Sandia National Laboratories

R. Michael Cahoon
Manager
Scientific Computing

Sandia is a Multiprogram Laboratory
Operated by Sandia Corporation,
a Lockheed Martin Company,
for the United States Department of Energy
Under Contract DE-ACO4-94AL85000.

Sandia National Laboratories sites

Kauai Test Facility,
Hawaii

Albuquerque,
New Mexico

Livermore,
California

Tonopah Test Range,
Nevada

Sandia National Laboratories

Sandia's strategic plan identifies four mission objectives in national security

- **Ensure that the nuclear weapons stockpile is safe, secure, and reliable and fully capable of supporting our nation's deterrence policy**
- **Reduce the vulnerability of the United States to proliferation, use of weapons of mass destruction, and threats of nuclear incidents**
- **Advance the surety (safety, security, and reliability) of critical global infrastructures**
- **Develop high-impact responses to emerging national security threats**

Sandia is responsible for the non-nuclear components and subsystems of nuclear weapons

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"Weaponization"

Design, engineering, testing, integration, and production interface for non-nuclear components

W88/MK5

Arming, Fuzing, and Firing System

Total parts > 3000

- Radars
- Impact fuzes
- Shock absorbers
- Casing
- Detonators
- Firing sets
- Transverters
- Capacitors
- Switches
- Switch tubes
- Rectifiers
- Programmers
- Neutron generators
- Reservoirs
- Stronglinks
- Batteries
- Timers
- Spin generators
- Parachutes
- Ejector systems
- PAL controllers

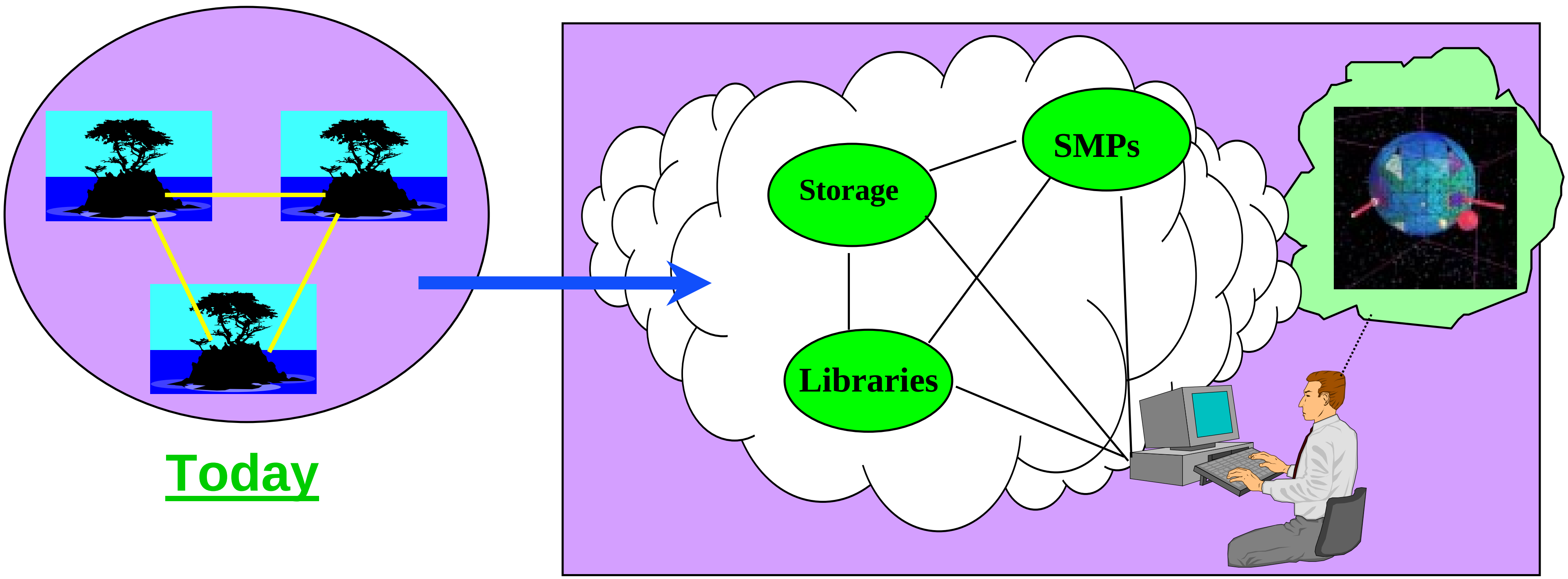
B83 Strategic Bomb

Total parts - 6,519

- Sandia developed - 3,922
- Sandia specified - 2,378

Distributed Computing Environment

Being able to transparently access computing and information resources regardless of location while maintaining security and need-to-know constraints is key to the efficient use of resources across the DP labs and the complex.



