Grid computing for energy exploration and development

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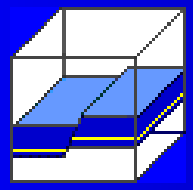
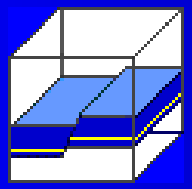


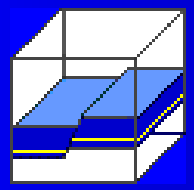
Why Grids for Seismic Imaging ?

- The construction of accurate 3-D images of the subsurface of the Earth is an extremely resource-intensive task. The most advanced technologies are not feasible in traditional environments.
- Harnessing remote resources effectively across different organizational domains is fundamentally important in the oil and gas industry.
- Globus middleware allows the sharing of resources in virtual organizations, enabling compute intensive seismic imaging services on the Grid. This addresses a critical need in a compute and resource intensive industry.



Outline

- Overview of seismic depth imaging
  - The computational challenge.
- Parallelization Issues
  - Cluster deployment of PSDM
  - Grid deployment of PDSM
- Seismic imaging on the Grid
  - The INSP client-server system.
  - The Grid-enabled implementation.
- Operational procedures
  - Scenarios
  - Issues
  - Benefits to the oil and gas industry



3-D Depth Imaging Methods

Wave-equation of mathematical physics

Kirchhoff Integral equation

Wave-equation PDE

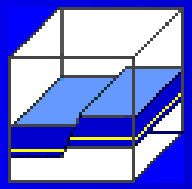
Shot-Gather

Shot-Receiver

Shot profile

Common Azimuth migration

Narrow Azimuth migration



Kirchhoff Migration

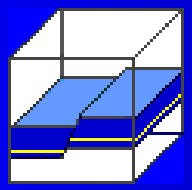
The essence of 3-D prestack ***Kirchhoff*** migration can be expressed in the following integral equation:

$$\text{Image}(\mathbf{x}) = \int \int_{\mathbf{x_S}} \int_{\mathbf{x_r}} G(\mathbf{x_s}, \mathbf{x}, \omega) G(\mathbf{x}, \mathbf{x_r}, \omega) \text{Data}(\mathbf{x_s}, \mathbf{x_r}, \omega) d\mathbf{x_r} d\mathbf{x_s} d\omega,$$

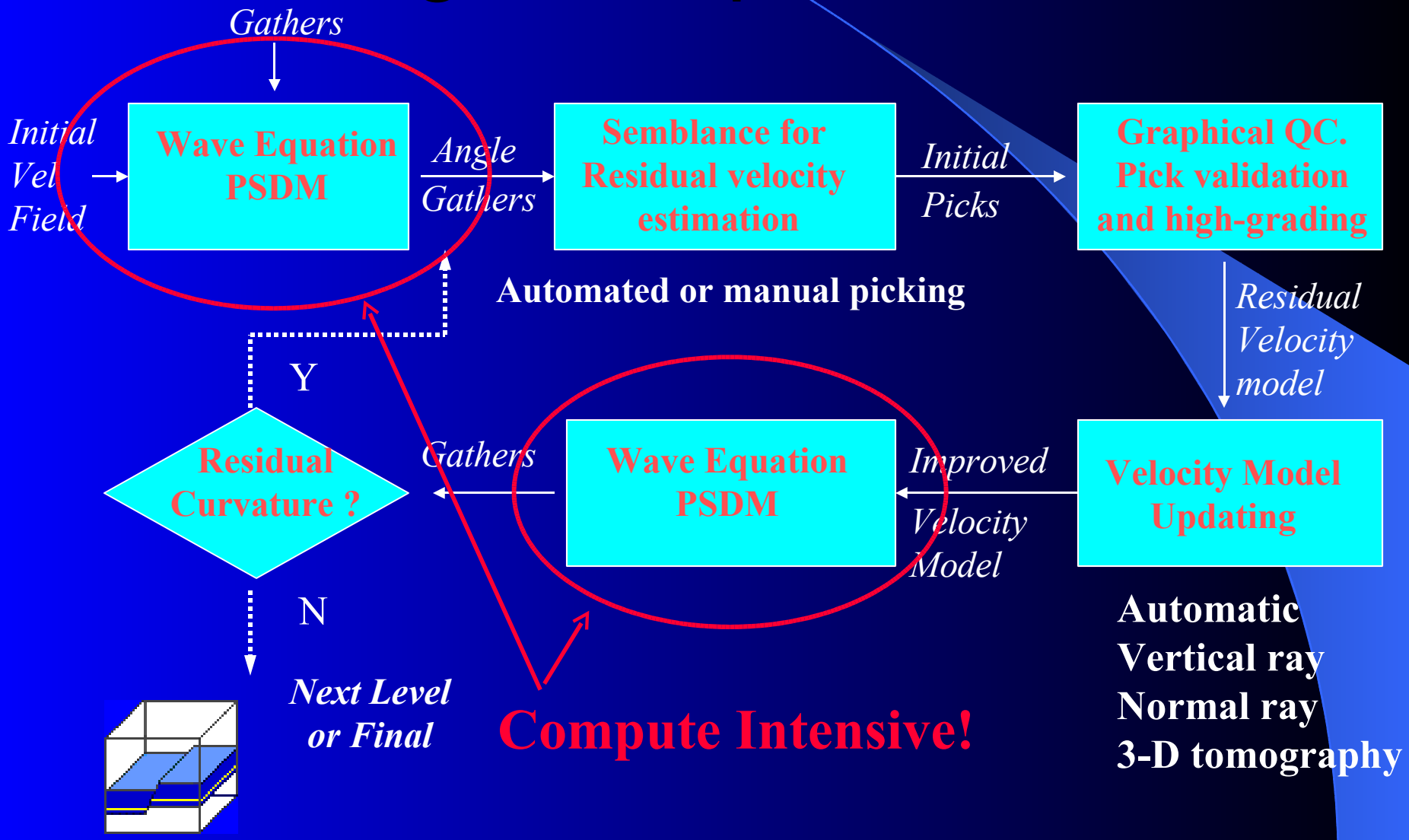
If the Green's functions are completely specified, this solution is as accurate as any "wave-equation" implementation.

