Visual Computing Group

Part 2.2

Mobile Graphics Trends: Applications

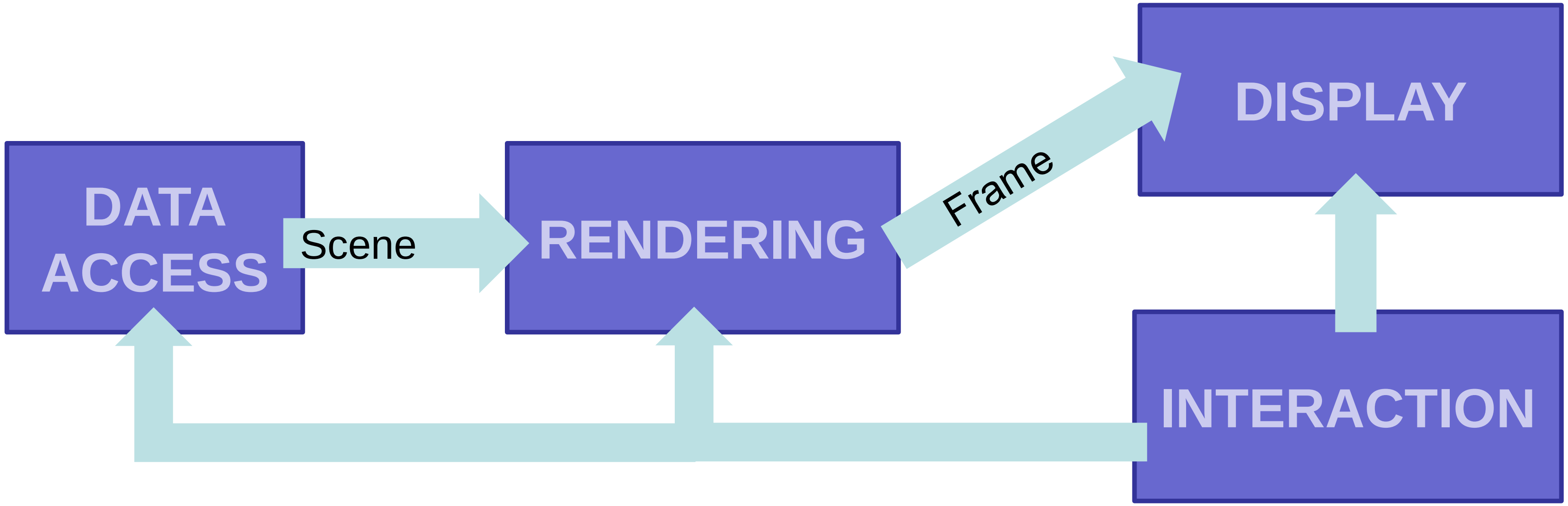
Marco Agus, KAUST & CRS4

Applications

- **Wide range of applications**
  - Cultural Heritage
  - Medical Image
  - 3D object registration
  - GIS
  - Gaming
  - VR & AR
  - Building reconstruction
  - Virtual HCI