Today

Tomorrow

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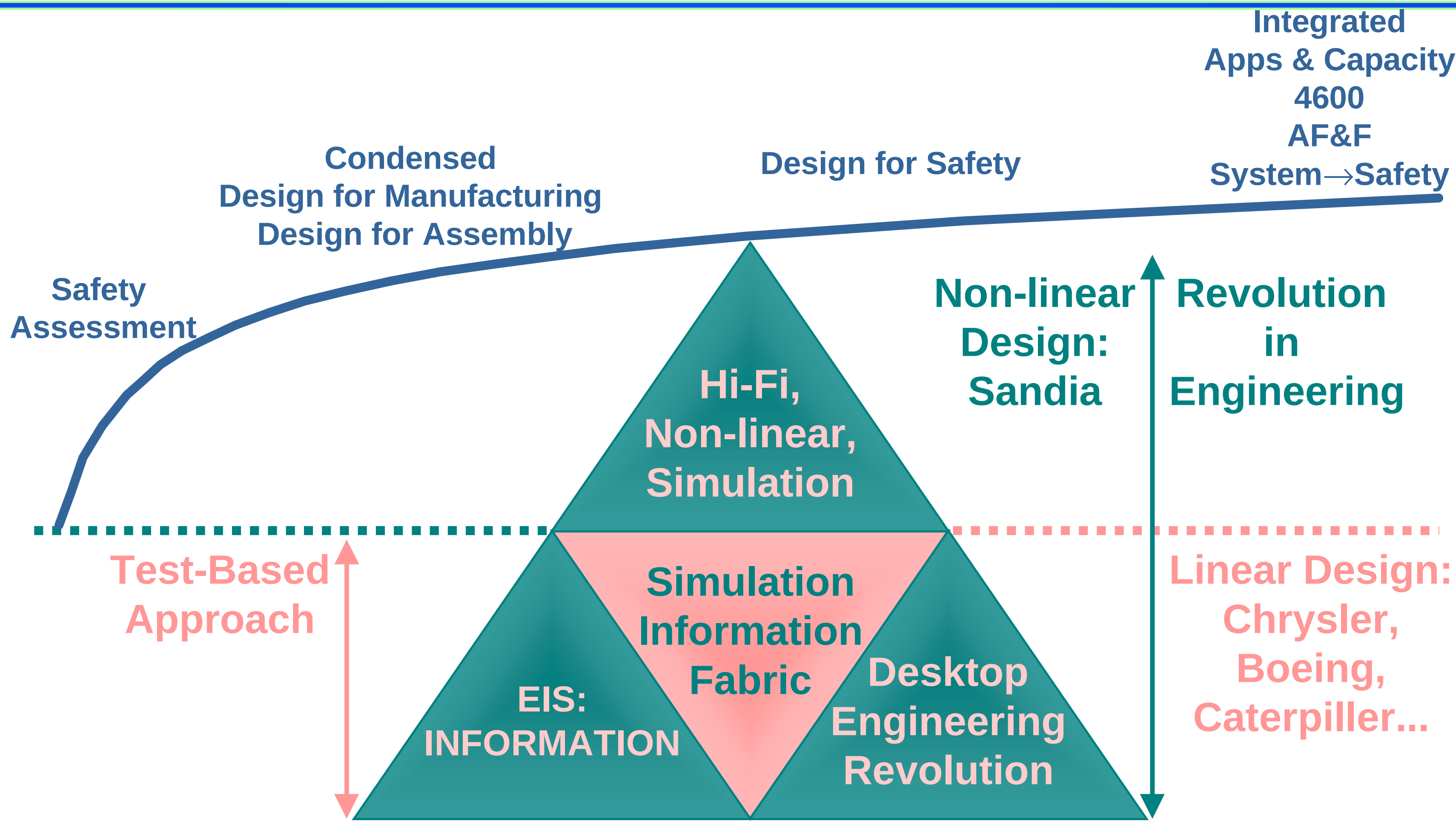
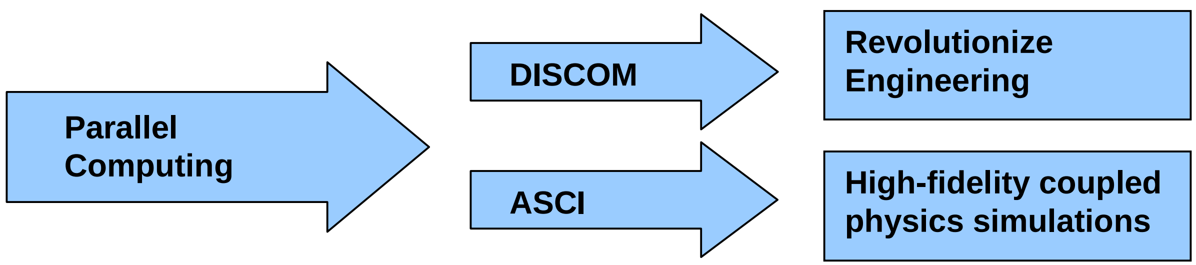
The REVolution In ENGineering



