

---

---

**National Ignition Facility laser to be controlled by  
Ada software distributed over CORBA**

---

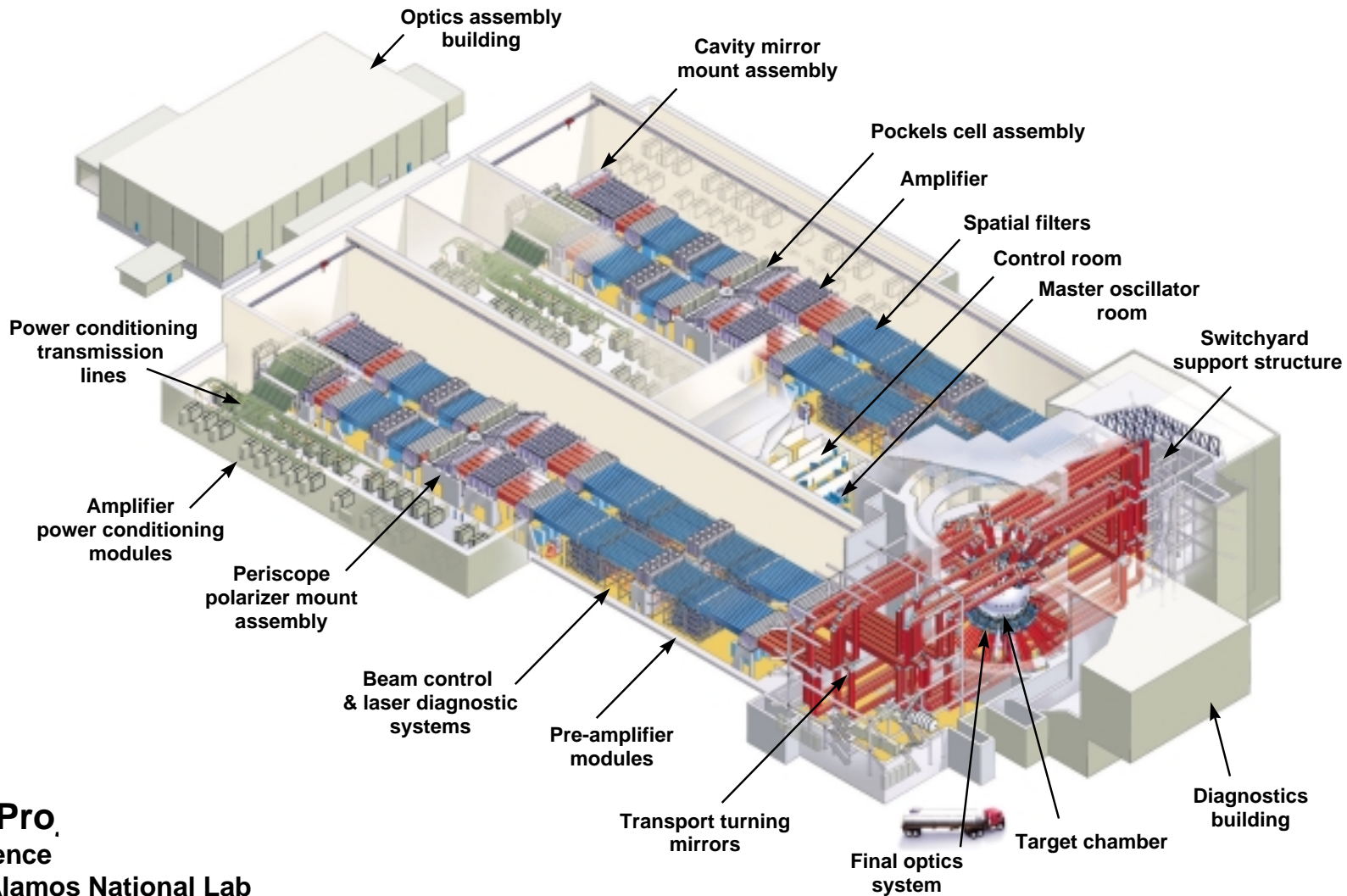
---



**John P. Woodruff  
woodruff1@llnl.gov  
Lawrence Livermore National Lab**

**Presented at Software Technology Conference  
Salt Lake City, Utah  
May 5, 1999**

# The National Ignition Facility is a \$1.2 Billion project to be completed in 2003



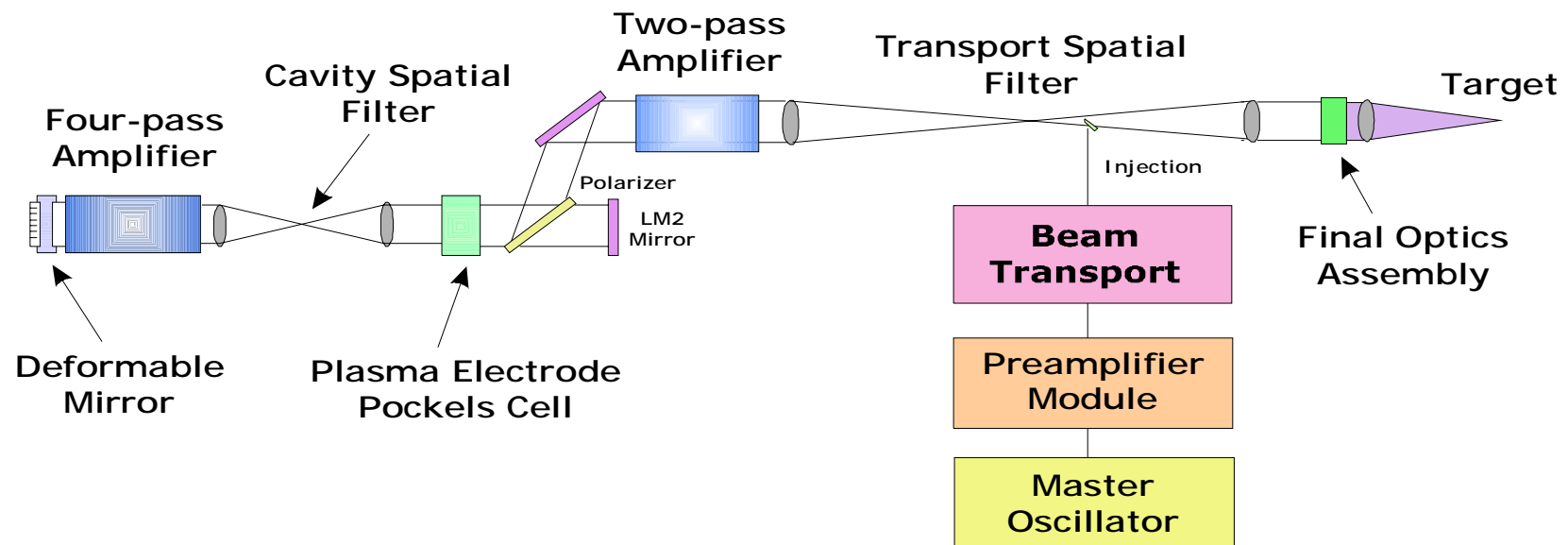
**NIF Pro.**  
Lawrence  
Los Alamos National Lab  
Sandia National Lab  
Univ. of Rochester/Lab for Laser Energetics

