Distributed Sensors, Instrument, and Software
In Situ Instruments Workshop

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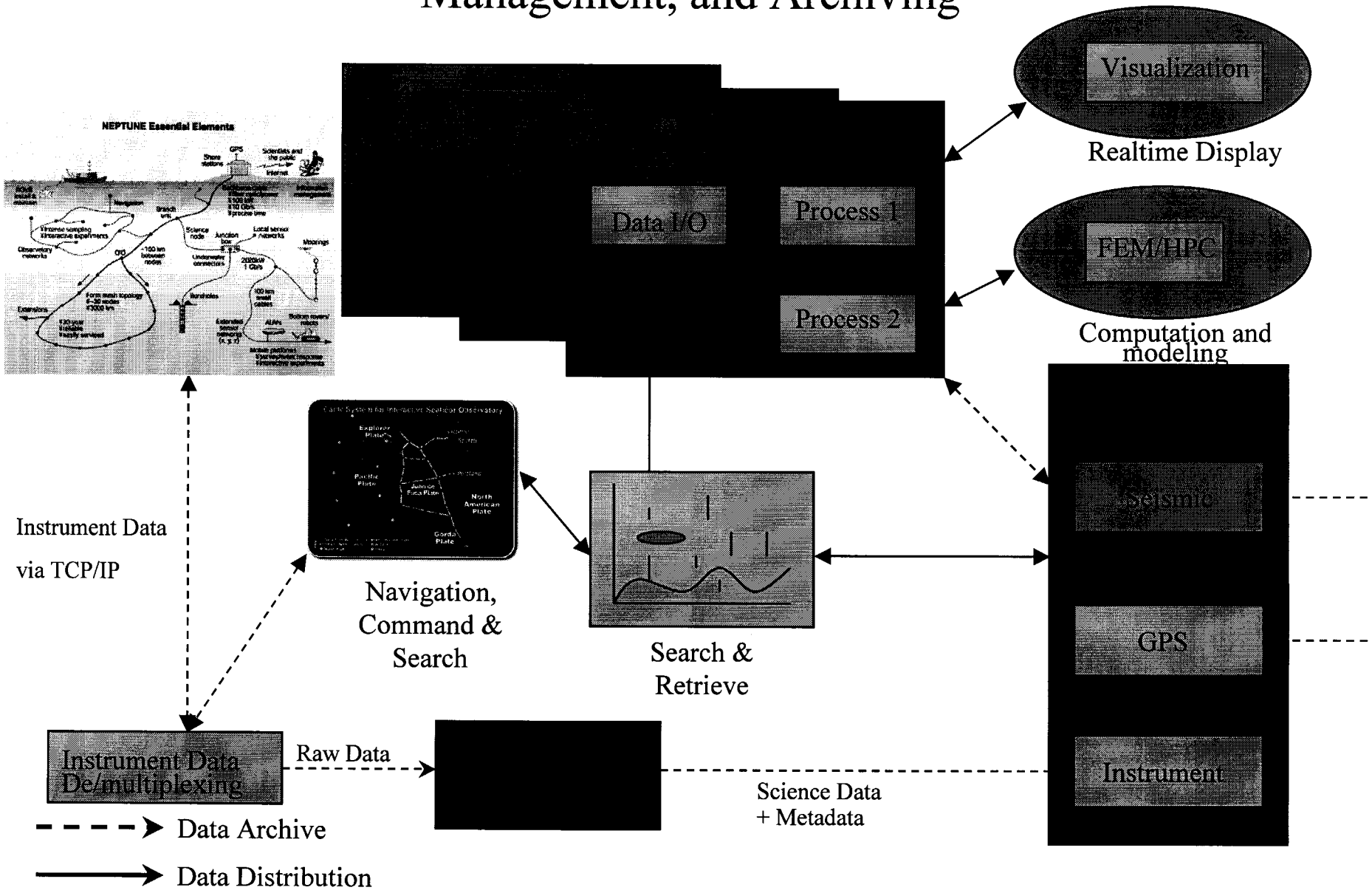
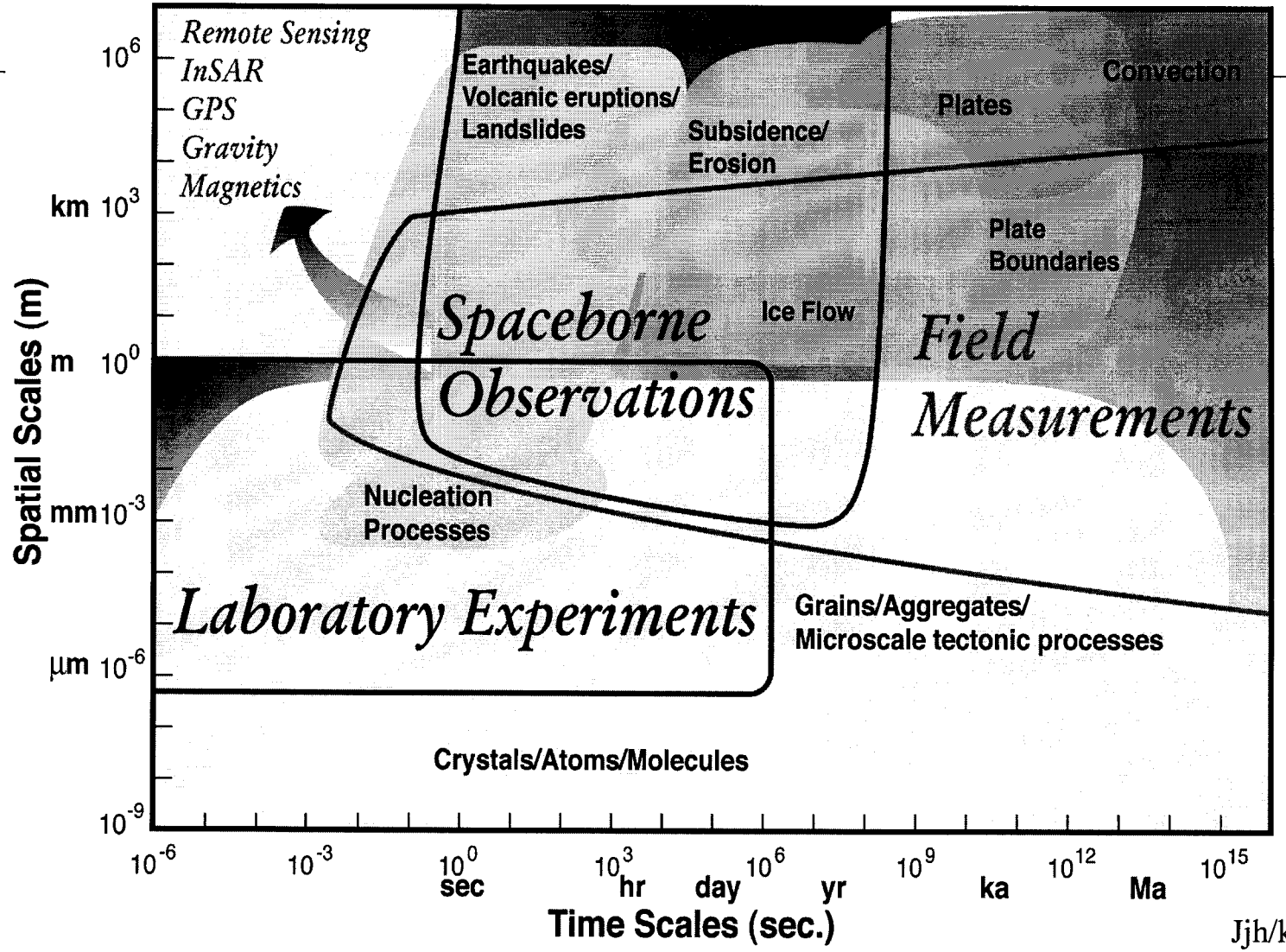
Realtime Scenario for Data Processing, Management, and Archiving



