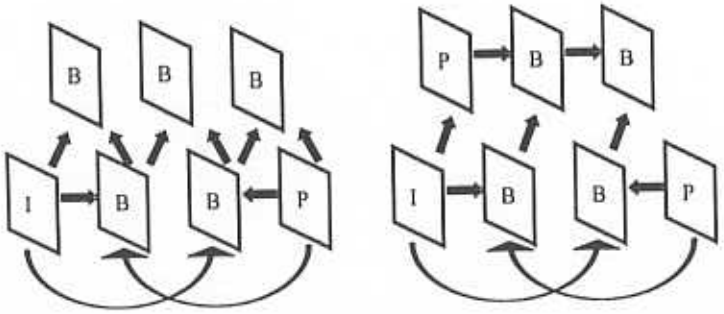
3D AG Project

- MPEG-2: Scalability Tools
  - Temporal Scalability
    - BL: codes higher priority bitstream at a lower frame rate
    - Enhancement layer: codes the intermediate frames



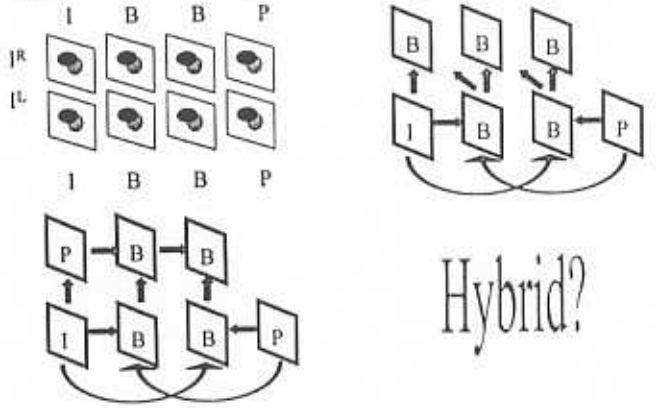
3D AG Project

- MPEG-2: Scalability Tools
  - Temporal Scalability: Prediction Configuration
    - Interlayer MC
    - MC & interlayer MC



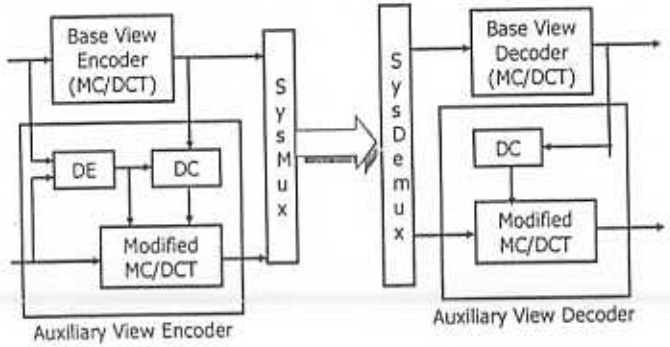
3D AG Project

- Stereo Video Coding
  - Simulcast vs. Compatible Coding



3D AG Project

- Structure of Stereo Codec
  - Compatible with MPEG-2
    - MPEG-2 (13818-3 AMD 3): Multiview Profile (9/96)
    - Temporal scalability



3D AG Project

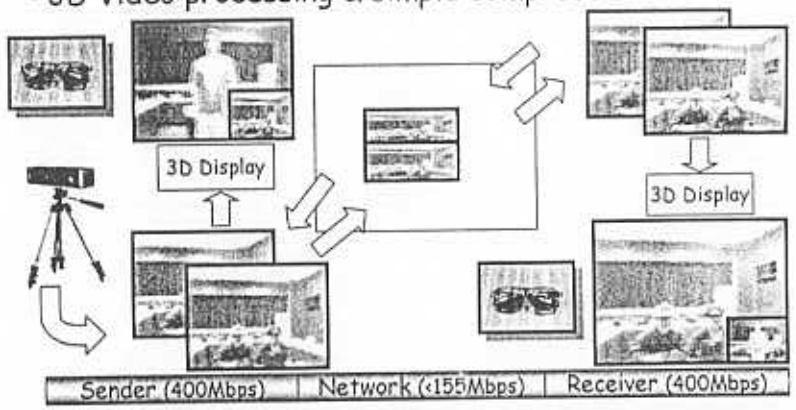
- Stereo Coding: Possible Research Topics
  - Functionality:
    - Segmentation-based Coding
    - Efficient representation of segmented objects
  - Flexible Viewing Angle:
    - Multiview video
    - Synthesis of intermediate-view
  - Joint DE and ME:
    - DE: larger horizontal search range due to its geometry
    - Accurate DE with occlusion detection
  - 3D IBMRL & SNHC: MPEG-21 ?