In computer implementations, we express the integral as a sum:

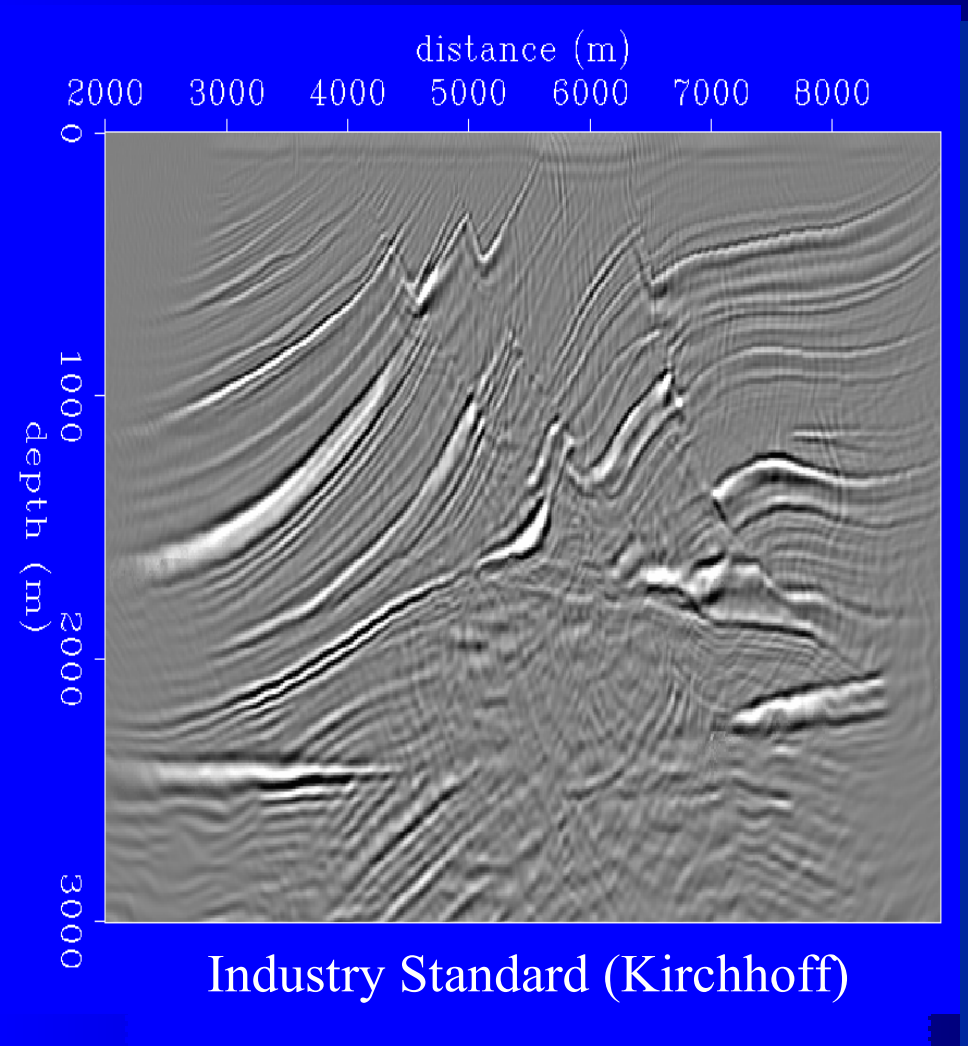
$$\text{Image}(\mathbf{x}) = \sum_{\mathbf{x_S}} \sum_{\mathbf{x_r}} A_s A_r \text{Input}(\mathbf{x_s}, \mathbf{x_r}, t_s + t_r)$$



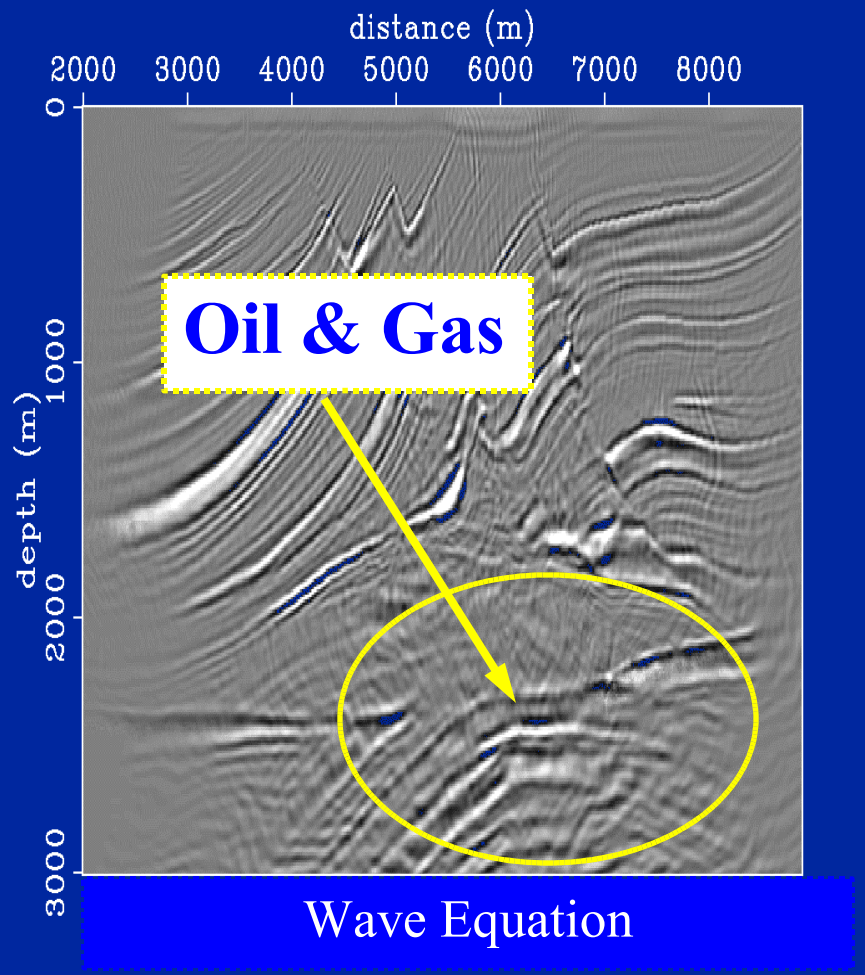
Building a 3D seismic image through multiple iterations



