Research Challenges for Immersive Video Communication Ecosystems over Future Internet

Tasos Dagiuklas, Ph.D., SMIEEE

Assistant Professor

Converged Networks & Services (CONES) Research Group

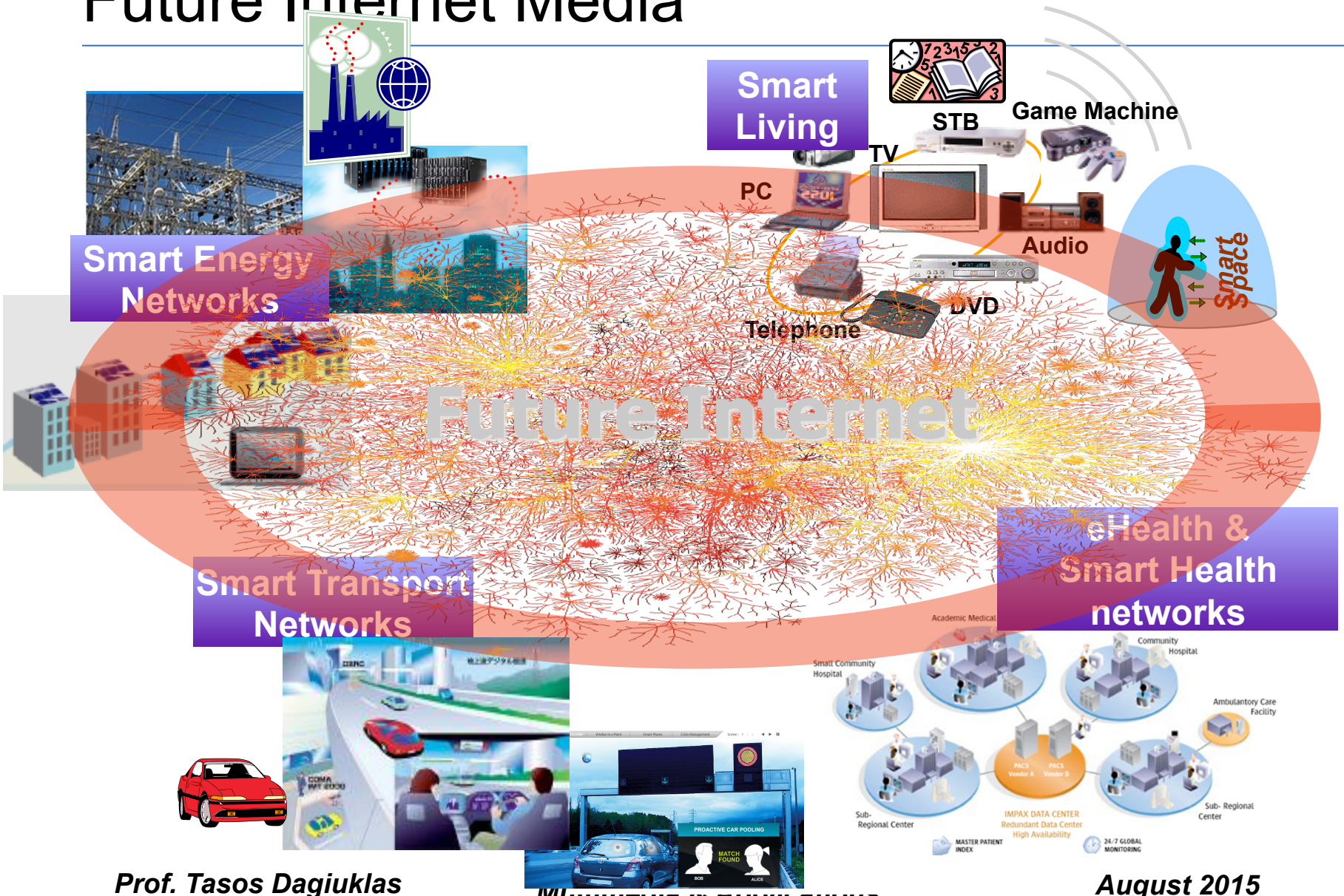
Hellenic Open University, Greece

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Presentation

- Networked Media in Future Internet
- 3D Video Characteristics
- 3D Media Representations, Coding & Transmission
- 3D Video QoE
- 3D Media Research Challenges
- Questions

Future Internet Media



Future Internet Characteristics

Everything on Cloud



- Giga-bit Data Rate
- Ultra Low Latency

Immersive Experience



- Giga-bit Data Rate
- Ultra Low Latency

Ubiquitous Connectivity



- Massive Connectivity
- Ubiquitous Coverage

Telepresence



- Giga-bit Data Rate
- Ultra Low Latency

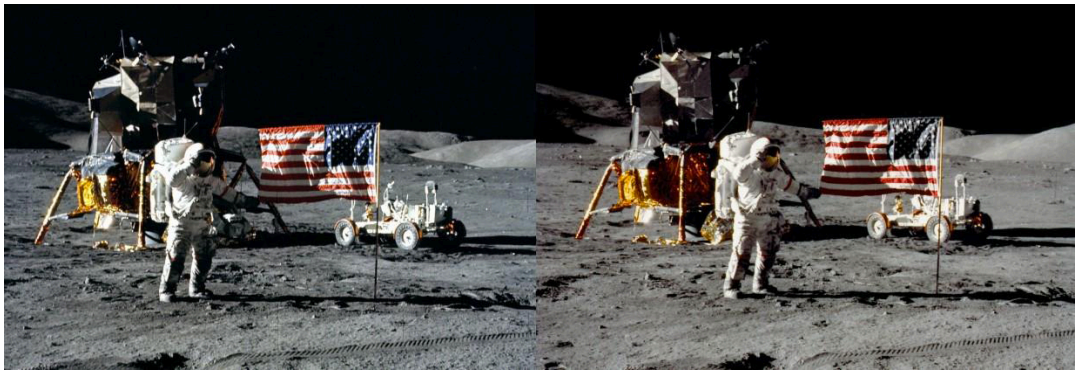
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3D Applications