# **Integrated Computer Control System is a distributed system that does not have hard real time requirements**

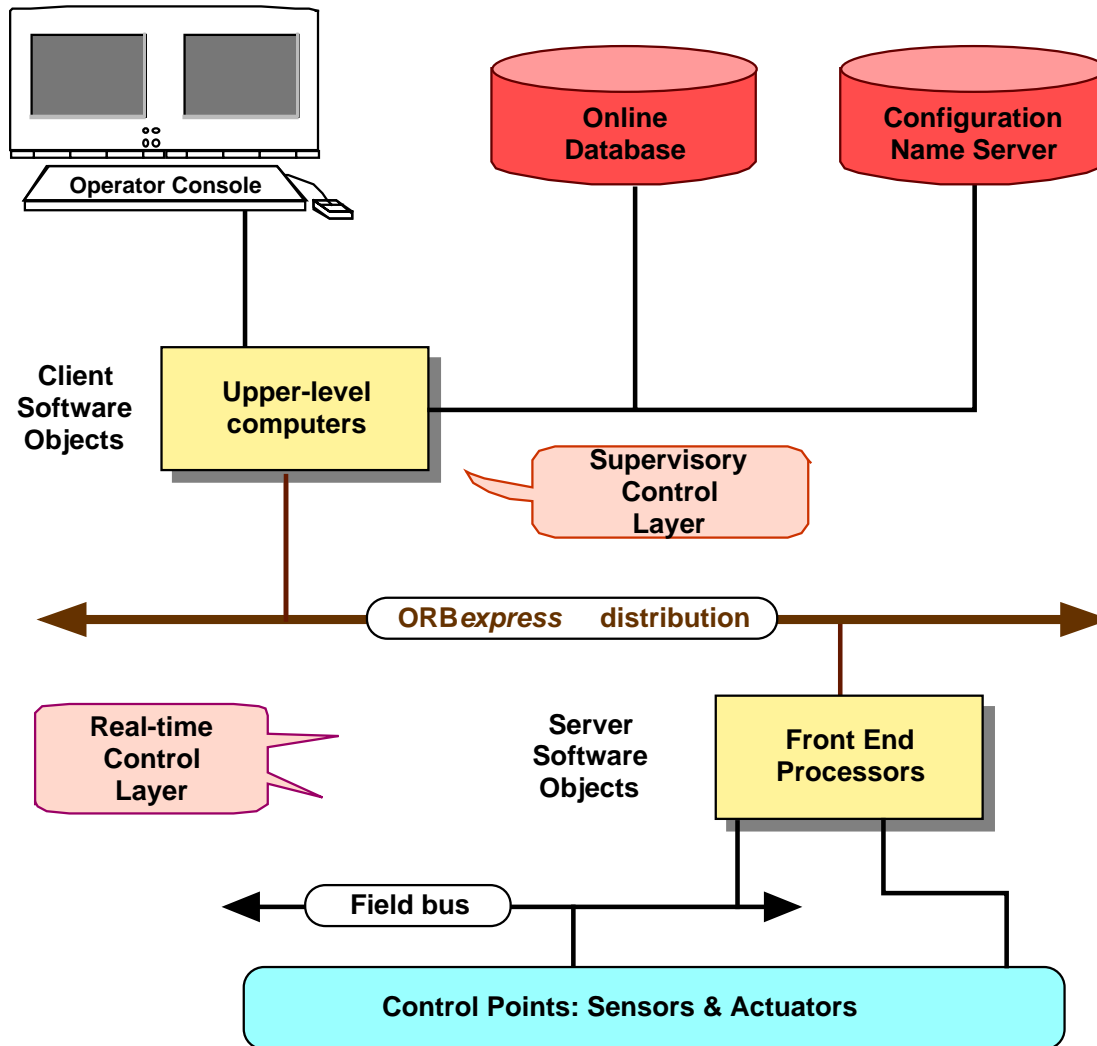
- **Supervisory software is event driven**
  - **Operator-initiated actions and scripted sequences do not require specific response times**
  - **Status information is propagated from the laser to updates on graphic user screens**
  - **Speed requirements derive from operator needs for interactive response**
- **No process-related hard deadlines must be met**
  - **Several hours of preparation precede shot**
  - **Shot executes in microseconds controlled by dedicated hardware**
  - **Data gathering and reporting occurs in minutes after the shot**
- **Some process controls are encapsulated in front-ends**
  - **Automatic alignment**
  - **Capacitor charging**