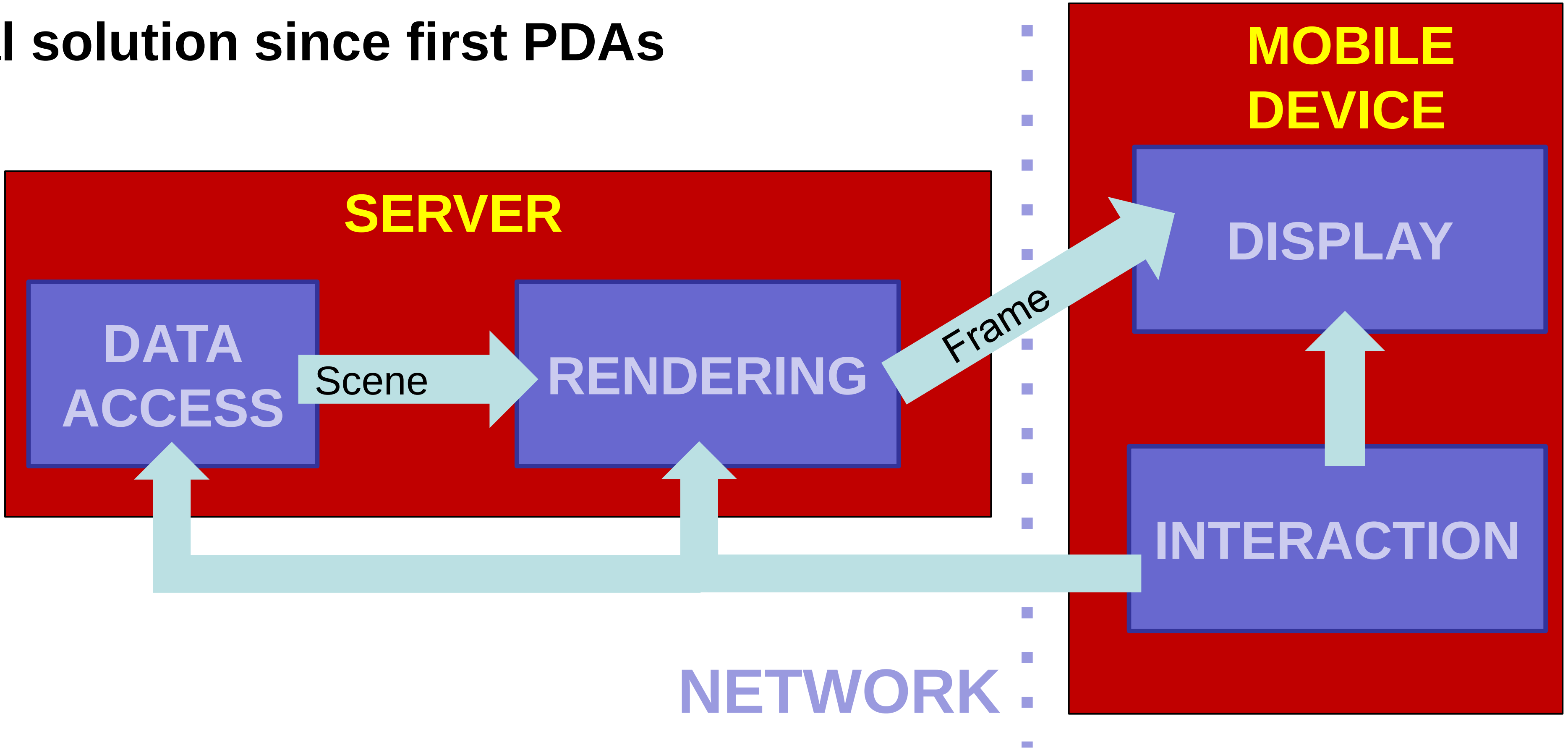
Mobile 3D interactive graphics

- **General pipeline similar to standard interactive applications**



Remote rendering

- **General solution since first PDAs**

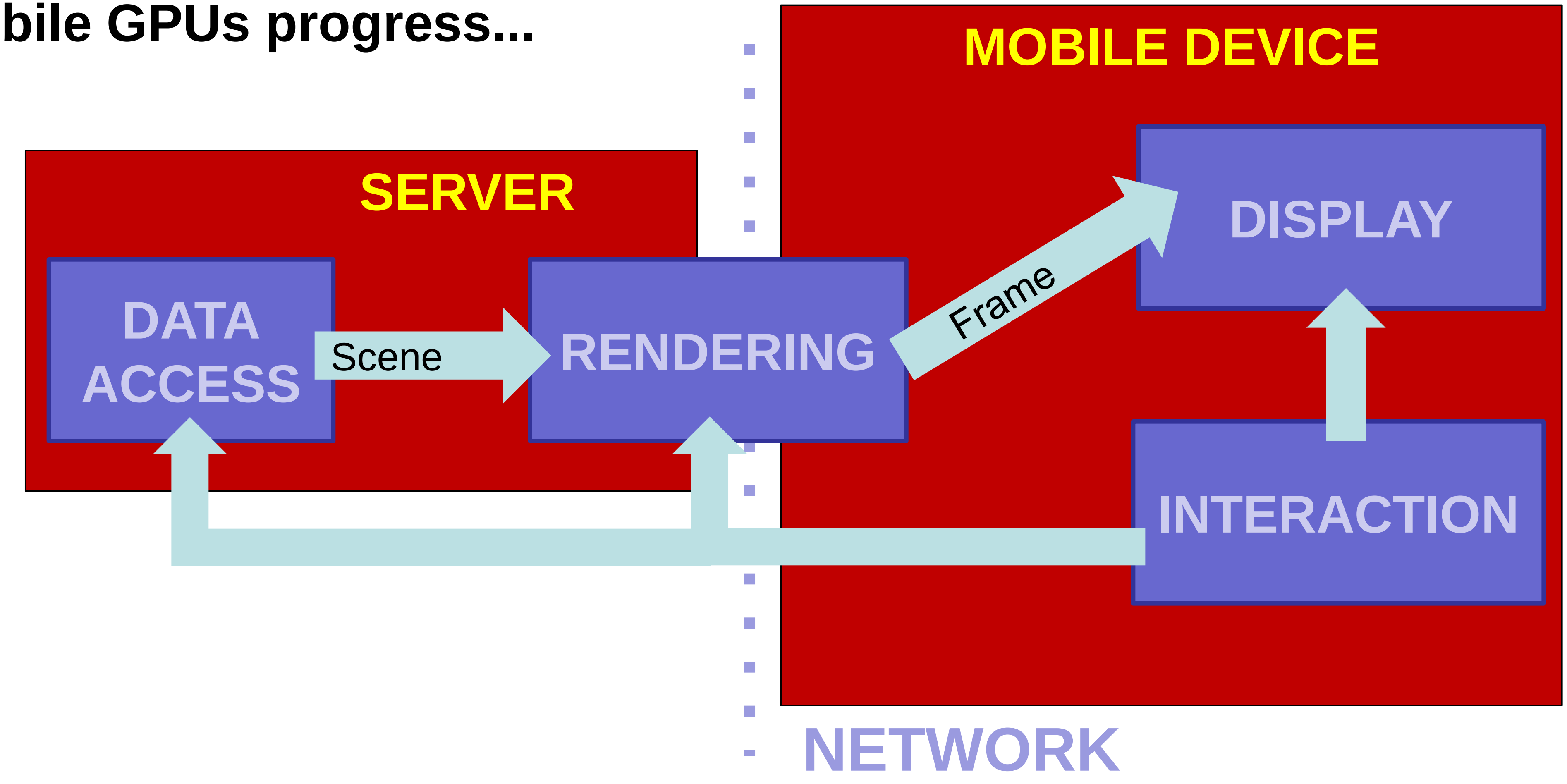


Remote rendering

- **3D graphics applications require intensive computation and network bandwidth**
  - electronic games
  - visualization of very complex 3D scenes
- **Remote rendering has long history and it is successfully applied for gaming services**
  - Limitation: interaction latency in cellular networks

Mixed Mobile/Remote rendering

- **As mobile GPUs progress...**



Mixed Mobile/Remote rendering

- **Model based versus Image based methods**
- **Model based methods**
  - Original models
  - Partial models
  - Simplified models
    - Couple of lines
    - Point clouds

Eisert and Fechteler. **Low delay streaming of computer graphics** (ICIP 2008)

Gobbetti et al. **Adaptive Quad Patches: an Adaptive Regular Structure for Web Distribution and Adaptive Rendering of 3D Models.** (Web3D 2012)

Balsa et al.,. **Compression-domain Seamless Multiresolution Visualization of Gigantic Meshes on Mobile Devices** (Web3D 2013)

Diepstraten et al., 2004. **Remote Line Rendering for Mobile Devices** (CGI 2004)

Duguet and Drettakis. **Flexible point-based rendering on mobile devices** (IEEE Trans. on CG & Appl, 2004)

Mixed Mobile/Remote rendering

- **Model based versus Image based methods**
- **Model based methods**

Point clouds organized as hierarchical grids. Tested on PDAs

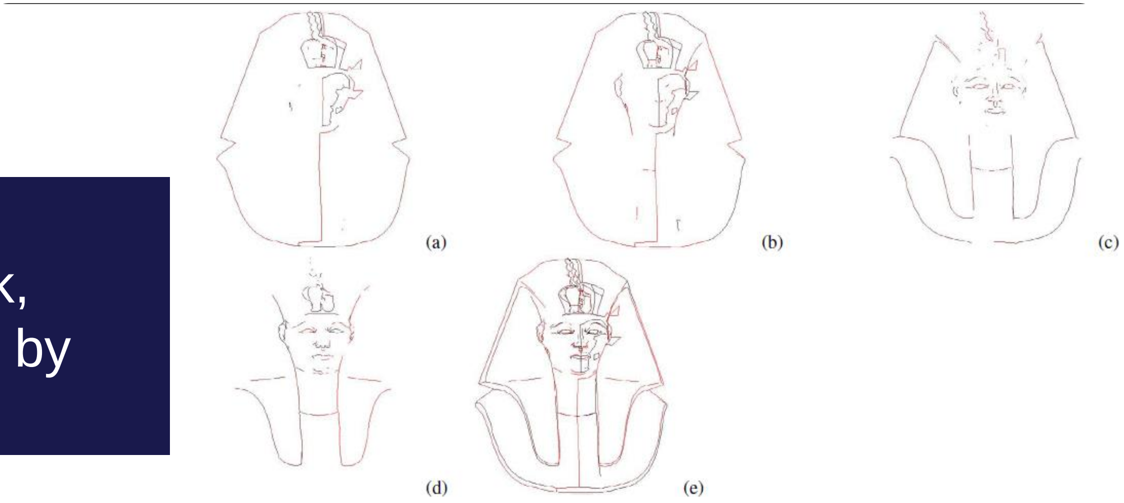
- Point clouds

Duguet and Drettakis. **Flexible point-based rendering on mobile devices** (IEEE Trans. on CG & Appl, 2004)