3D AG Project

- MPEG-2: Scalability Tools

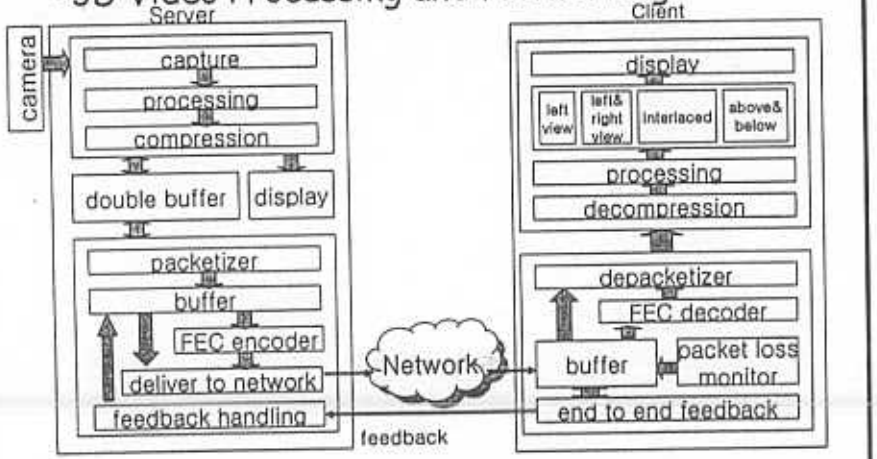
3D AG Project

- KJIST e-AG (3D Video Delivery)
  - Completed interface btw 3D Video + Networking
  - 3D Video processing & simple compression



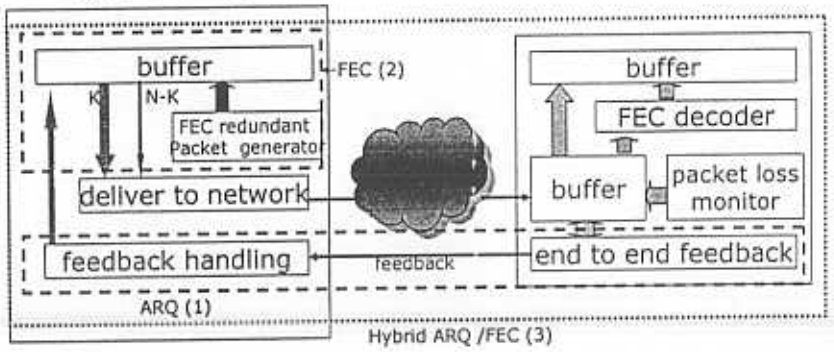
3D AG Project

- KJIST e-AG:
  - 3D Video Processing and Networking



3D AG Project

- KJIST e-AG: Module for Reliable Delivery
  - ARQ
  - FEC
  - Hybrid ARQ / FEC

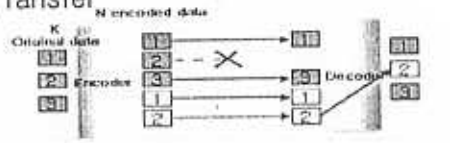


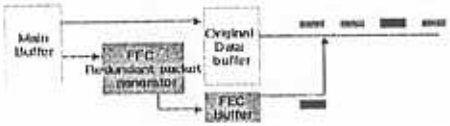
3D AG Project

- KJIST e-AG: Module for Reliable Delivery
  - ARQ:
    - RB_UDP : UDP augmented with aggregated ACK

Bulk Data Transfer

  - FEC
    - Loss : end site Buffer switch queue
    - → Full packet loss
    - → " Packet level FEC "
  - Hybrid ARQ / FEC

