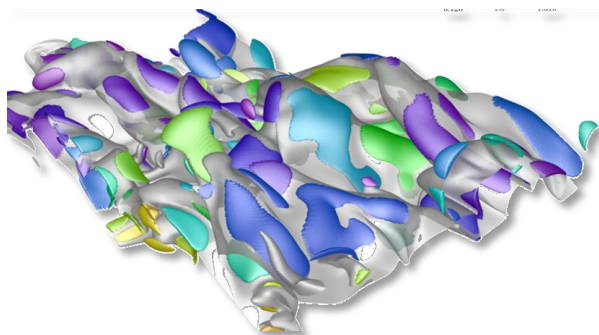
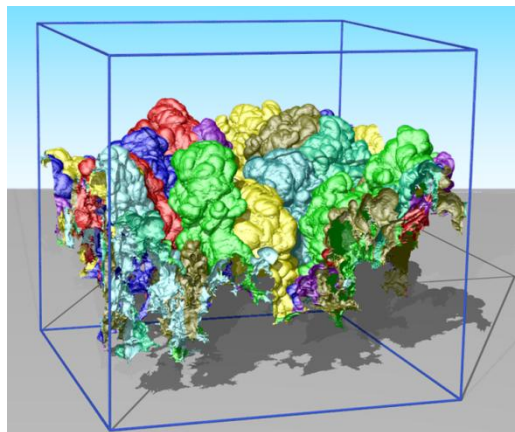
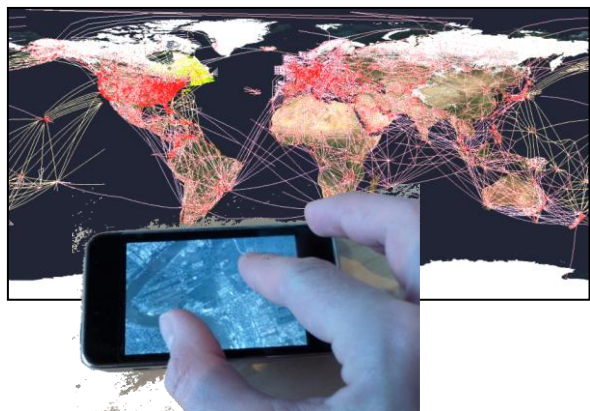


ViSUS: Massive Data Management, Analysis, and Visualization with Scaling From Handheld Devices to Supercomputers

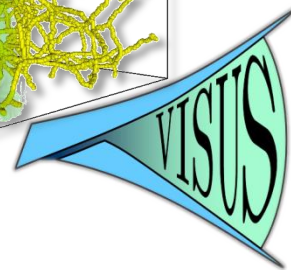
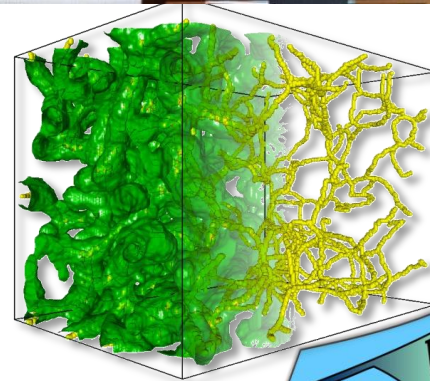


ViSUS Framework

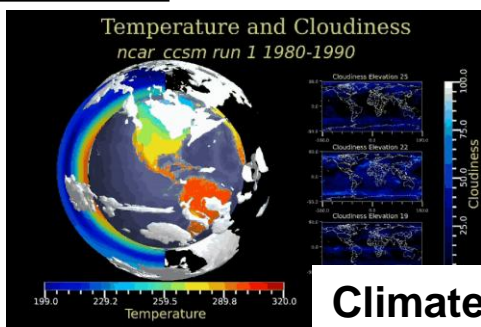
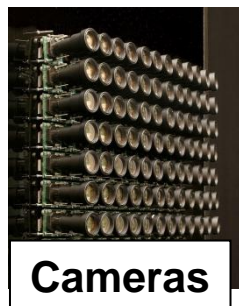
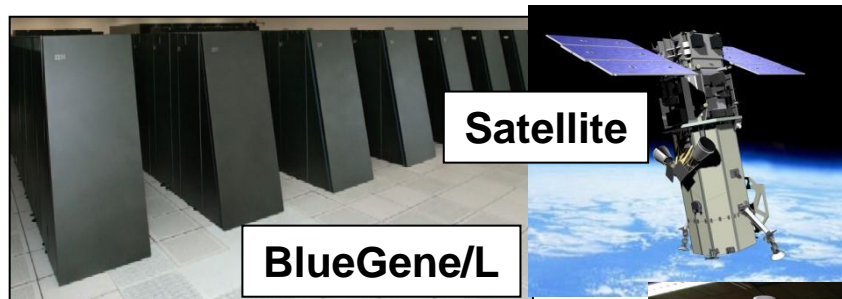
Valerio Pascucci

Director, CEDMAV

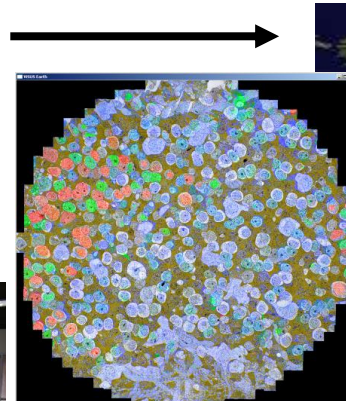
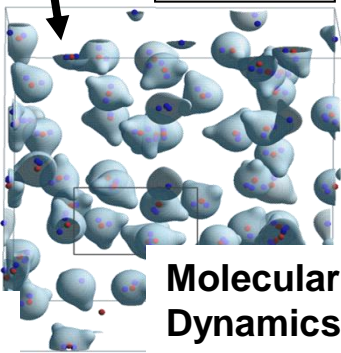
Professor, SCI Institute & School of Computing
Laboratory Fellow, PNNL



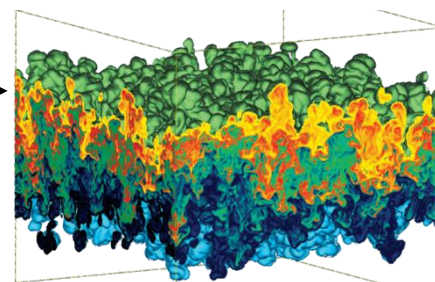
Massive Simulation and Sensing Devices Generate Great Challenges and Opportunities



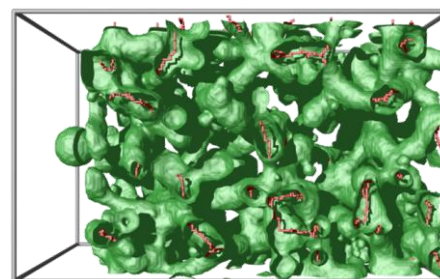
Climate



Retinal Connectome



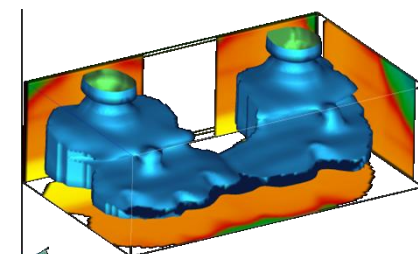
Hydrodynamic Inst.



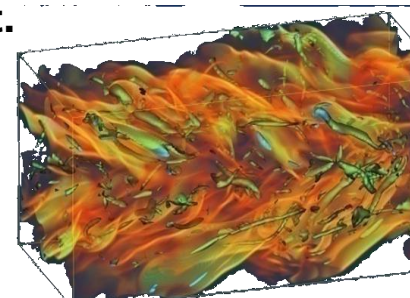
Porous Materials



Earth Images



Carbon Seq.
(Subsurface)



Turbulent
Combustion

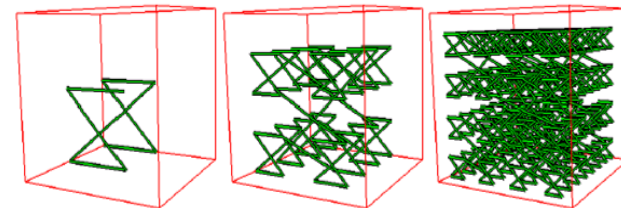


Photography

A Cyberinfrastructure Requires Efficient Data Management and Processing

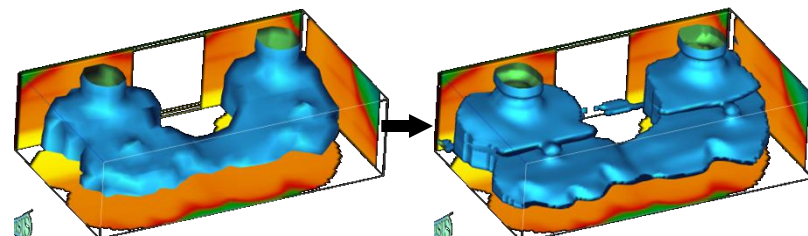
- **Advanced data storage techniques:**

- Data re-organization.
- Compression.



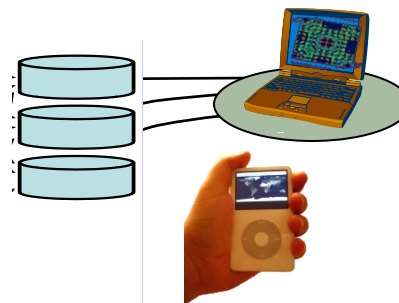
- **Advanced algorithmic techniques:**

- Streaming.
- Progressive multi-resolution.
- Out of core computations.



