



A Scalable Integrated System for Real-time Interactive 3D Visualization of NEXRAD Level II Data

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Motivation

- **Weather Surveillance Radar Data** - NWS NEXRAD II data contains high temporal and spatial resolution of three attributes of weather, viz., reflectivity, radial velocity and spectrum width.
- **Real-time Availability** - Purdue is one of the NWS NEXRAD II data resource provider. This data is available in real-time.
- **3D Visualization** - It is critical for meteorological researchers to access, analyze, and visualize in 3D the data in real-time.
- **Main Challenge** - Large volume and real-time streaming (50 Megabytes/second) presents major computational and data management challenges.

Challenges in State-of-the-art

- **Cumbersome Access Method** - Current data access is through FTP/HTTP and cannot be used for time-critical weather events.
- **Hard-to-Understand Data Format** - The data is available in Radar-native format compressed using modified bzip2.
- **Intensive Computation** - Analyzing data over a long period or large geographical region or both requires computation that overwhelms even powerful computers.
- **Lack of interactive 3D visualizations** - Despite the availability of 3D information in the new generation, the data is most commonly visualized as 2D images, simple 3D Point clouds or iso-surfaces.

Our Scalable Integrated System for Interactive 3D Visualization

The Integrated System

We built a functional end-to-end integrated system that retrieves radar data, processes it and remotely renders it in 3D in near real-time for a few stations. The components of the integrated system are:

- **Data Access**
 1. Download the radar files from SRB (Storage Resource Broker).
 2. Uncompress the data using modified bzip2.
- **Data Processing**
 1. Align data from multiple sites according to a specific timestamp.
 2. Convert the values to the global geographic coordinate system and construct the 3D volumes.
 3. Compress and store the 3D volumetric data available within 3D volumes from data on the disk.
- **Visualization/ Data Rendering**
 1. Import and uncompress the volumetric data from the disk.
 2. Create 3D textures and slices.
 3. Apply the texture-based volume-rendering techniques.
 4. Utilize transfer functions to render the data on GPU.

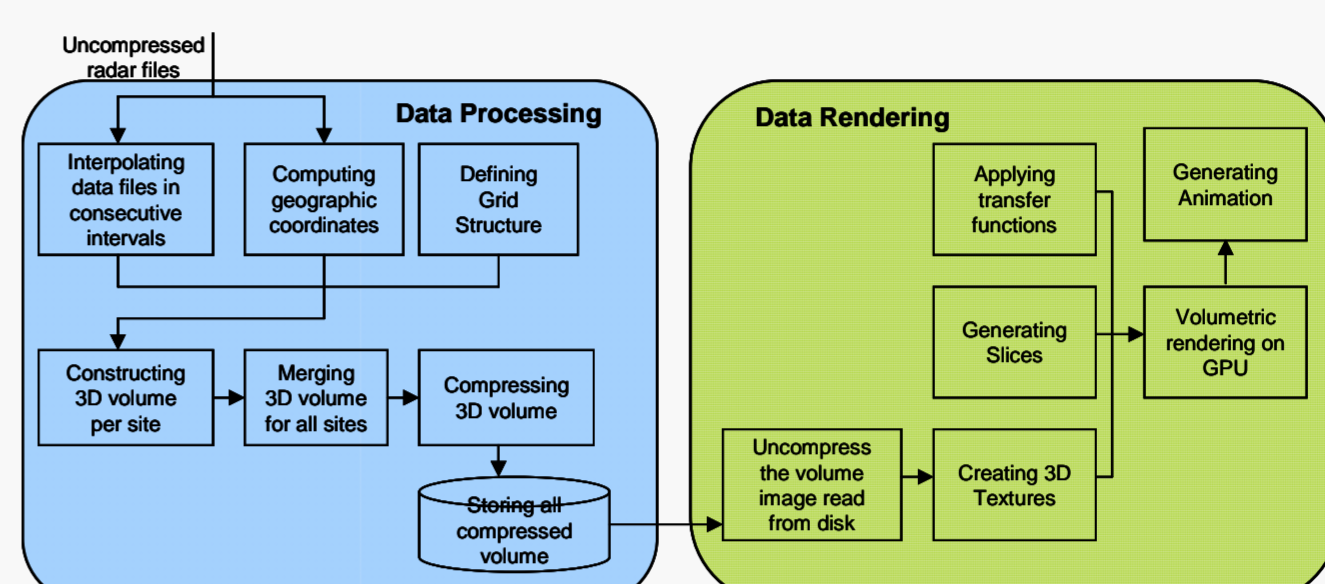


Figure 1. Components of the integrated system: data processing and data rendering / visualization

Scaling on the TeraGrid

We scaled our integrated system to visualize in 3D several tens of stations across the nation in real-time by exploiting parallelism and offline processing as explained below.