Distributed sensors measure spatial patterns



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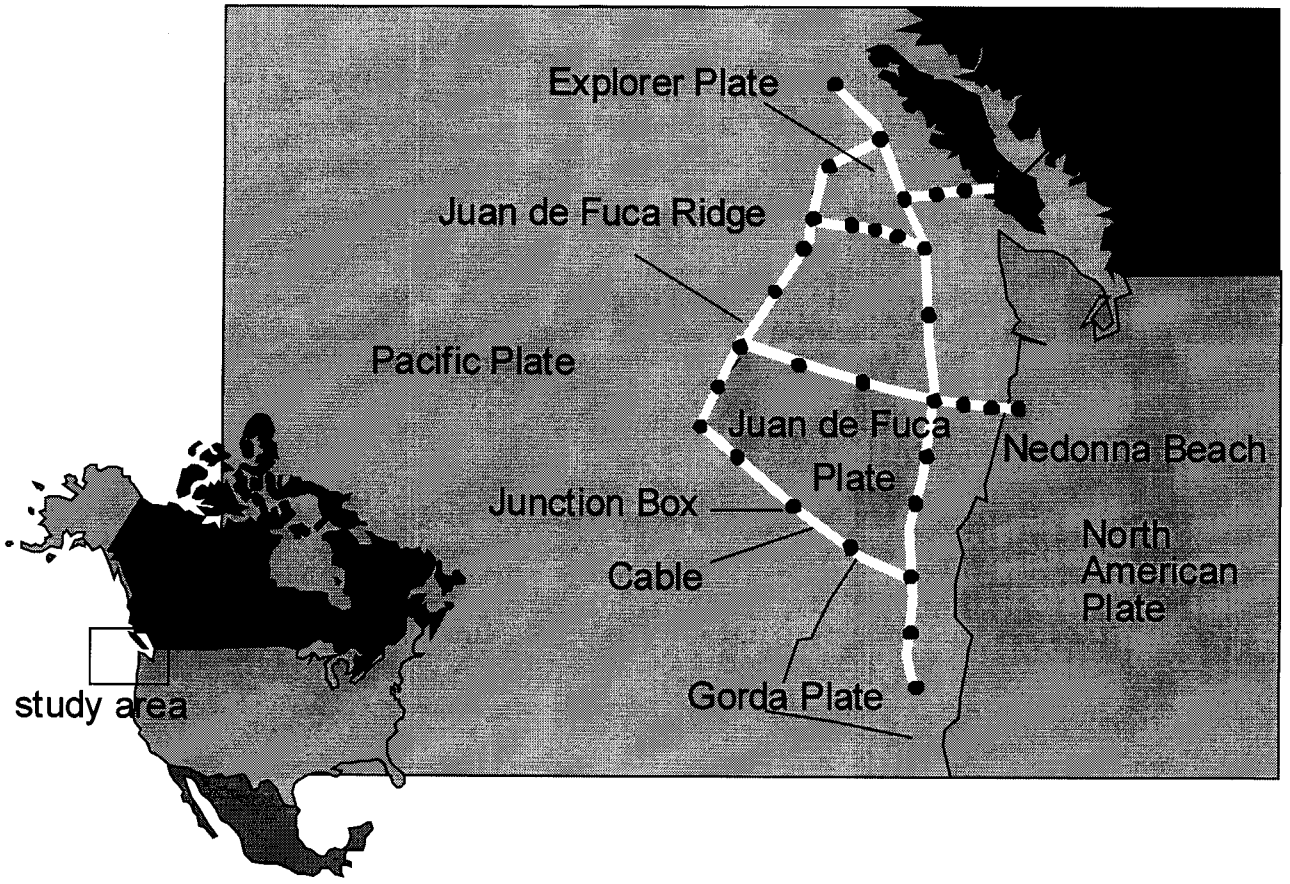
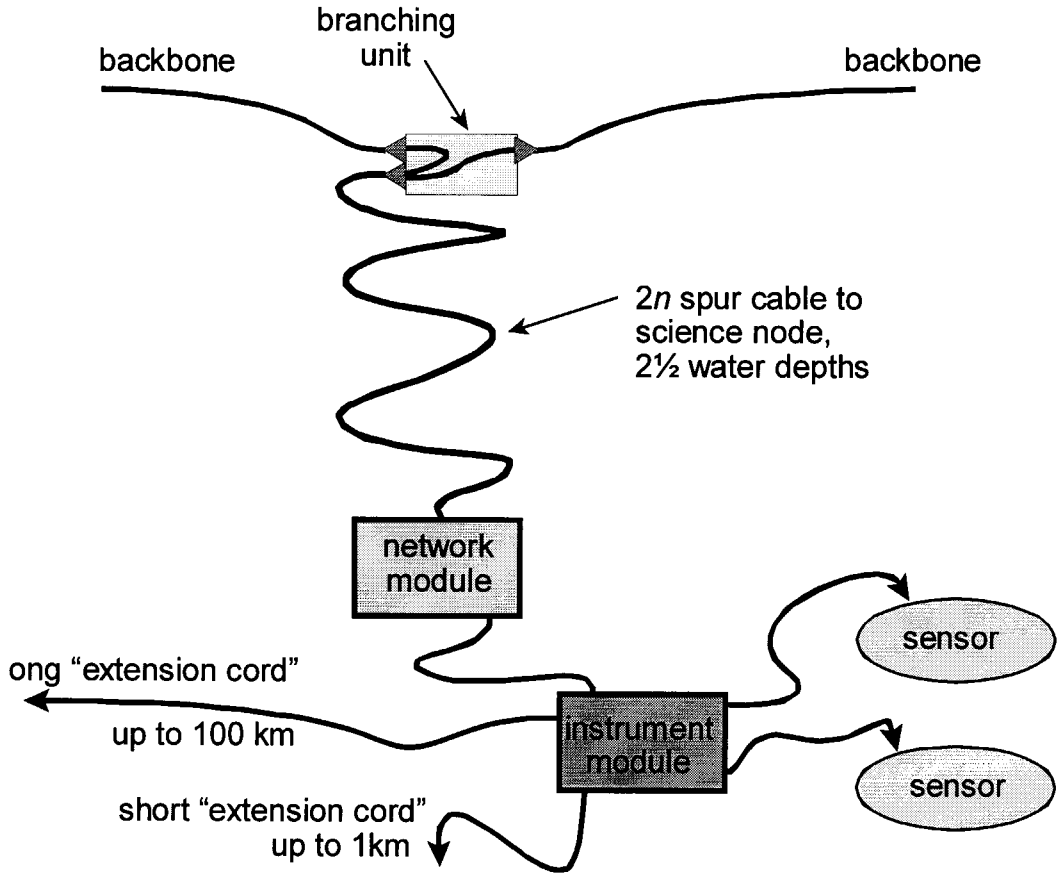
NEPTUNE – sensors on the Juan de Fuca plate