# The hardware boundary is the solid ground on which we build our software architecture

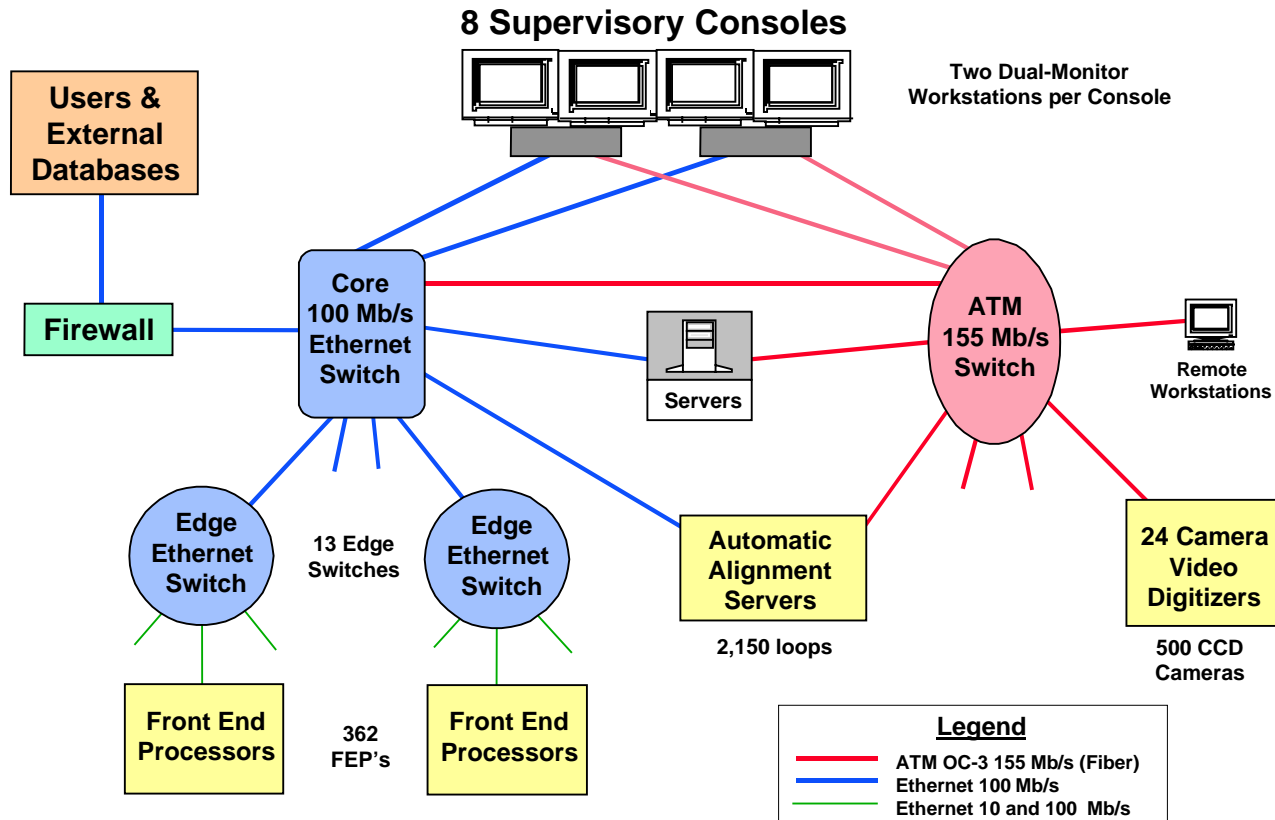
- Each of 192 beamlines has the same control points
  - 60\_000 points in all
