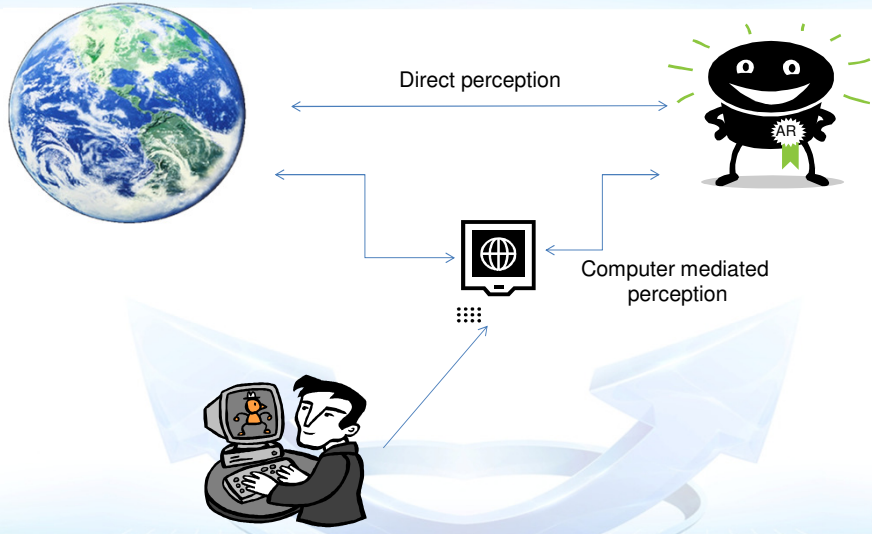# MAR Reference Model

Results of the 4th MAR JAhG Meeting hold in
Seoul, January 2014

Author, Co-Chair: Marius Preda, TELECOM SudParis, SC29
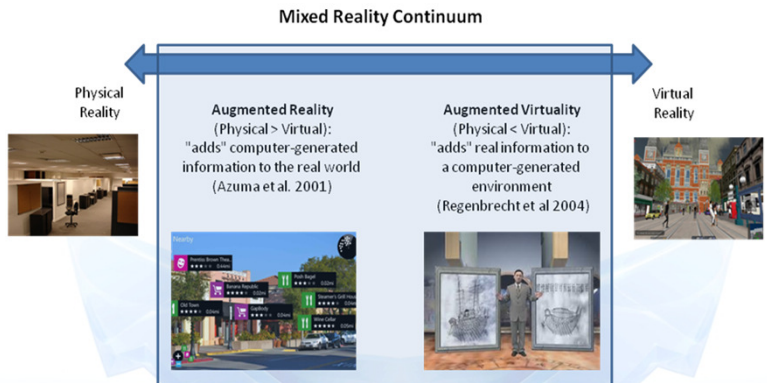*Presenter: Don Brutzman, Web3D Consortium and NPS*
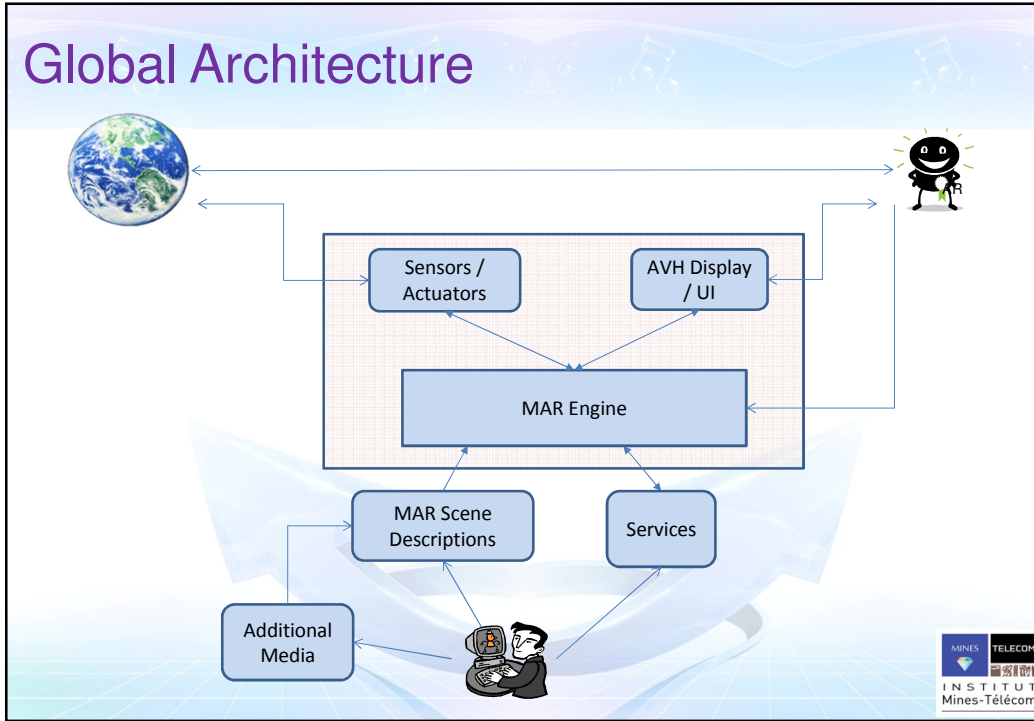
Definition and architecture