Imaging comparison: Kirchhoff vs. Wave Equation

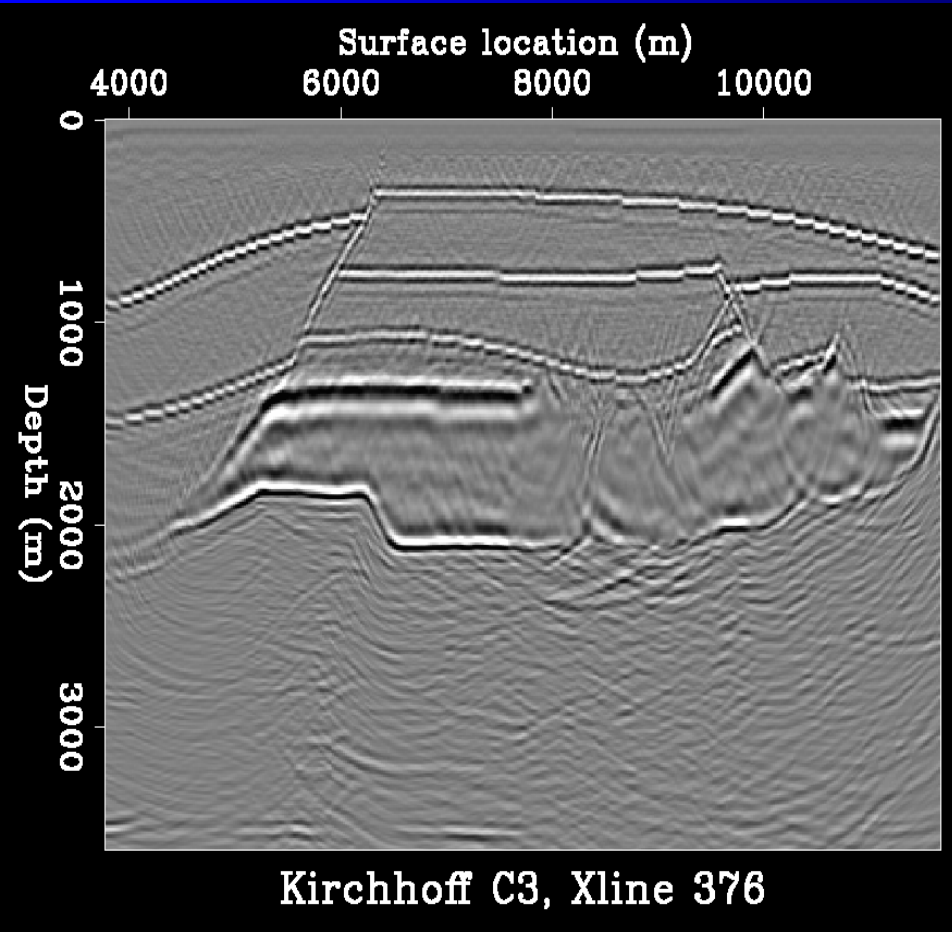


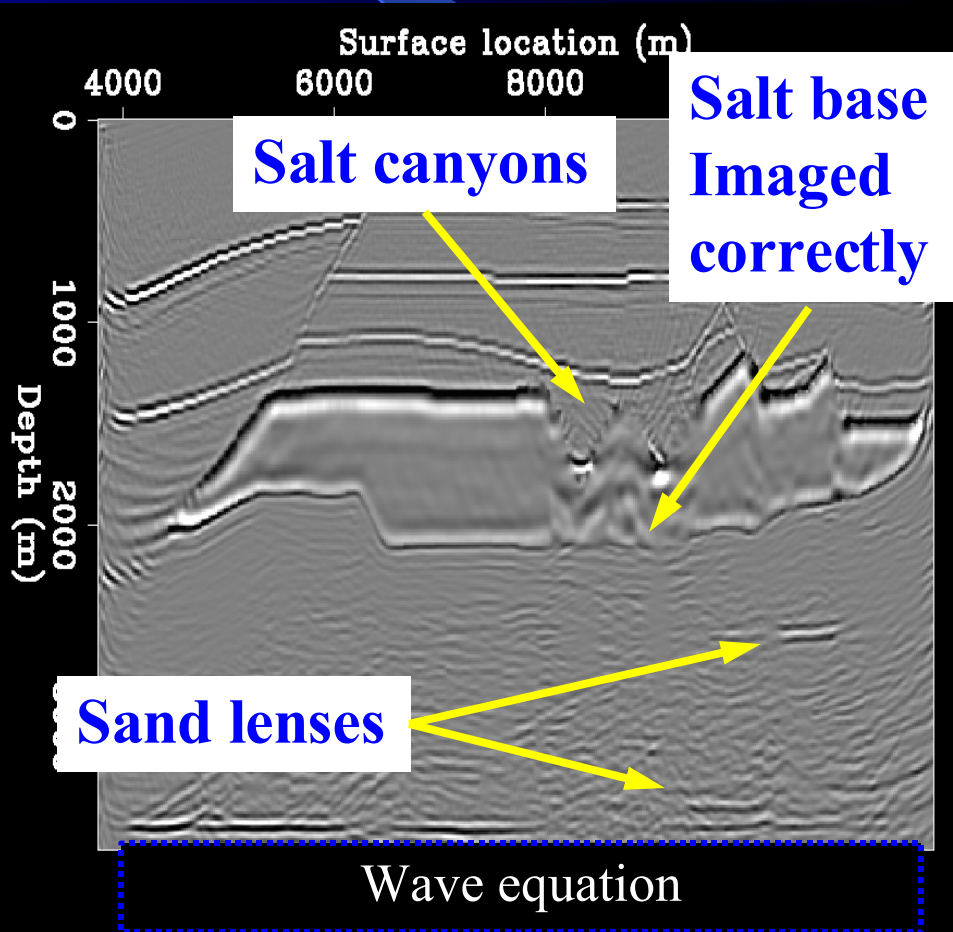
Industry Standard (Kirchhoff)