- The control points are relatively inflexible
- But the experimental plans will evolve during 30 years of operation



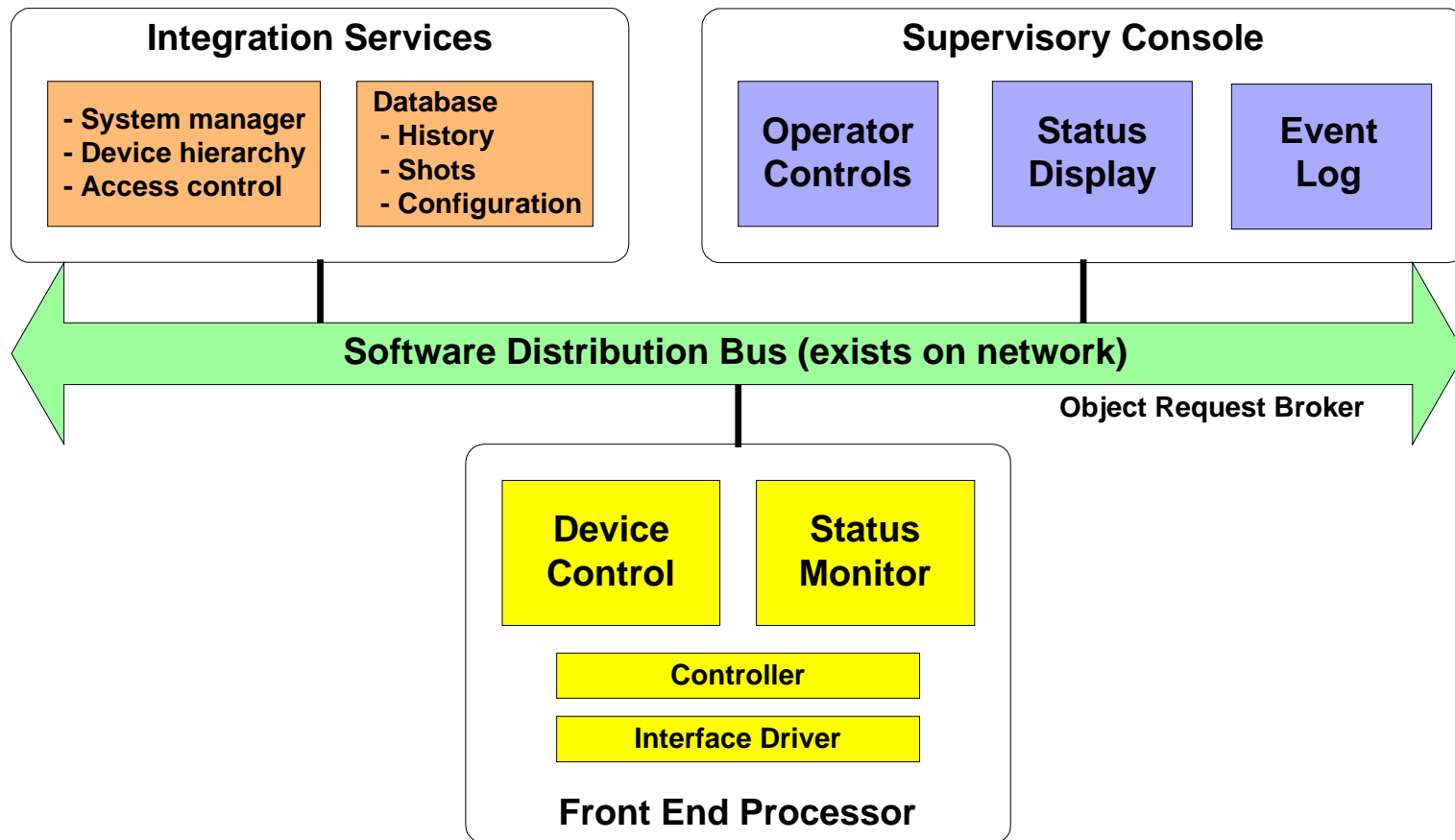
# ICCS software is distributed on some 500 computers in two layers