Definition

MAR focus

Global Architecture

Enterprise Viewpoint

Device Manufacturer (DM)
Device Middleware/Component Provider (DMCP)

Service Middleware/Component Provider (SMCP)
AR Service Provider (ARSP)

Telecommunication Operator (TO)

End-User Profile (EU)

AR Authoring Tools Creator (ARATC)
AR Experience Creator (AREC)
Content Creator (CC)

Content Aggregator (CA)
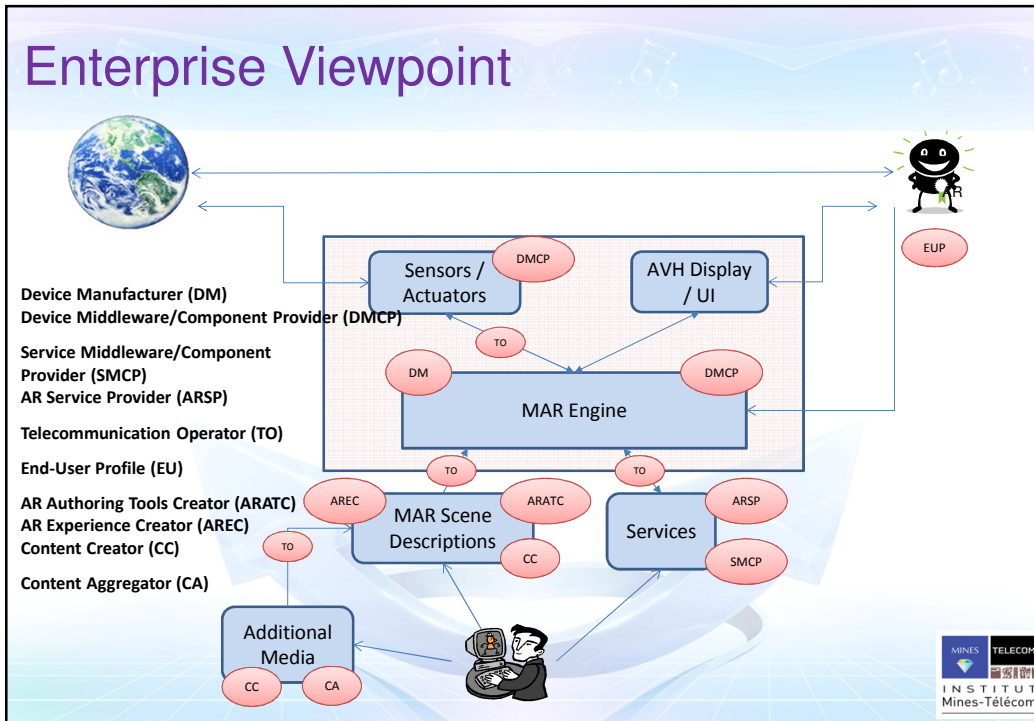
Computational Viewpoint
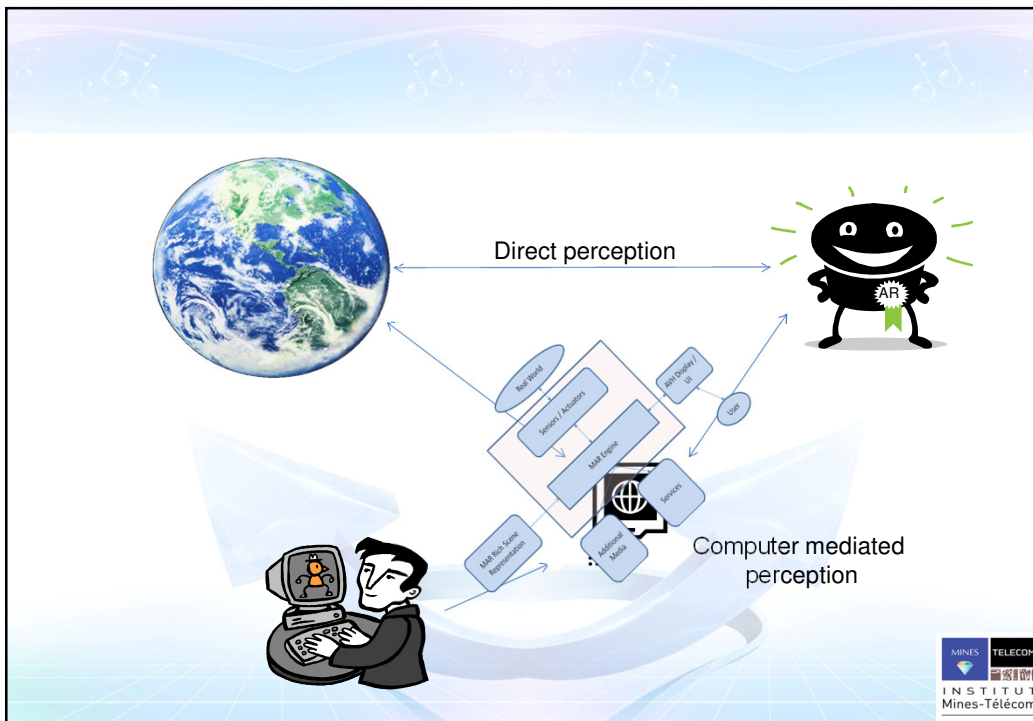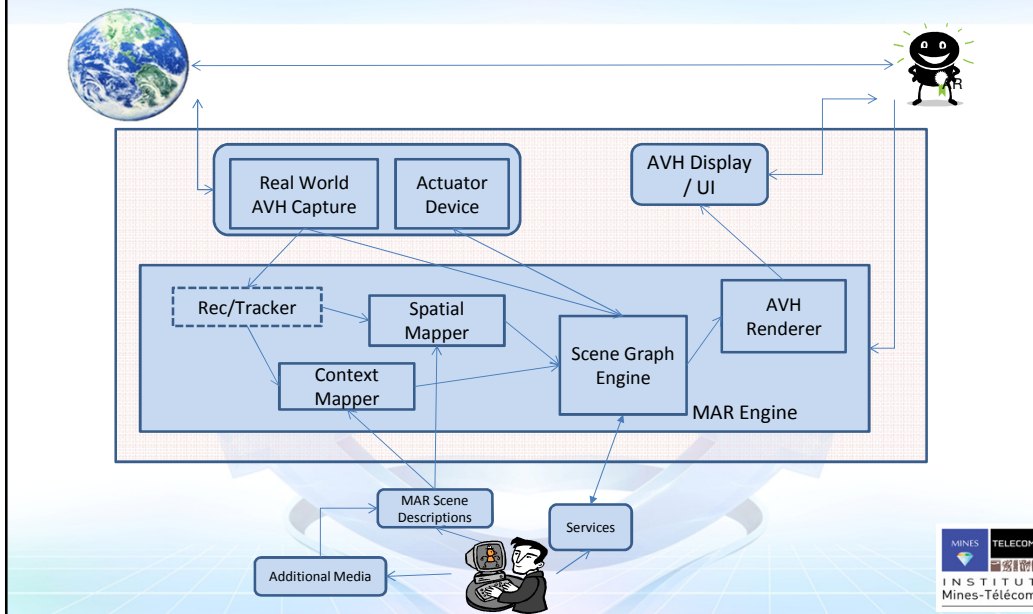
MAR Reference Model