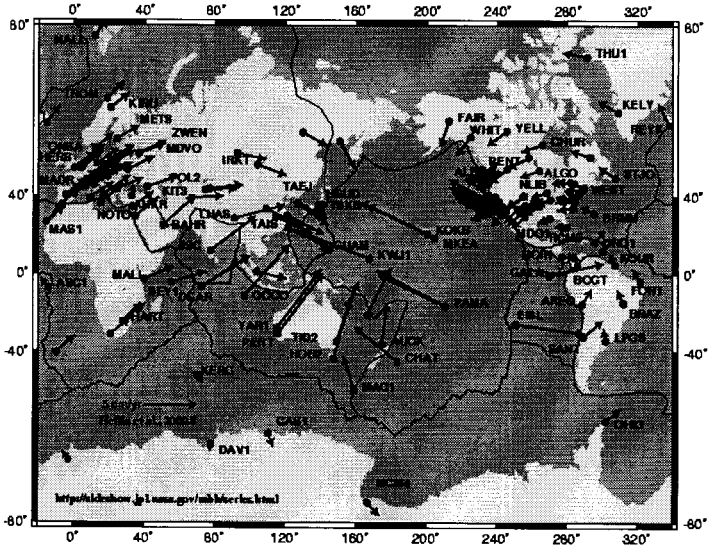


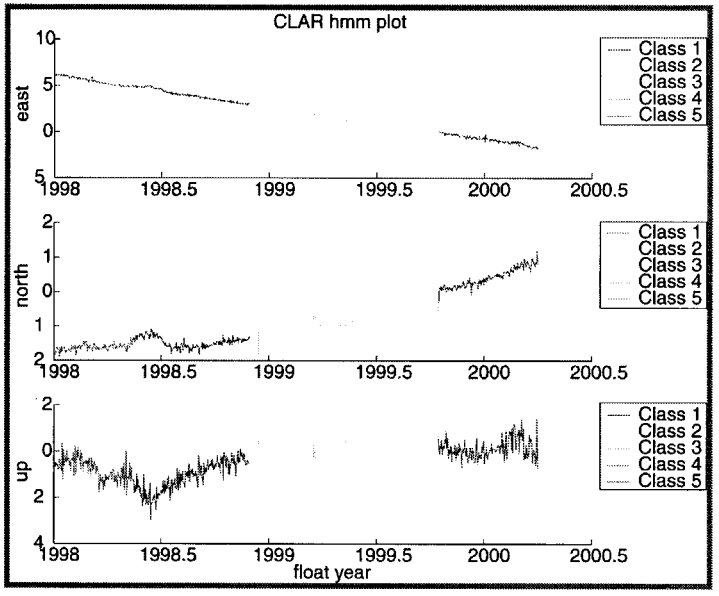
NEPTUNE – node detail



GPS networks

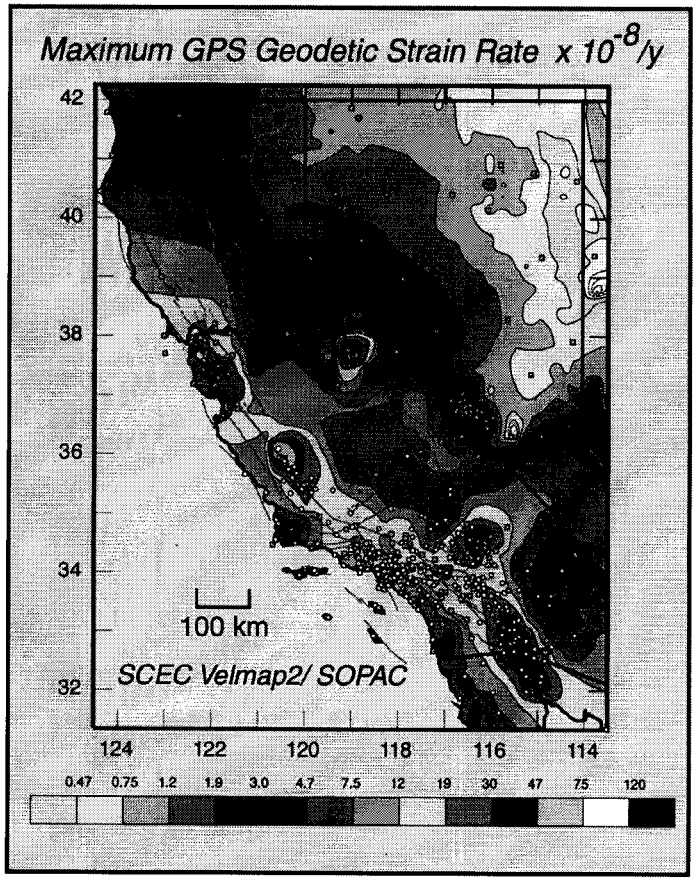
- Southern California Integrated GPS Network (SCIGN) is made of about 250 stations.
- Hundreds of stations in the global network.
- Automated analysis picks out earthquakes.
- Shows other problems with data (e.g. ground water pumping).