Mixed Mobile/Remote rendering

- **Model based versus Image based methods**
- **Model based methods**

Transfer couple of 2D line primitives over the network, which are rendered locally by the mobile device



- Couple of lines

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Mixed Mobile/Remote rendering

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Intercept and stream OpenGL commands
Better performances with respect to video streaming
Limitation: clients need powerful GPU

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Mobile

g on mobile devices (IEEE Trans. on CG & Appl, 2004)

More details in Part 4

Mixed Mobile/Remote rendering

- **Image based methods**
  - Image impostors

Noimark and Cohen-Or. **Streaming scenes to mpeg-4 video-enabled devices** (IEEE, CG&A 2003)

Lamberti and Sanna. **A streaming-based solution for remote visualization of 3D graphics on mobile devices** (IEEE, Trans. VCG, 2007)

  - Environment maps

Bouquerche and Pazzi. **Remote rendering and streaming of progressive panoramas for mobile devices** (ACM Multimedia 2006)

  - Depth images

Zhu et al. **Towards peer-assisted rendering in networked virtual environments** (ACM Multimedia 2011)

Shi et al. **A Real-Time Remote Rendering System for Interactive Mobile Graphics** (ACM Trans. On Multimedia, 2012)

Doellner et al. **Server-based rendering of large 3D scenes for mobile devices using G-buffer cube maps** (ACM Web3D, 2012)

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  - Envir

Bouque ... **amas for mob**

  - Depth

Image representations are created by the server, and warped in real time by the client to account for user interaction

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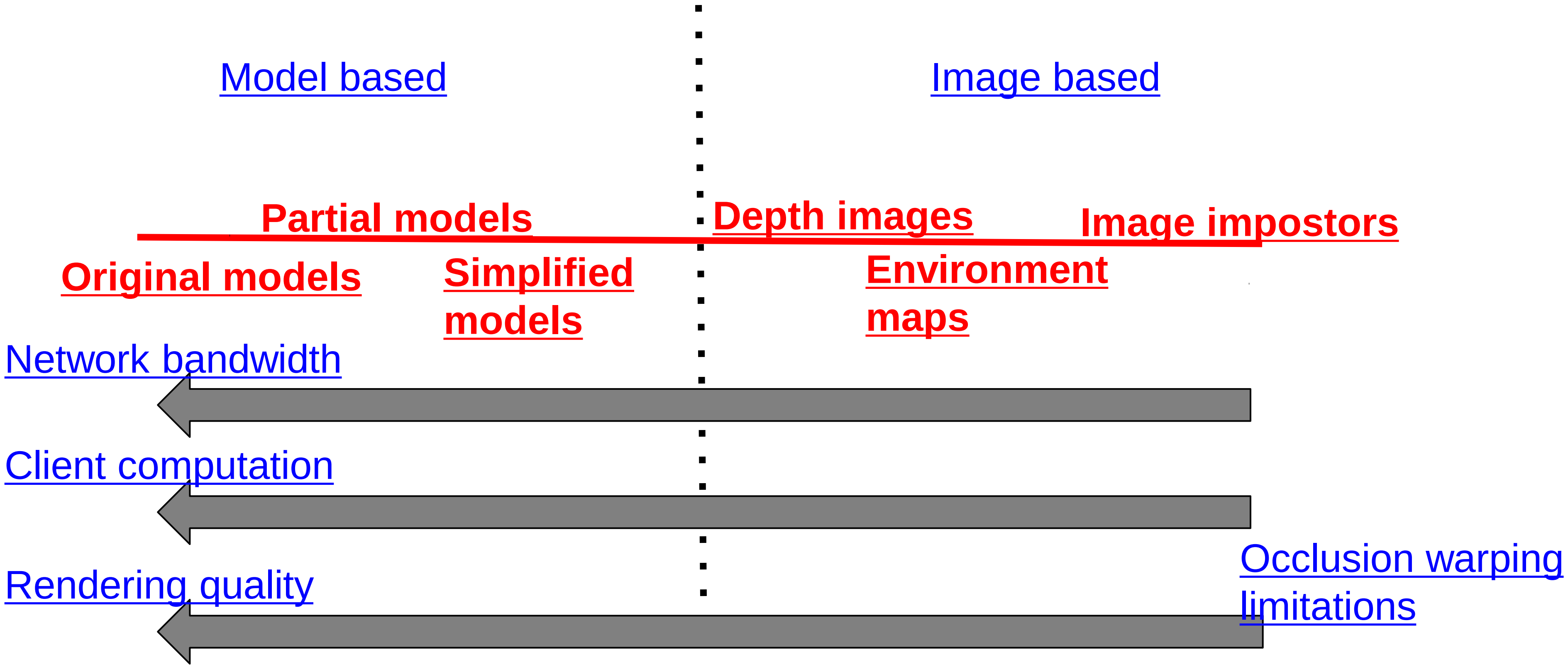
Mixed Mobile/Remote rendering

- **Model based vs Image based methods**
  - Constraints: rendering quality, bandwidth, interactivity



Mobile visualization systems

- **Volume rendering**

  Moser and Weiskopf. **Interactive volume rendering on mobile devices**. Vision, Modeling, and Visualization VMV. Vol. 8. 2008.

  Noguerat al. **Volume Rendering Strategies on Mobile Devices**. GRAPP/IVAPP. 2012.

  Campoalegre, Brunet, and Navazo. **Interactive visualization of medical volume models in mobile devices**. Personal and ubiquitous computing 17.7 (2013): 1503-1514.

  Rodríguez, Marcos Balsa, and Pere Pau Vázquez Alcocer. **Practical Volume Rendering in Mobile Devices**. Advances in Visual Computing. Springer, 2012. 708-718.