- 3D cinema
  - Technology: stereoscopic 3D, glasses based
  - Good stereo 3D viewing
  - Decent number of 3D productions
- 3D mobile
  - Technology: auto-stereoscopic 2 view display with fixed viewing position
  - Good 3D viewing despite of small display sizes
- 3D home entertainment (3DTV)
  - Technology: Different types of displays available: stereoscopic, auto-stereoscopic with 2 … N views
  - Various technologies, input formats and display sizes
  - Glasses based systems may not be acceptable

Stereo versus Multiview Video Data



- Stereo
  - One 3D Representation



- Multiview
  - Several Number of Views

3D Video Experience

- Depth perception in stereoscopic displays
  - Effect provided through stereo video pairs, targeting the left and right eyes, allowing the perception of depth using stereo parallax
- Depth perception in auto-stereoscopic displays
  - Effect provided through N video views, targeting the left and right eyes in multiple positions, allowing the perception of depth using stereo and motion parallaxes
- Navigation
  - Effect provided through n video views, allowing navigating the 3D scene by changing the viewpoint and view direction within certain ranges; the viewer may experience a look around effect as well as depth perception

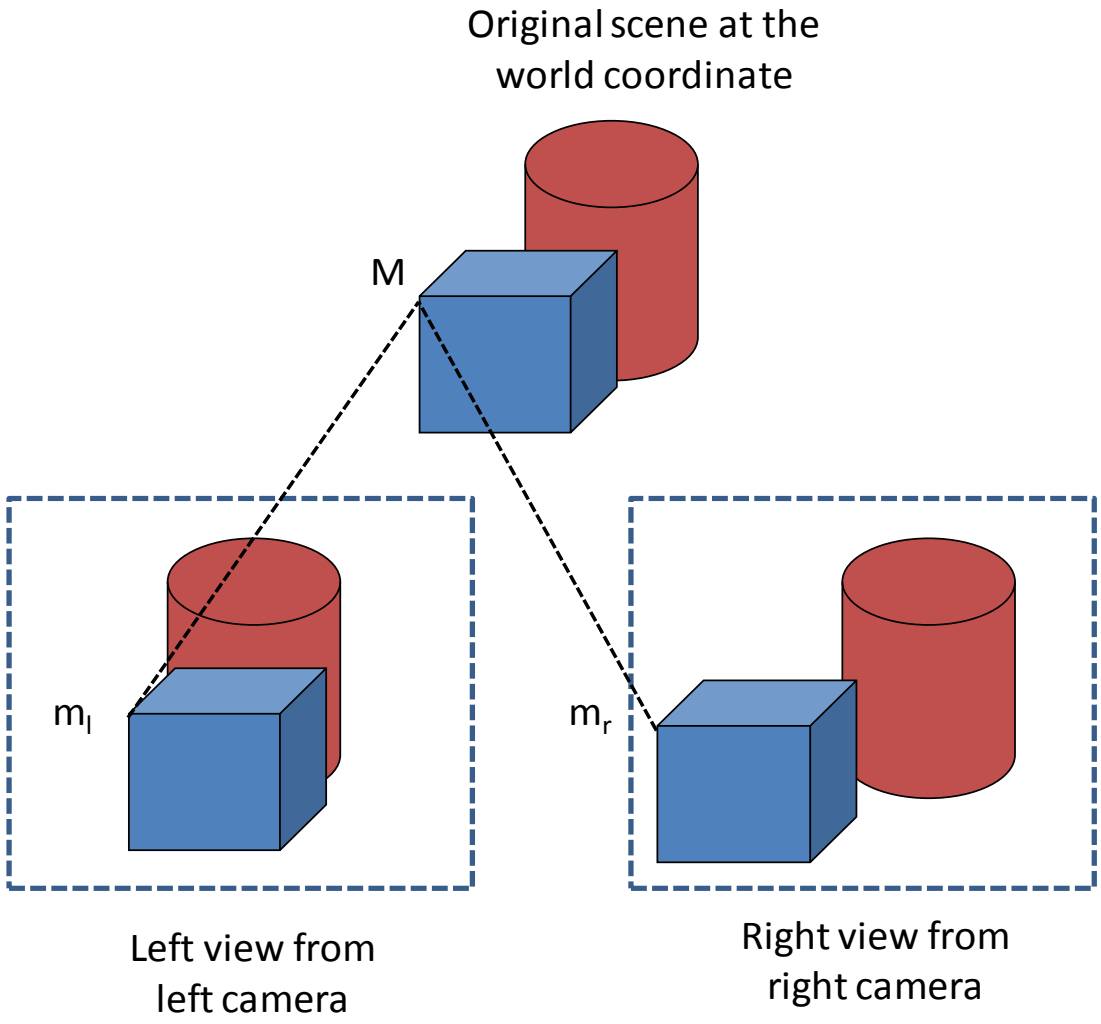
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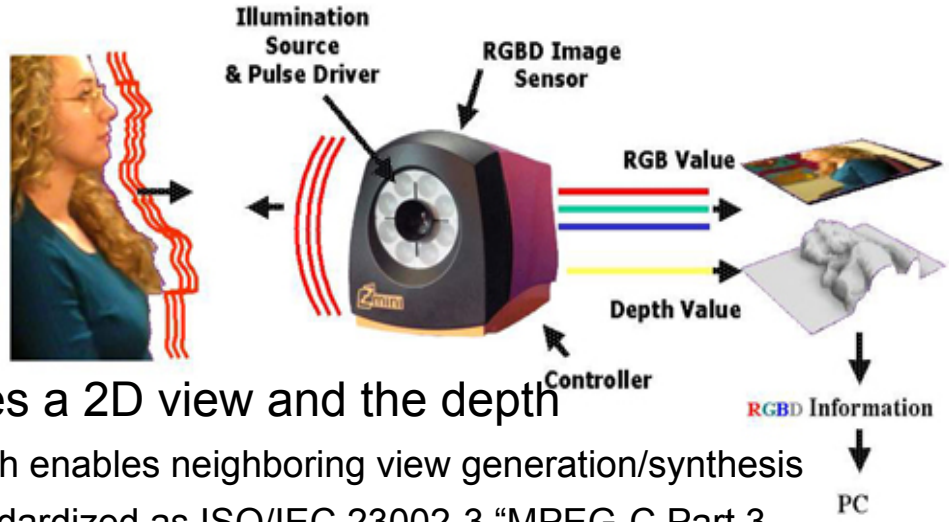
Left-Right 3D Representation