# The ICCS Computer System and Network Architecture as deployed for NIF



# The software architecture distributes control over a facility-wide software bus



**This software framework is reused to construct 8 supervisory applications and 18 types of front end processors**

# Framework components are reused across the NIF

- **Common services provided anywhere on the network**
  - **Operator control and equipment status**
  - **Database archiving and trending**
  - **Integration services**
    - **Orderly starting of the software**
    - **Device-level access controls**
    - **Plug and play communications**
  - **Steps in preparation for an experimental shot**
  - **Logging of control system events**
  - **Operator-programmable checklists**
- **These services strive to be “decentralized”**
  - **Clients should know little about their location**
  - **Services should be largely independent of each other**

# **CORBA provides decentralized distribution services**

- **A standard model of distributed objects resolves a major development risk**
  - **Anticipate 30-year life of the standard**
  - **ICCS software engineers are freed from building a “homebrew” communication infrastructure**
- **CORBA defines loose coupling between objects**
  - **Communication becomes nearly invisible**
    - **Neither clients nor servers depend directly on communication infrastructure**
    - **Names of communicating objects hide locations**
  - **Transparent interoperability**
    - **IDL specifications are language-neutral interfaces**
    - **Data marshalling hides differences between hosts**
- **Allocation of object implementations to processes can be deferred**

# Using IDL to define interfaces implies some compromises

- **Interfaces must be declared in terms of IDL types**
  - These types “diffuse” into the rest of the system
  - IDL type model is less strict than Ada’s
    - No range constraints
    - No initial values for record components
  - No default parameter values
  - No operator overloading in interfaces
- **Configuration management must accommodate to the possibility that implementation details might be loaded into client processes**