Wave Equation

Imaging comparison: Kirchhoff vs. Wave Equation





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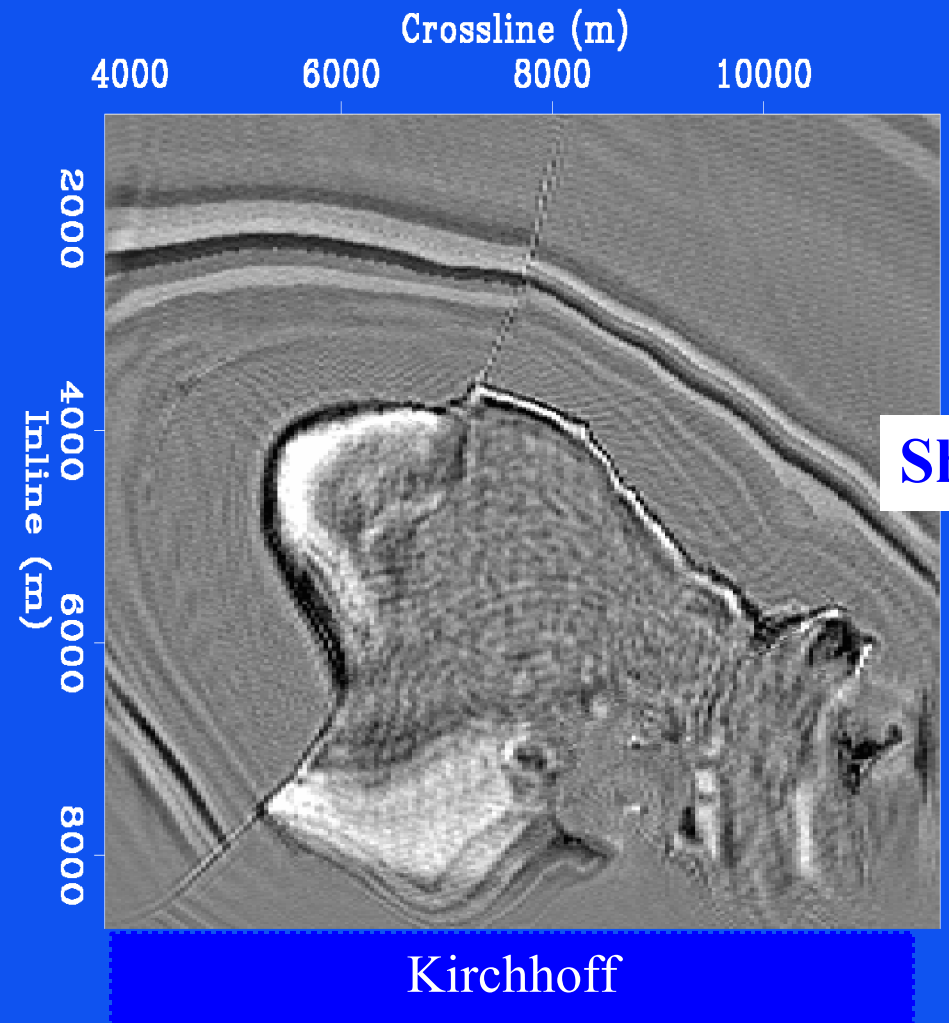
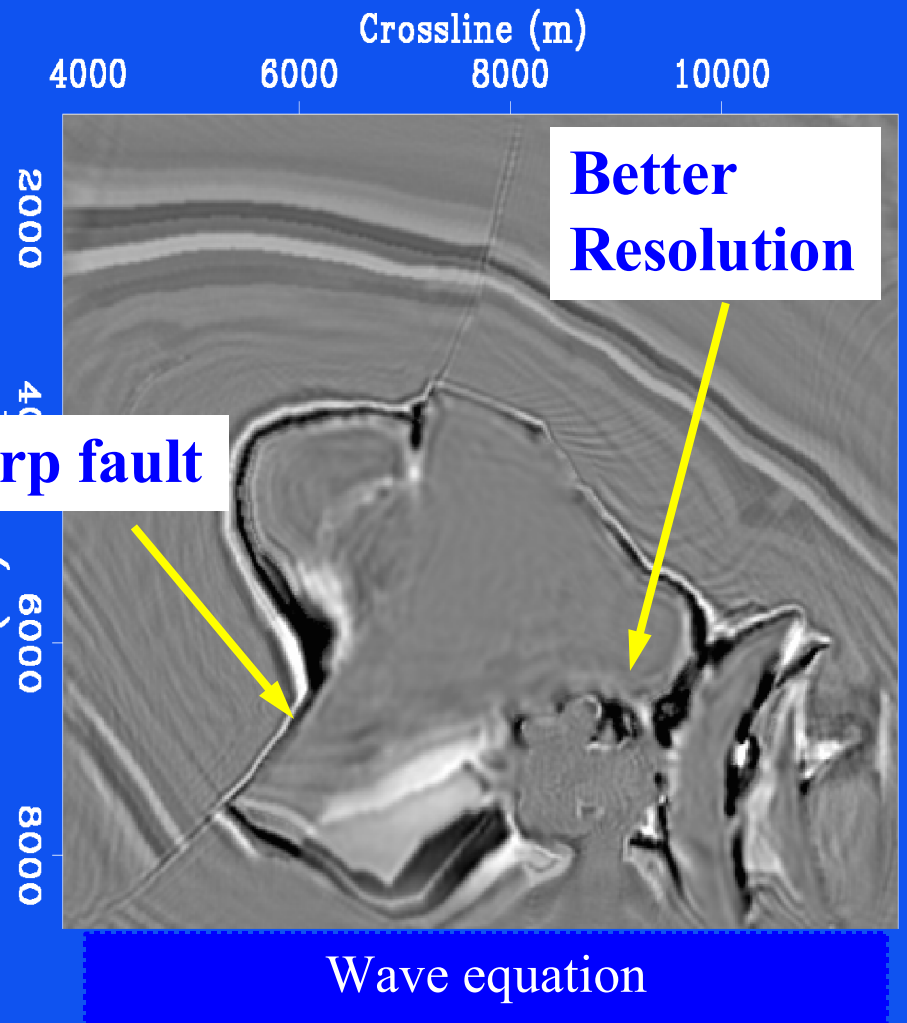