- Left and Right Cameras

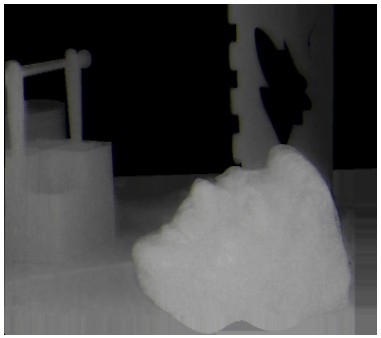


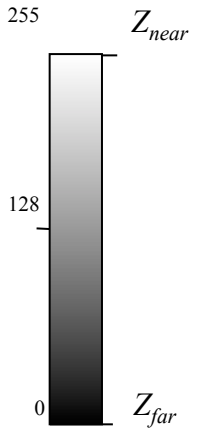
Colour Plus Depth Representation





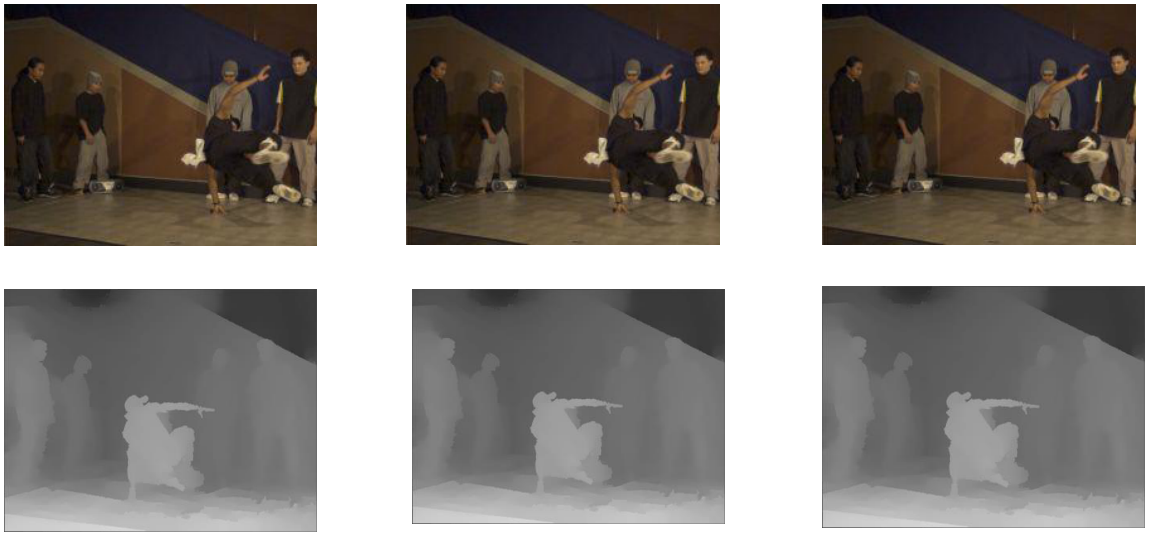
- Includes a 2D view and the depth
  - Depth enables neighboring view generation/synthesis
  - Standardized as ISO/IEC 23002-3 “MPEG-C Part 3
- Advantages
  - 2D video is backward compatible with legacy devices
  - Agnostic of coding format; can utilize MPEG-2, H.264/AVC
  - Additional bandwidth to code depth could be minimal
  - Support both stereo and multiview displays
- Drawbacks
  - Stereo signal not easily accessible and error-prone
  - No provisions to handle occlusions
  - Limited depth range rendering capability





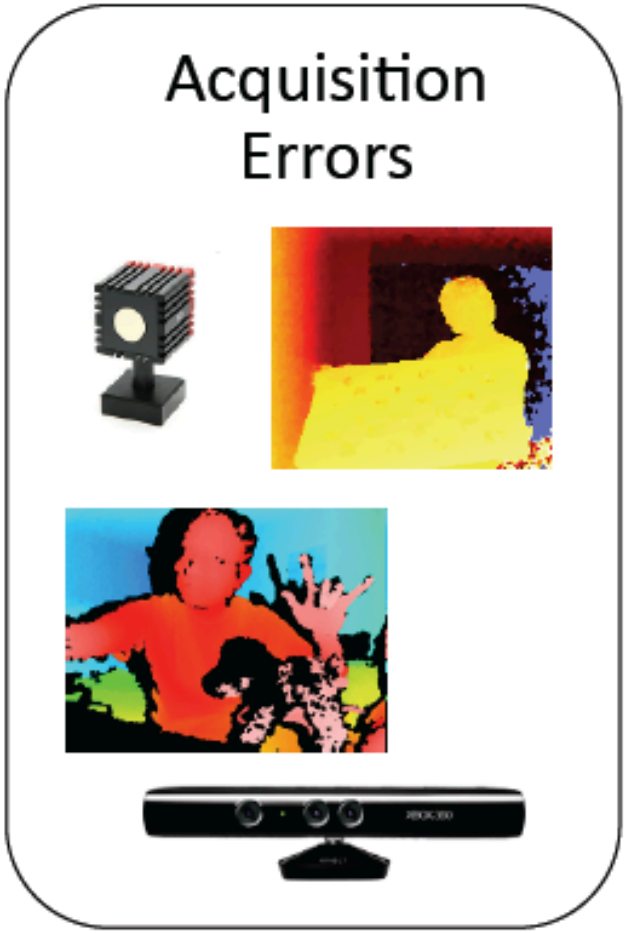
Multiview Video plus Depth (MVD)