A History of Progress

Paragon	TFLOPS	CPLANT
• Prove massively parallel supercomputing • 10s of users • Periods processing for classified • World record performance • SUNMOS (Light weight kernel) • Fast mesh interconnect • OC12 interface (predecessor to VIA) • Enabled routine 3D simulation (single physics) • W88 safety assessment against sympathetic detonation	• Production massively parallel supercomputing • 50-100 users • Dramatically increased reliability • 10x performance and memory increase • Fast periods processing with dedicated Red & Black partitions • Virtual channels in interconnect • Redundancy & Hot Swaps • Enables high-fidelity coupled physics 3D simulation • W76 NG standoff for contact fuse mode	• Extend parallel computing to commodity • 500-1000+ users • Commodity OS, interconnect, applications • Integration with Intranet • Capacity & Capability • Main stream technologies • Horizontal markets • Enables incremental growth of capacity • Integration of mid-range with high-end computing for revolution in engineering



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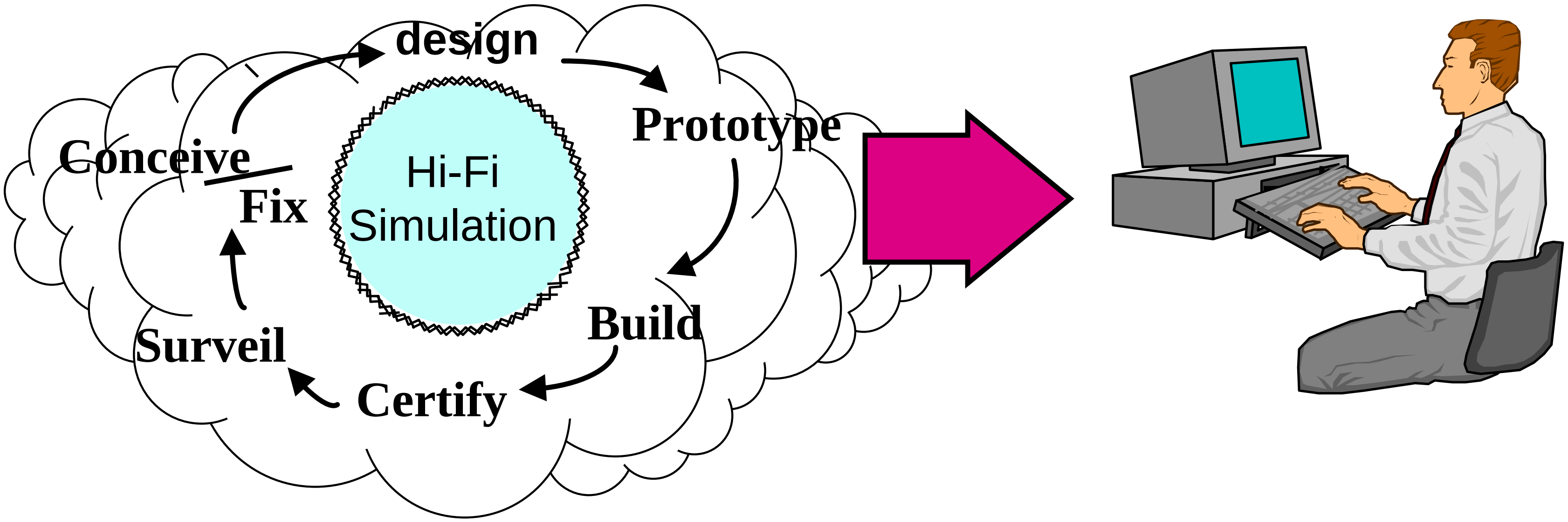
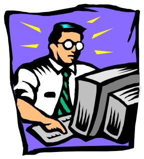
In the Coming Decade Computing Will Pervade Our Business



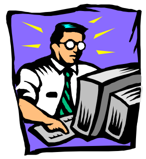
- **A Better Stockpile Updated Faster and Less Expensively Through Computation-Based *EVERYTHING***
- **Simulation capability is the cornerstone of our confidence and the foundation for a *Revolution in Engineering***

REVolution In ENGineering



System Designer

- Archival data
- Pro-E
- Full system prototyper
- Conceptual design tools
- Requirements management
- EIS