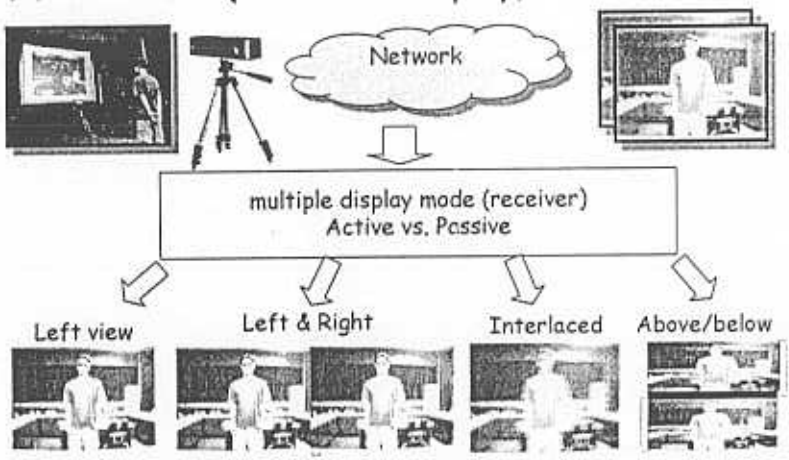




FEC module

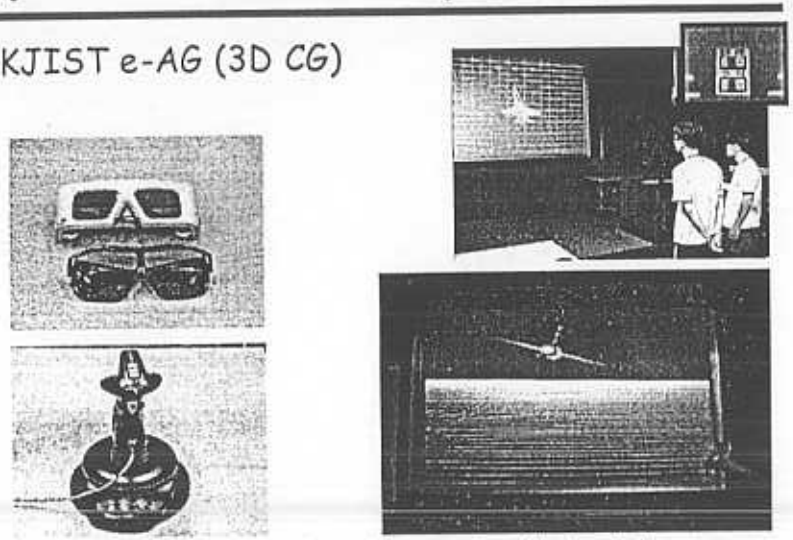
3D AG Project

- KJIST e-AG (3D Video Display)



3D AG Project

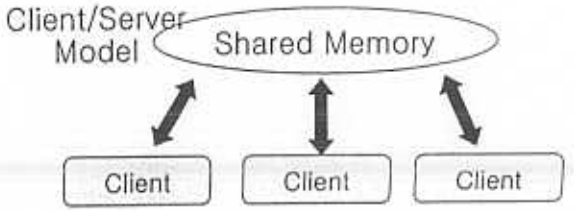
- KJIST e-AG (3D CG)



Stereoscopic Display and Interaction with Joystick

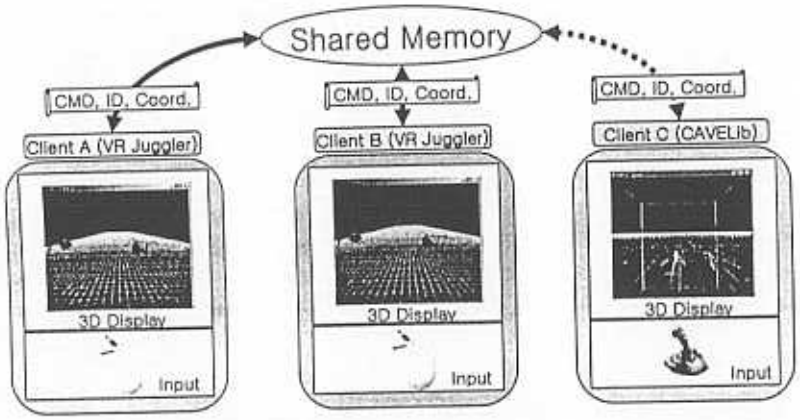
3D AG Project

- KJIST e-AG (Panorama)
  - Shared DB Model: Client/Server Model
    - Using TCP Reflector
      - Hybrid: Centralized Repository & Repository In Server Memory
    - Clients: Sending information to server
    - Server: update information to all clients