- **Scalability across a wide range of running conditions:**

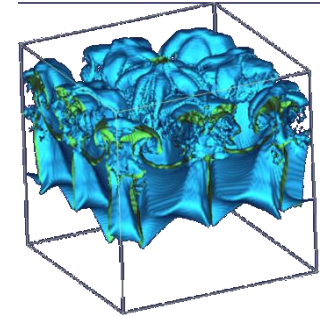
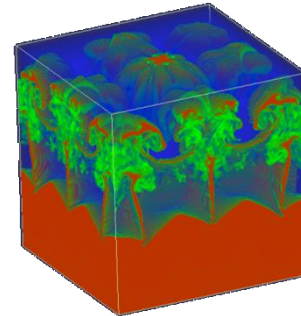
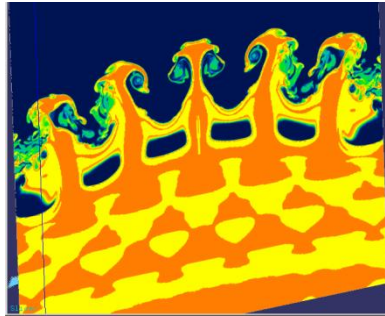
- From laptop, to office desktop, to cluster of PC, to BG/L.
- Memory, to disk, to remote data access.



We Redesigned the Data Management and Visualization Pipeline with New Principles

- **Basic core techniques:**

- Slicing
- Volume rendering
- Iso-surfaces

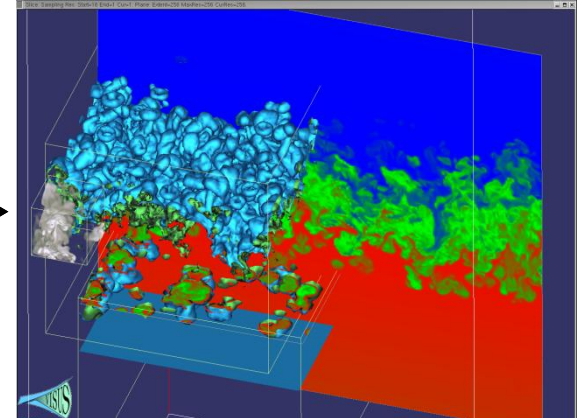
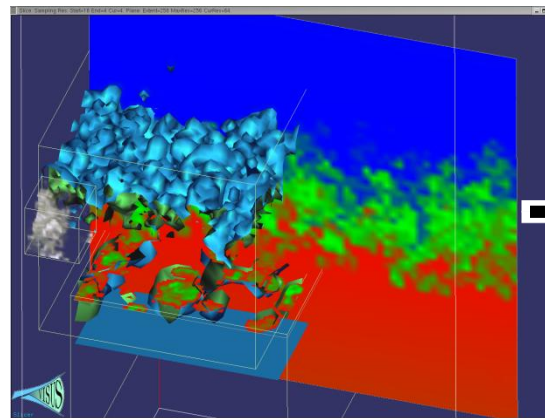
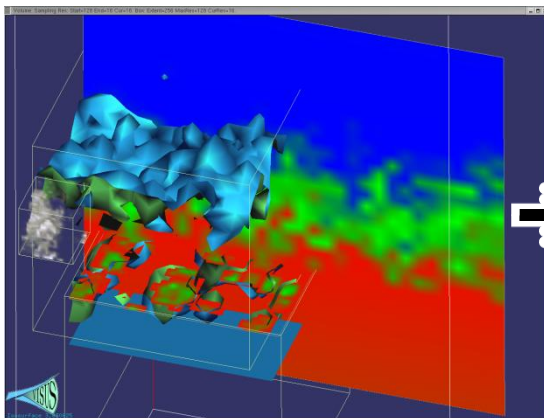


- **Cache-oblivious** out-of-core processing optimizing access locality for any size of data blocks

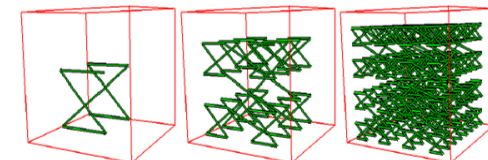
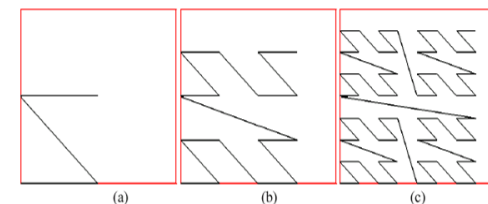
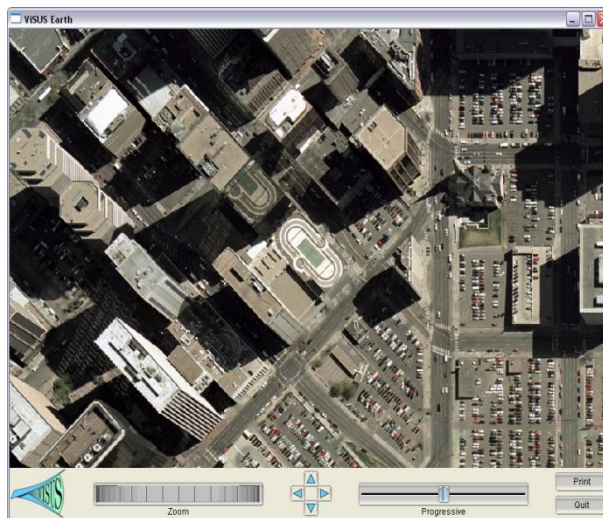
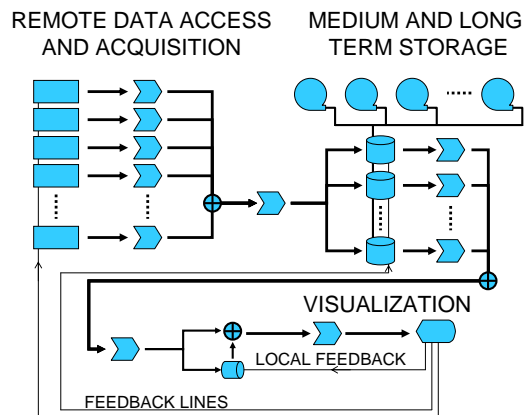
- **Coarse-to-fine** construction of multi-resolution models

- Pipelines of **progressive algorithms**

- Remote **data streaming**

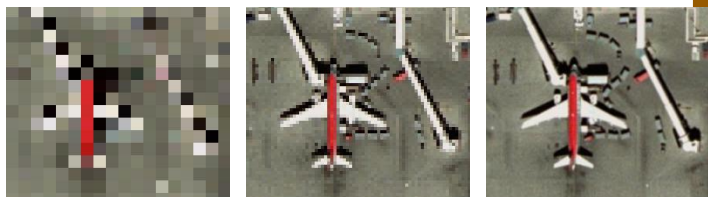


We Consider the Three Main Components Defining a Computing Infrastructure

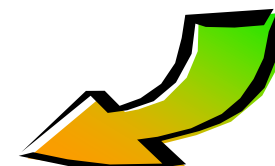


**Processing
Network**
(Data Access Path)

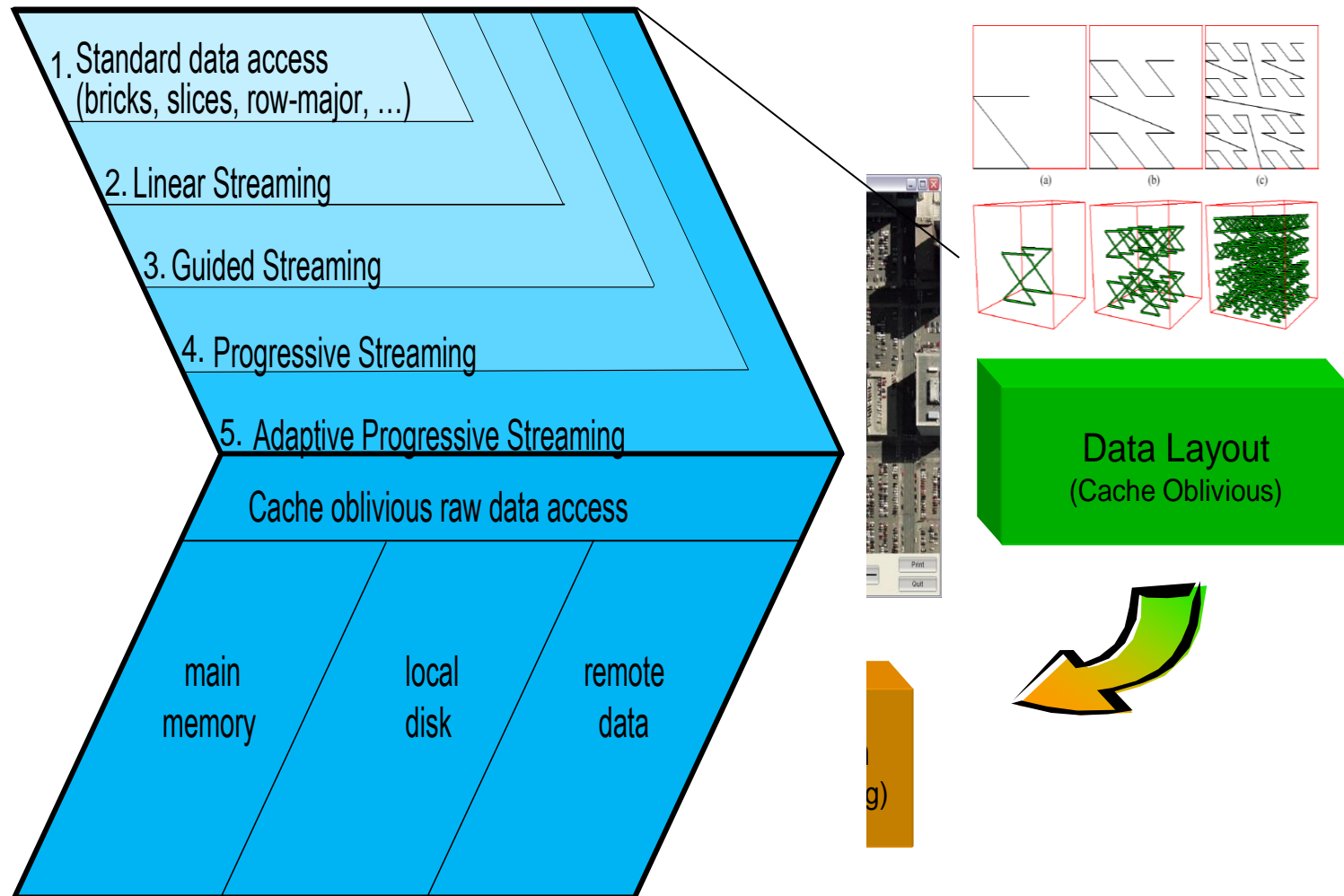
Data Layout
(Cache Oblivious)