Electronic Components

- SPICE
- PISCES
- VERILOG
- DAVINCI
- Virtual Catalogs
- Product data object
- EIS

Mechanical Design

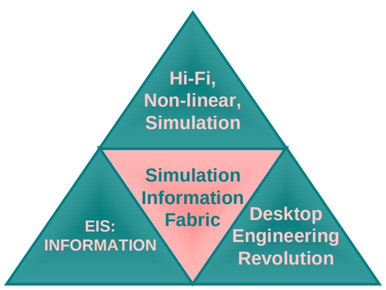
- STS prototyper
- Pro-Mechanica
- ANSYS
- ABACUS
- NASTRAN
- Pro-E
- EIS

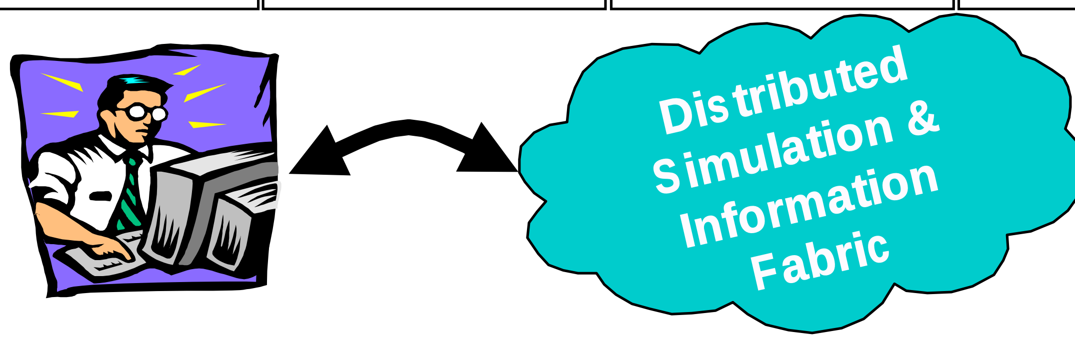
Manufacturing Process Design

- Pro-E
- Mold flow
- ARCHIMEDES
- COYOTE
- Pro-Mechanica
- GOMA
- Scheduling Tool
- EIS

Model-based Safety

- Pro-E
- ARRAMIS
- RAMS/CRASH
- COYOTE
- SABLE
- TEMAC
- Product data object





Distance and Distributed Computing

Vision

A highly responsive and efficient nuclear weapons complex through the use of distance and distributed computing

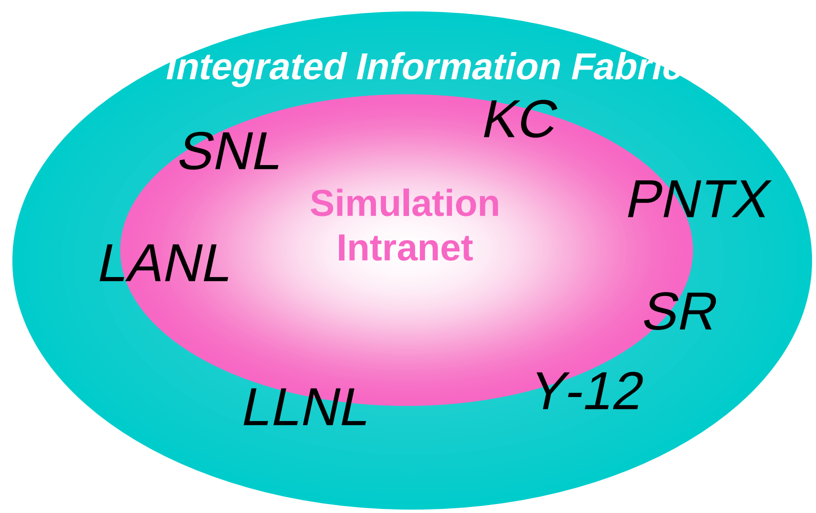
Mission

Accelerate the ability of DP labs and plants to apply:

- **high-end computing resources**
- **distributed computing resources**

across thousands of miles,

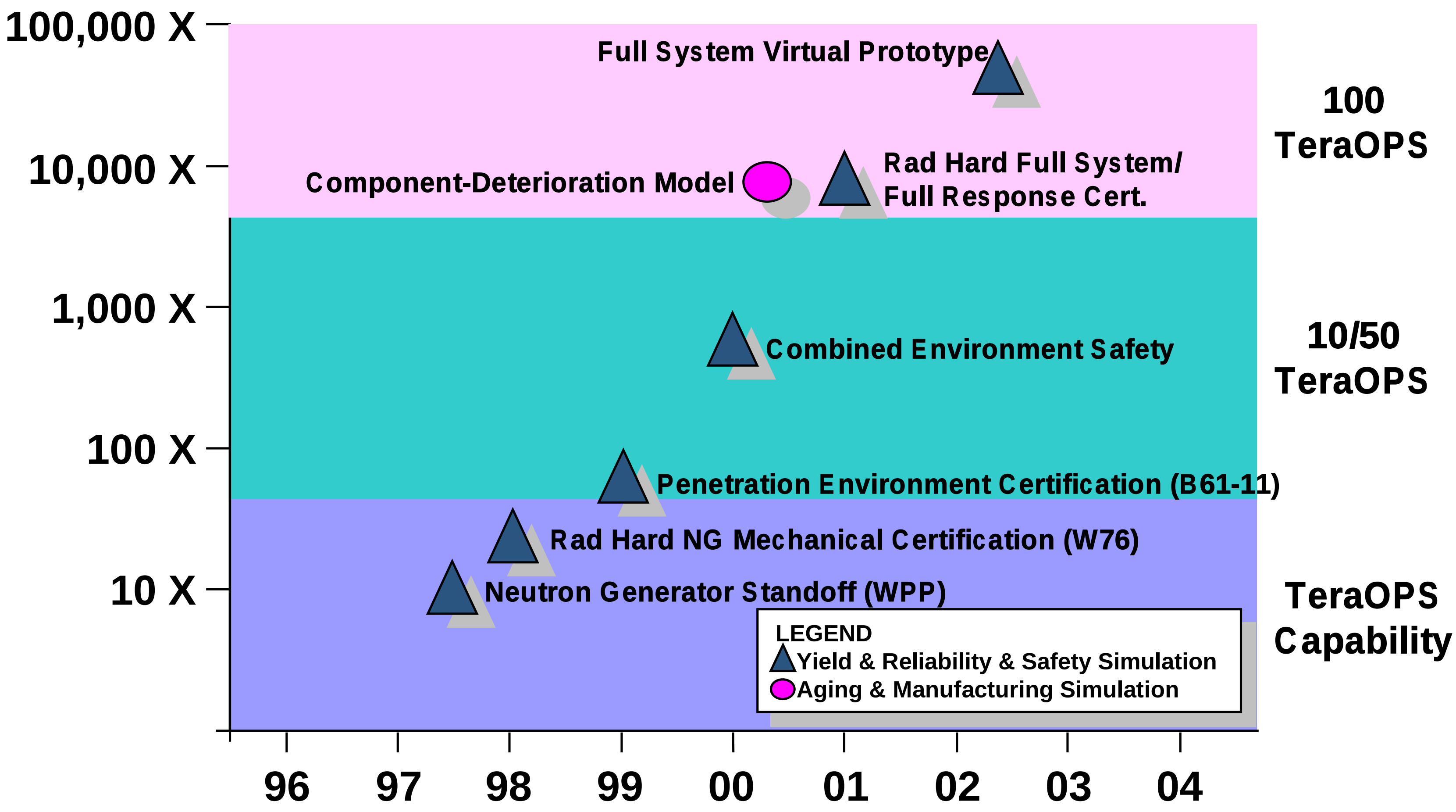
to meet the urgent and expansive design, analysis, and engineering needs of stockpile stewardship