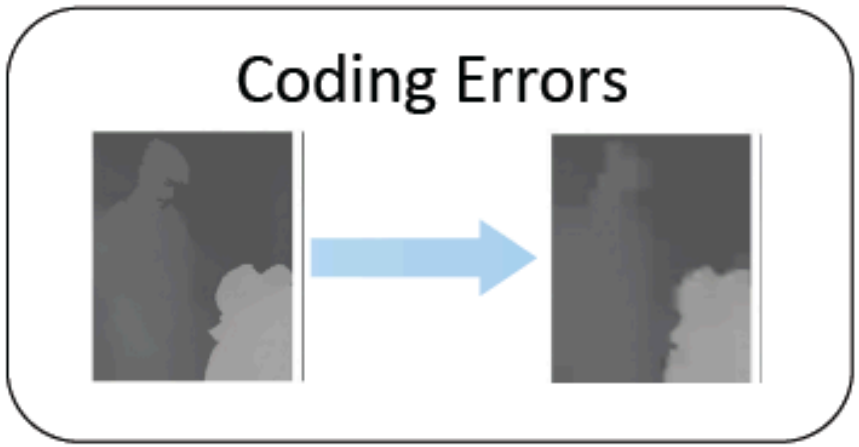
- The MVD format encodes both the texture and the depth data for the same number of views.
- Coding texture and depth simultaneously is a direction currently explored in MPEG as part of the 3D Video coding activity.
- MVD is the reference format for MPEG 3D Video



Depth Errors







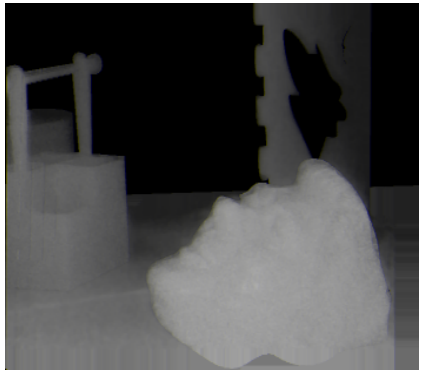
Depth-Image Based Rendering

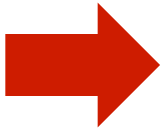
Colour



+

Depth





Left View



Right View



3D Display Technologies



- Anaglyphic (passive red-cyan glasses)
- Wavelength multiplexing (passive glasses)
- Polarization (passive polarized glasses)
  - Two images are projected superimposed onto the same screen through different polarizing filters
  - Polarized 3D glasses restrict the light that reaches each eye, exploiting the polarization of light

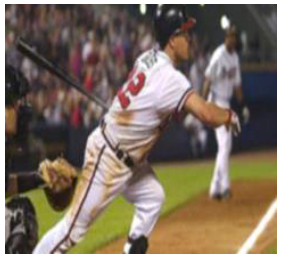


- Alternate-frame sequencing (active shutter glasses)
- Autostereoscopic multiview (no glasses)
  - They provide a different viewpoint to each eye at different viewing positions, producing both stereo & motion parallax with a fixed number of views

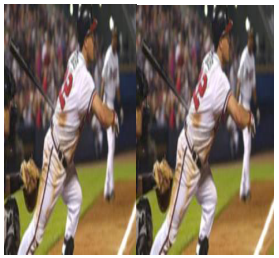
Conventional 3D to 2D Conversion (1)

- The stereo signal is a multiplex of the two views into a single frame or sequence of frames to be coded with 2D video coding solutions.
  - Spatial Multiplexing
    - Top-Bottom
    - Side-by-Side
    - Row Interleaved
    - Column Interleaved
  - Temporal Multiplexing
- Embraced by broadcasters for initial phase of 3D video services

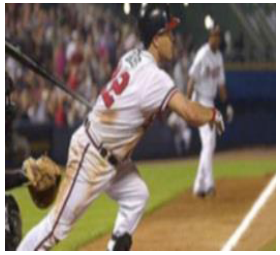
Conventional 3D to 2D Conversion (2)



Left Eye



LE RE



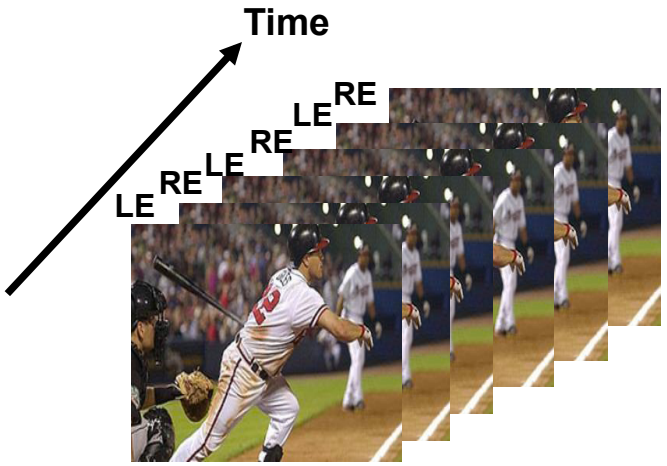
Right Eye



LE

RE

Spatial Multiplexing

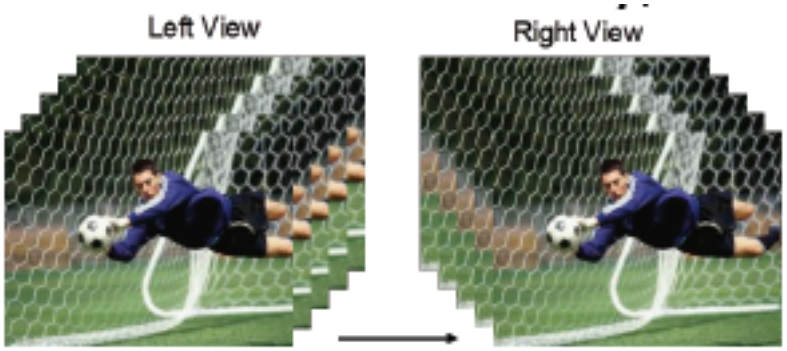


Temporal Multiplexing

Compression Schemes (1)