Component based classification system

Component	Dimension	Types				
Real World AVH Capture Dimension (compute the context)	1. Modality	Visual	Auditory	Electro-magnetic waves (e.g. GPS)	Temperature	Other physical properties
	2. Source type	Live	Pre-captured			
Real World AVH Capture Dimension (contribute to composition)	1. Modality	Visual	Auditory	Haptics properties	Other	
	2. Form of Visual Modality	Stil image	2D Video	3D Video (video + depth)	3D mesh	Other
	3. Source type	Live	Pre-captured			
Recognizer	1. Form of Target Signal	Image patch	3D primitives	3D Model	Earth-reference coordinates	None
	2. Form of the Output Event	Recognized or not	Additional data: Type, Timestamp, Recognition confidence level, other attributes			
	3. Execution place	Local	Remote			
Tracker	1. Form of Target Signal	Image patch	3D primitives	3D Model	Earth-reference coordinates	None
	2. Form of the Output Event	Spatial (2D, 3D, 6D, …)	Aural (Intensity, Pitch, …)	Haptic (Force, Direction, …)		
	3. Execution place	Local	Remote			
Actuator	1. Modality	Motion	Temperature	Lighting	Object shapes	Other
	2. Execution place	Local	Remote			
Scene Graph Engine	1. Space & time	2D + t	3D + t			
	2. User Interactivity	Yes	No			
	3. Execution place	Local	Remote	Hybrid		
	4. Number of simultanous users	Single-user	Multi-user			
AVH Renderer	1. Modality	Visual	Aural	Haptics	Other	
	2. Execution place	Local	Remote	Hybrid		
Visual Display	1. Presentation	optical see through	video see through	projection		
	2. Mobility	Fixed	Mobile	Controlled		
	3. No of channels	2D (mono)	3D stereoscopic	3D holographic		
Aural Display	1. No of channels	Mono	Spatial			
	2. Acoustic space coverage	Headphones	Speaker			
Haptics Display	1. Type	Vibration	Pressure	Temperature	Other	

Terminology

Terminology

Definition of a set of terms

Usage cases

MAR Reference Model

Local *vs* Remote

Modeling of 6 state of the art AR use cases:

1. Real-time, local detection, no registration
2. Real-time, local detection, local registration

3. Real-time, remote detection, no registration
4. Real-time, remote detection, remote registration

5. Real-time, remote detection, local registration

6. Real-time, remote detection, registration and augmentation, local presentation

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MAR Reference Model

Points of Interests

Modeling of 2 AR use cases using Point of Interests:

1. Content embedded POIs
2. Server available POIs

MAR Reference Model

2D *vs* 3D video

Modeling of 4 AR use cases using 3D video:

1. Real-time, local depth estimation, condition based augmentation
2. Real-time, local depth estimation, model based augmentation

3. Real-time, remote depth estimation, condition based augmentation
4. Real-time, remote depth estimation, model based augmentation

MAR Reference Model

Stereo *vs* 3D audio

Modeling of 2 AR use cases using 3D audio:

1. Real-time, spatial audio based in intensity
2. Real-time, 3D audio based HRTF (Head-related Transfer Function)

MAR Reference Model

Use cases

Local vs Remote
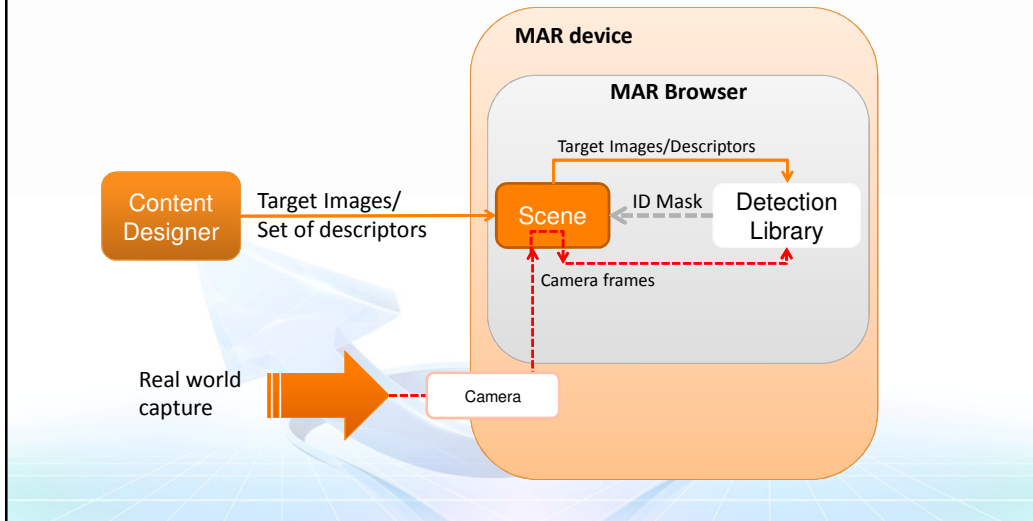Point of Interests
3D video
3D audio