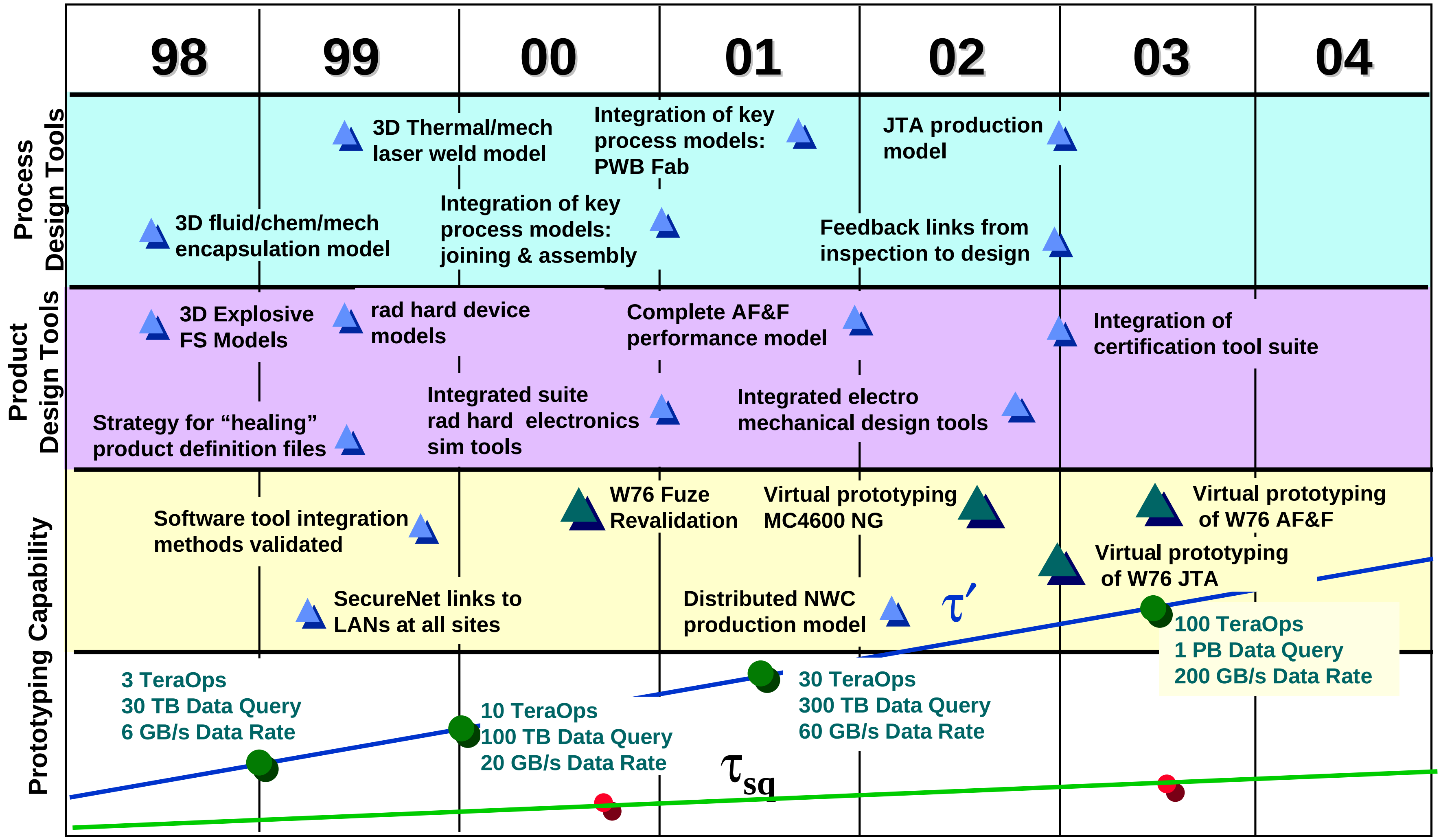
Create a flexible, integrated *simulation intranet*

High-End Computing Requirements Drive Distance Computing Needs

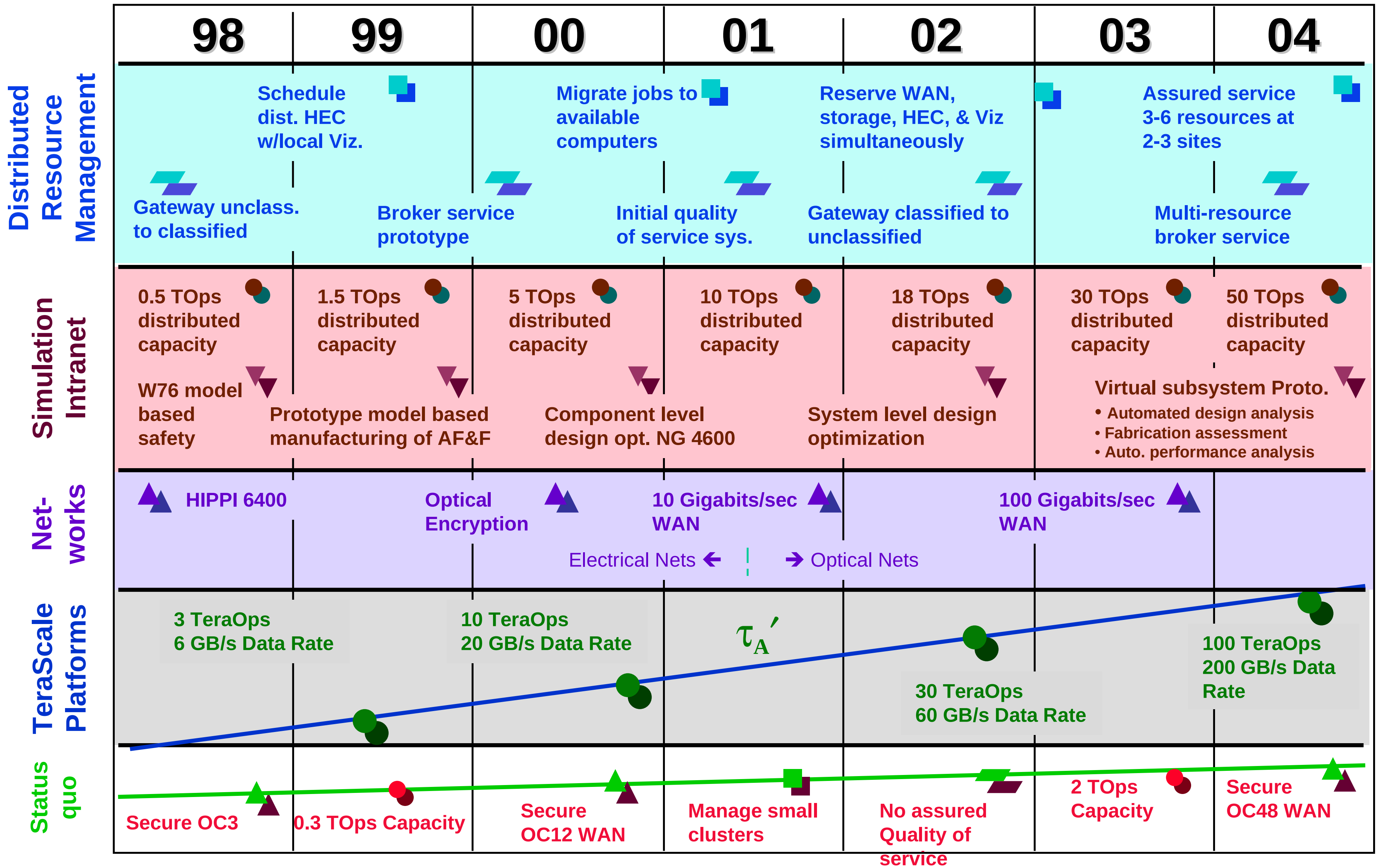
...3D - "more-complete-physics" - high fidelity simulation, has key milestones tied to stockpile requirements or expected aging & manufacturing requirements - i.e., Green Book or SDR