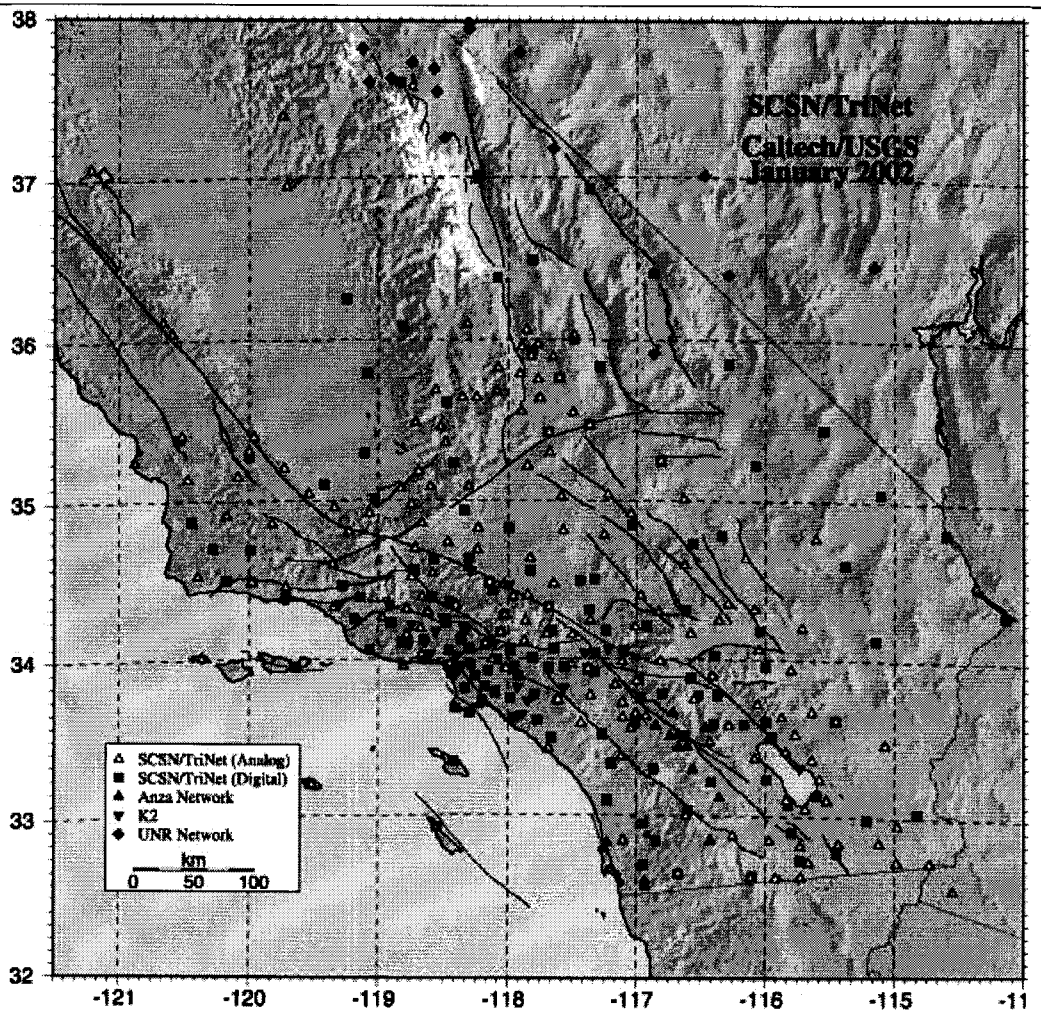
Courtesy R. Granat and M. Heflin

Strain rates from GPS



Strain rates determined from GPS measurements in California.
Courtesy Steve Ward

SCSN seismometer network



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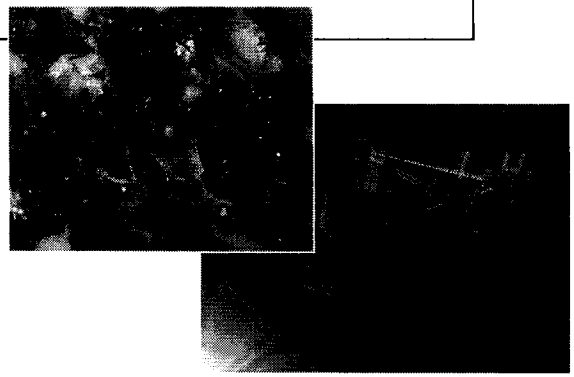
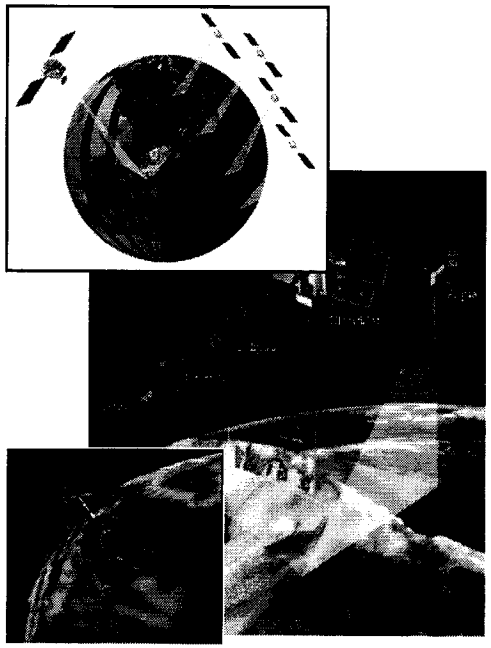
Space-based sensor