- **Point cloud rendering**

  Balsa et al. **Interactive exploration of gigantic point clouds on mobile devices.** (VAST 2012)

  He et al. **A multiresolution object space point-based rendering approach for mobile devices** (AFRIGRAPH, 2007)

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see section 4 for details

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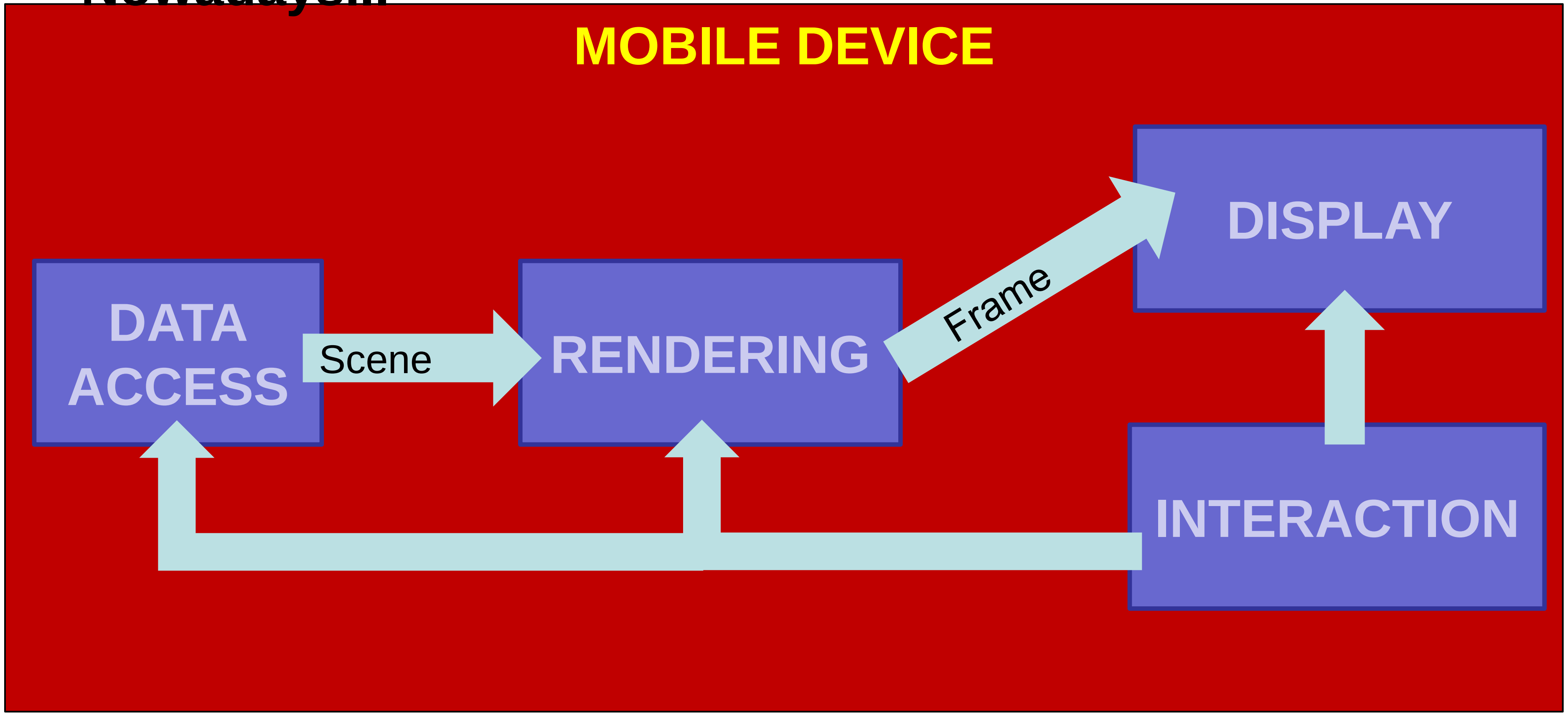
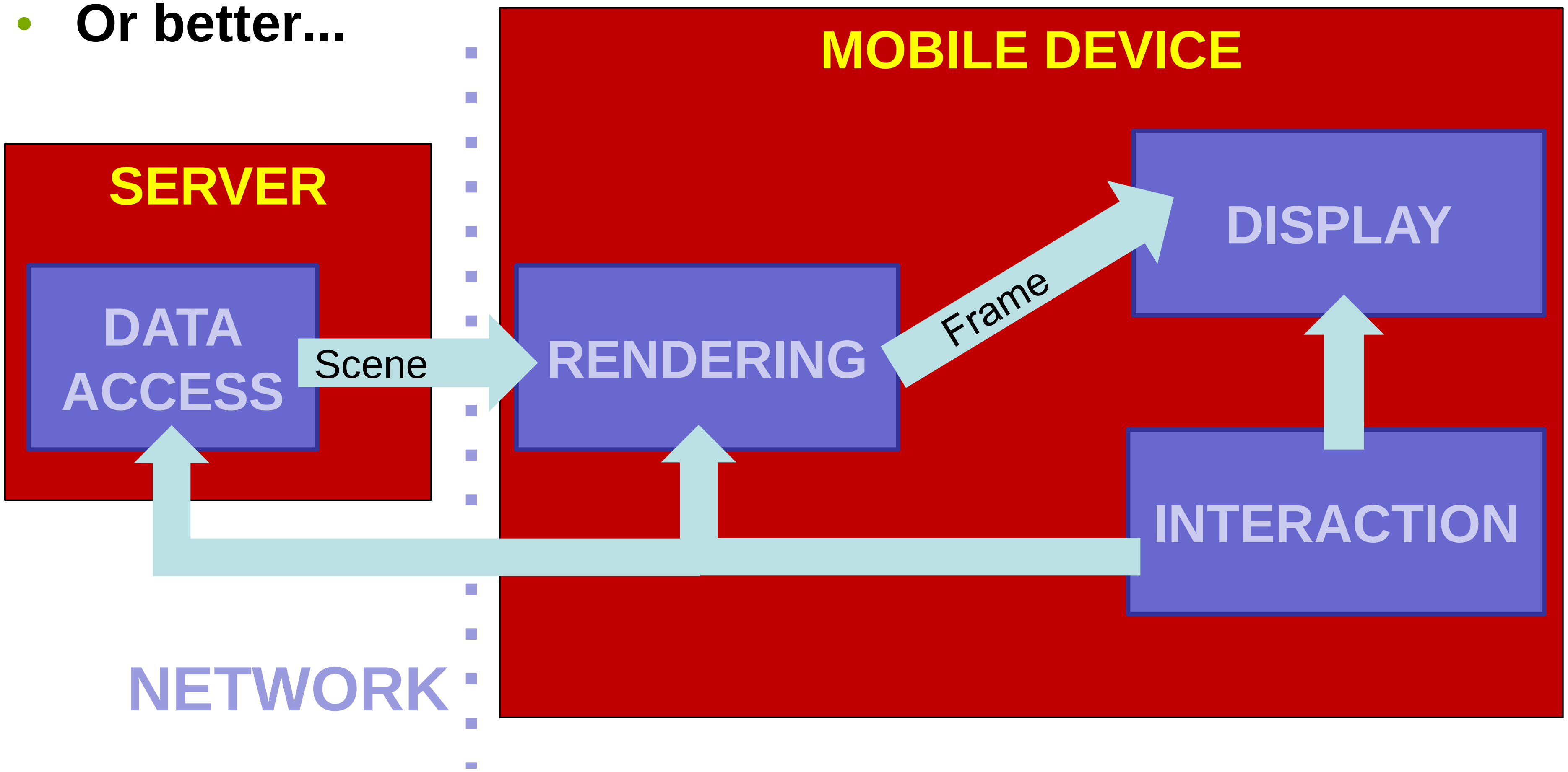
Mobile rendering