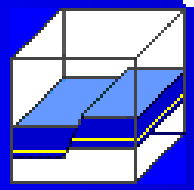
Kirchhoff



Wave equation

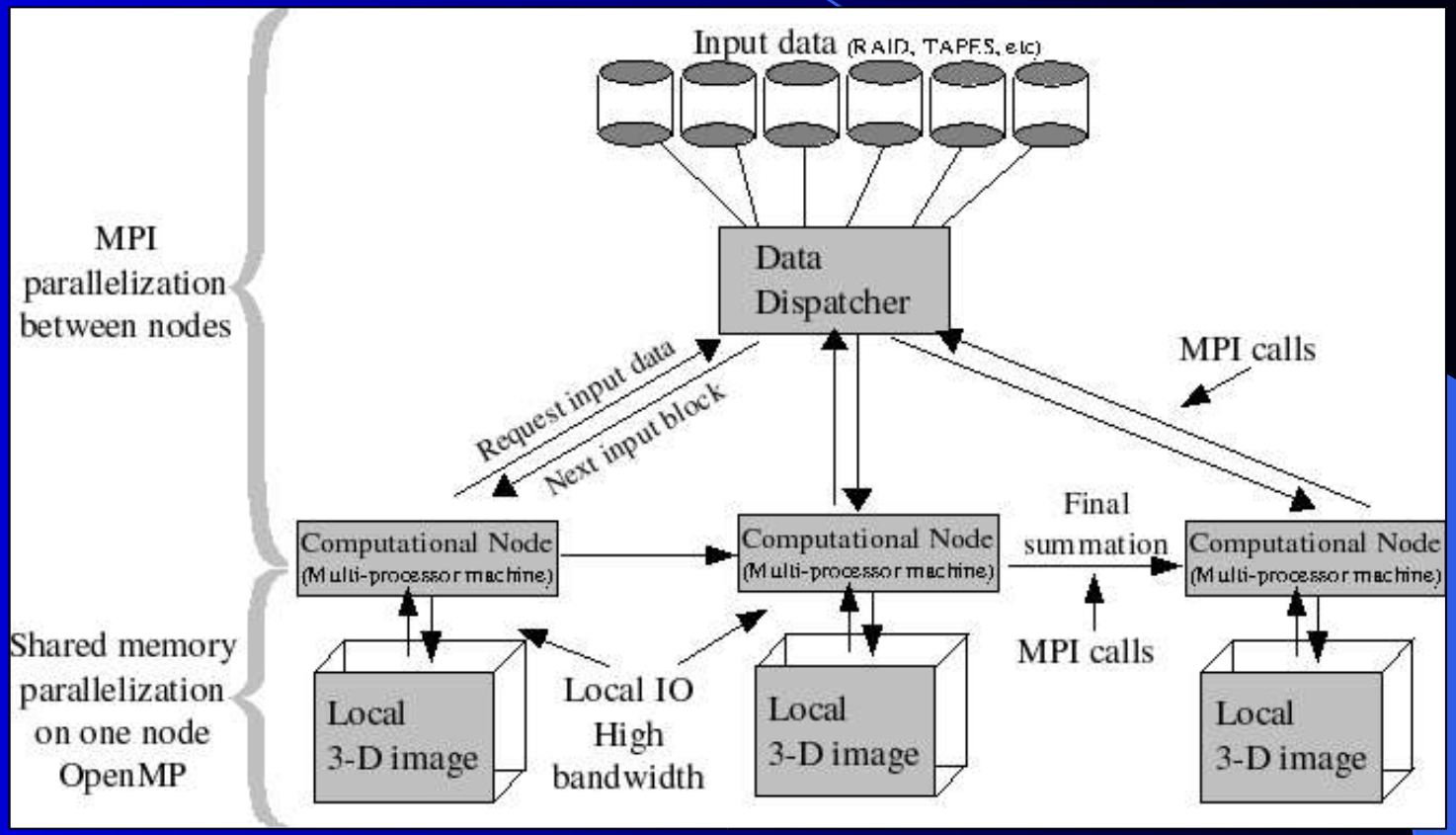
The computational challenge: Gulf of Mexico marine surveys

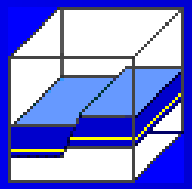
		Runtime (days)		
Blocks	Gbytes	Kirchhoff & ComAz	Narrow Azim.	Shot Profile
10	620	3	31	184
100	6,200	111	1,100	6,640
500	30,700	996	9,960	59,800 164 yrs!



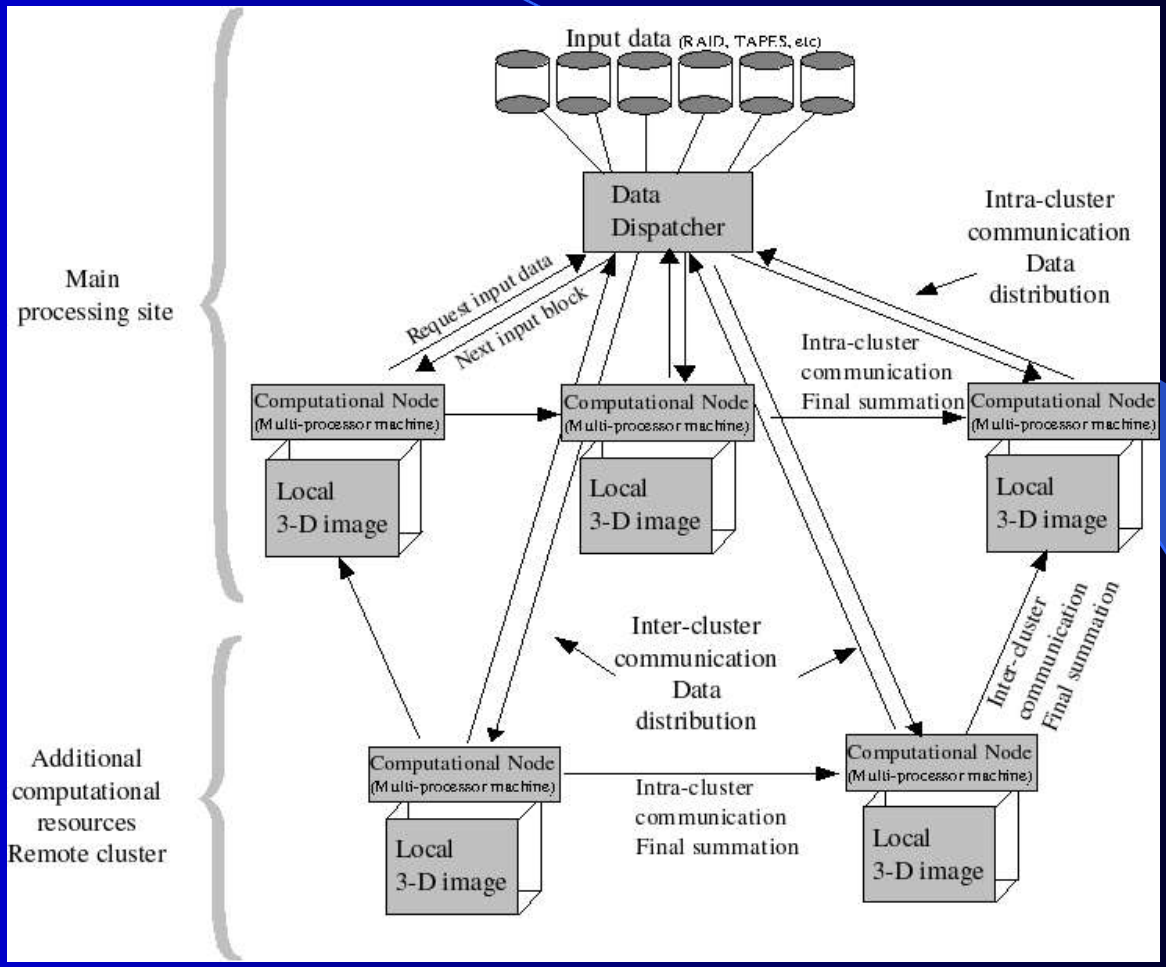
128 CPU Pentium 4 Cluster
(2.4 Ghz – 900 Mflops/cpu sustained)

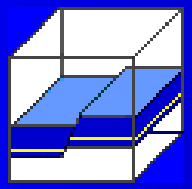
PSDM cluster deployment





PSDM for Grid deployment



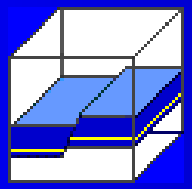


Distribute to additional compute resources:
- support distributed heterogeneous computing environments
- through Web Service Resource Framework (WSRF)

What is INSP?