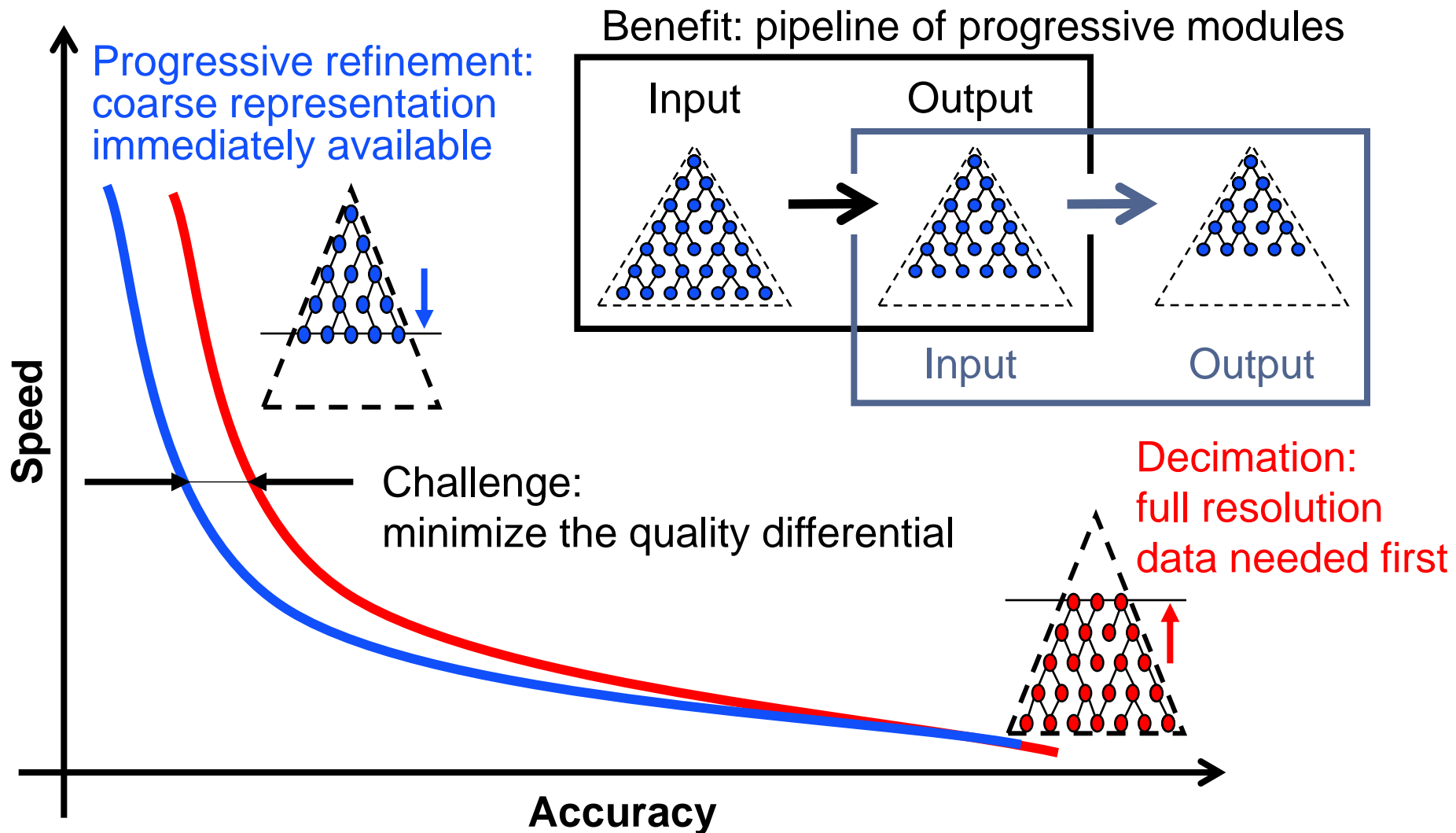
Algorithm Design
(Progressive Processing)



We Characterize Algorithmic Classes Based on Effect in a Processing Network

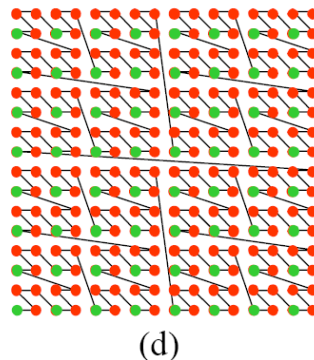
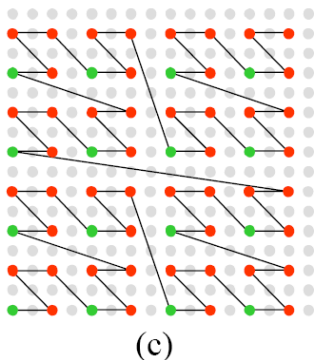
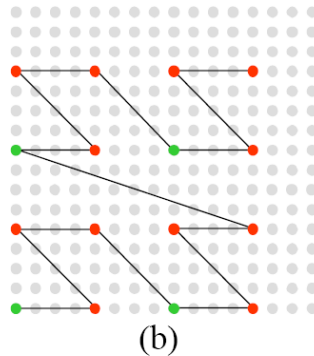
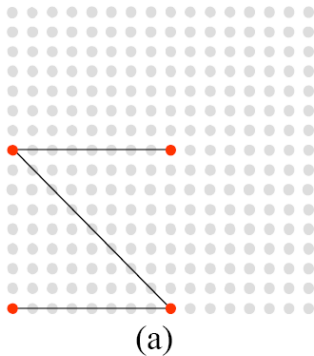


The use of top-down and bottom-up processes have a strong impact on the data stream



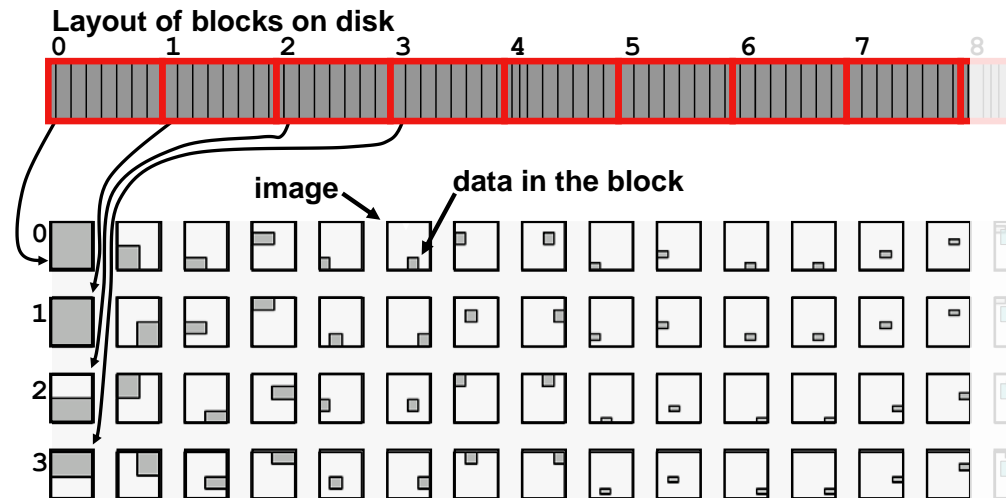
We Introduced Multi-resolution Cache Oblivious Layouts for Image Data