- **Nowadays...**



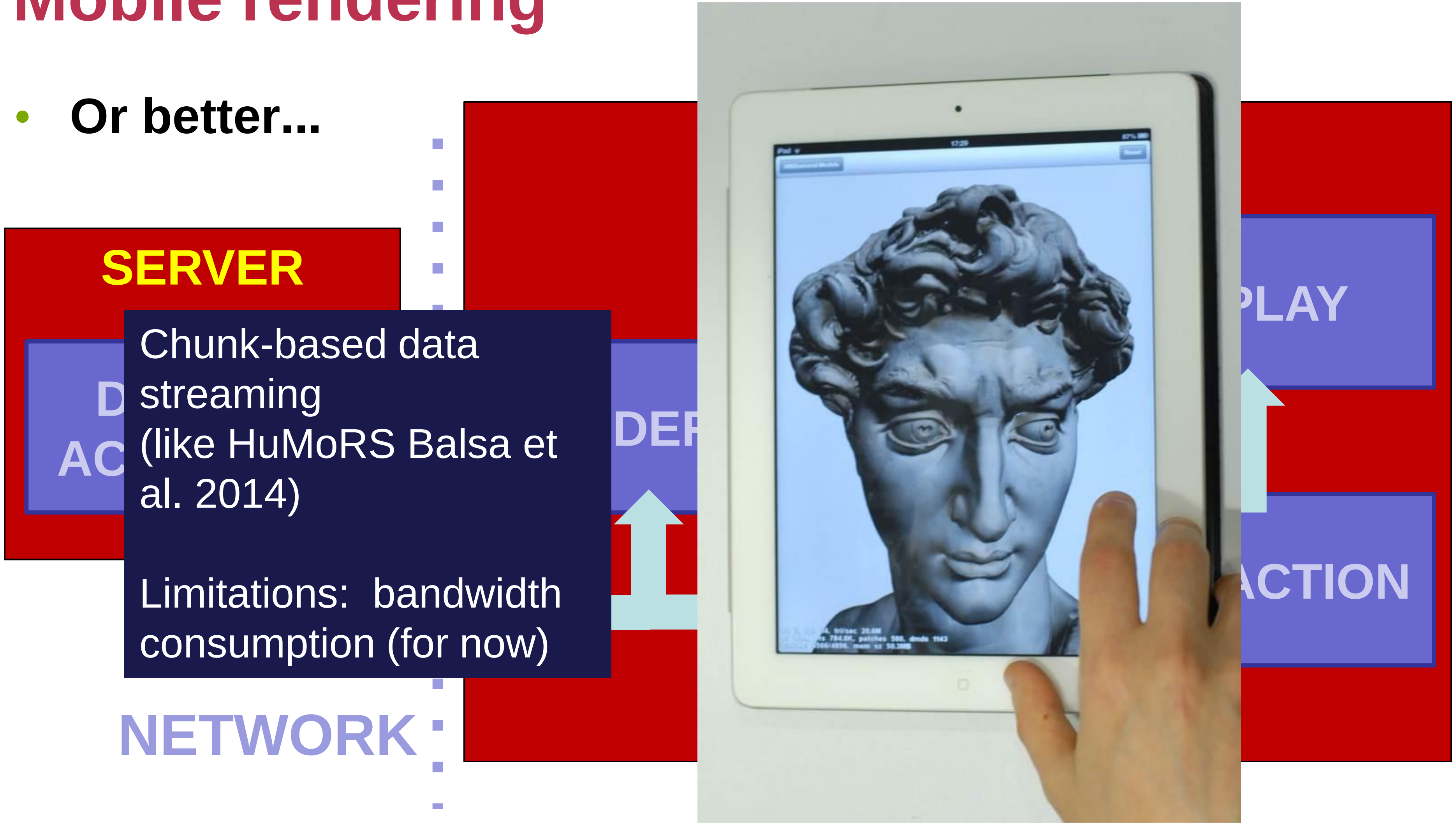
Mobile rendering

- **Or better...**



Mobile rendering

- **Or better...**

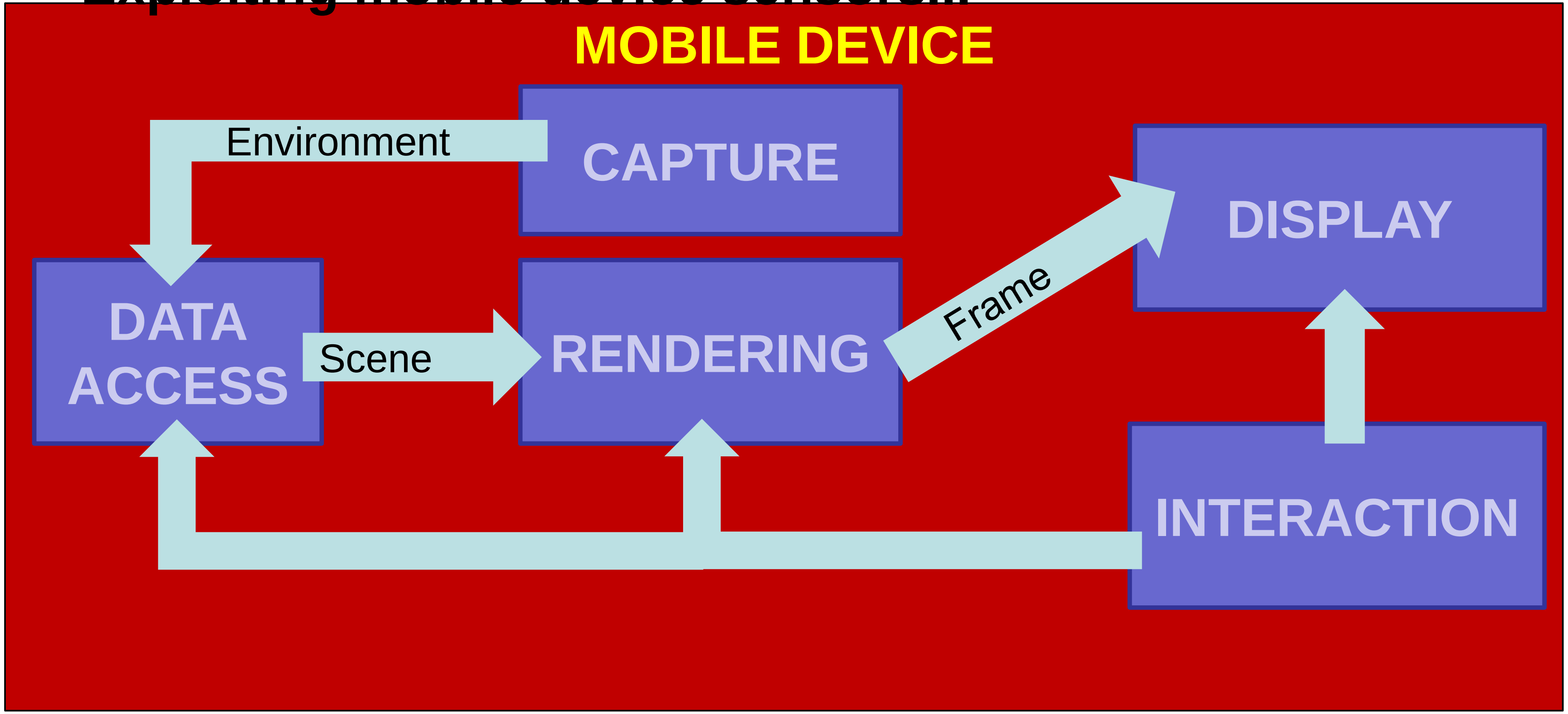


Chunk-based data streaming
(like HuMoRS Balsa et al. 2014)

Limitations: bandwidth consumption (for now)

Mobile rendering with capture

- **Exploiting mobile device sensors...**



Mobile rendering with capture