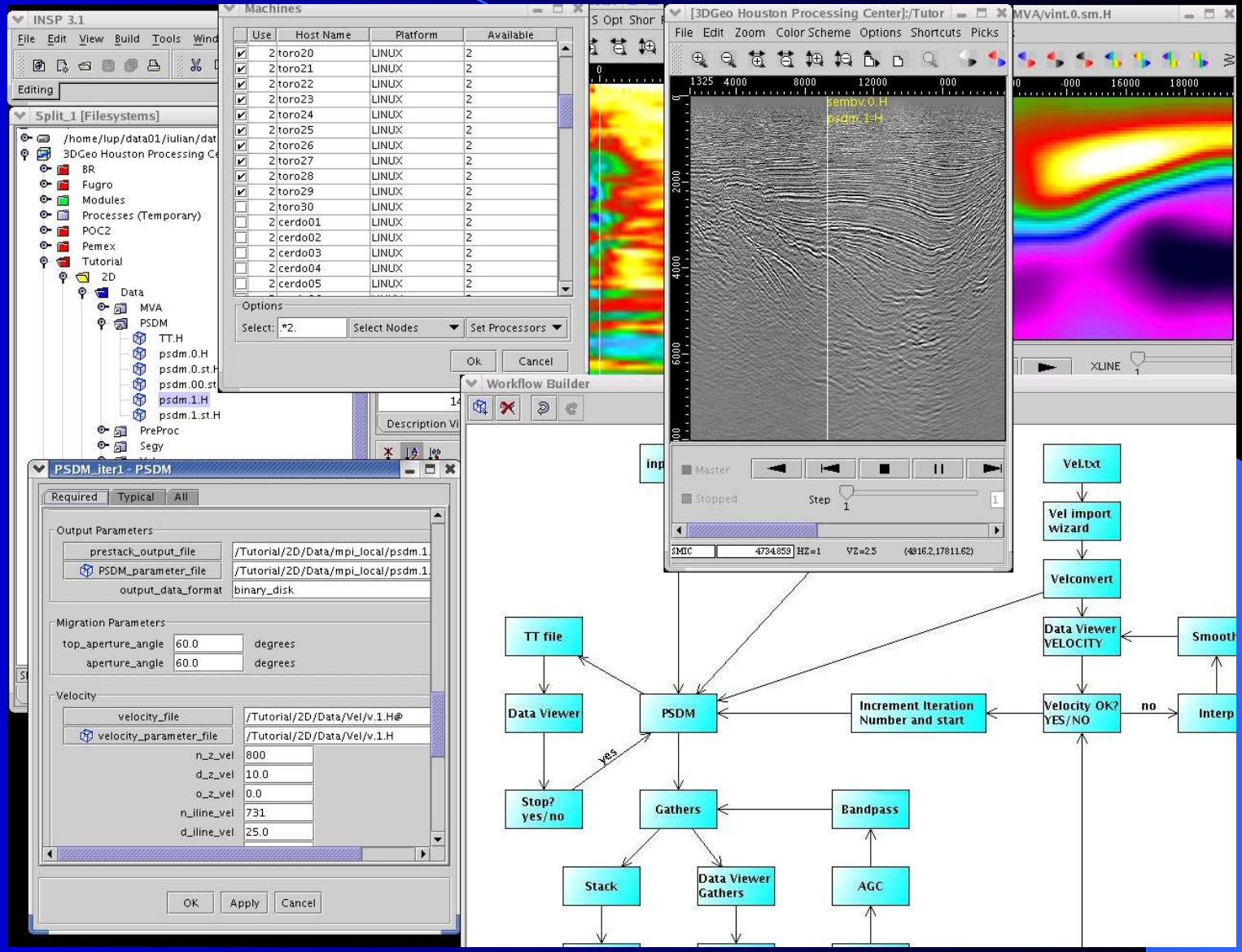
Internet Seismic Processing – started in '97

- 3DGeo's graphical interface to our processing system.
- Job Setup and Progress Monitoring.
- Remote Quality Control.
- Interpretation and Velocity Model Building.
- Network Collaboration.