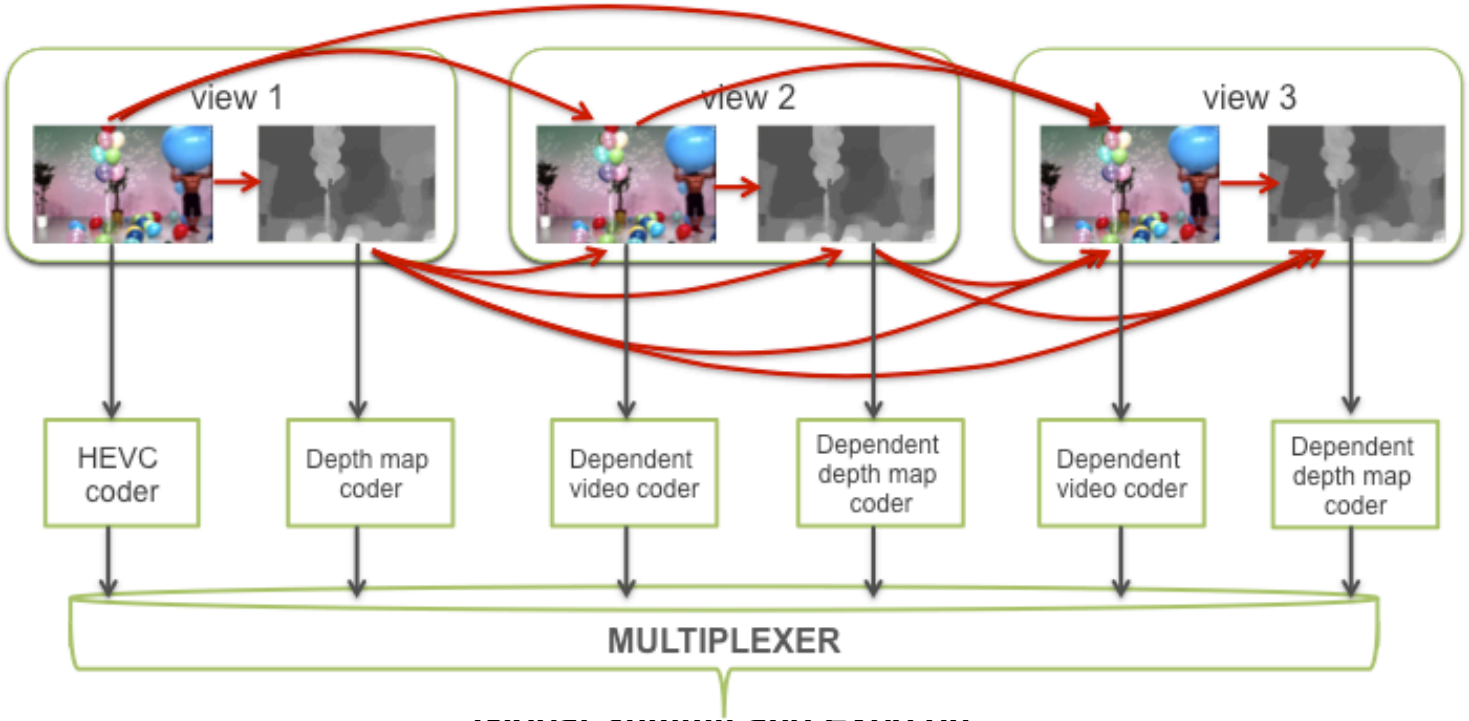
- Frame Compatible Stereo
  - Reduced resolution Leverages existing infrastructure
  - Used for first phase of 3D broadcast
- Muliview Video Coding (MVC)
  - Full-resolution, exploits correlation among views
  - Adopted as 3D format for Blue-ray, ATSC & Phase 2 DVB