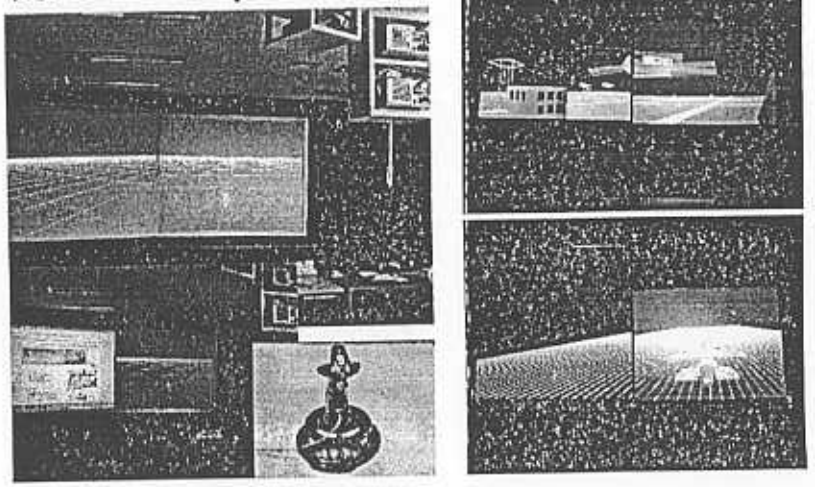
3D AG Project

- KJIST e-AG (Panorama)
  - Shared DB Model: Client/Server Model



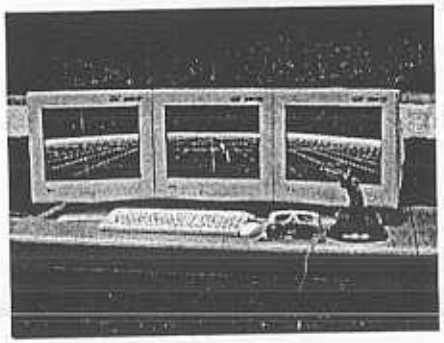
3D AG Project

- KJIST e-AG (Panorama)



3D AG Project

- KJIST e-AG (Panorama)
  - Setup
    - WildCat6110, Matrox Mystique
    - Active Stereo Display
    - CAVELib, VR Juggler
  - Networking
    - CAVELib & VR Juggler
    - Quanta

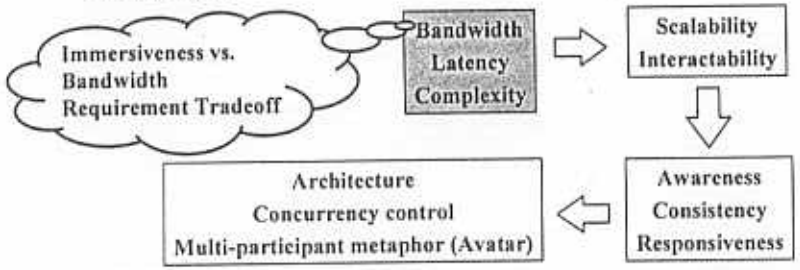


3D AG Project

- Next Phase (Nov.)
  - Delivery test and enhancement: KJIST - KISTI
  - Wrap-up
- Next Phase (in 2003)
  - Networked 3D panoramic VE setup between
    - KJIST e-AG and KISTI CAVE
    - KJIST e-AG and KIST CAVE
    - KJIST e-AG and UIC EVL
  - Networked real-time I-cubed VE
    - Perceptual Interface,
    - Natural Interaction,
    - Emotional Intelligence