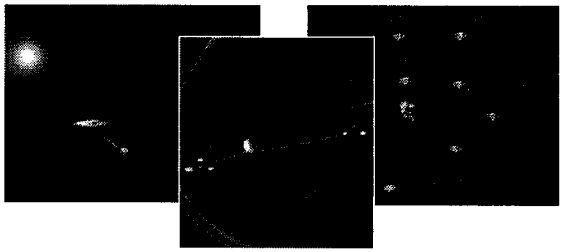
Origins Program

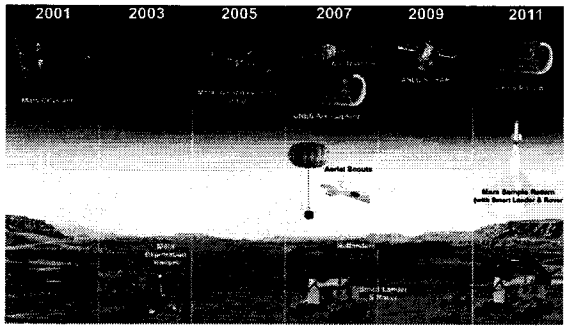


Earth Observing System

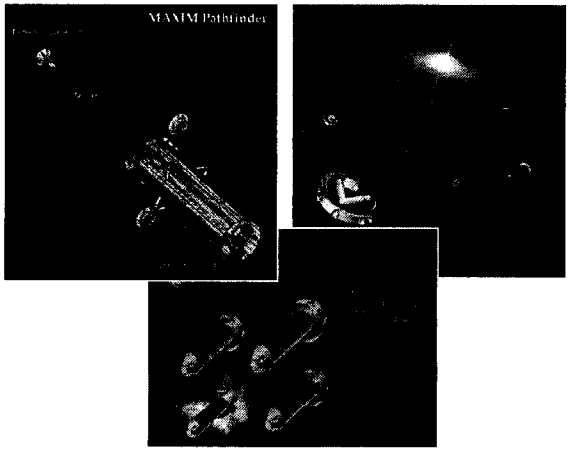


Sun-Earth Connections

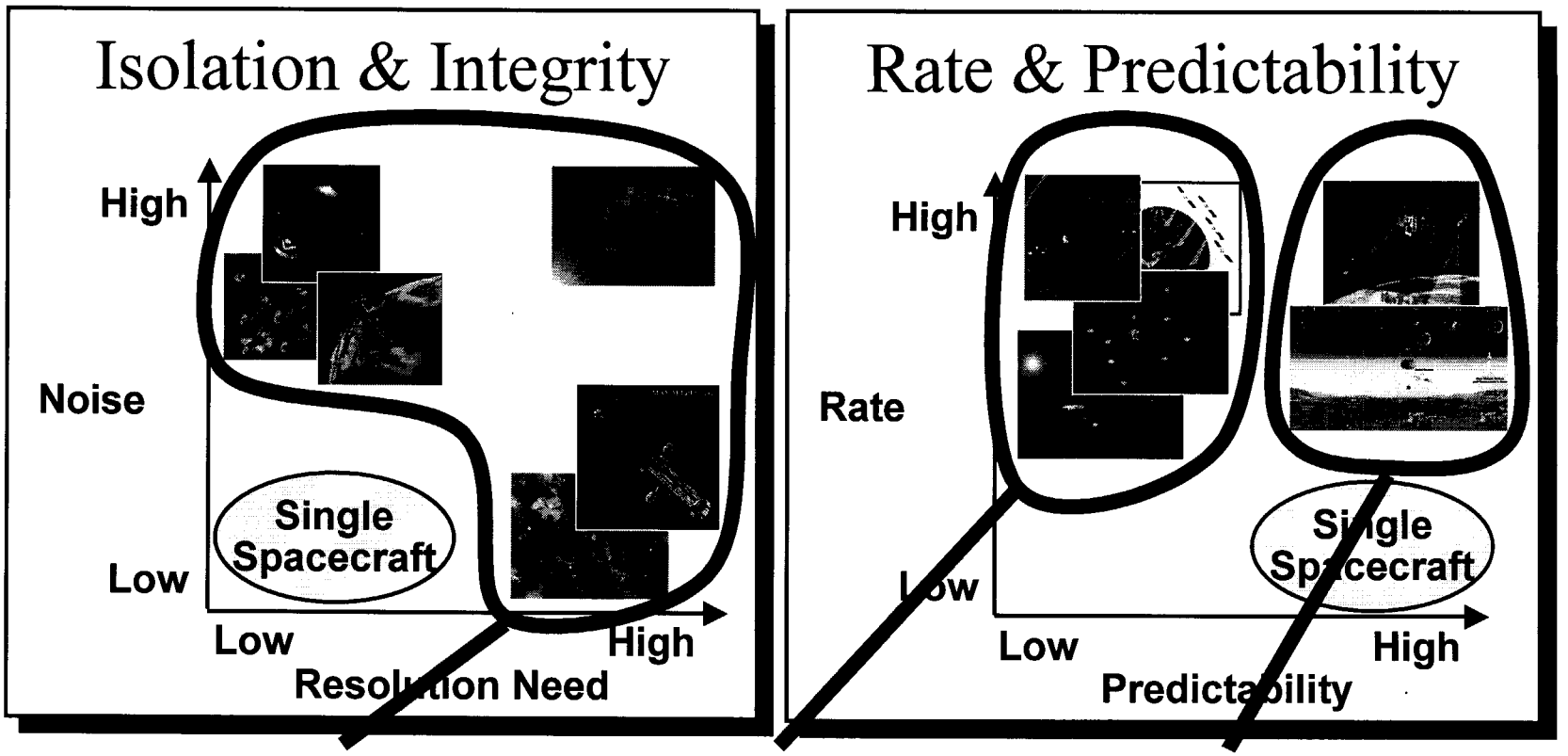




Structure & Evolution of the Universe



Space-based sensor application



Signal Separation

Signal Space Coverage

Signal Combination

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Software Needs for Types of In Situ Sensors

- Integrated Payload
  - Stationary (On Board data management & processing)
  - Mobile (Location)
- Distributed Sensors
  - Wired (Network control)
  - Wireless (Communication, silicon micro-machining, LPE)
  - Mobile (Routing, Adaptive algorithms)
  - Combination of above (Clustering)

Communication Challenges Introduced by Mobile Instruments

- Location Tracking
- Routing of data between receivers and senders
- Data volume – processed vs raw
- Efficient dissemination of information – Communication strategy
- Fault tolerance
- Data security

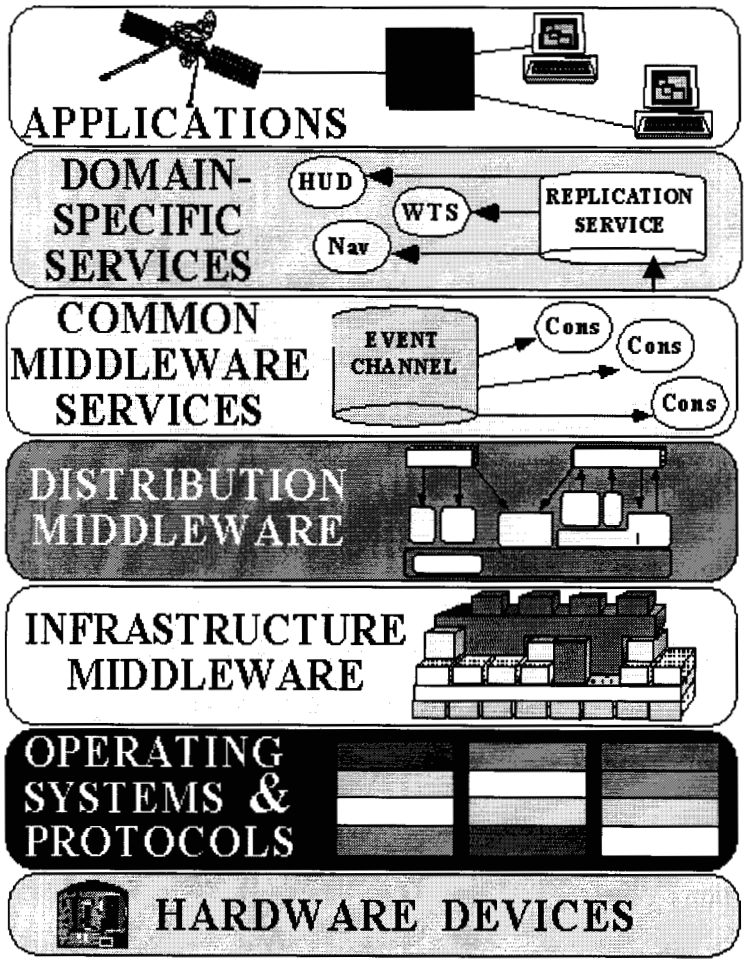
Distributed Communication Examples

- WINS (Wireless Integrated Network Sensors) – UCLA
  - Integrated solution for low power communication environment
- LEACH (Low Energy Adaptive Clustering Hierarchy) – MIT
  - Efficient strategy for communication with data negotiation and resource-adaptive algorithms
- Architecture for Distributed Sensor Network – Lyndell St. Ville, U of Glasgow
  - An approach to a solution