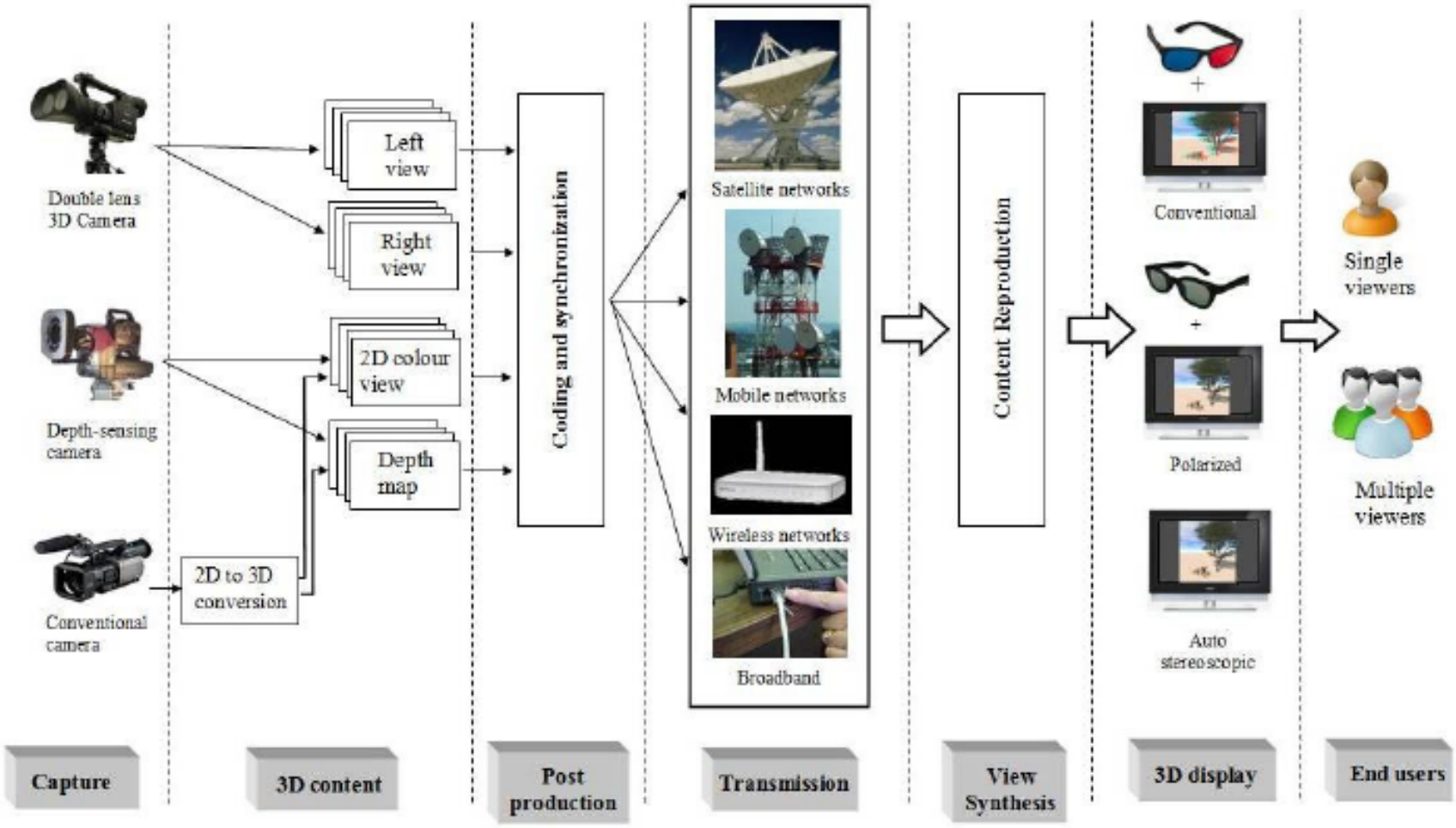


Compression Schemes (2)

- 3D-HEVC
  - It introduces hierarchical layers and new depth coding tools
  - 3D-HEVC uses inter, intra, and inter-view predictions
  - View: combination of a texture video and its associated depth map
  - Layer: texture videos and depth maps are each called a layer.



End-to-End 3D Video Chain



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3D Video Quality Artifacts

- "3D video quality of experience" is more than just visual quality in the 2D sense
- New types of artifacts compared to 2D:
  - Issues in capture of stereoscopic signals
  - Geometric distortions, camera miscalibration, …
- Differences in color, contrast, asymmetric coding, …
- View reconstruction
- Interpolation of occluded areas, …
- 3D Rendering issues
  - Crosstalk, color and brightness deficiencies, …

3DTV QoE

- 2D image quality
- Depth Quantity
  - Amount of perceived depth using the monocular and binocular depth cues
- Visual Comfort
  - Related to multisymptoms (e.g. eye strain, dry eyes, double vision) as well as the sensation of visual impairment or the sense of vision difficulties
- Depth Rendering
  - Quality of perceived depth, depending on the subject's preference, compression of the depth and the shape of objects
- Naturalness
  - Natural appearance of images, i.e. more or less representative of reality
- Visual Experience
  - Overall quality of experience in terms of immersion, perceived image quality as well as depth rendering (shape and dimension)

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Video Evolution in 2020

- New video formats and codec
  - UHDTV (Ultra High Definition TV; 7680 x 4320)
  - New coding standard HEVC
    - 1920 x 1080, 60 fps → 15 Mbit/s (half the bitrate of H.264/AVC)
    - 7680 x 4320, 120 fps → up to 800 Mbit/s
- Transition to 3D and interactive video services
  - Immersive service
    - High Resolution Panoramas
    - 3D video content with more than 2 views (e.g lenticular displays with 8 views)
  - Interactive content
    - Select your viewpoint
  - Augmented/Mixed Reality
    - Gaming
    - Manufacturing/Design
    - Cultural Heritage