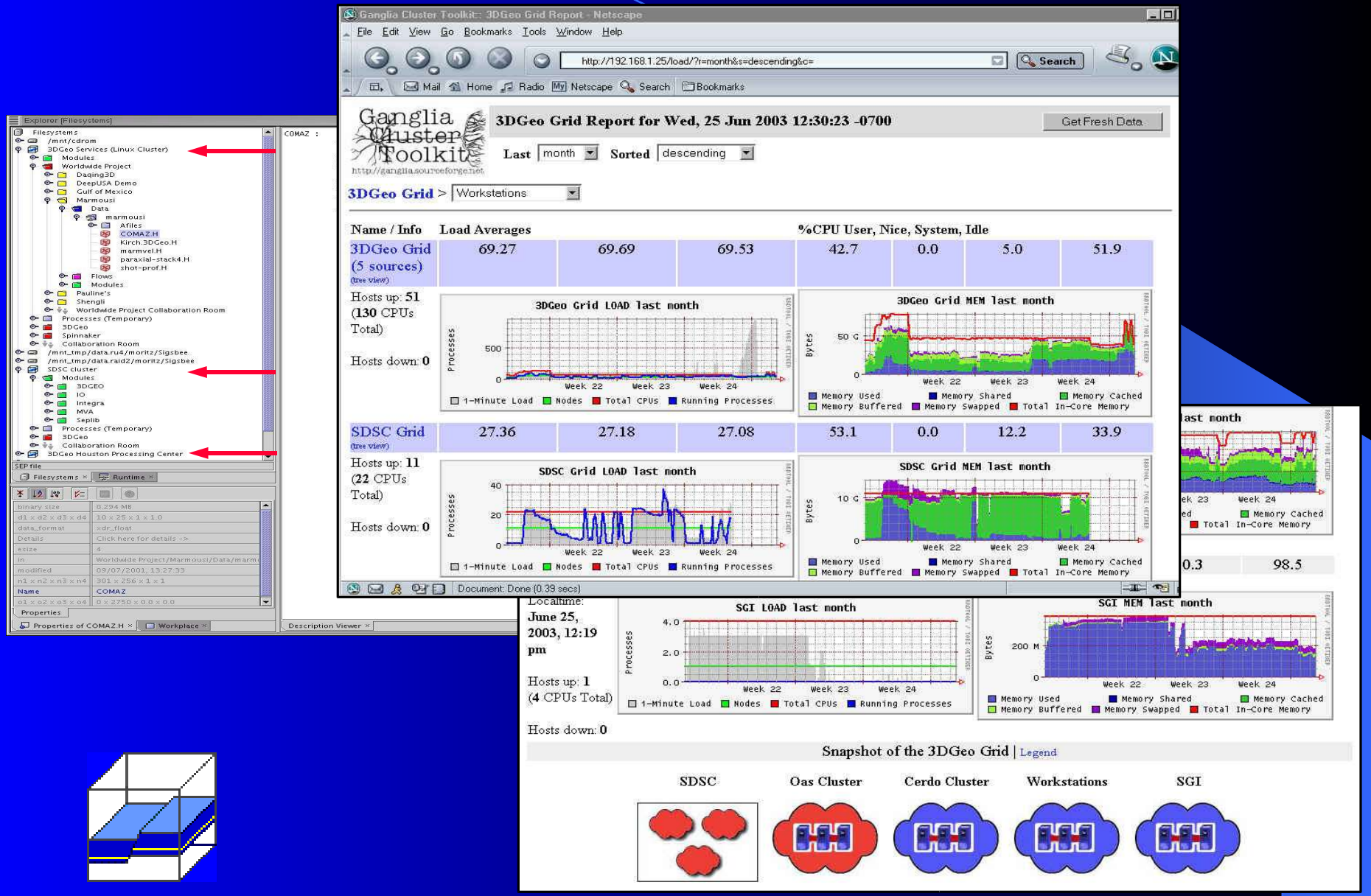


The Grid is a natural evolutionary step for INSP

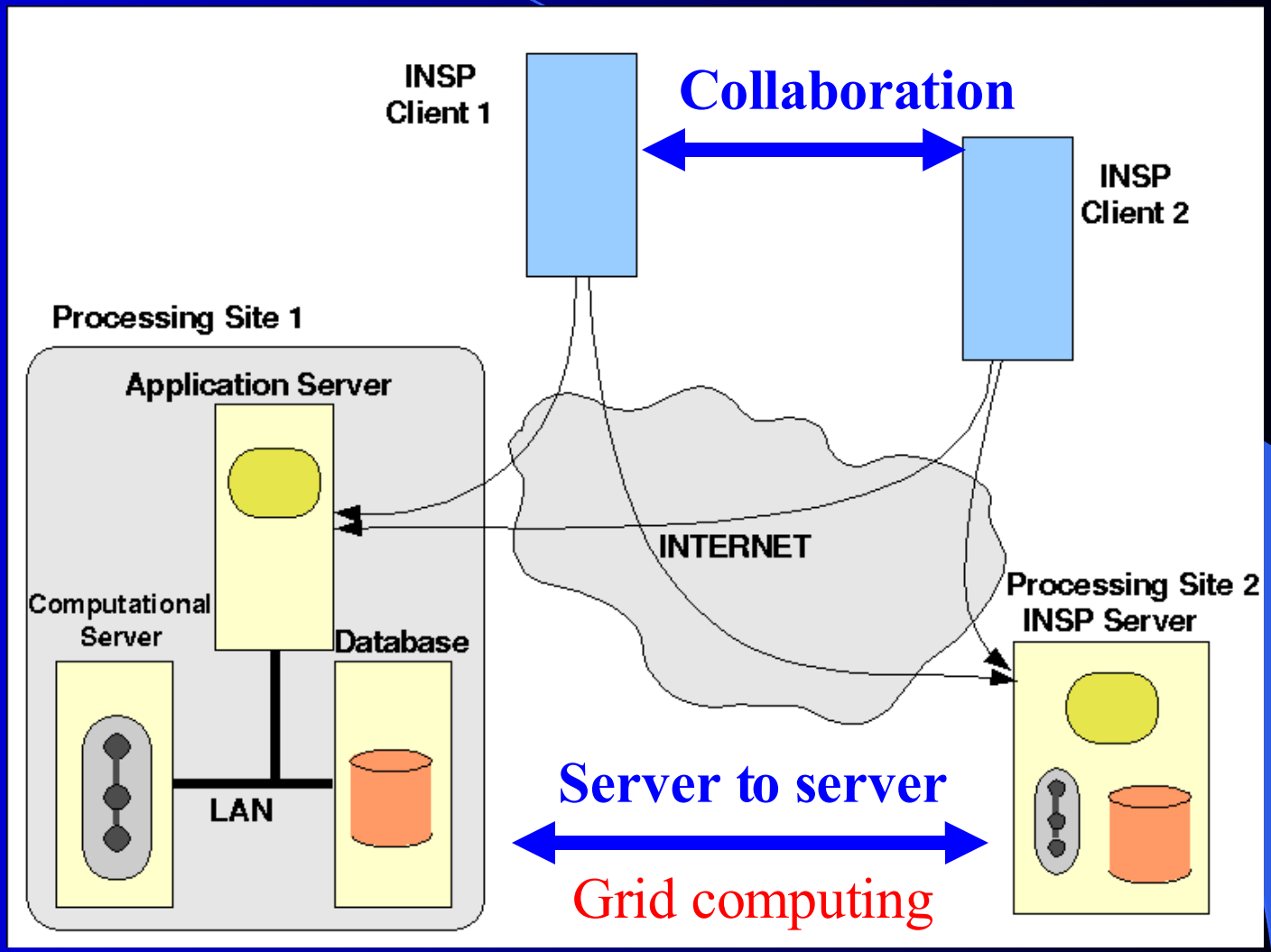
INSP user interface

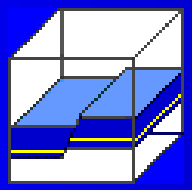


Grid status, resource monitoring



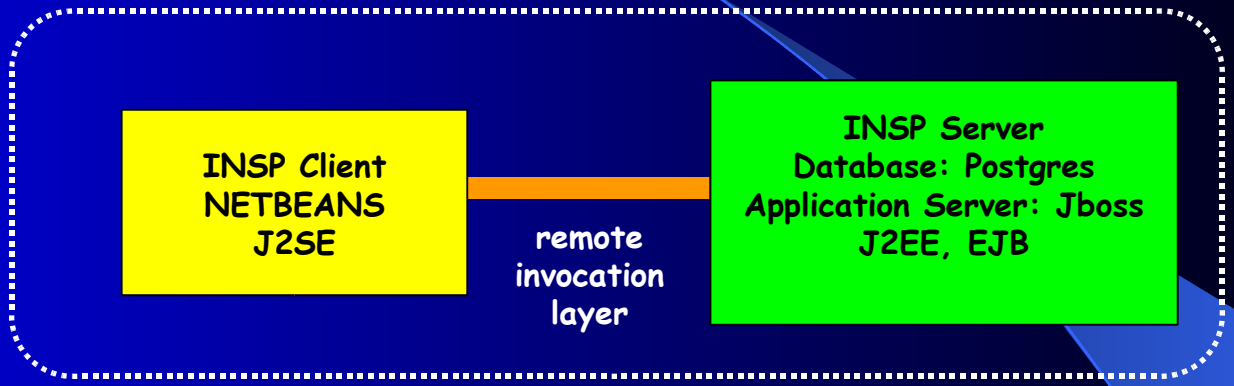
INSP architecture



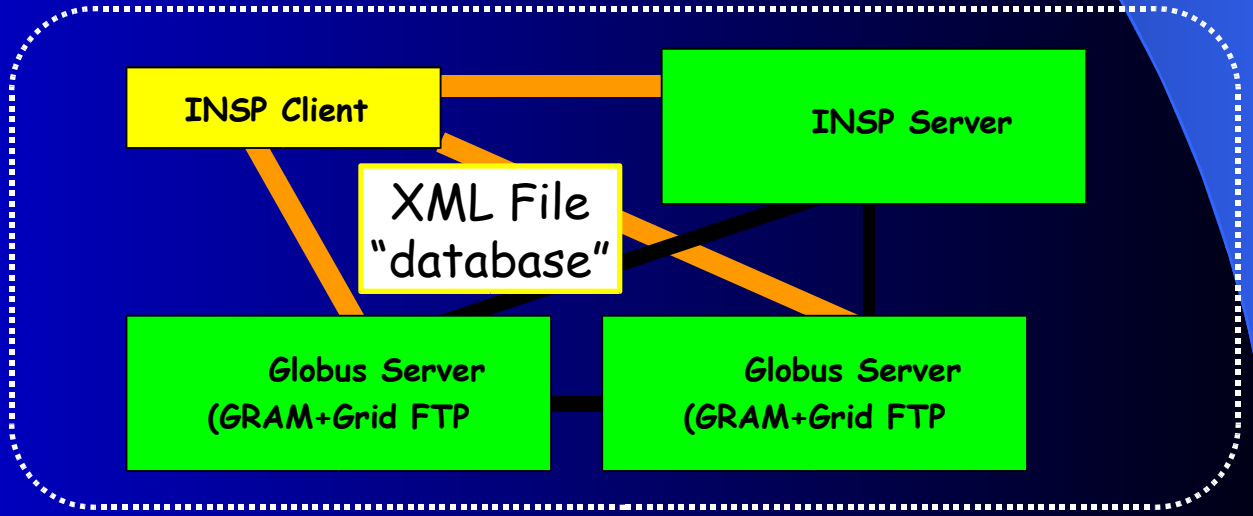


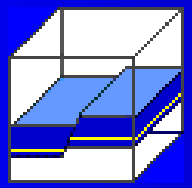
Grid-enabling INSP

current design



target design





Today's operational scenario

Data acquisition

100's of TBytes

Preprocessing

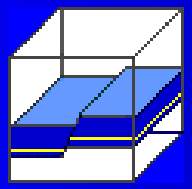
Data bank

Drilling decision

Site a platform

Oil Company

Depth Imaging



Data analysis
& Interpretation

1 –2 yr process

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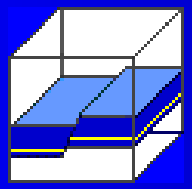

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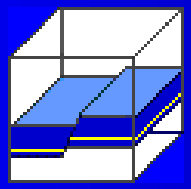

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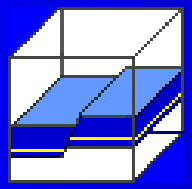

Depth Imaging

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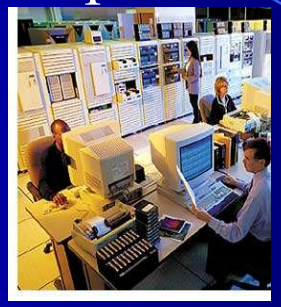
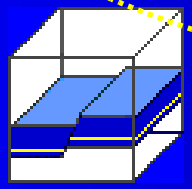


Data banks

Drilling decision

Site a platform

Oil Company



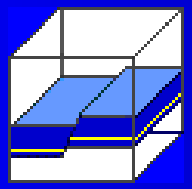
Data analysis
& Interpretation

1/2 yr process

Depth Imaging

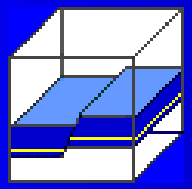
Algorithmic issues

- Dynamic optimization of workload
- Data partitioning
  - Kirchhoff: distribute input, velocity model, Green's functions, image volumes.
  - Wave-equation migration: frequency slices, distribute input, velocity model, image volumes