# The majority of NIF's CORBA objects are long-lived

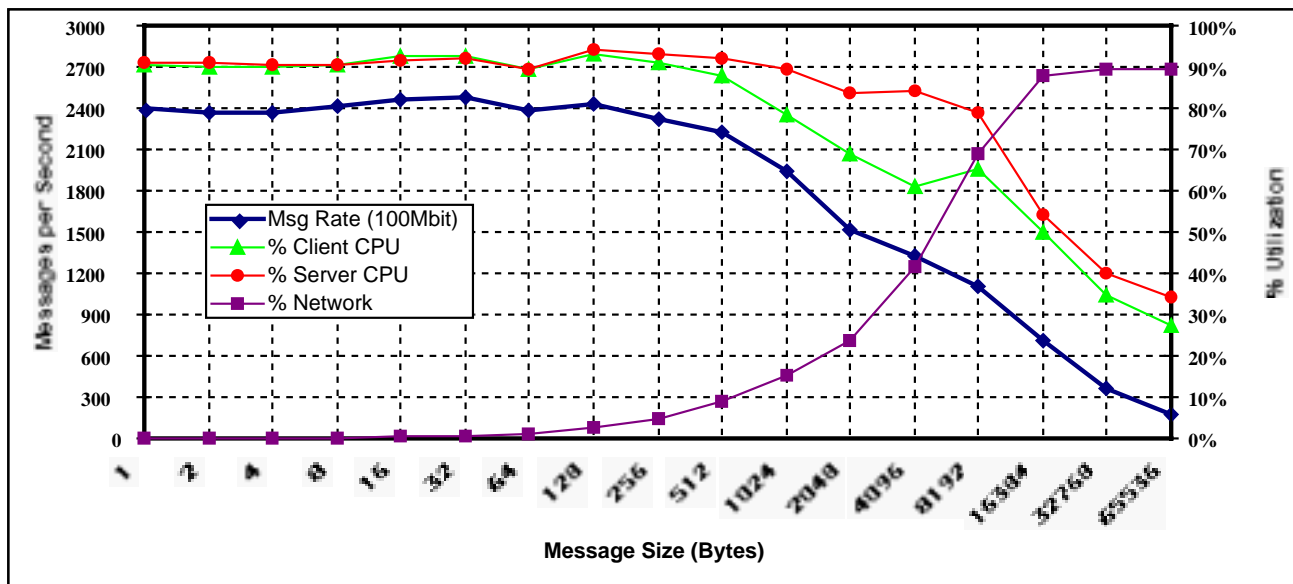
- **60\_000 objects implement the class Device in Front-End Processors**
  - About 250 subclasses
  - Each instance is initialized at system start-up
  - A framework manages data and naming
    - Oracle database maintains configuration
    - Persistence broker objects implement SQL queries on behalf of CORBA clients
- **A dead server is an error to be diagnosed and recovered**
  - Failover to a replacement of the same class is not automated

# Efforts to economize on message traffic

- **Status of every Device must be observable at multiple consoles**
  - **Some status reports require latency as small as 0.1 second**
  - **Monitor objects are co-located with Devices**
    - **Local polling in the FEP**
    - **Notification of “significant” change**
  
- **Supervisory objects collect and collate change reports**
  - **GUI’s that display “broad view” status subscribe to these supervisors**
  - **GUI’s receive their status updates via “data push” from the supervisor**

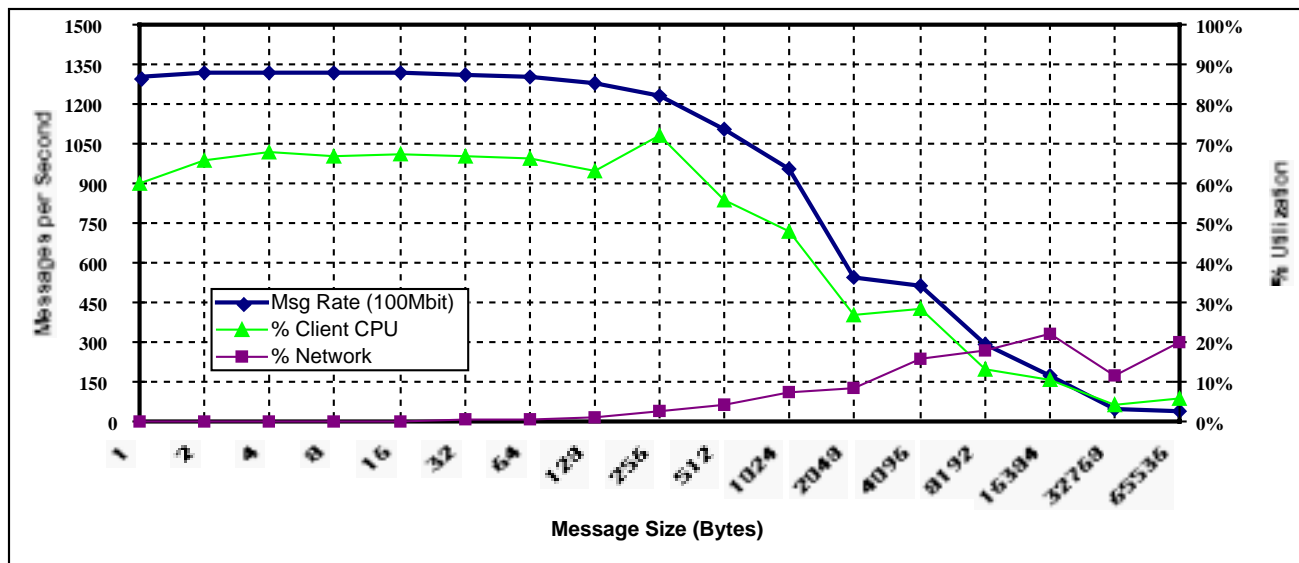
# Measurements of ORBexpress 2.0.1 confirm adequate performance