- Z-order curve used to define a hierarchical sub-sampling over a grid



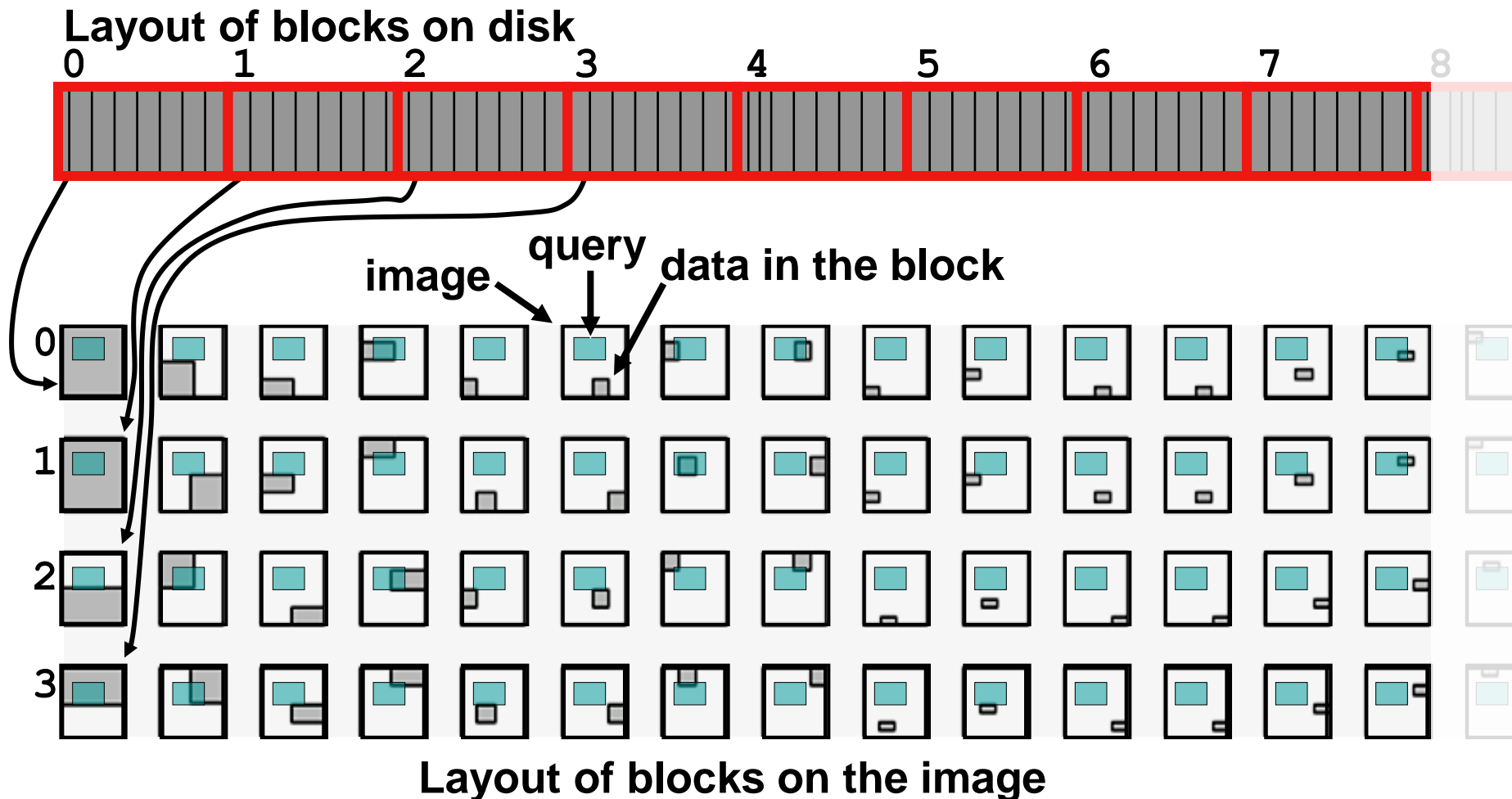
● coarse data ● new level data

- Improve access locality:
 - Interleaving hierarchical levels
 - Maintaining geometric proximity
- Data layout is independent of the traversal of the data



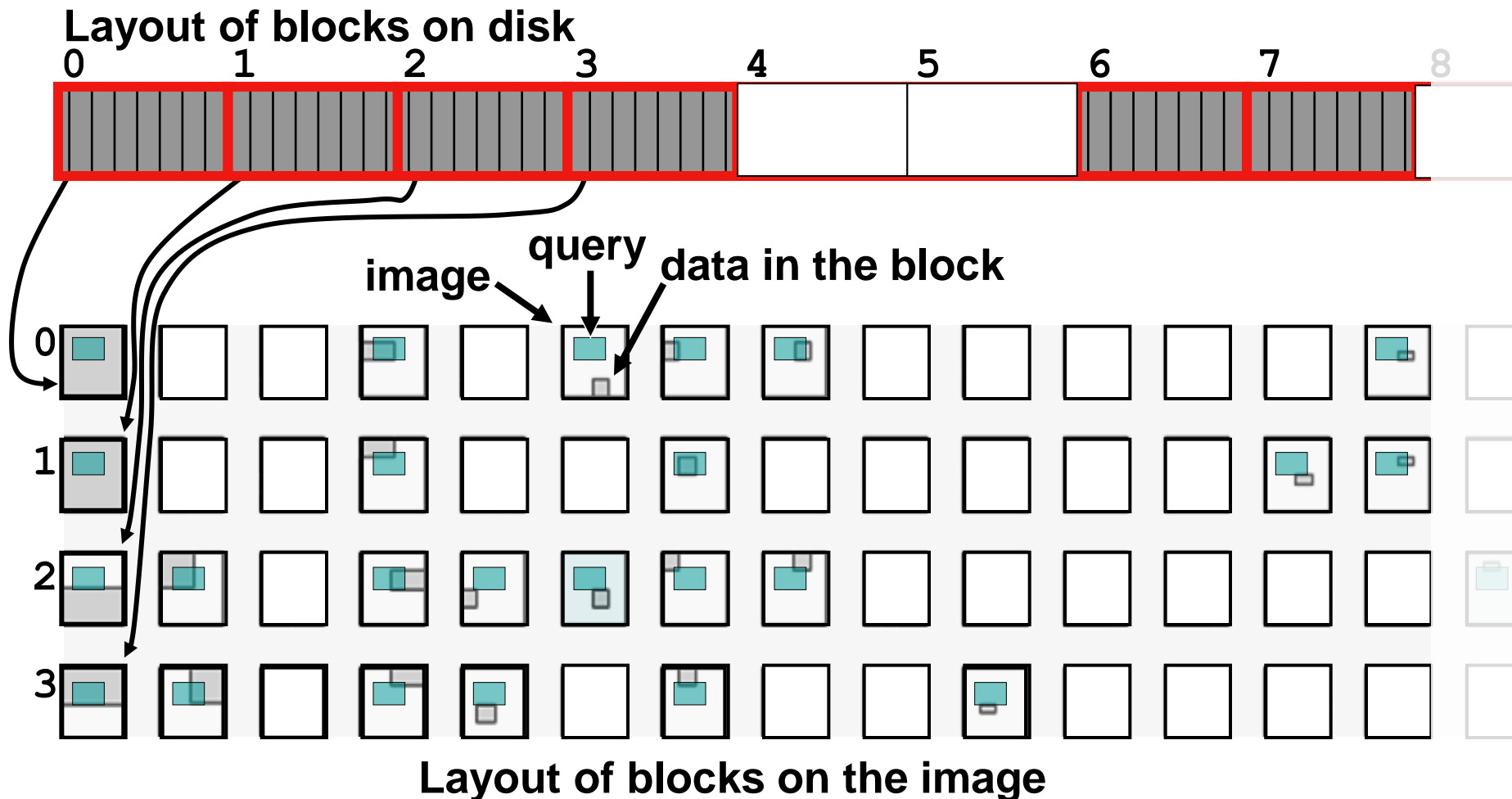
We Introduced a Progressive Range Query Avoiding Unnecessary Data Access

Blocks touched by the region 



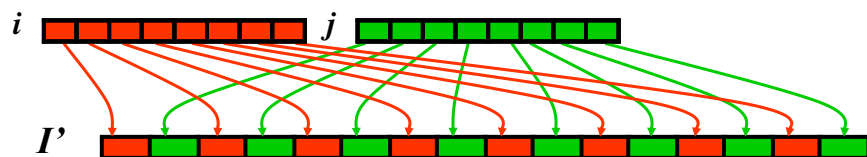
We Introduced a Progressive Range Query Avoiding Unnecessary Data Access

Blocks touched by the region 

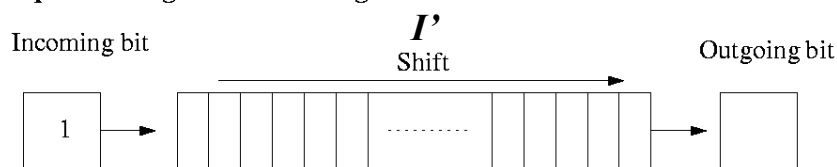


We Provided a Fast Address Computation Based on Simple Bit Manipulation

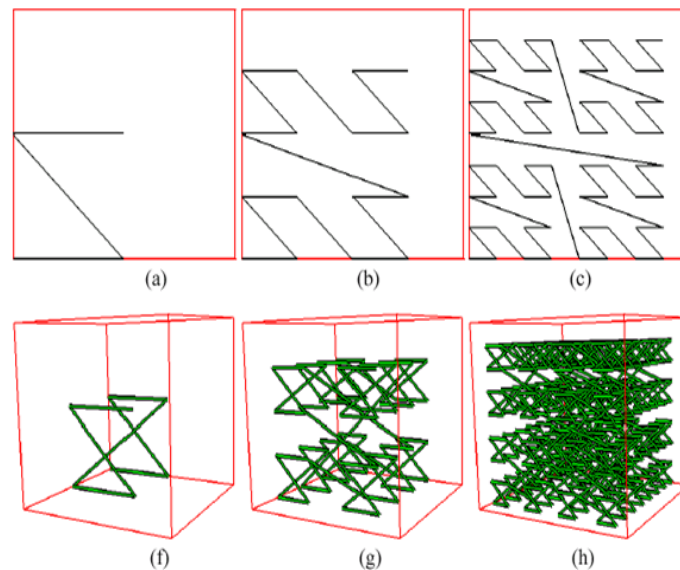
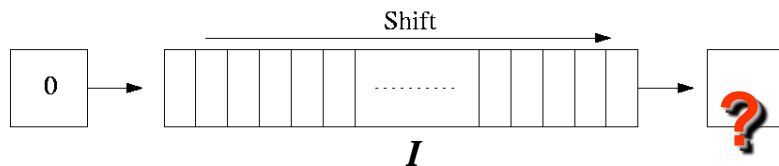
- Simple bit manipulations to convert row major to hierarchical Z-order
- 3D version (also nD): basic Z shape replaced by a connected pair of Z shapes