- **Exploiting Parallelism in Data Processing**
 1. The volumes for individual radar sites can be individually processed and merged with other sites.
 2. Reading data from SRB for each site can also be done in parallel.
- **Offline Processing and Storing 3D Volumes**
 1. The radar files are processed into 3D volumes and stored for each site when new data are received from NWS.
 2. The 3D volumes generated are *two orders of magnitude* smaller than the radar data itself.
 3. The 3D volumes for the selected sites are merged on demand when the user selects the radar stations.
 4. Visualization happens in near real-time.

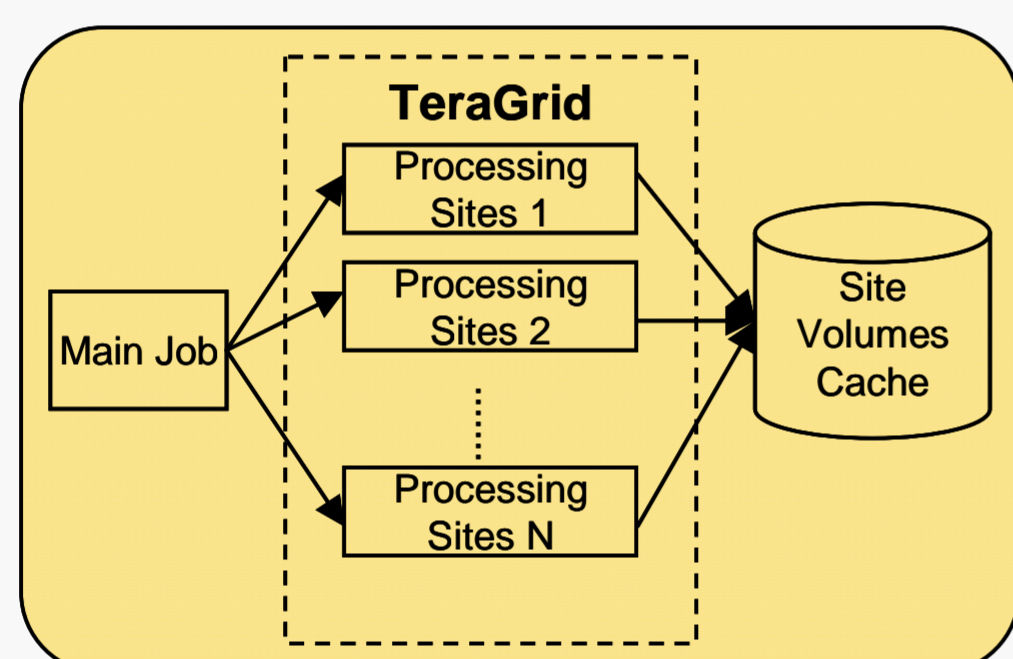


Figure 2. Parallel processing on TeraGrid

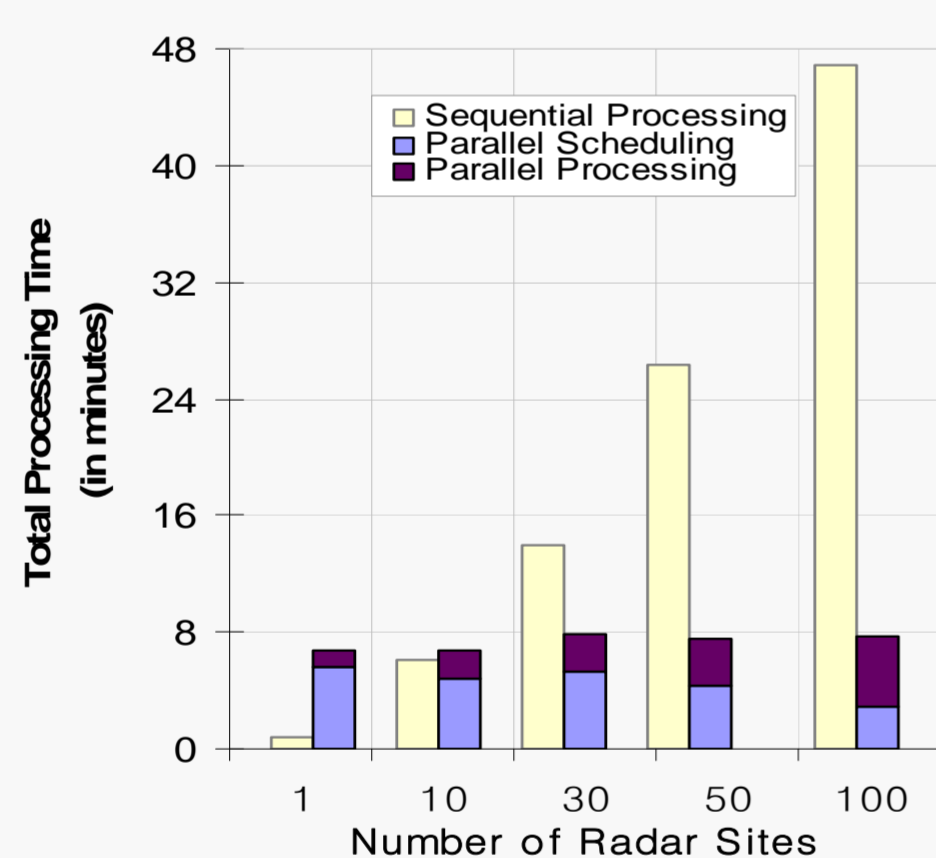


Figure 3. Performance improvement obtained using parallel processing

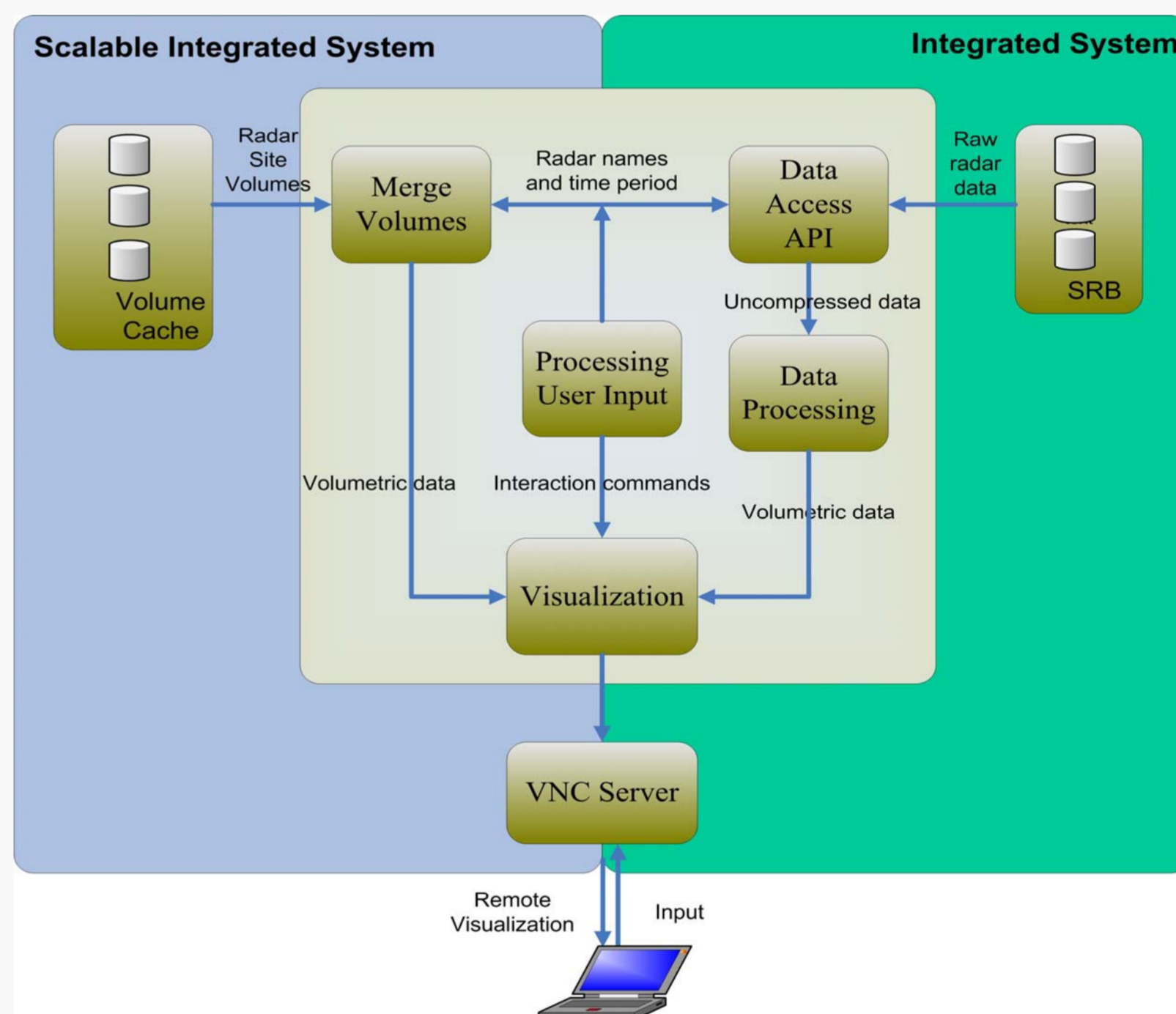


Figure 4. The integrated system and scaling on the TeraGrid

Visualization Results – 3D Images Generated Using Our System