- Network is 100 Megabit ethernet
- Both client and server are 2-processor Sun Enterprise 3000's
  - Client runs 40 Ada tasks; server runs 5
  - Runtime is Apex 3.0
    - GNAT 3.11 is roughly 10% faster

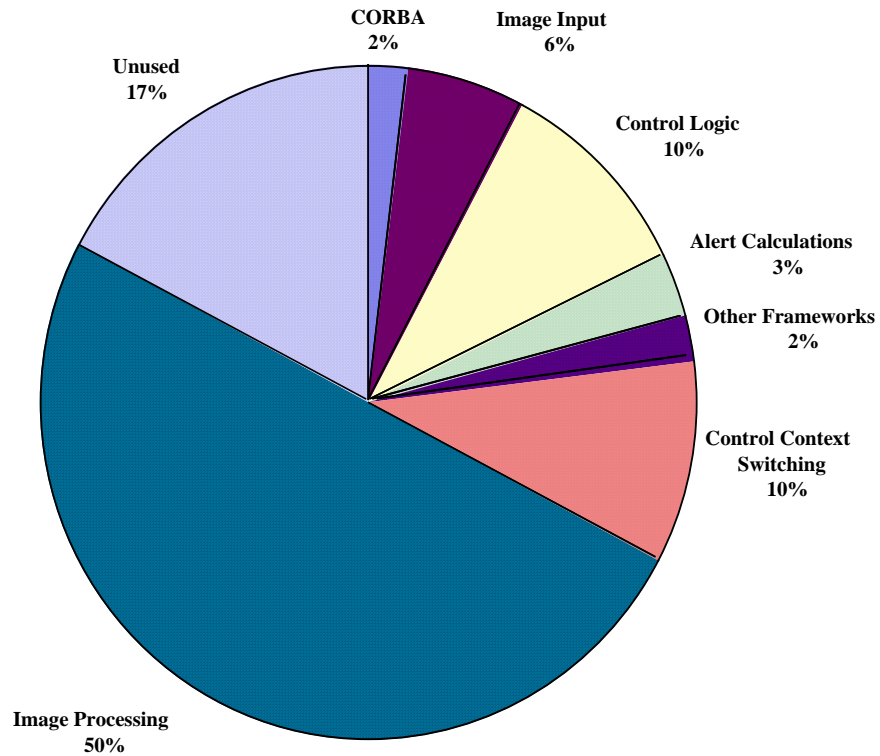


# Server performance is comparable on the Front-End processor

- Server is a 300 MHz PowerPC in a VME crate
- Runtime is VxWorks operating system with ApexWorks 3.0
- Same tasking implementation as previous data



# Simulation models show how resource usage scales to full-scale operation



Automatic Alignment CPU Utilization per Processor

## Numerous online sources offer further information

- **The National Ignition Facility**
  - <http://lasers.llnl.gov/lasers/nif.html>
- **The NIF Integrated Computer Control System**
  - <http://lasers.llnl.gov/lasers/ICCS/>
- **Controlling the World's Most Powerful Laser**
  - Science & Technology Review, November 1998
  - <http://www.llnl.gov/str/11.98.html>
- **A Large Distributed Control System Using Ada in Fusion Research**
  - Proceedings ACM SIGAda International Conference 1998
  - UCRL-JC-130569 (\*)
- **Integrated Computer Control System CORBA-Based Simulator**
  - UCRL-ID-133243 (\*)
- **Evaluation of CORBA for Use in Distributed Control Systems**
  - UCRL-ID-133254 (\*)

\* Numbered reports are accessible from <http://www.llnl.gov/tid/opac.html>

# DISCLAIMER

## UCRL - MI - 133457

- This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.
- Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.