MAR Reference Model

Use cases

Local vs Remote
Point of Interests
3D video
3D audio

MAR Reference Model

1. Real-time, local detection, no registration

MAR device

MAR Browser

Content Designer

Target Images/ Set of descriptors

Scene

Target Images/Descriptors

ID Mask

Detection Library

Camera frames

Real world capture

Camera

MAR Reference Model

2. Real-time, local detection, local registration

Mobile device

AR Browser

Augmentation media

Content Designer

Target Images/ Set of descriptors

Scene

Target Images/Descriptors

ID Mask + TM

Detection & Tracking Library

Camera frames

Real world capture

Camera

TM = Transformation Matrix

MAR Reference Model

3. Real-time, remote detection, no registration

Mobile device

AR Browser

Processing Server URL

Target Images/Descriptors + IDs

Content Designer

Target Images/ Set of descriptors

Scene

Timestamp + ID Mask

Processing Server

Detection Library

Video stream/timed images

Real world capture

Camera

MAR Reference Model

4. Real-time, remote detection, remote registration

Mobile device

AR Browser

Processing Server URL

Target Images/Descriptors + IDs

Content Designer

Target Images/ Set of descriptors

Scene

Timestamp + ID Mask + TM

Processing Server

Detection & Tracking Library

Augmentation media

Video stream/timed images

Real world capture

Camera

TM = Transformation Matrix

MAR Reference Model

5. Real-time, remote detection, local registration

Mobile device

AR Browser

Processing Server URL

Content Designer

Scene

Tracking Library

Region

Initial Region + Augmentation Media

Video stream/timed images

Real world capture

Camera

Processing Server

Augmentation Media

Detection Library

Large Image DB

Rectangle = Target Image to be detected locally
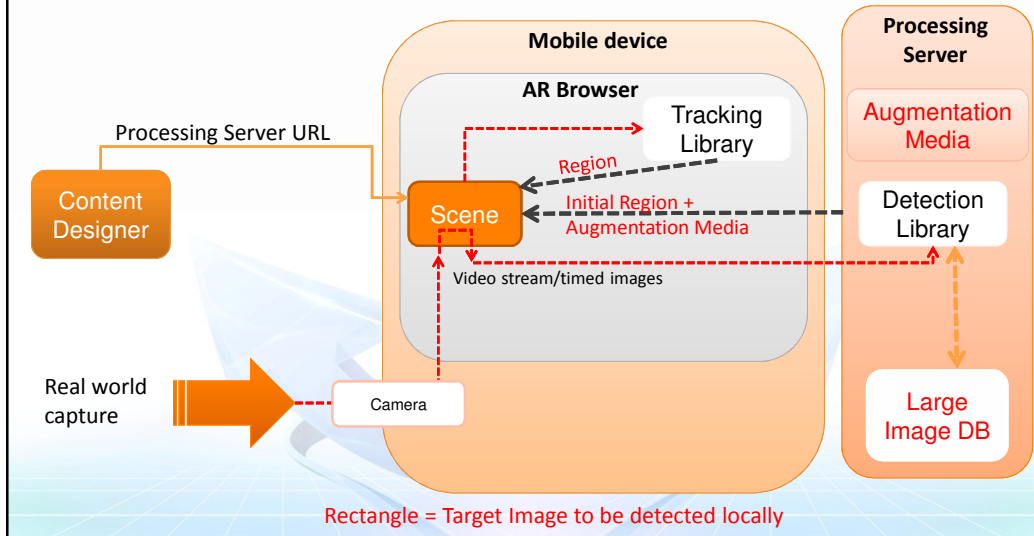
MAR Reference Model