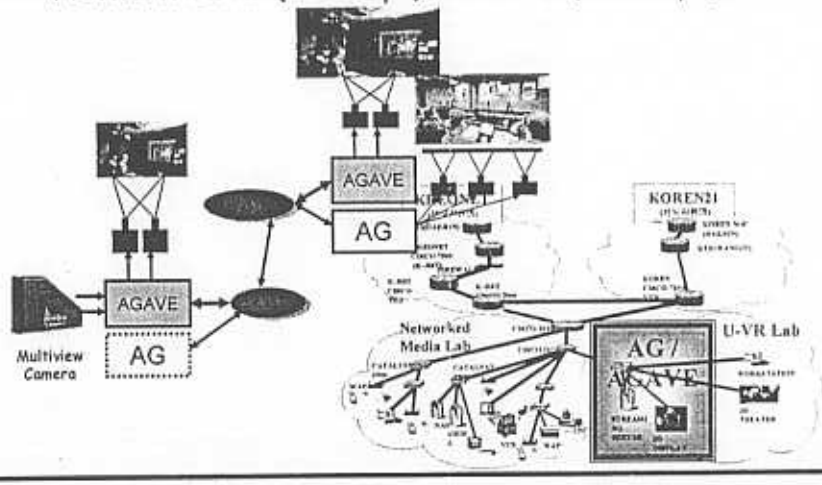
3D AG Project

- Next Phase (in 2003)
  - Immersive Media + e-AG Challenges
    - Bandwidth - Content (Stereo video 1K x 1K x 30fps x 24 bits x 2 = 1.4 Gbps)
    - Latency
    - Consistency
    - Scalability



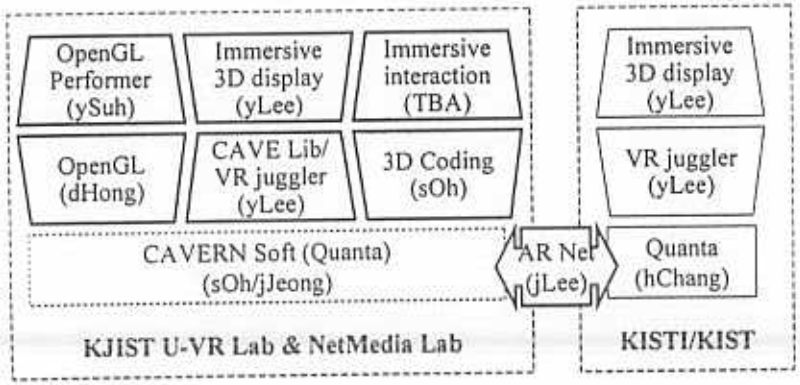
3D AG Project

- Demo
  - Network: Local (100Mbps) + KOREN (155Mbps)



3D AG Project

- Testbed: e-AG (VR Grid)
  - Networking btw KJIST & KISTI/KIST:



3D AG Project

- KJIST testbed: HW & SW Spec
  - 3D display
    - Projectors with polarizing filters & (silver) screen
      - Standard projection screens do not preserve polarization
    - Or stereo shutter glasses
  - PC: Dell 530 (dual Xeon 1.7GHz)
    - CG card: Wildcat6110 (Matrox G550, GeForce2 MX)
    - Software (Redhat Linux 7.3)

- Redhat linux: http://www.redhat.com/
- xfree86 4.0.2: http://www.xfree.org/
- Wildcat 6110: drivers http://www.3dlabs.com/
- CAVE Library: http://www.vrco.com/
- OpenGL Performer: http://www.sgi.com/software/performer/
- CAVERNsoft: http://www.evl.uic.edu/cavern/cavernG2/

Summary & Discussion

Thank You!

- Discussions (Q&A)
  - mailto:wwoo@kjist.ac.kr

References

- Access Grid: http://www.accessgrid.org/
- ACE: http://calder.ncsa.uiuc.edu/ACE-grid/
- Quanta (The Quality of Service Adaptive Networking Toolkit): http://www.evl.uic.edu/cavern/quanta/
- L. Childers et. al., "Access Grid: Immersive Group-to-Group Collaborative Visualization," *Proceedings of the Fourth International Immersive Projection Technology Workshop*, June, 2000.
- J. Leigh et. al., "AGAVE : Access Grid Augmented Virtual Environment", in *Proc. AccessGrid Retreat*, Argonne, Illinois, Jan. 2001.
- Ian Foster, "Peer to Peer & Grid Computing," Internet2 Peer to Peer Workshop, Jan. 2002.