Step 1: shift right with incoming bit set to 1



Loop: While the outgoing bit is zero
shift right with incoming bit set to 0



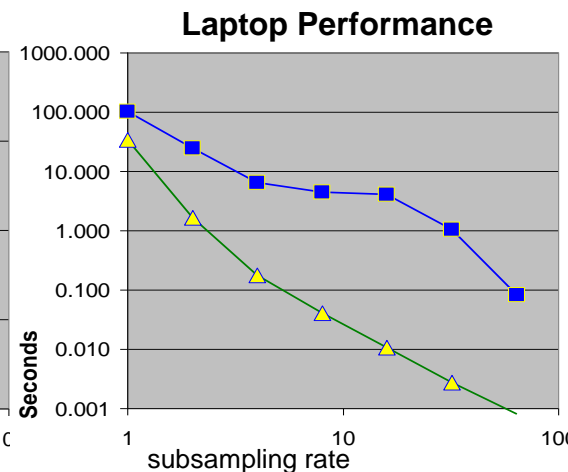
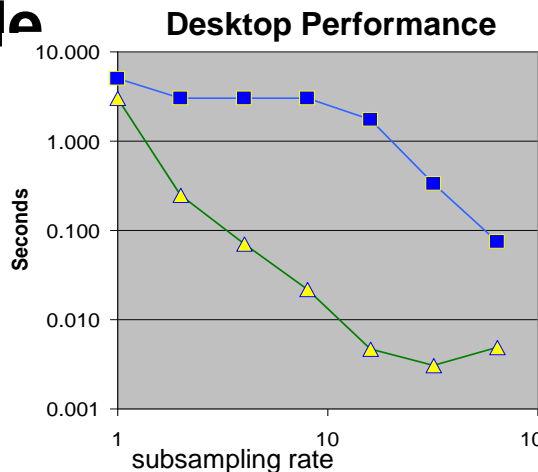
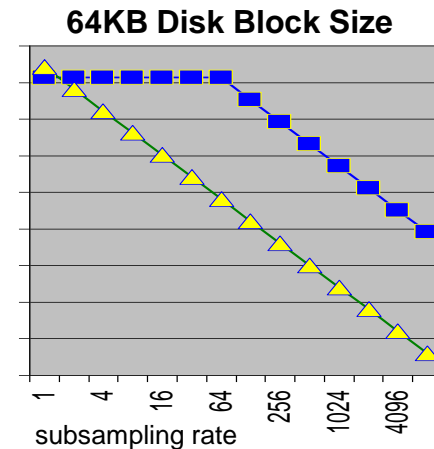
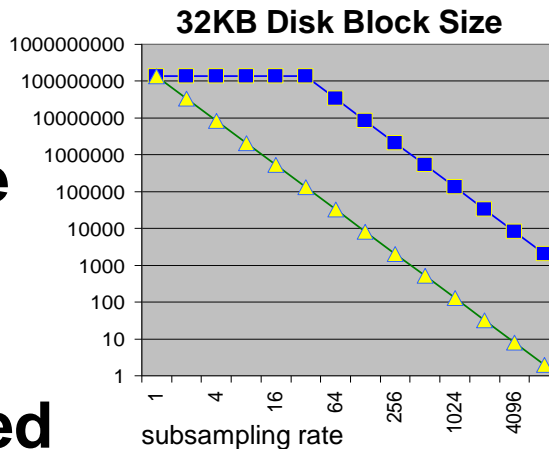
Cache-Oblivious Data Layouts Scale Well Across Different Storage Blocking Factors





**Formal analysis
predicts performance
and scalability**

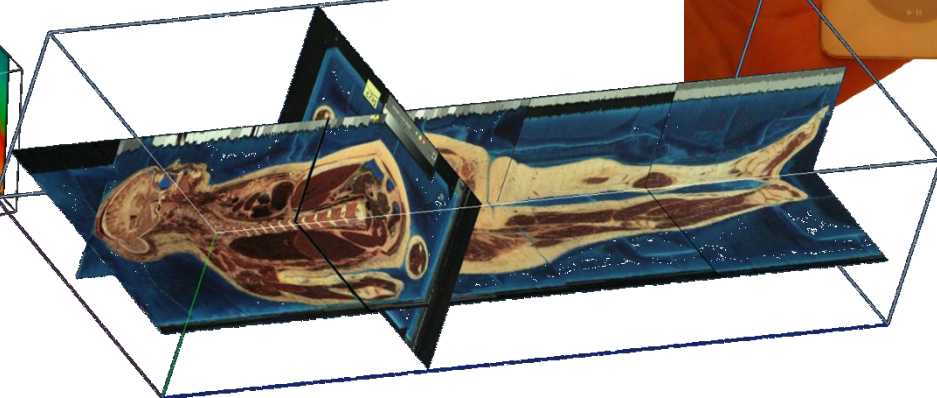
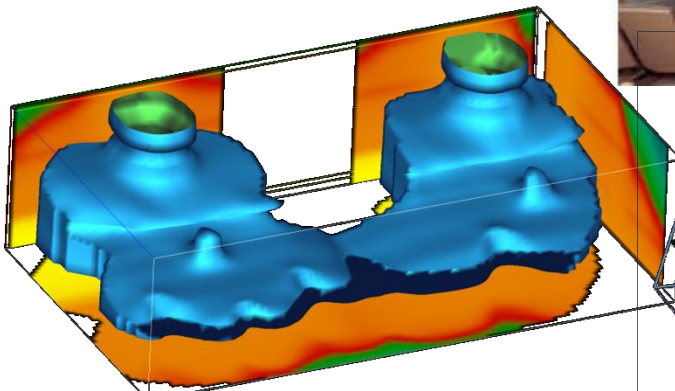
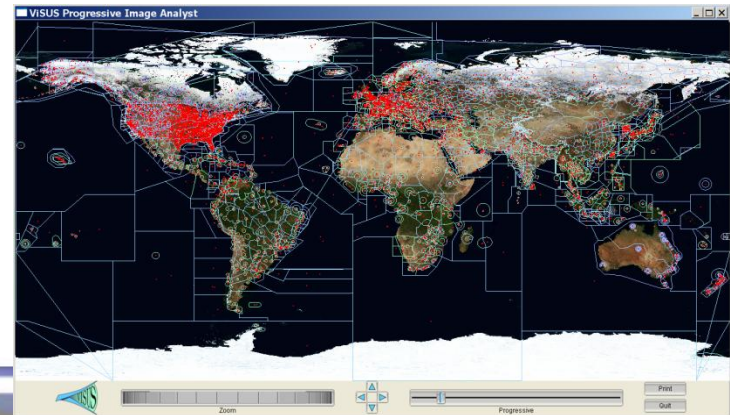
**Performance improved
by orders of magnitude**

**Independence of
architecture
and storage
characteristics**



 HZ-order  Regular Tiles

We Demonstrated Performance and Scalability in a Variety of Applications



Server can be wrapped in Apache plug-in Client can be run in a web browser



One billion polygons to billions of pixels

www.sci.utah.edu/news/60/431-visus.html

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The Scientific Computing and Imaging Institute
at the University of Utah

SCI Home » News » Projects » One billion polygons to billions of pixels

One billion polygons to billions of pixels

Welcome to the first gigapixel, multi-view rendering of The Digital Michelangelo Project's David.

The David model consists of 933 million triangles from a laser-scan of the original statue created by Professor Marc Levoy and members of The Digital Michelangelo Project at Stanford university. The model was aligned by Benedikt Brown and Szymon Rusinkiewicz using the non-rigid alignment method described in their 2007 SIGGRAPH paper.

Each of the 4 2-gigapixel sized frames (28280 x 70416 pixels) was rendered using the Manta Interactive Ray Tracer. Manta is a highly portable interactive ray tracing environment designed at the SCI Institute to be used on both workstations and super computers. For these renderings, Manta leveraged a recursive 4-level grid to accelerate the rendering. In all, each frame took 30 hours to render using 64 cores each (256 total) of the SCI Institute's 264 core SGI UV 1000 with 2.8TB of RAM and 2.67GHz Intel Xeon X7542 cores. More information on Manta can be found at: http://manta.wiki.sci.utah.edu/manta/index.php/Main_Page

The final rendering was stored in the hierarchical, space-filling curve format of the VISUS technology. VISUS intelligently reorganizes the raw data enabling efficient, streaming pipelines that process the information while in movement. The results are then visualized in a progressive environment allowing for meaningful explorations with minimal required resources. This technology enables real-time management of large datasets on a variety of systems ranging from desktops and laptop computers to portable devices such as iPhones/iPads. VISUS has been deployed in a variety of large data applications such as the monitoring of large scientific simulations and the editing of massive images and panoramas.

The VISUS David viewer is currently available as a Windows web browser plugin (Firefox and Chrome) or as a standalone application for Windows, Mac OS X, or OpenSUSE. Please follow the links below to access the gigapixel David.

- Download and install VISUS application and plugin for Windows
- Download the VISUS application for OS X
- Download the VISUS application for OpenSUSE
- View David via web plugin
- View David via web plugin (for slower connections)

visus

Streams for Ultimate Scalability

Official Visus site www.pascucci.org Sci Utah

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Project description

A Research Project in Scientific Visualization centered on the development of cache efficient approaches for the management, streaming and rendering of large surface and volume meshes. Principal Investigator: Valerio Pascucci Other team members: Eric Langer, Daniel Langer, Peter Lindemann. Main Collaborators: Mark Duchateau, Randall J. Frank, Giorgio Sorselli, Dave Bremer. Students: Justine Bennett (Ph.D.), Rita Borgo (Ph.D.), Ben-Tzion Brenner (Ph.D.), Kira Cole-McLaughlin (BS), Ajith Harasimedes (Ph.D.), Vijay Natarajan (Ph.D.), Simeon Pöschel (Postdoc), Jonathan Stewer (MS).