6. Real-time, remote registration and detection, local presentation
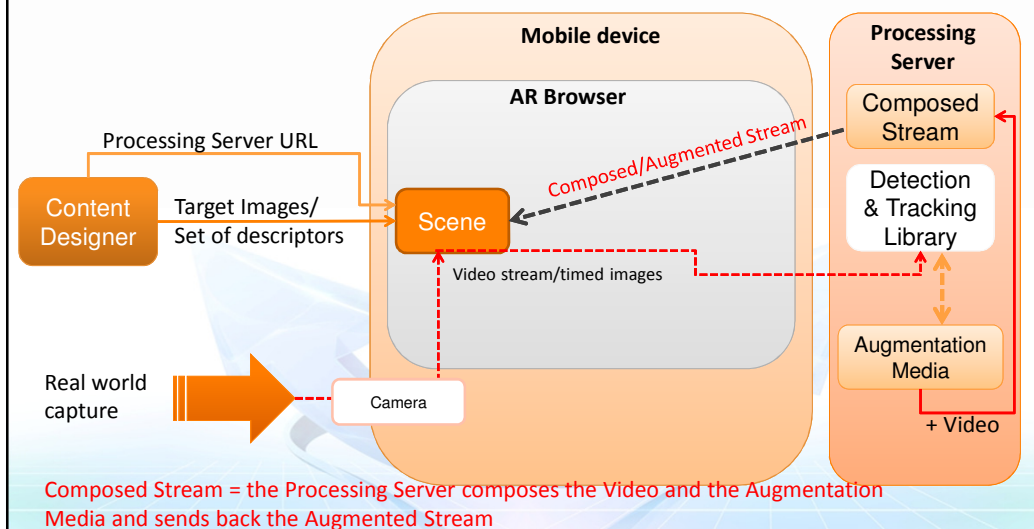
Mobile device

AR Browser

Processing Server URL

Content Designer

Target Images/ Set of descriptors

Scene

Composed/Augmented Stream

Video stream/timed images

Real world capture

Camera

Processing Server

Composed Stream

Detection & Tracking Library

Augmentation Media

+ Video

Composed Stream = the Processing Server composes the Video and the Augmentation Media and sends back the Augmented Stream

MAR Reference Model

Use cases

Local vs Remote
Point of Interests
3D video
3D audio

MAR Reference Model

1. Content embedded POIs

Mobile device

Sensors

AR Browser

Augmentation media

Content Designer

POIs

Scene

TM

Scene/World coordinates Registration

Real world capture

Camera

Map service

TM = Transformation Matrix
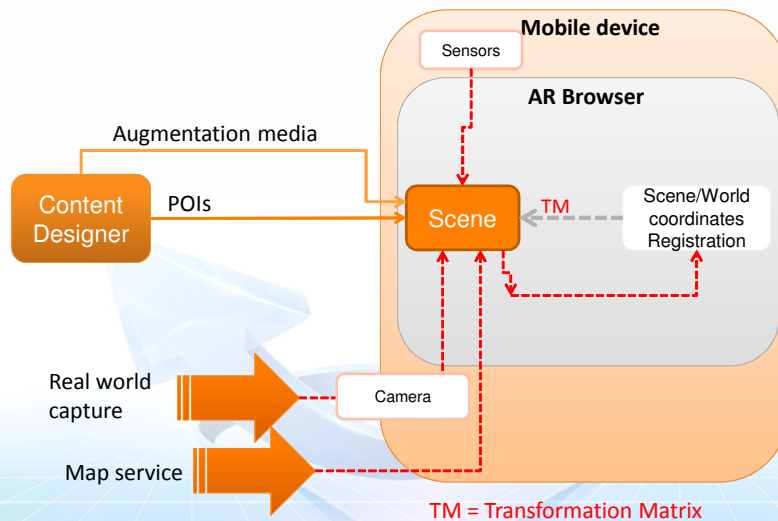
MAR Reference Model