- Scaling across heterogeneous resources
- Modeling the application



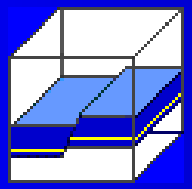
Practical issues

- Proprietary data – security
- Data volumes – transfer rates, compression
- Data distributed in data banks – access, & data transfer
- Authority delegation across organizational boundaries – change of business culture
- Computationally intense – months of runtime
- Peak loads – access to on-demand computing



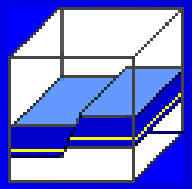
What we're doing today

- INSP used today: client-server Internet app.
- Collaboration between 3DGeo's Houston and Santa Clara offices, and oil company client sites.
  - use facilities & personnel more efficiently.
- Access computers at SDSC for remote jobs.
- Outsource excess compute needs.
- Moving toward GT 4.0.



The future

- Seamless access to resources over the web
- Utility computing:
  - Companies based on IP shouldn't have to worry about buying computers or maintaining, and administrating computer hardware
- Ultimate goal is to tie in all stages from acquisition, to interpretation, to drilling decision into a "real time" process.



Benefits to the oil & gas industry

- Better results sooner – shorten the time to making a drilling decision
- More flexible way of processing and interpreting data – increased productivity
- Process and interpret data as it is acquired – the instrumented oil field
- Utility computing – outsourcing model allows access to the latest hardware
- The *IntraGrid* within Oil Companies