In the VISUS project (see the featured article in the LODS report) we develop data streaming techniques for progressive processing and visualization of large scientific datasets. Our strategy is to exploit the coupling between time-spatial algorithms and progressive multi-resolution data structures to realize an end-to-end optimized flow of data from the original source, such as remote storage or large scientific simulation, to the rendering hardware. The implementation of this approach will enable three major visualization modalities: (i) Interactive visualization on high resolution power-walls, (ii) Interactive visualization on desktop workstations of large datasets that cannot be stored locally, (iii) Immediate monitoring of remote simulations from a desktop workstation. These modalities target multiple phases in the process of generating and exploring very large simulation datasets where real-time user interaction can increase the productivity of scientists.

Download Windows Visus Installer

San diego

Type: RGB
Size: 204 Gb
Width: 200,000
Height: 365,000

Visible male

Type: RGB
Size: 15 Gb
Width: 2048
Height: 1216
Depth: 1876

Atlanta

Type: RGB
Size: 292 Gb
Width: 320,001
Height: 327,001

Hamilton

Type: RGB
Size: 195 Gb
Width: 140,000
Height: 232,000

Chattanooga

Type: RGB

2kbit1

Type: Gray
Size: 8 Gb
Width: 2048
Height: 2048
Depth: 2048

Nuclear

Type: Float32
Size: 1 Gb
Width: 600
Height: 600
Depth: 100
Num fields: 7

Phoenix

Type: RGB
Size: 1086 Gb
Width: 720,000
Height: 540,000

San Francisco

Type: RGB
Size: 207 Gb
Width: 225,000
Height: 130,000

Microscopy

Type: RGB

Geospatial Data Rendering on iPad

Both client and SERVER run of handheld devices,
e.g. multiple iPhones can be clients and servers for
each other to share information on the field



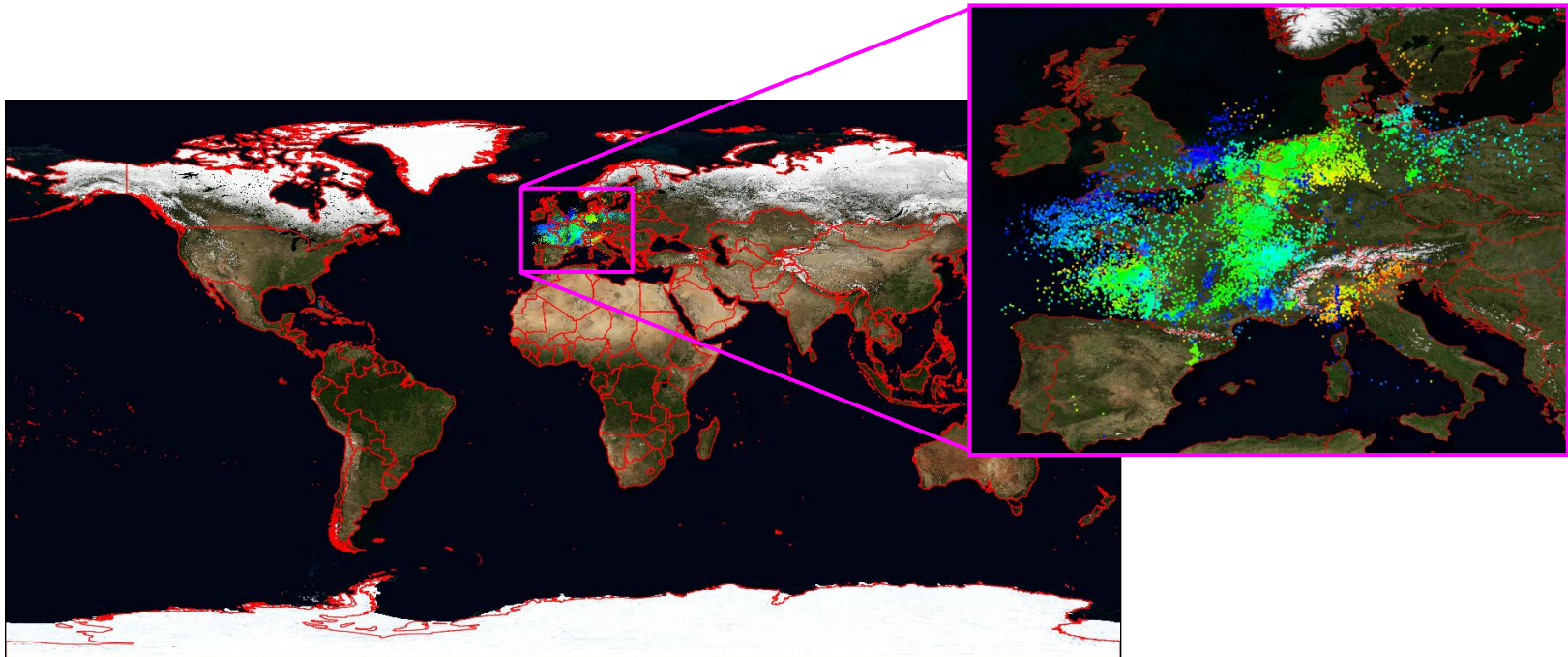
We Address the Need for Scalable Algorithms and Infrastructures



- **Data formats that minimize I/O and memory transfer for most frequent operations**
- **New algorithms and data structures for management of large collections of time dependent information**
- **New theoretical models that predict the behavior of modern architectures**
- **New algorithms that are “intrinsically scalable” with respect to:**
 - **Processing capabilities**
 - **Diversity of hardware available**
 - **Locality of data**
- **Can benefit a variety of tools**
- **Scalable system infrastructures**

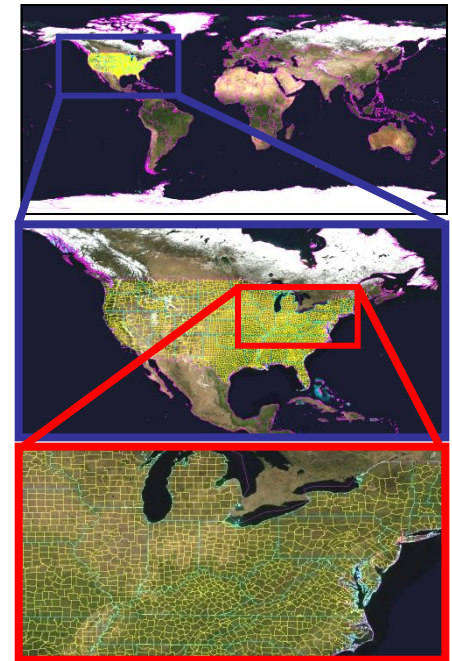
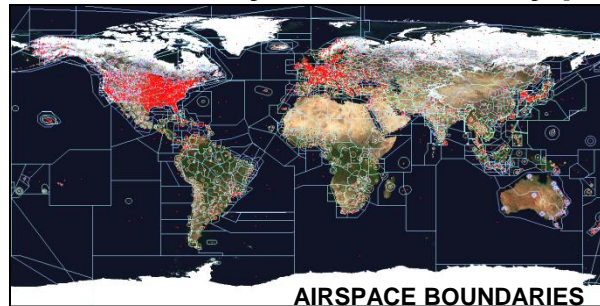
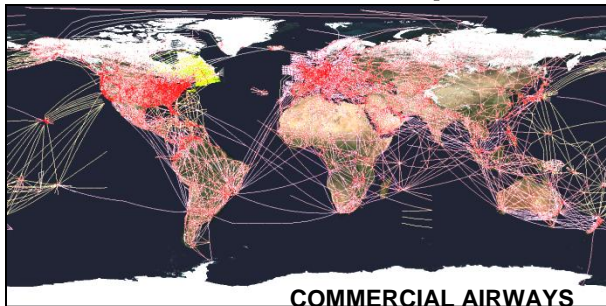
We provide real-time access to large scale time dependent data and sensory data

- **Blue Marble Earth (next generation) provided by NASA:**
 - Twelve months in 2004 (11GB per month)
 - Resolution: 86400 x 43200 pixels (500 meters per pixel)
- **Lightning events from distributed sensing devices over Central Europe (Blitzortung.org)**



We Are Moving Towards Support of a Combination of Different Data Types

- Concurrent access to several information sources requires similar techniques for a variety of data types.