2. Server available POIs

Mobile device

Sensors

AR Browser

Augmentation parameters

Content Designer

POIs server address

Scene

TM

Scene/World coordinates Registration

Real world capture

Camera

POI + content server

Map service
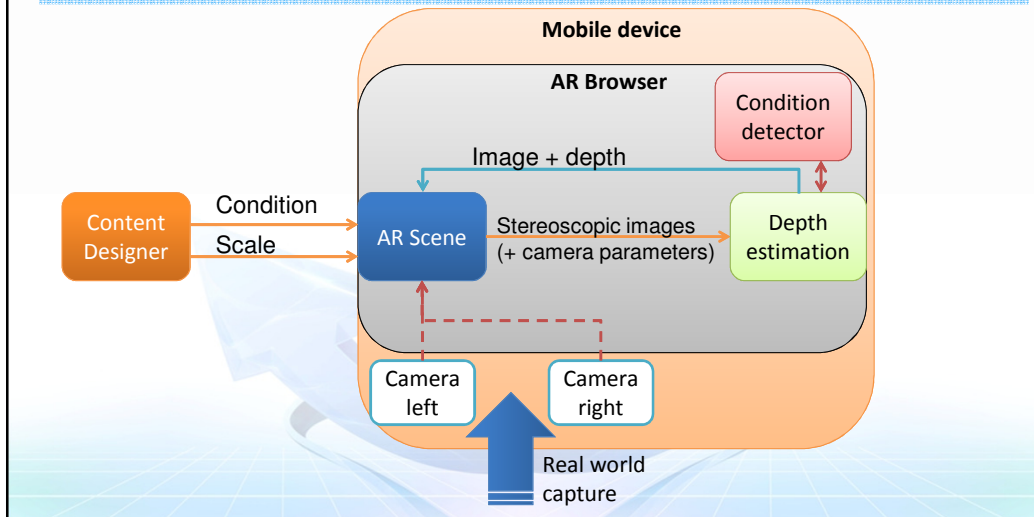
TM = Transformation Matrix

MAR Reference Model

Use cases

Local vs Remote
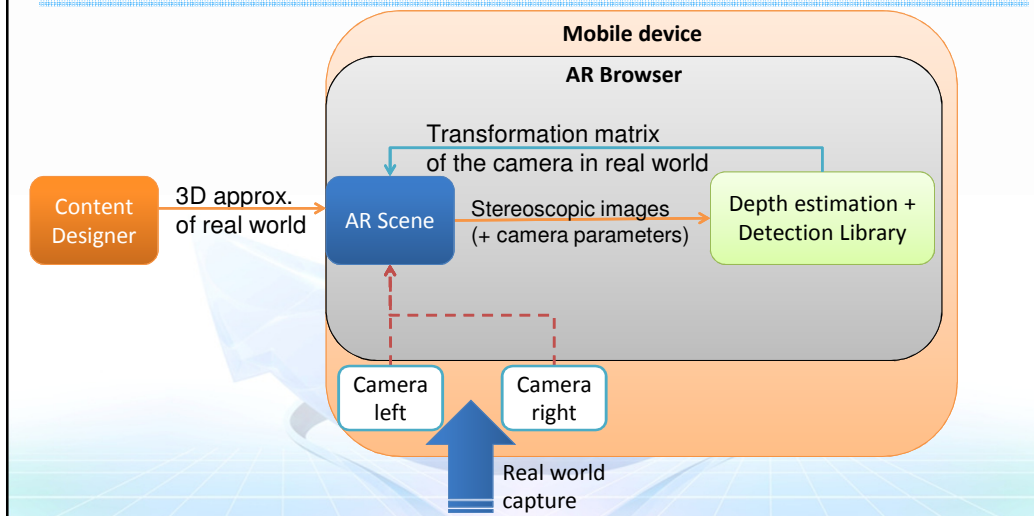Point of Interests
3D video
3D audio

MAR Reference Model

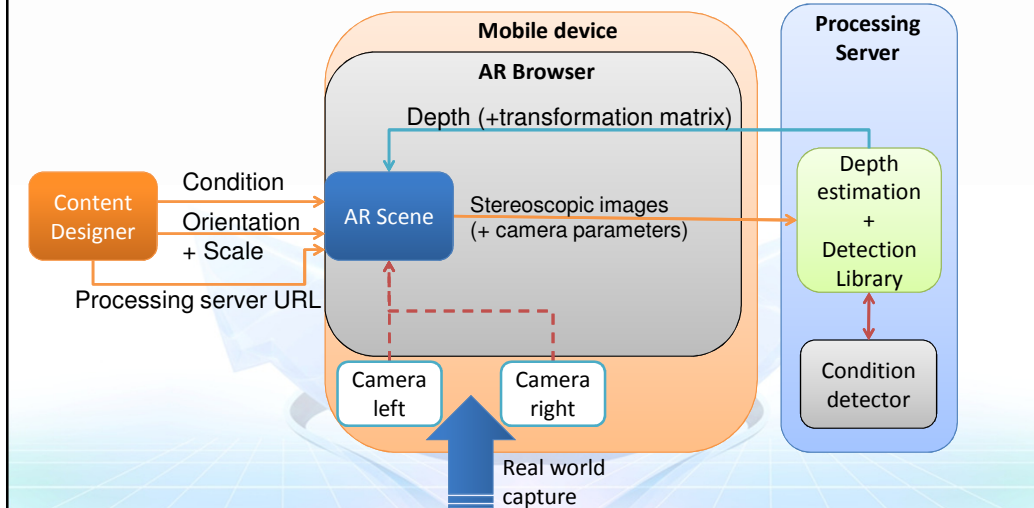## 1. Real-time, local depth estimation, condition based augmentation