Realtime Data Management and Instrument Control

- Instrument Interfaces
- Data Processing
- Data Transport
- Data Management
- Autonomy - feature extraction, optical navigation, network control (WDM, BS)
- Fault tolerance
- System Architecture

The Evolution of COTS



There are multiple COTS layers & research/ business opportunities

Historically, mission-critical apps were built directly atop hardware & OS

- Tedious, error-prone, & costly over lifecycles

Standards-based COTS middleware helps:

- Manage end-to-end resources
- Leverage HW/SW technology advances
- Evolve to new environments & requirements

The domain-specific services layer is where system integrators can provide the most value & derive the most benefits

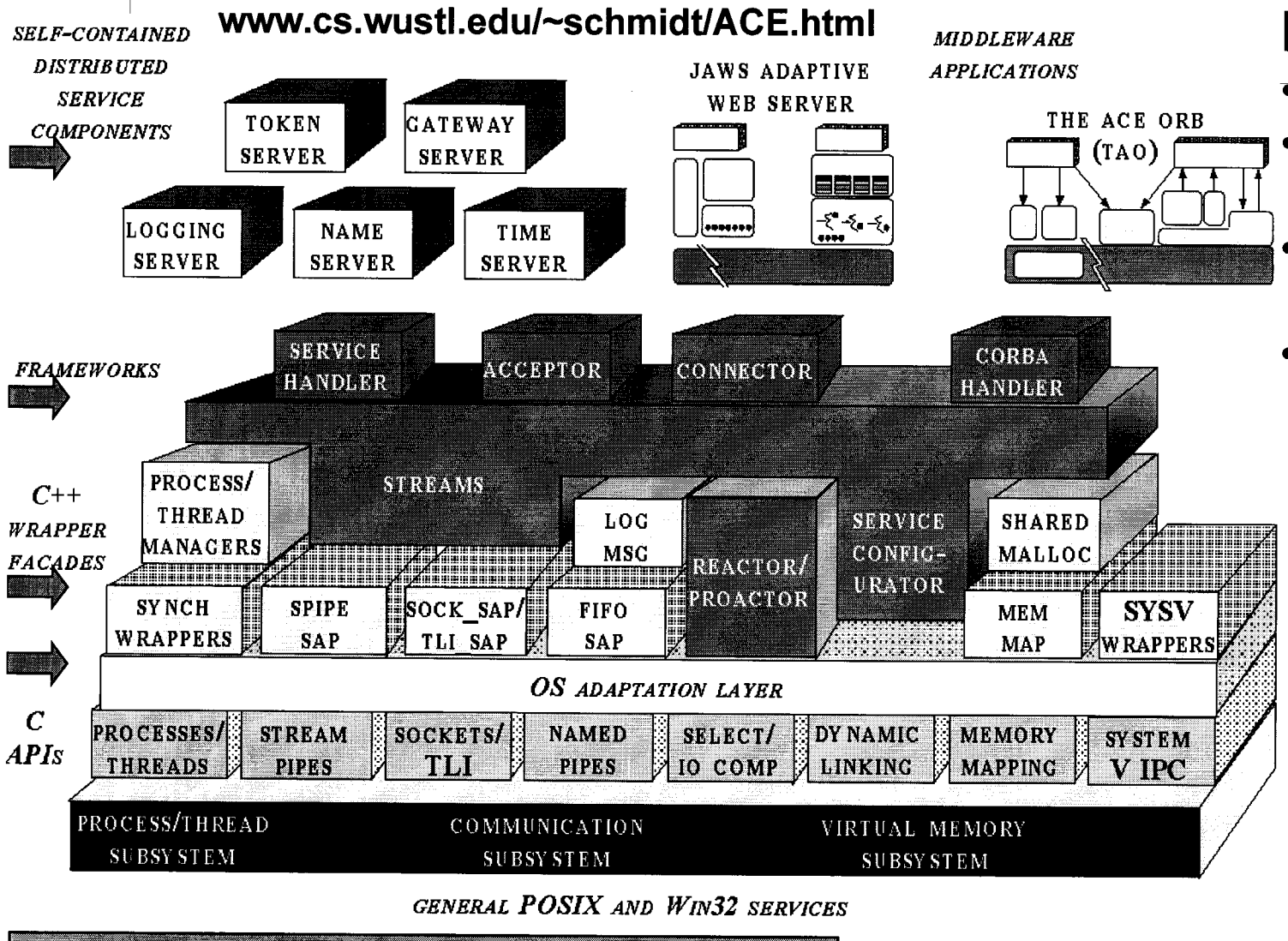
Key R&D challenges include:

- **Layered QoS specification & enforcement**
- **Separating policies & mechanisms across layers**
- **Time/space optimizations for middleware & apps**
- **Multi-level global resource mgmt. & optimization**
- **High confidence**
- **Stable & robust adaptive systems**

Prior R&D efforts have address some, *but by no means all*, of these issues

Overview of the ACE Framework

www.cs.wustl.edu/~schmidt/ACE.html



Features

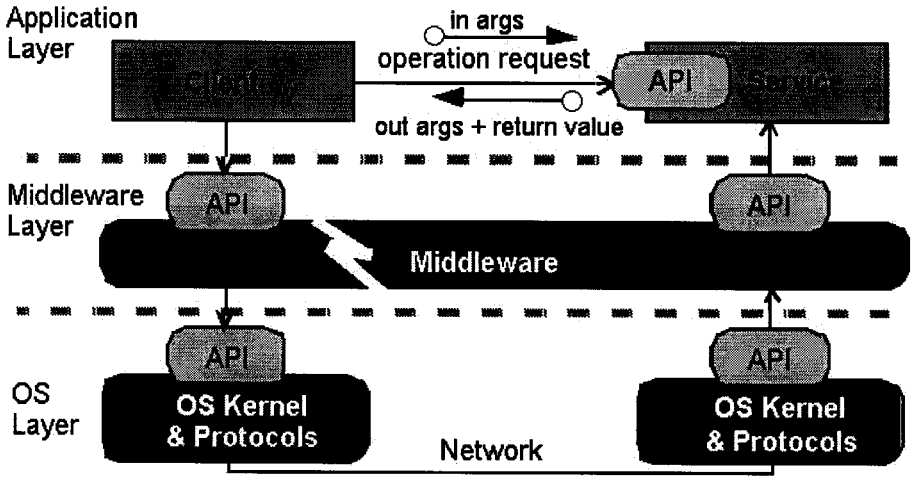
- Open-source
- 200,000+ lines of C++
- 30+ person-years of effort
- Ported to Win32, UNIX, & RTOSs
  - *e.g.,* VxWorks, pSoS, LynxOS, Chorus, QNX

