VACET focuses on leveraging scientific visualization and analytics software technology as an enabling technology for increasing scientific productivity and insight. Advances in computational technology have resulted in an "information big bang," which in turn has created a significant data understanding challenge. This challenge is widely acknowledged to be one of the primary bottlenecks in contemporary science. The vision for our Center is to respond directly to that challenge by adapting, extending, creating when necessary and deploying visualization and data understanding technologies for our science stakeholders. Using an organizational model as a Visualization and Analytics Center for Enabling Technologies (VACET), we are well positioned to be responsive to the needs of a diverse set of scientific stakeholders in a coordinated fashion using a range of visualization, mathematics, statistics, computer and computational science and data management technologies.

### Techniques

#### Visualization

<table>
<thead>
<tr>
<th>Technical Point of Contact</th>
<th>Visualization</th>
<th>Analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td>VACET / ORNL</td>
<td><img src="visualization.png" alt="" /></td>
<td><img src="analytics.png" alt="" /></td>
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</tbody>
</table>

#### Applications

- **Fusion**
- **Combustion**
- **Accelerator**
- **Astrophysics**
- **Turbulence**
- **Climate**
- **Environmental Management**

Our main goal is to develop and deploy a variety of data analysis and visualization tools for our science stakeholders. They have diverse data understanding needs, use a variety of computing resources, and are geographically distributed. Additionally, we want to leverage solutions developed and deployed for one stakeholder to many other projects. We address these challenges by using a flexible approach to software development and project management that draws from the diverse strengths of our team. Based upon specific input from science stakeholders—which include the fields of climate modeling, fusion, combustion chemistry, astrophysics, and environmental management—we group their needs into two main categories: (1) visualization techniques, ranging from classical rendering to the most advanced data streaming and remote data access algorithms for managing extremely large datasets; and (2) analytics techniques, including data exploration, feature extraction, tracking and comparison that aid the scientist in the actual information discovery process.

We achieve real-time exploration of large regular grids via a novel hierarchical z-order data layout combined with progressive computation of output slices or volume rendering.

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**Figure 1:** Comparative visual analysis of a time-varying 2D field. Each image is colored by the ensemble mean values, which are shown as green bars. Red bars indicate three weeks' worth of network connection data. The histogram shows organized coverage in the destination address space. A regular, organized unsuccessful connection attempt from 450 time steps of this simulation, including the 2.8 million particles per time step, was visualized interactively using the PVF2 user interface (PVF2) a single Linux machine running 8-16 core processors (16 cores). The particles are colored based on temperature, particle size corresponds to particle volume.

**Figure 2:** Drilling in to a finer temporal resolution reveals organized unsuccessful connection attempts over one year with 1094360704 attempts. Red bars indicate three weeks' worth of network connection data. The histogram shows organized coverage in the destination address space. A regular, organized unsuccessful connection attempt from 450 time steps of this simulation, including the 2.8 million particles per time step, was visualized interactively using the PVF2 user interface (PVF2) a single Linux machine running 8-16 core processors (16 cores). The particles are colored based on temperature, particle size corresponds to particle volume.

**Figure 3:** Comparative visual analysis of a time-varying 2D field. Each image is colored by the ensemble mean values, which are shown as green bars. Red bars indicate three weeks' worth of network connection data. The histogram shows organized coverage in the destination address space. A regular, organized unsuccessful connection attempt from 450 time steps of this simulation, including the 2.8 million particles per time step, was visualized interactively using the PVF2 user interface (PVF2) a single Linux machine running 8-16 core processors (16 cores). The particles are colored based on temperature, particle size corresponds to particle volume.

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**VisTrails**

- **Query-driven visualization and analytics:** refers to the process of limiting visualization and analytics processing to data a user deems "interesting." This approach offers a promising alternative for high performance visualization and analysis by quickly finding, sorting, and sampling "needles in haystacks." QDV is built upon a combination of technologies from scientific data management, visualization and analytics.

- The example below illustrates how QDV technologies are applied to discovery and characterizes a distributed network scanning attack hidden in a hero-sized data set consisting of 42 weeks' worth of network connection data.

- **An adaptive approach:** to quantify the differences in methodology used to produce visualizations, analytics. This approach uses a comparison of visualizations to quantify differences in methodologies used to produce visualizations.