- **Exploiting mobile device sensors...**

3D scanning with mobile phone
Kolev et al, CVPR 2014
ETH Zurich

Kolev et al. **Turning Mobile Phones into 3D Scanners** (CVPR 2014)

Tanskanen et al. **Live Metric 3D Reconstruction on Mobile Phones** (ICCV 2013)

Mobile rendering with capture

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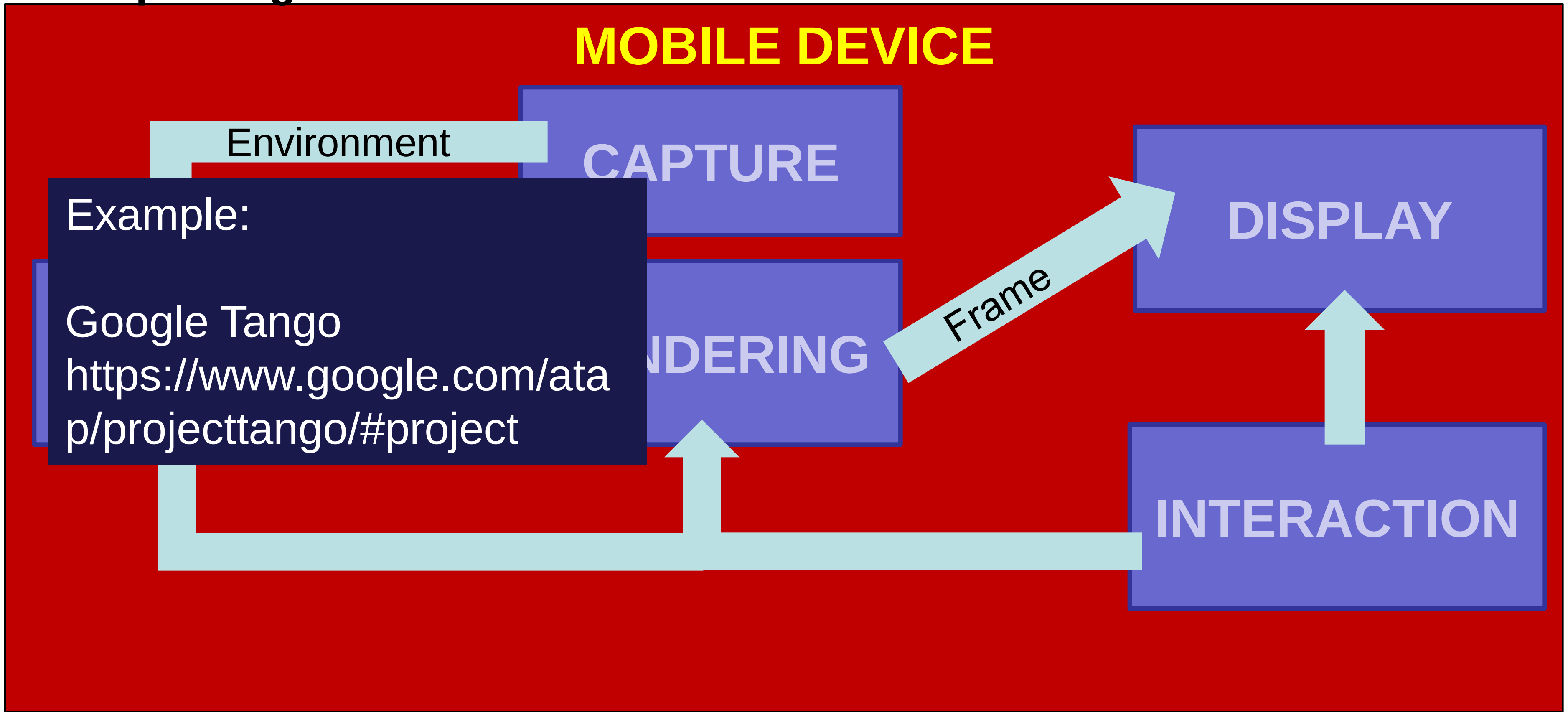