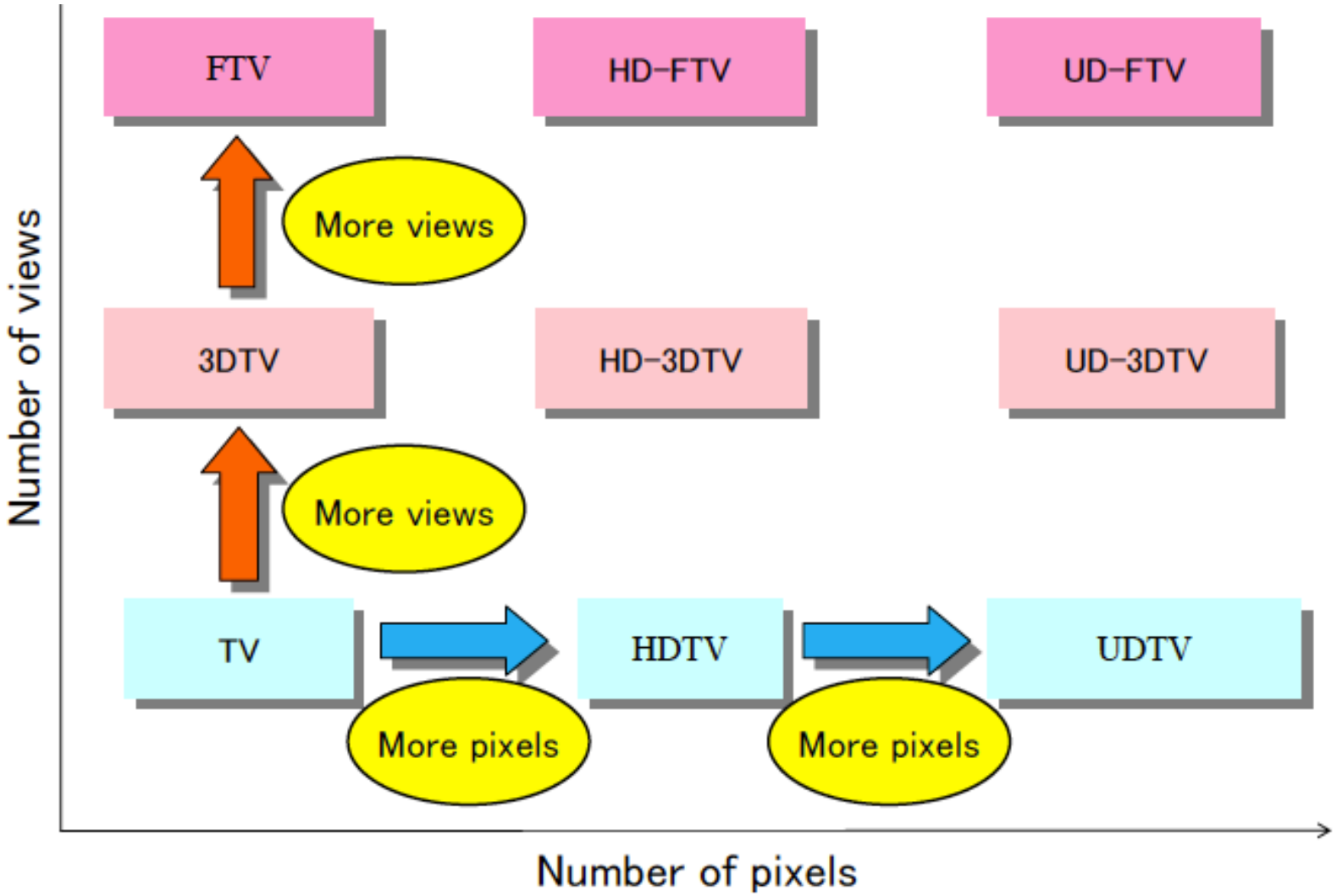




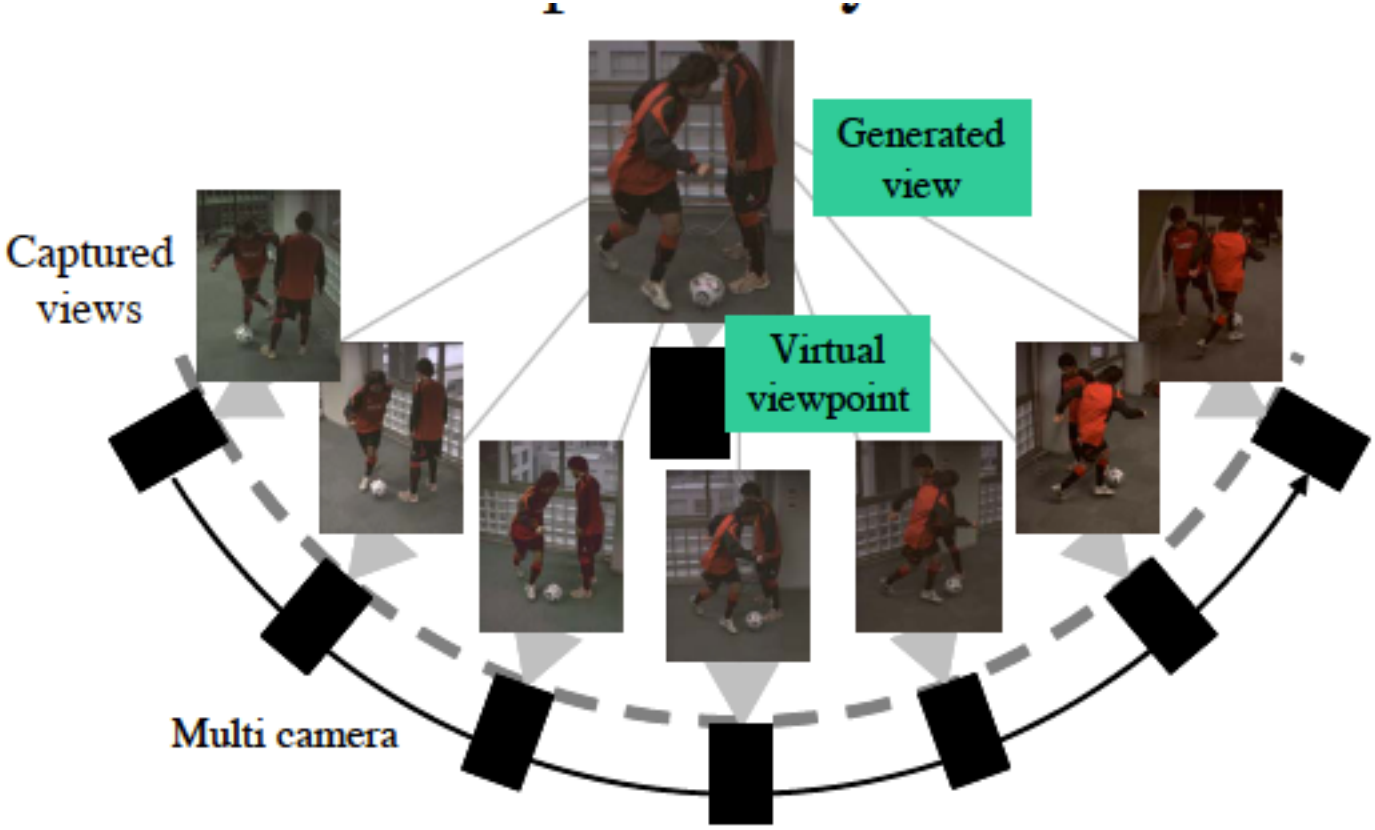




Visual Media Evolution

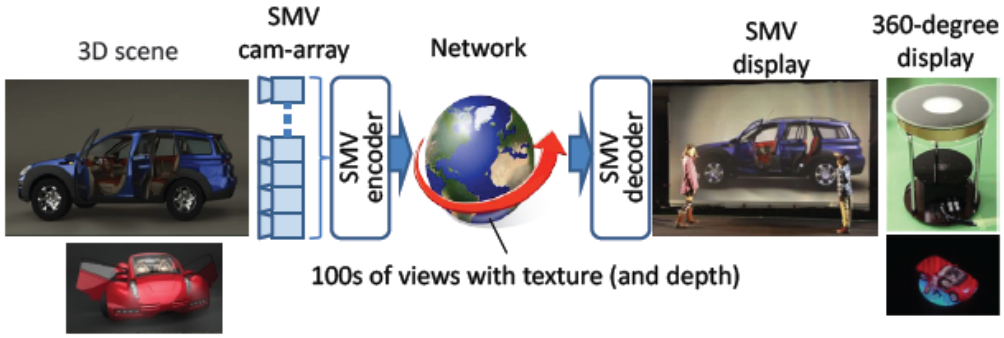


FTV Technology

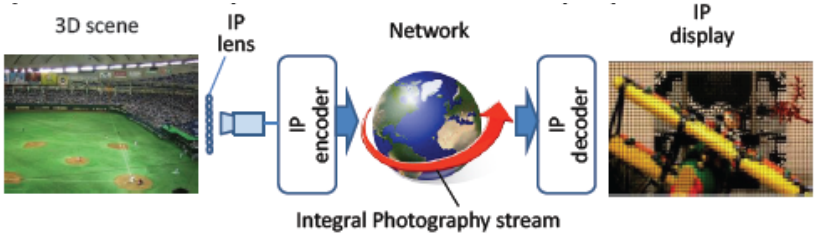


FTV Exploration in MPEG

- **Super Multiview Displays**: hundreds of very densely rendered views provide horizontal motion parallax for realistic 3D visualization