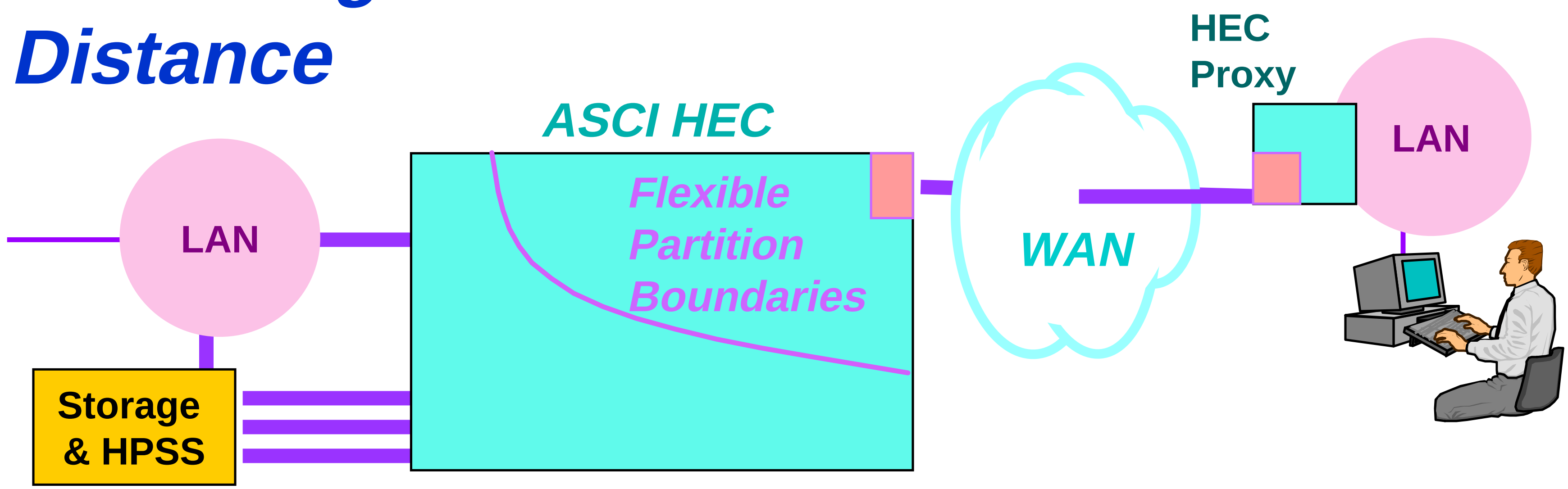
Accelerate Our Ability to Provide Virtual Prototypes of Weapons Systems & Components