- **Large open-source user community**
  - www.cs.wustl.edu/~schmidt/ACE-users.html

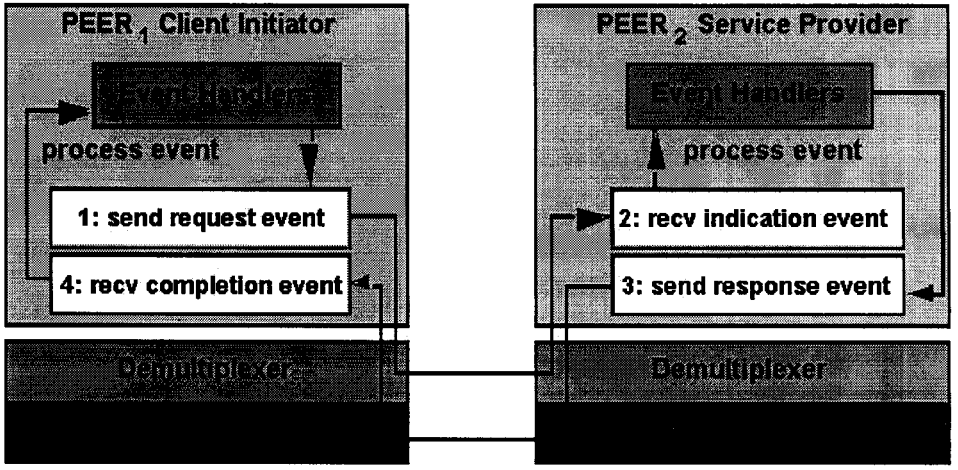
- **Commercial support by Riverace**
  - www.riverace.com/