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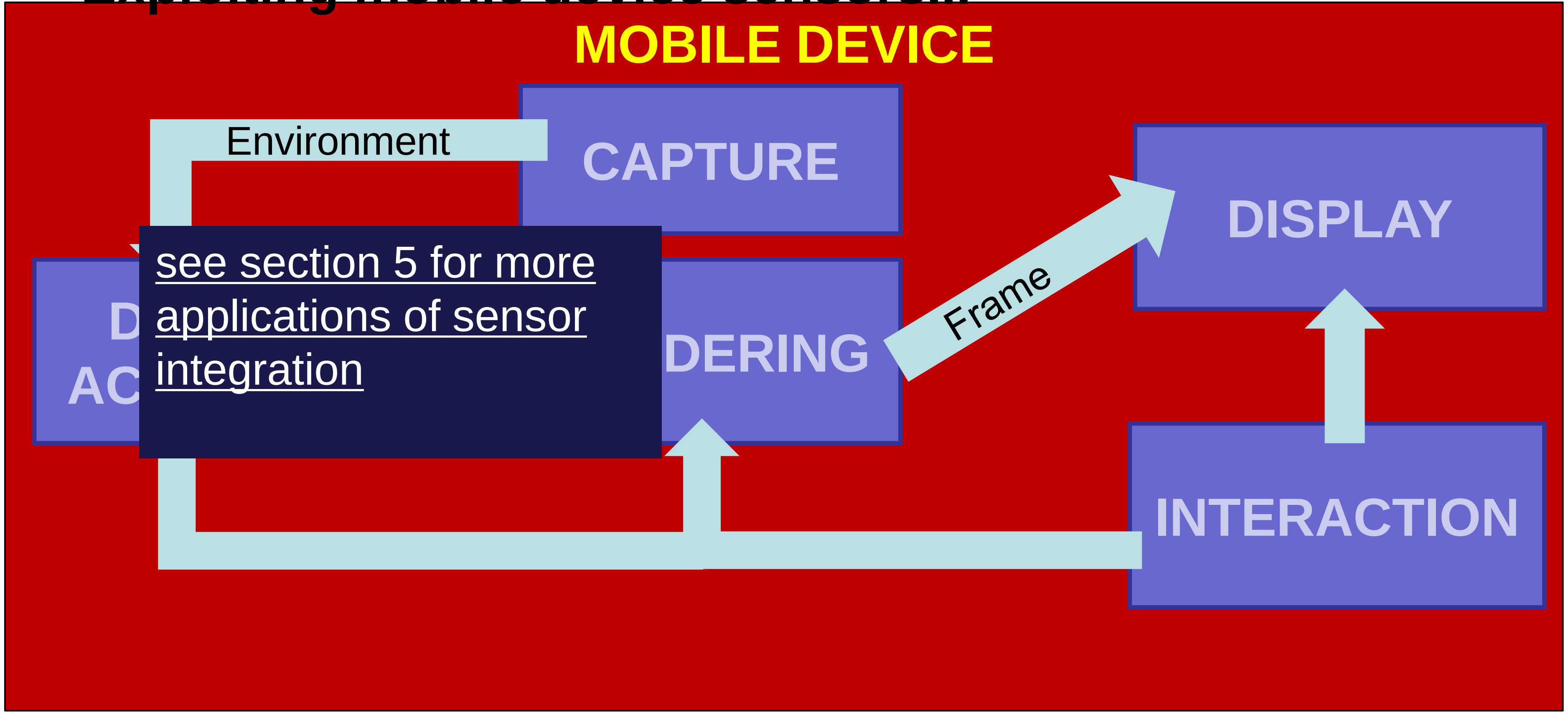


see section 5 for more applications of sensor integration

Trends in mobile graphics

- **Hardware acceleration for improving frame rates, resolutions and rendering quality**
  - Parallel pipelines
  - Real-time ray tracing
  - Multi-rate approaches

SGRT: Real-time ray tracing

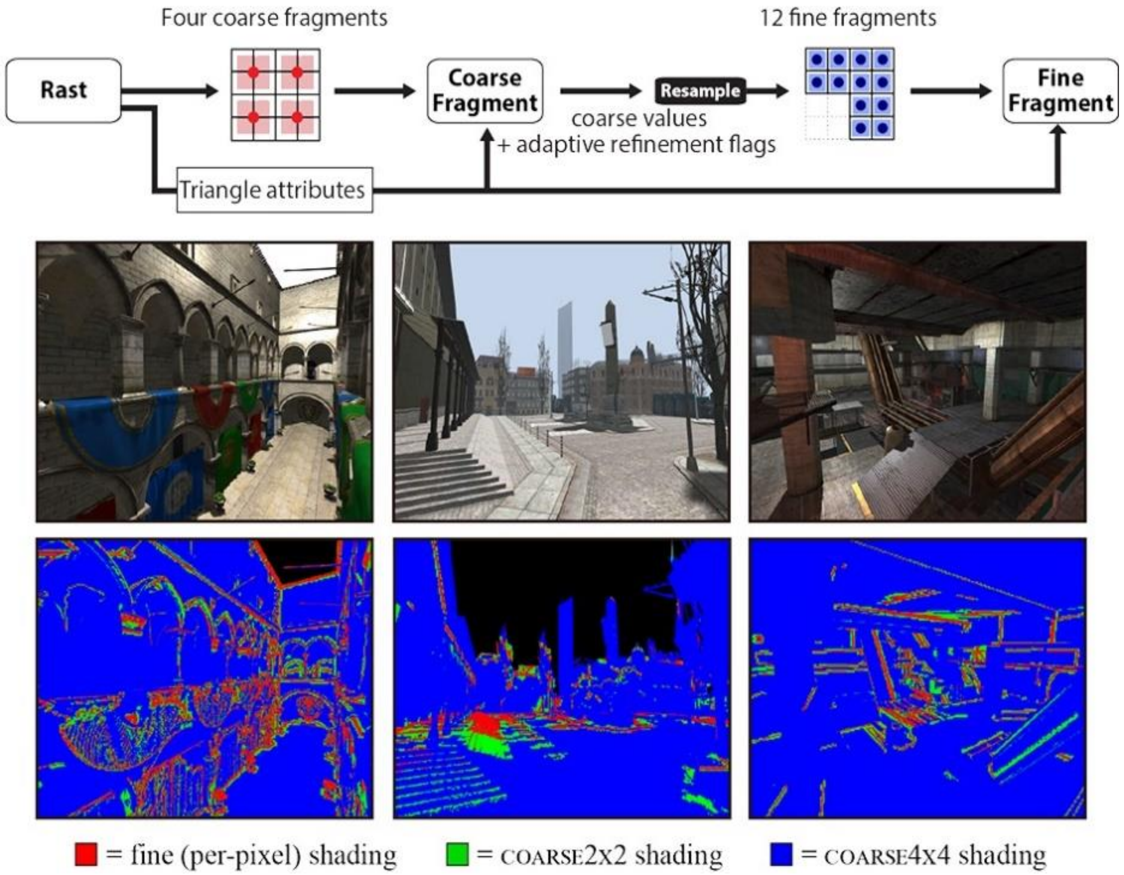
- **Samsung reconfigurable GPU based on Ray Tracing**
- **Main key features:**
  - an area-efficient parallel pipelined traversal unit
  - flexible and high-performance kernels for shading and ray generation

Shin et al., **Full-stream architecture for ray tracing with efficient data transmission**, 2014 IEEE ISCAS

Lee, Won-Jong, et al. **SGRT: A mobile GPU architecture for real-time ray tracing**. Proceedings of the 5th High-Performance Graphics Conference, 2013.

Adaptive shading

- **Triangles rasterized into coarse fragments that correspond to multiple pixels of coverage**
- **Coarse fragments are shaded, then partitioned into fine fragments for subsequent per-pixel shading**



He et al. **Extending the graphics pipeline with adaptive, multi-rate shading**. ACM Transactions on Graphics (TOG) 33.4 , 2014.

Clarberg, Petrik, et al. **AMFS: adaptive multi-frequency shading for future graphics processors.** ACM Transactions on Graphics (TOG) 33.4 , 2014.

Won-Jong Lee, et al. **Adaptive multi-rate ray sampling on mobile ray tracing GPU.** In SIGGRAPH ASIA 2016 Mobile Graphics and Interactive Applications (SA '16).