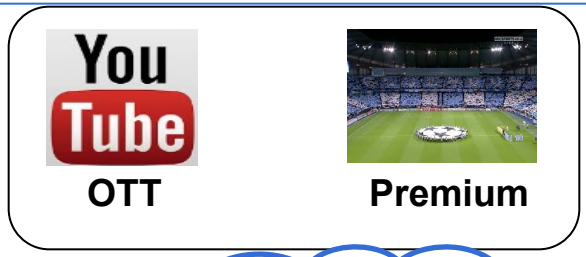
- **Integral Photography**: 3D video with both horizontal & vertical motion parallax are captured for realistic display.



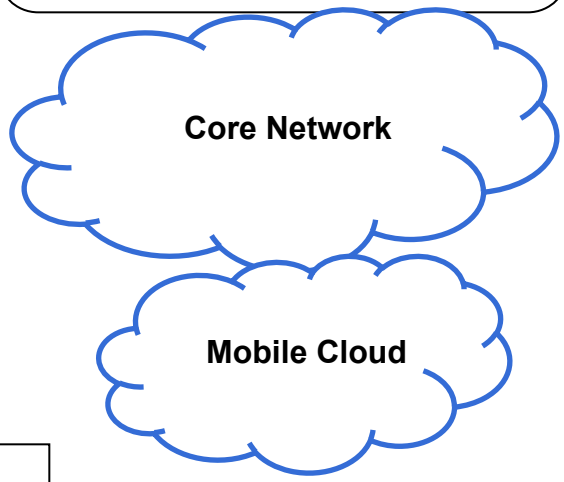
- **Free Navigation**: allow the user to freely navigate or fly through the Scene, not just along predefined pathways



3D Media Research Challenges



3D Compression	Cloud-based CDN
Cloud-based media (IaaS, PaaS, SaaS)	Adaptive Streaming



QoS-QoE path selection (SDN)
Traffic policing

Rendering	Multiview generation
Transcoding	QoE management
Application-layer Filtering	

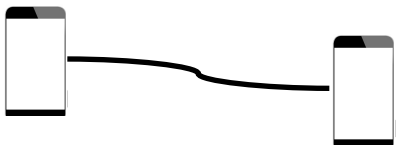


UEP
Multi-user scheduling



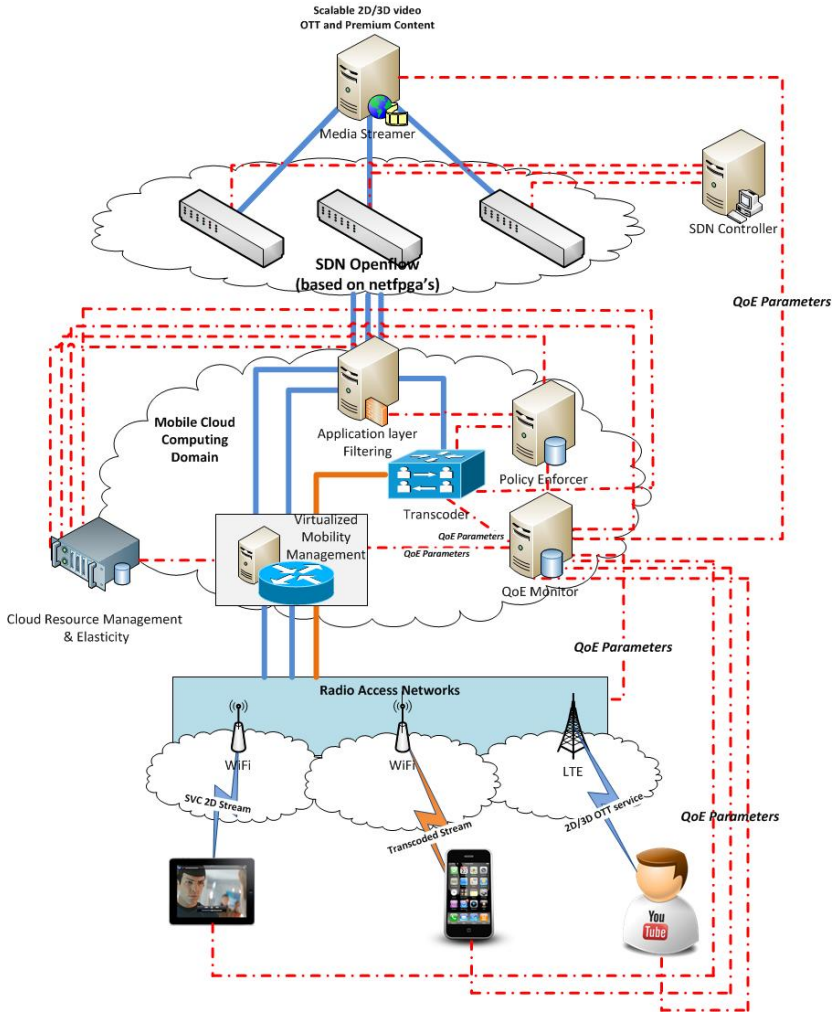
Het-net scheduling

P2P
D2D



Error Concealment

Research Project “DIOGENES” Use Case



- http://diogenes.eap.gr

Critical Success Factors for 3D

- High quality experience not burdened with high transition costs or turned off by viewing discomfort or fatigue
- Usability and consumer acceptance of 3D viewing technology, e.g., glasses vs no glasses
- Availability of premium 3D content in the home
- Availability of an appropriate data format providing interoperability through the delivery chain and taking into consideration the constraints imposed by each delivery channel

Questions



http://cones.eap.gr