IXPUG Annual Conference 2019 - CERN (Geneva, Switzerland)

High-Fidelity Rendering for Large-Scale Tiled Displays

"The purpose of computing is insight not numbers."
– R. W. Hamming (1961)

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High-Fidelity Rendering for Large-Scale Tiled Displays

Why Remote Visualization?

- **Moving data to the Visualization Machine**

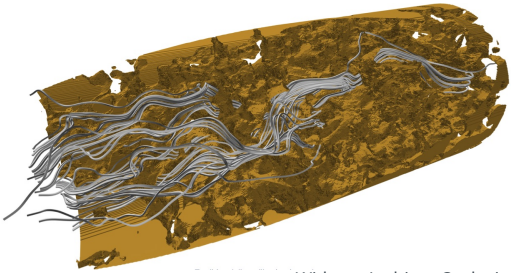
	100 Gbps	10 Gbps	1 Gbps	300 Mbps
1 Gb	< 1 Sec	1 Sec	10 Sec	35 Sec
1 Tb	≈ 100 Sec	≈ 17 Min	≈ 3 Hours	≈ 10 Hours
1 Pb	≈ 1 Day	≈ 12 Days	≈ 121 Days	≈ 1 Year

- **Image resolution limits in some software cannot capture feature details**
- **Displays cannot show entire high-resolution images at their native resolution**

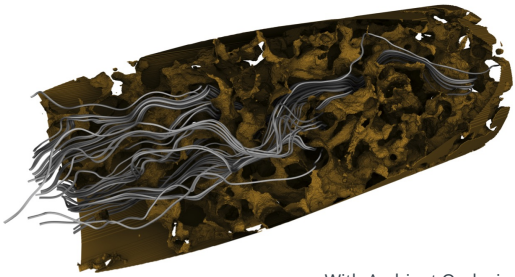
High-Fidelity Rendering for Large-Scale Tiled Displays

Software-Defined Visualization Stack

Intel Visualization Technology (Embree and OSPRay), GraviT and Galaxy [TACC]



Without Ambient Occlusion



With Ambient Occlusion

South Florida Ground Core Sample Sade Garcia, Michael Sukop (Florida International University), Kevin Cunningham (US Geological Survey),Carson Brownlee, Aaron Knoll (TACC)

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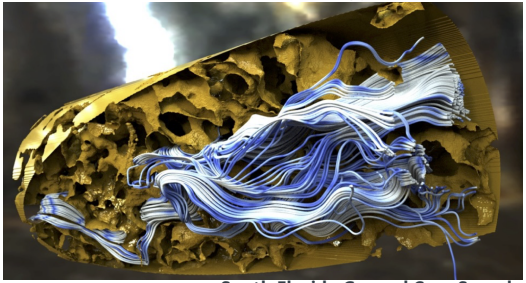

South Florida Ground Core Sample
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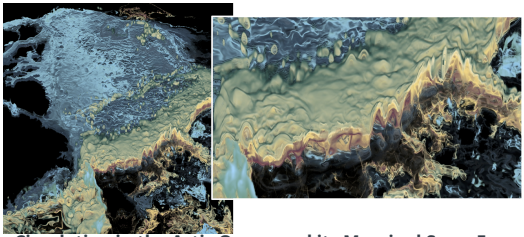
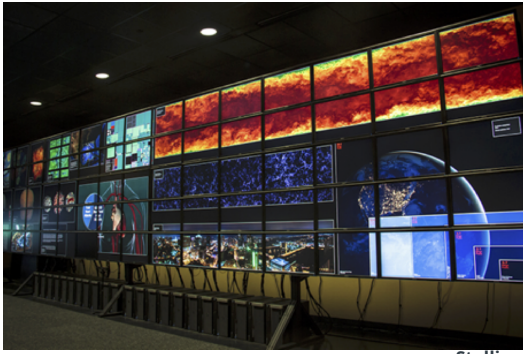


Circulation in the Artic Ocean and its Marginal Seas: From Low LAtitudes to the Pole and Back. Greg Foss, Briana Bradshaw (TACC), An Nguyen, Arash Bigdeli, Victor Ocana and Patrick Heinbach (ICES & UTIG UT-Austin)

High-Fidelity Rendering for Large-Scale Tiled Displays

Stallion and Rattler



Stallion

- Total Pixels : **328 Mpix**
- 80 (2600x1600) LCD Displays
- 20 Workstations

Rattler

- Total Pixels : **174 Mpix**
- 21 4k OLED Displays
- 21 Workstations

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High-Fidelity Rendering for Large-Scale Tiled Displays

Why large-scale tiled displays

Motunui island,rendered on Stampede 2
Model from Walt Disney Animation Studios,
https://www.technology.disneyanimation.com/collaboration-through-sharing

Enable the ability to explore detail, ...

High-Fidelity Rendering for Large-Scale Tiled Displays

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High-Fidelity Rendering for Large-Scale Tiled Displays

Why large-scale tiled displays

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Without losing context.