Key Capabilities Provided by ACE

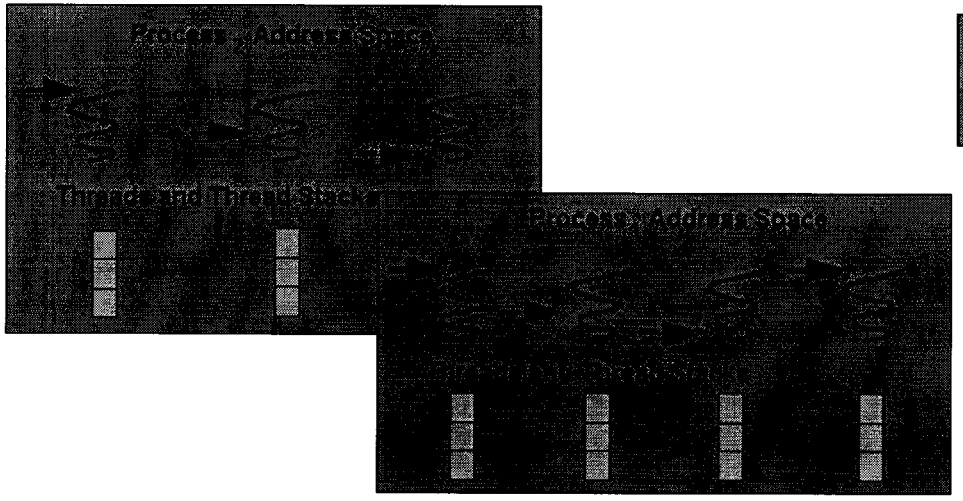
Service Access & Control



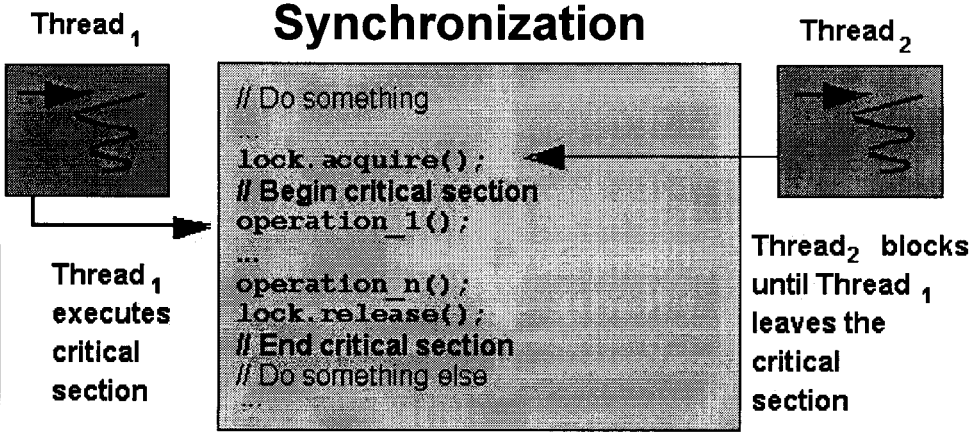
Event Handling



Concurrency



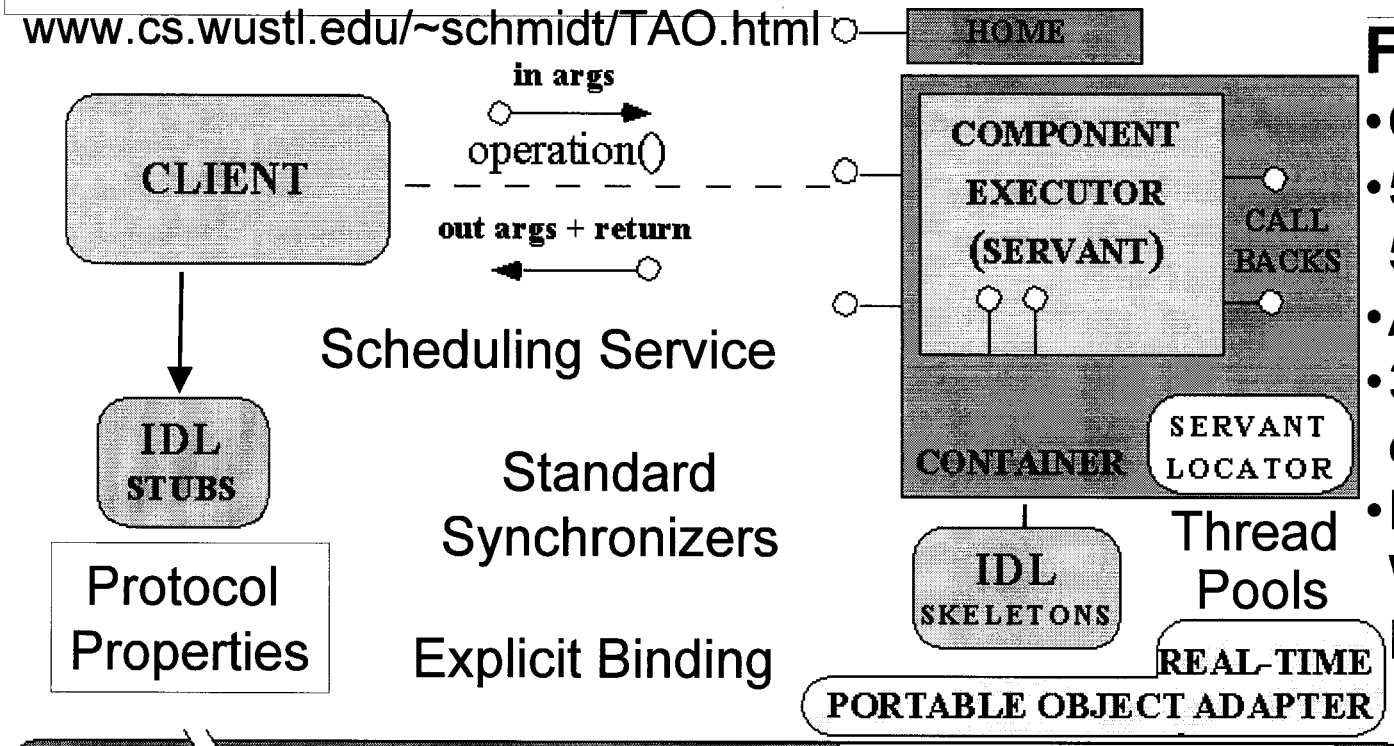
Synchronization



Example of Applying Patterns & Frameworks:

Real-time CORBA & The ACE ORB (TAO)

www.cs.wustl.edu/~schmidt/TAO.html



Features

- Open-source
- 500+ classes & 500,000+ lines of C++
- ACE/patterns-based
- 30+ person-years of effort
- Ported to UNIX, Win32, MVS, & many RT & embedded OSs
  - *e.g.,* VxWorks, LynxOS, Chorus, QNX

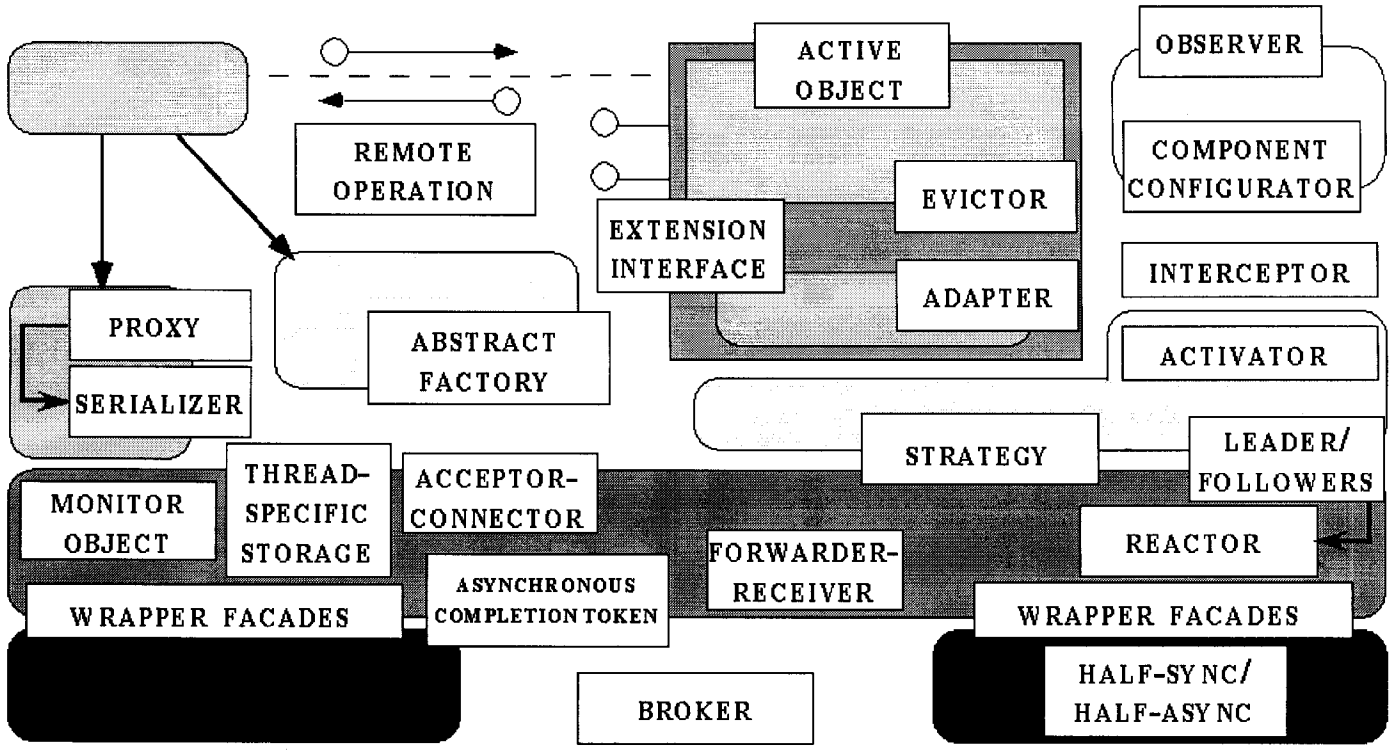
- **Large open-source user community**
  - www.cs.wustl.edu/~schmidt/TAO-users.html

- **Commercial support by OCI**
  - www.theaceorb.com/

Tutorial Example 3:

Applying Patterns to Real-time CORBA

UML models of a software architecture can illustrate *how* a system is design, but not *why* the system is designed in a particular way



Patterns are used throughout *The ACE ORB (TAO)* Real-time CORBA implementation to codify expert knowledge & to generate the ORB's software architecture by capturing recurring structures & dynamics & resolving common design forces

Concluding Remarks

- Researchers & developers of distributed applications face common challenges
  - e.g., connection management, service initialization, error handling, flow & congestion control, event demuxing, distribution, concurrency control, fault tolerance synchronization, scheduling, & persistence
- Patterns, frameworks, & components help to resolve these challenges
- These techniques can yield efficient, scalable, predictable, & flexible middleware & applications