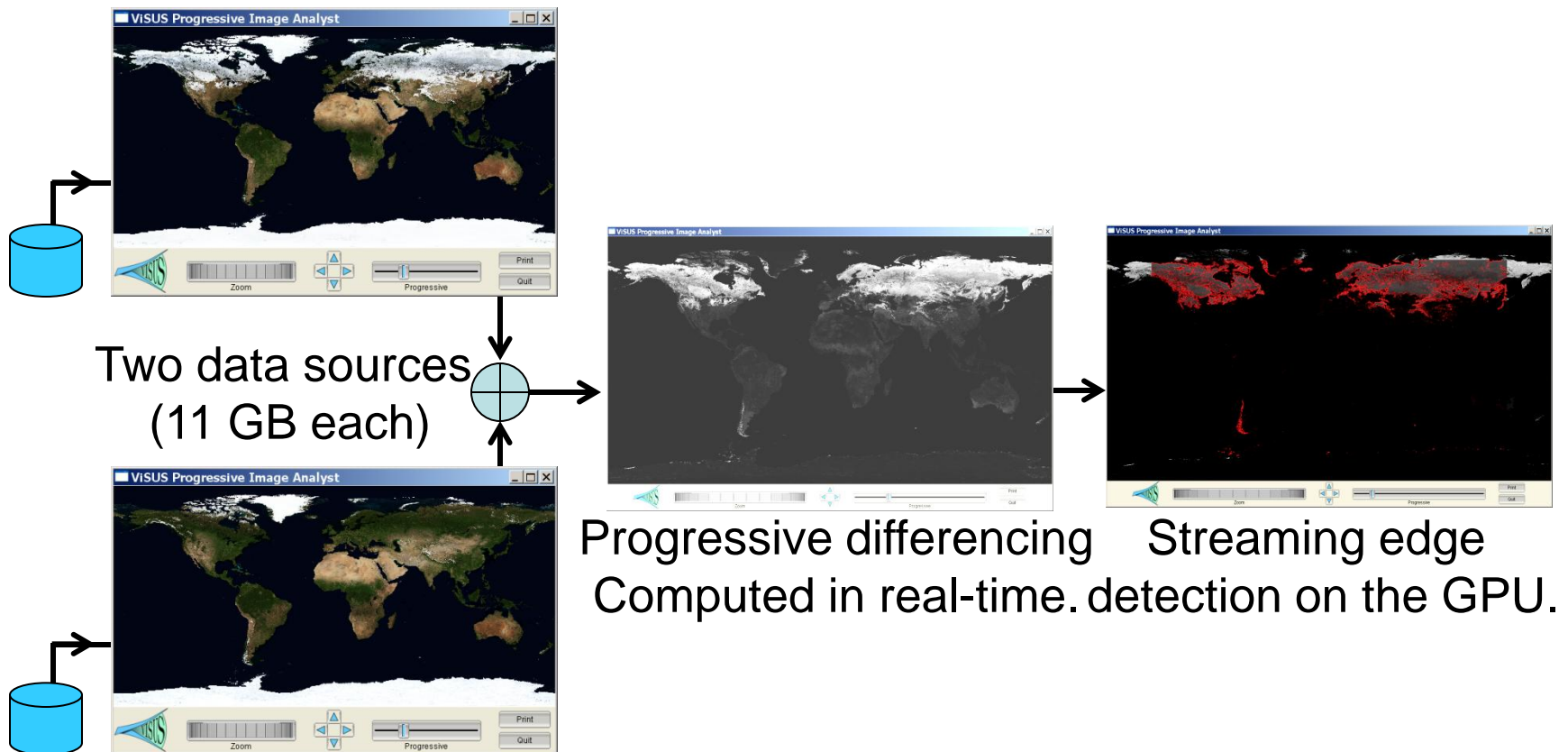


BOUNDARIES OF US COUNTIES

- **Algorithmic directions:**
 - integration with other frameworks
 - progressive streaming infrastructure for “vector data” (points, lines, polygons);
 - uncertainty/incompleteness in the data
 - progressive resolution of queries with quantification and visualization of error/confidence;
 - on-line update of internal data structures to render new data immediately available.

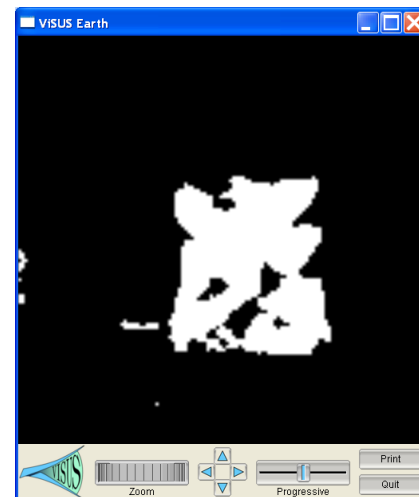
We Allow Distributed Computations at Different Stages of the Data Stream

- Progressive Image Differencing + Editable GPU filter.

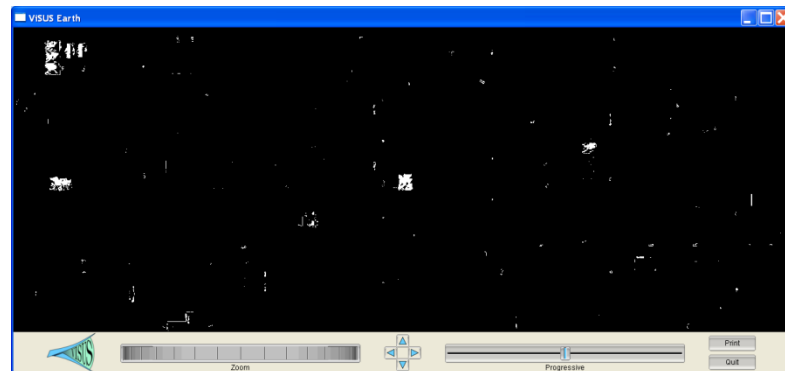
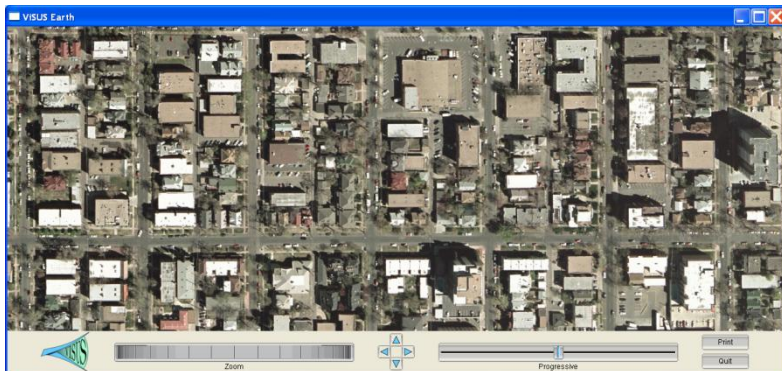


We are Developing Progressive Scheme for Content Based Image Processing

- Hypothesis:**



- Progressive Analysis:**



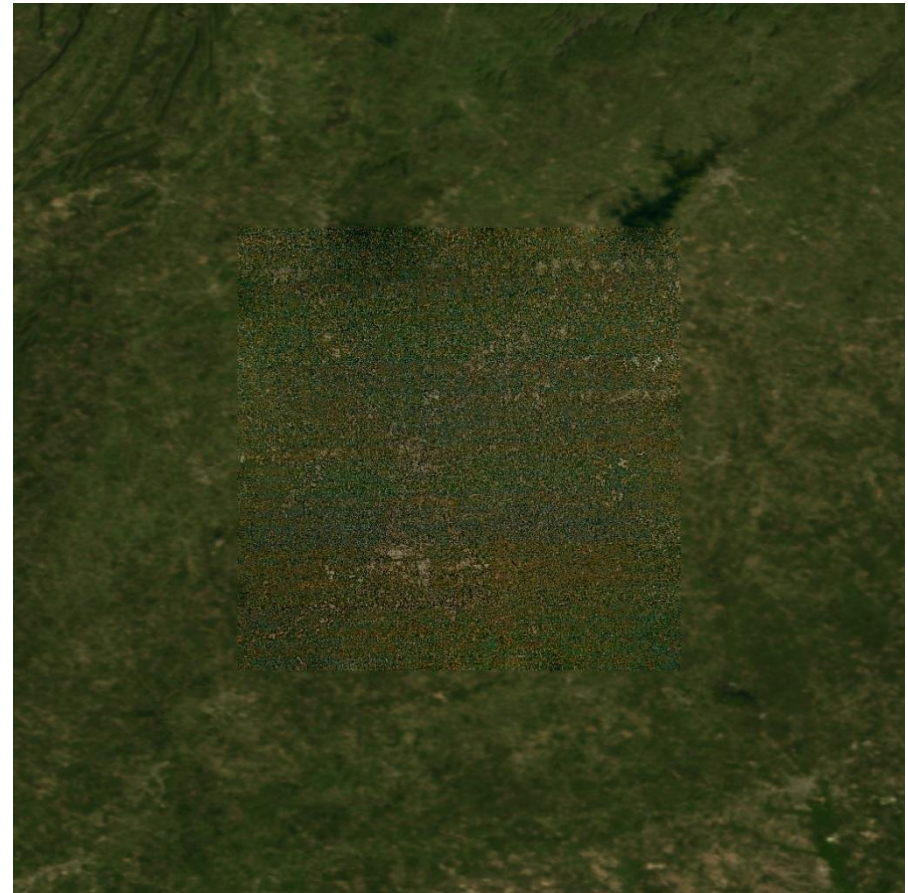
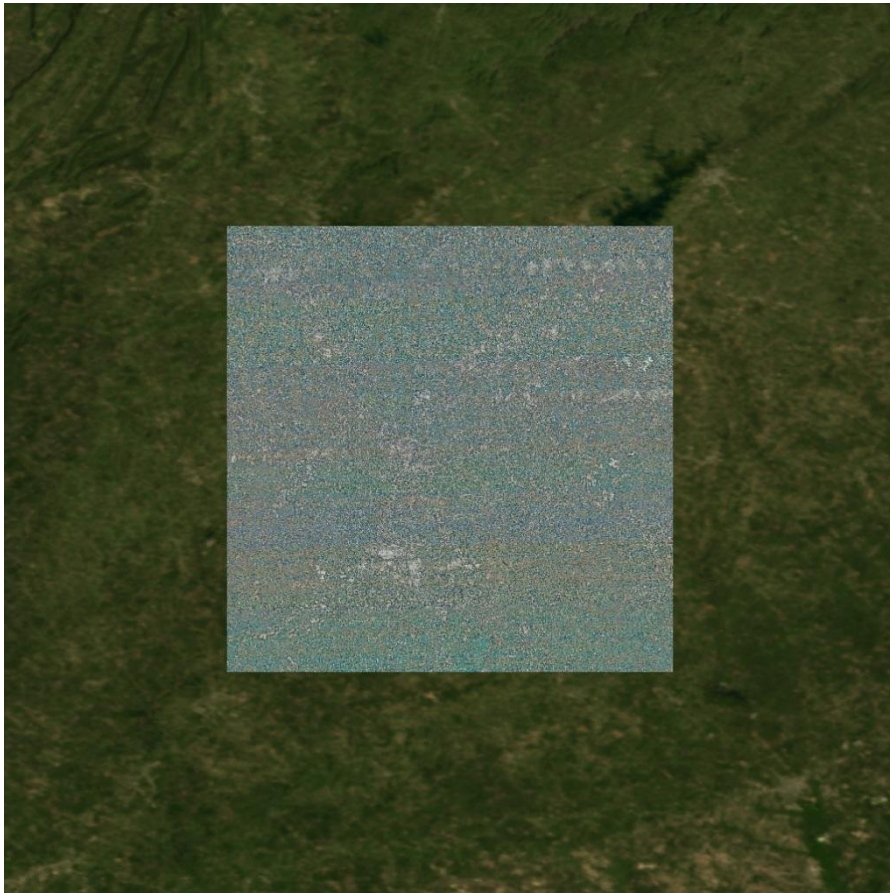
Poisson Solver for Image Cloning in Massive Image Collections