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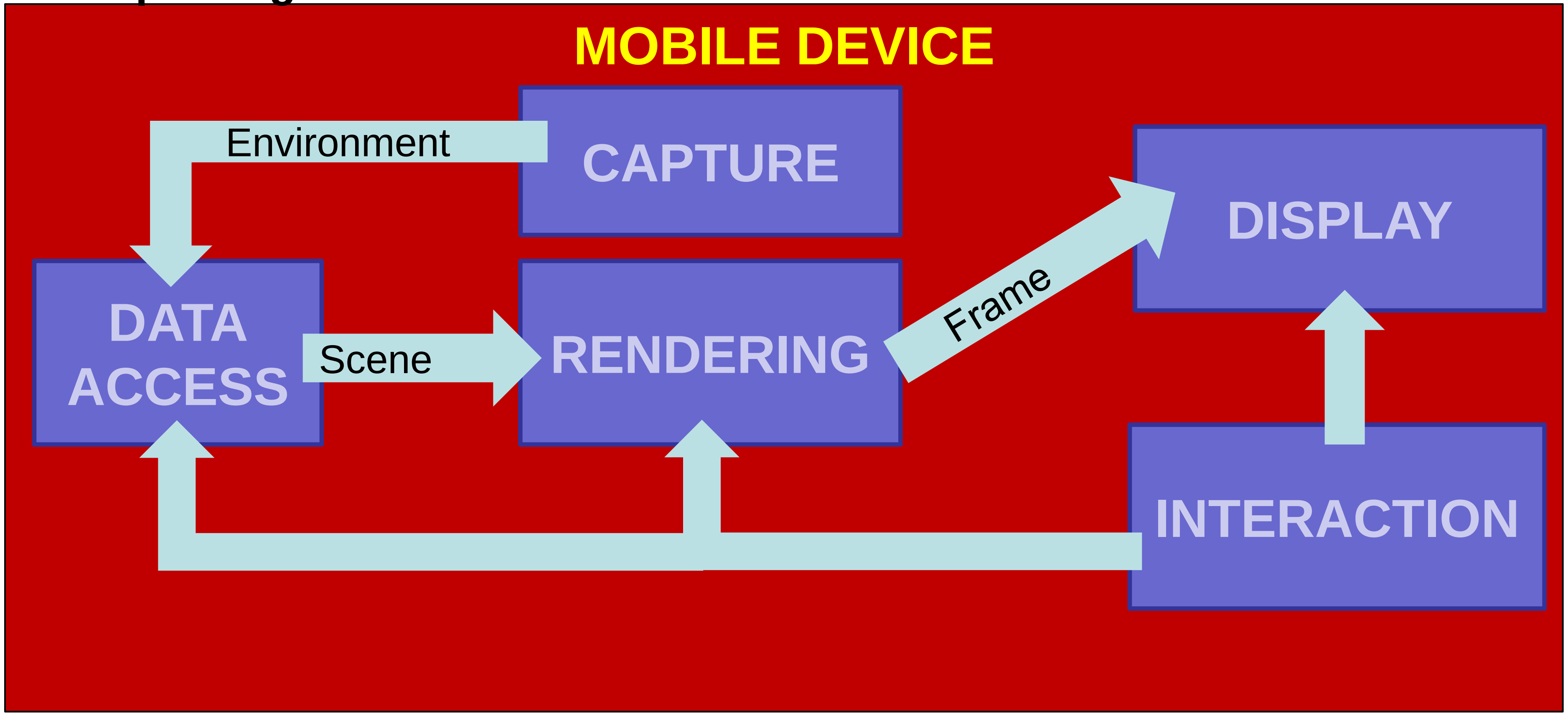


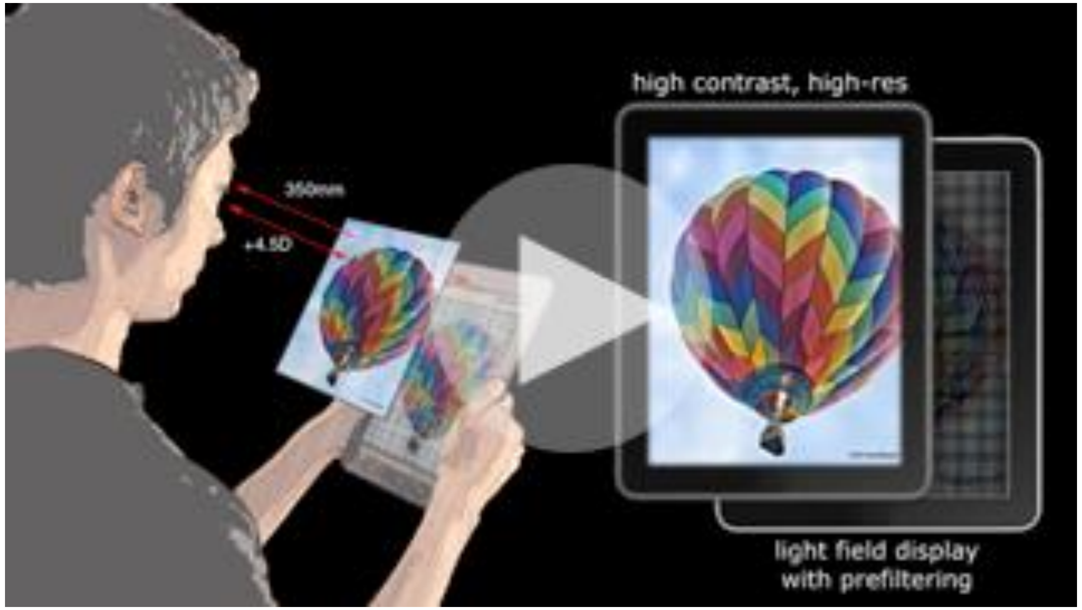
Examples: Physical simulations

- **Framework for physically and chemically-based simulations of analog alternative photographic processes**
- **Efficient fluid simulation and manual process running on iPad**

Echevarria et al. **Computational simulation of alternative photographic processes.** Computer Graphics Forum. Vol. 32. 2013.

Examples: Correcting visual aberrations

- **Computational display technology that predistorts the presented content for an observer, so that the target image is perceived without the need for eyewear**
- **Demonstrated in low-cost prototype mobile devices**



Huang, Fu-Chung, et al**. Eyeglasses-free display: towards correcting visual aberrations with computational light field displays.**ACM Transactions on Graphics (TOG) 33.4, 2014.

Conclusions

- **Heterogeneous applications**
  - driven by bandwidth and processing power
- **Trends**
  - desktop software solutions tend to be ported to the mobile world
    - gaming
    - modelling and 3D animation
    - complex illumination models
- **Sensor integration open new scenarios**
  - examples: live acquisition, mHealth (using sensors and cameras for tracking and processing signals)

Next Session

GRAPHICS DEVELOPMENT FOR MOBILE SYSTEMS