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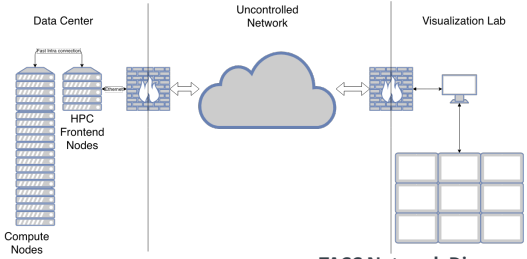
High-Fidelity Rendering for Large-Scale Tiled Displays

Related work and Challenges

- **OSPRay distributed module** (Intel Visualization Technologies)
  - Enables distributed raytracing across the cluster
  - PROBLEM: Image rendered to a compute node or to disk
- **DisplayWald OSPRay module** (Ingo Wald et. al.)
  - Enables local raytracing in Display Cluster
  - Could only use remote *farm* but only if it is in the same MPI fabric
    - Security concerns compute nodes and display nodes need to be exposed

High-Fidelity Rendering for Large-Scale Tiled Displays

TACC Network connectivity



TACC Network Diagram

- Display Walls do not share the same intraconnect fabric
- They don't even share the same network
- SSH Tunnel required to publish *rending farm* connection port from the compute node to the frontend
- Multiple hops between datacenter and display walls

High-Fidelity Rendering for Large-Scale Tiled Displays

Bridge Display Wall

Security

- Encrypted data / Authenticated packet header

Rendevouz Server:

- Fast packet forward to compute and display
- Client Authentication

Compute/HPC Side:

- Build on top of OSPRay distributed rendering model
- Display tile accumulation and compression

Display Side:

- Head-node
  - Sends updates to scene parameters (Camera, AO Samples, ...)
  - Coordinates render frame finish and request
- Display nodes
  - Signal head-node when local buffer is complete for current frame

High-Fidelity Rendering for Large-Scale Tiled Displays

Bridge Display Wall - Bandwith problem

Using a subset of rattler (3x3)

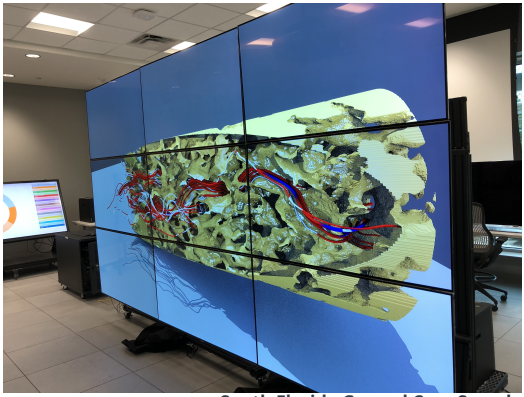
- Bandwidth
  - 9x4k = 300Mb of data
  - In a 10Gb link that limits the framerate to ≈ 4 FPS
- **Lossless**:
  - Density [https://github.com/centaurean/density]
  - Snappy [https://github.com/google/snappy]
- **Non-lossless**:
  - JPEG
  - PNG

High-Fidelity Rendering for Large-Scale Tiled Displays

Bridge Display Wall - Bandwith problem

"Magnetic Reconnection" Volume Rendered
courtesy Bill Daughton (LANL) and Berk Geveci (KitWare)

- 32 Nodes Hikari
- ≈ 1 FPS - Rattler

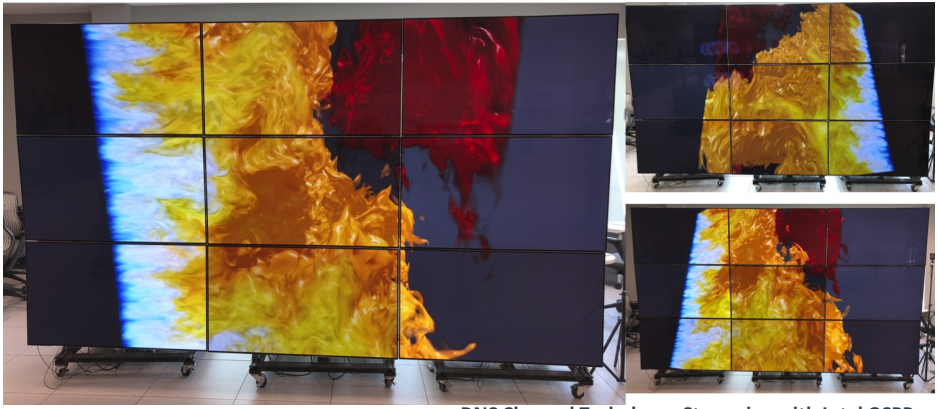


South Florida Ground Core Sample
Sade Garcia, Michael Sukop (Florida International University), Kevin Cunningham (US Geological Survey),Carson Brownlee, Aaron Knoll (TACC)

- 32 Nodes Hikari
- ≈ 2 FPS - Rattler

High-Fidelity Rendering for Large-Scale Tiled Displays

Bridge Display Wall - Bandwith problem



DNS Channel Turbulence Streaming with Intel OSPRay

Vis - João Barbosa (TACC); Data – MK Lee (Sandia), Bob Moser (UT-Austin)

- 8 Nodes Frontera
- 16 FPS on Frontera / Lossless transmission to Rattler: ≈ 3 FPS
- 16 FPS on Frontera / Interactive (30% JPEG Quality) transmission to Rattler: ≈ 8 FPS

Conclusions and Future Work

Conclusion

- The proof of concept is done and we are able to stream to rattler
  - The combination of lossless and non-lossless compression is helping achieve interaction
  - Still:
    - We are improving the compression algorithms
    - Exploring the rendering convergence metrics and entropy to identify areas that can be dropped or use non-lossless compression
    - Exploring new network protocols (UDP/STCP)
- As a nice side effect we are also able to use comercial cloud computing as a render farms
  - 4k image (3840x2160 $\approx$ 32Mb) at 12 FPS
  - We are still far from limit which is $\approx$ 32 FPS theoretical limit

Thank you

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