MAR Reference Model

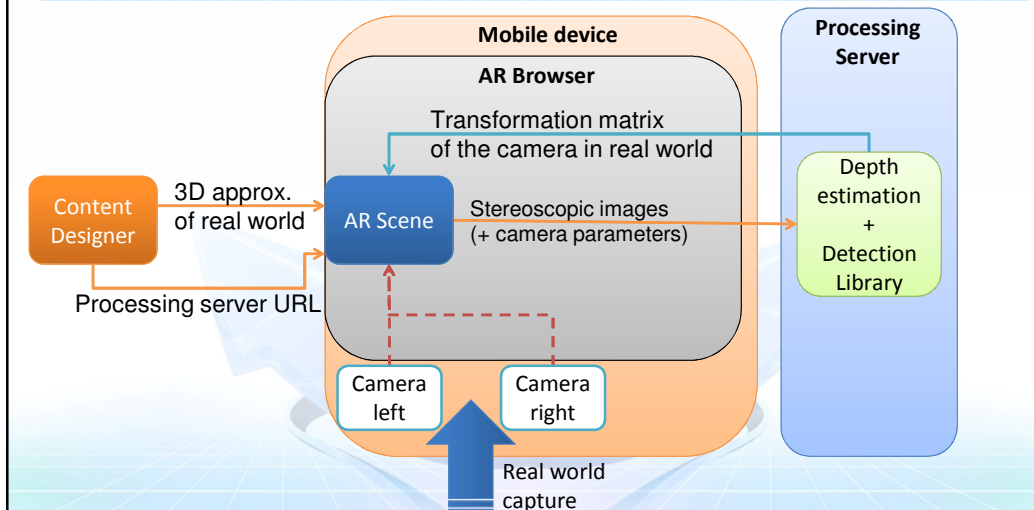## 2. Real-time, local depth estimation, model based augmentation

MAR Reference Model

3. Real-time, remote depth estimation, condition based augmentation

Mobile device

AR Browser

Depth (+transformation matrix)

Processing Server

Content Designer

Condition

Orientation + Scale

Processing server URL

AR Scene

Stereoscopic images (+ camera parameters)

Depth estimation + Detection Library

Condition detector

Camera left

Camera right

Real world capture

MAR Reference Model

4. Real-time, remote depth estimation, model based augmentation

Mobile device

AR Browser

Transformation matrix of the camera in real world

Processing Server

Content Designer

3D approx. of real world

Processing server URL

AR Scene

Stereoscopic images (+ camera parameters)

Depth estimation + Detection Library

Camera left

Camera right

Real world capture

Get involved in MAR Reference Model

1. Stakeholders and participants
   - MAR Reference Model is intended to become an ISO standard
   - Animated by SC24/WG9 and SC29/WG11
   - Contributions from Web3D, ARS, OGC
   - Open to all interested in developing an open and free standard
2. ISO Intellectual property rights policy
   - MAR Reference model will be published by ISO under the royalty free policy
3. How to get involved
   - Participate to meetings of any standard organization involved (ISO, Web3D, OGC)
   - Direct contributions on http://wg11.sc29.org/trac/augmentedreality
4. Contact information
   - Marius Preda (marius.preda@it-sudparis.eu)
   - Gerry Kim   (gjkim@korea.ac.kr)

What is Extensible 3D (X3D)?

X3D is a royalty-free open-standard file format
- Communicate animated 3D scenes using XML
- Run-time architecture for consistent user interaction
- ISO-ratified standard for storage, retrieval and playback of real-time graphics content
- Enables real-time communication of 3D data across applications: archival publishing format for Web
- Rich set of componentized features for engineering and scientific visualization, CAD and architecture, medical visualization, training and simulation, multimedia, entertainment, education, and more

X3D AR

- **X3D version 4.0 will support the MAR Reference model and HTML5/DOM/X3DOM**
  - Much work is complete already
- **X3D AR working group cochairs:**
  - ar_chairs@web3d.org
  - Gun Lee, University of New Zealand
  - Timo Engelke, Fraunhofer

- **Speaker contact, X3D working group cochair:**
  - Don Brutzman, Naval Postgraduate School
  - brutzman@nps.edu cell +1.831.402.4809