- Color correction of 600+ images in real time

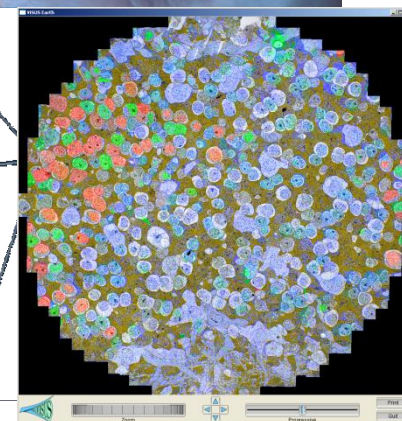
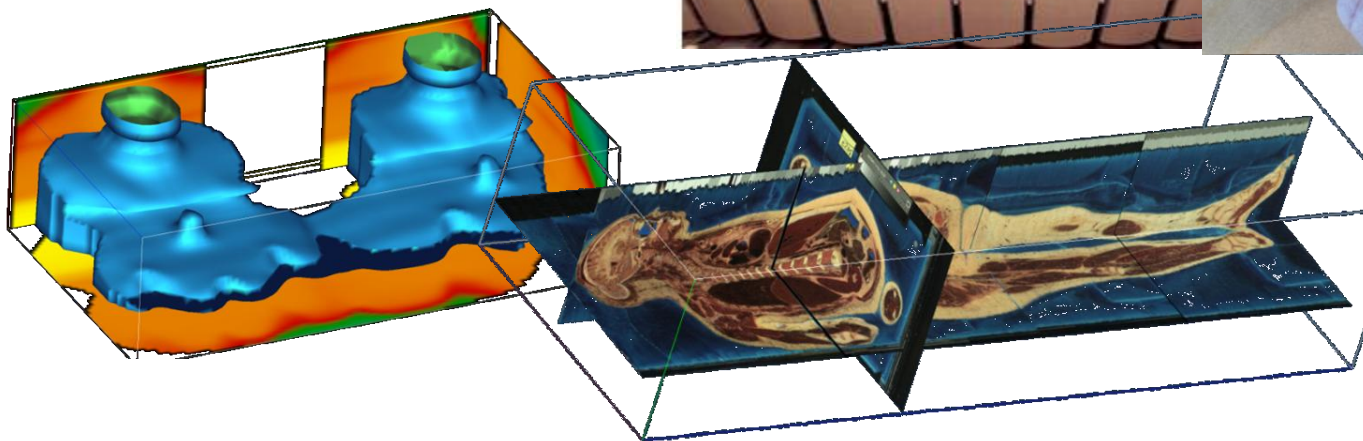
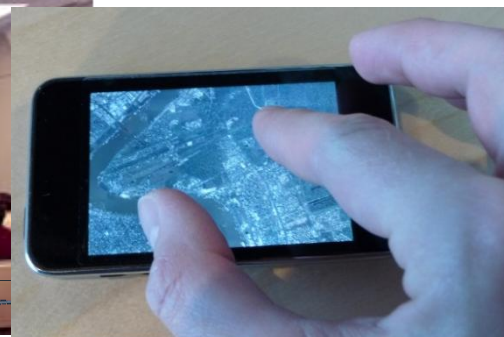
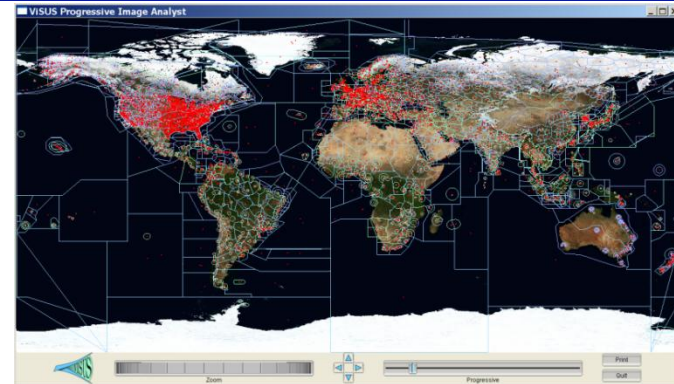


Poisson Solver for Image Cloning in Massive Image Collections

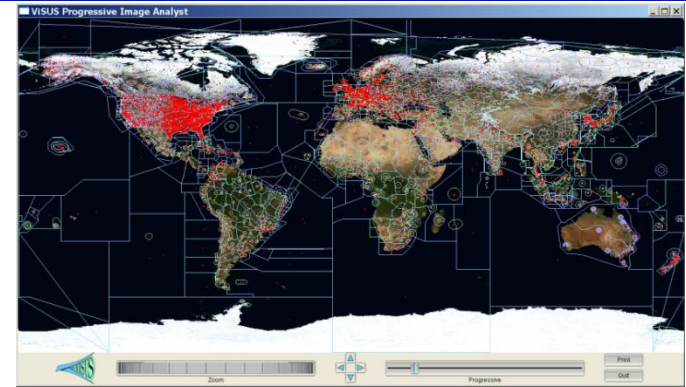
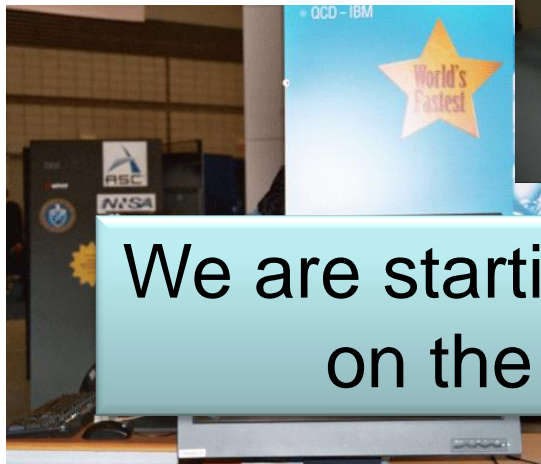
- Pasting a 300GB satellite image of a city in background world map merged in real time



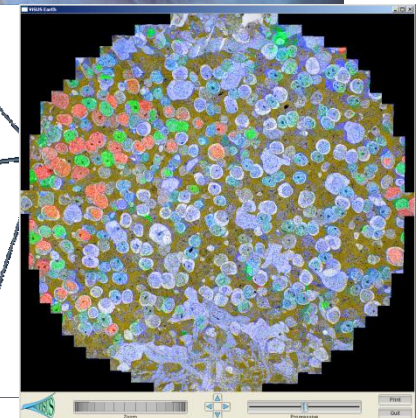
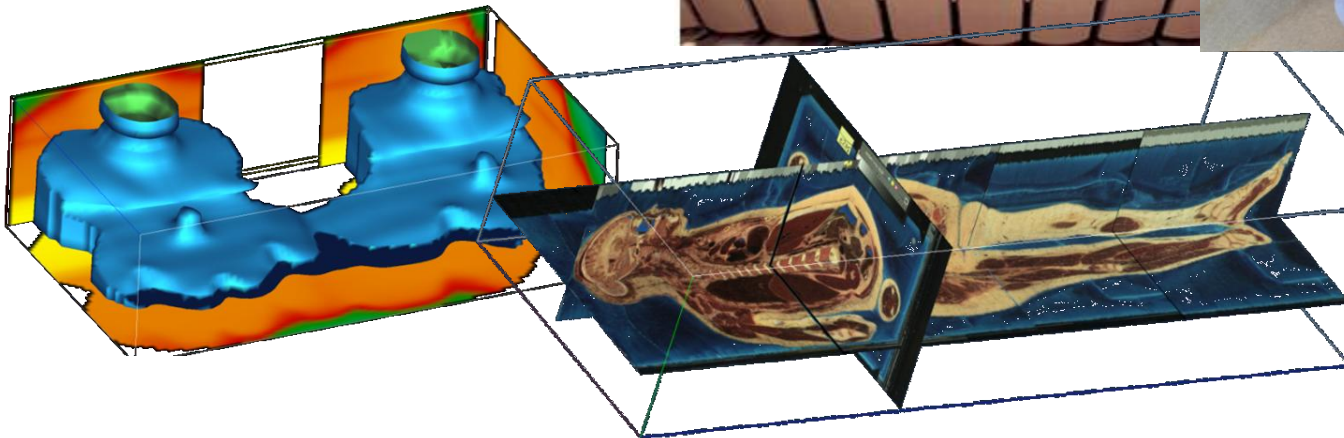
We Demonstrated Performance and Scalability in a Variety of Applications



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We are starting to redesign simulations based on the new algorithmic techniques



We Are Moving Towards a Distributed Storage and Processing Environment



- **Distributed storage**
- **Data redundancy**
- **Security**
- **Heterogeneous collaborative infrastructure**
- **Multi-scale collaborative interfaces accessing shared data sources:**
 - data collection and validation
 - interactive analytics
 - decision making