Accelerated Networking, Distributed Resource Management and Simulation Intranet



Extending Across Distance



Computational Resources

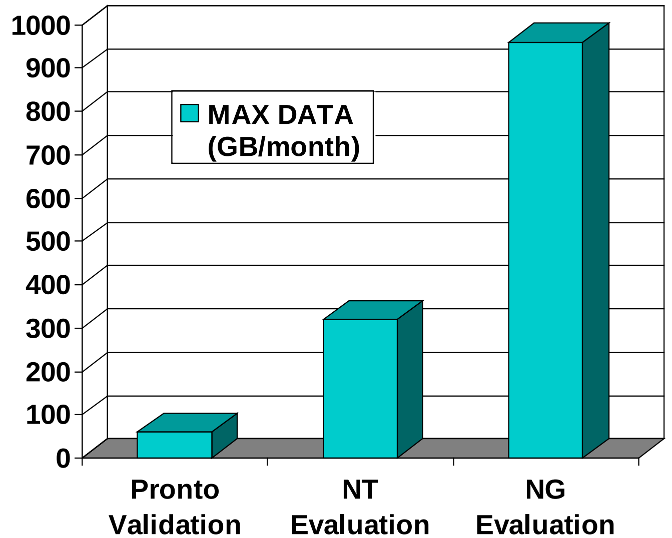
Interface: SAN-WAN router

Local Area Net and Resources

- **Local proxy for remote HEC**
- **Operate HEC & Proxy as single system**
- **Users see a consistent environment**
- **Support differing site cultures**
- **Eliminates need for high performance DCE**
- **Isolates the high-performance WAN interconnect**
- **Unified resource management of HEC capabilities**

NG Certification: Problem Characteristics

Problem	Pronto Validation	NT Evaluation	NG Evaluation
Dates	11/1-9/98	12/1-3/1	4/1-9/1
Classification	unc* & class	class	class
# of Cells (M)	1- 3	10	20
# of Variables (max)	12	12	12
# of time steps	100-200	100-200	100-200
size per run (GB)	5-30	30-100	120-240
# of runs (per month)	2	3-4	3-4



Notes:
* Edison went classified in Dec. Smaller unclassified machines at NM & CA will be used to support the unclassified Pronto Validation runs. If the problems get too large, they may have to be run on the classified side.

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Revolution in Engineering Mission Drives the Distributed Computing Need

- **Conduct life-cycle design trade-offs**
- **Computational optimization of designs**
- **High-end validation of system and component designs**
- **Predict aging effects**
- **Characterize catastrophic failure conditions**
- **Access design, analysis, and test info throughout the complex**
- **Collaborate using increasingly larger secure data sets**
- **Interact - problem generation, steering, and processing**

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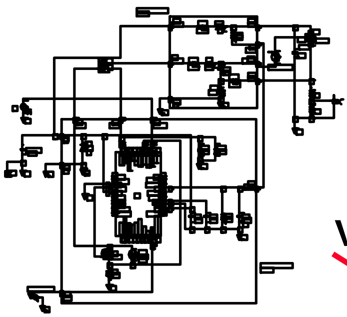
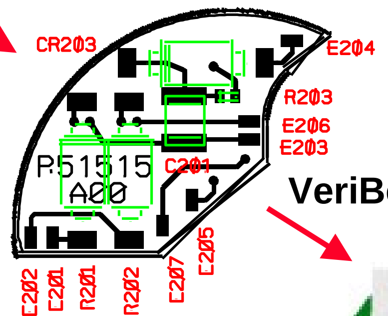
More Complex Implementations Are in Process



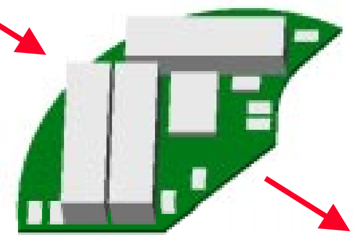
MicroSim to VeriBest Schematic Conversion

VeriBest Board Layout



- "Chains" of tools are being integrated to automate and simplify specific engineering processes

VeriBest to Pro/E



Pro/E Substitution

Analysis

- ❖ Our ability to accomplish this is improving as widespread object reuse becomes possible
- ❖ Major leveraging with commercial partners is occurring

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A Computing Industry in Transition

- **The high-end computing market is small**
- **High-volume desktop computers have closed the performance gap**
- **Web evolution is driving a market for high-performance interconnects**
- **Web services are driving a developing market for scalable clusters**

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Implications

- **High-volume low-cost building blocks**
  - **Pushing high-end technologies is increasingly difficult**
- **Getting large commodity clusters is easier than ever**
  - **and the cost-performance is compelling**
- **Incremental growth**
- **Simplified system management**

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Distributed Computing

Objectives:

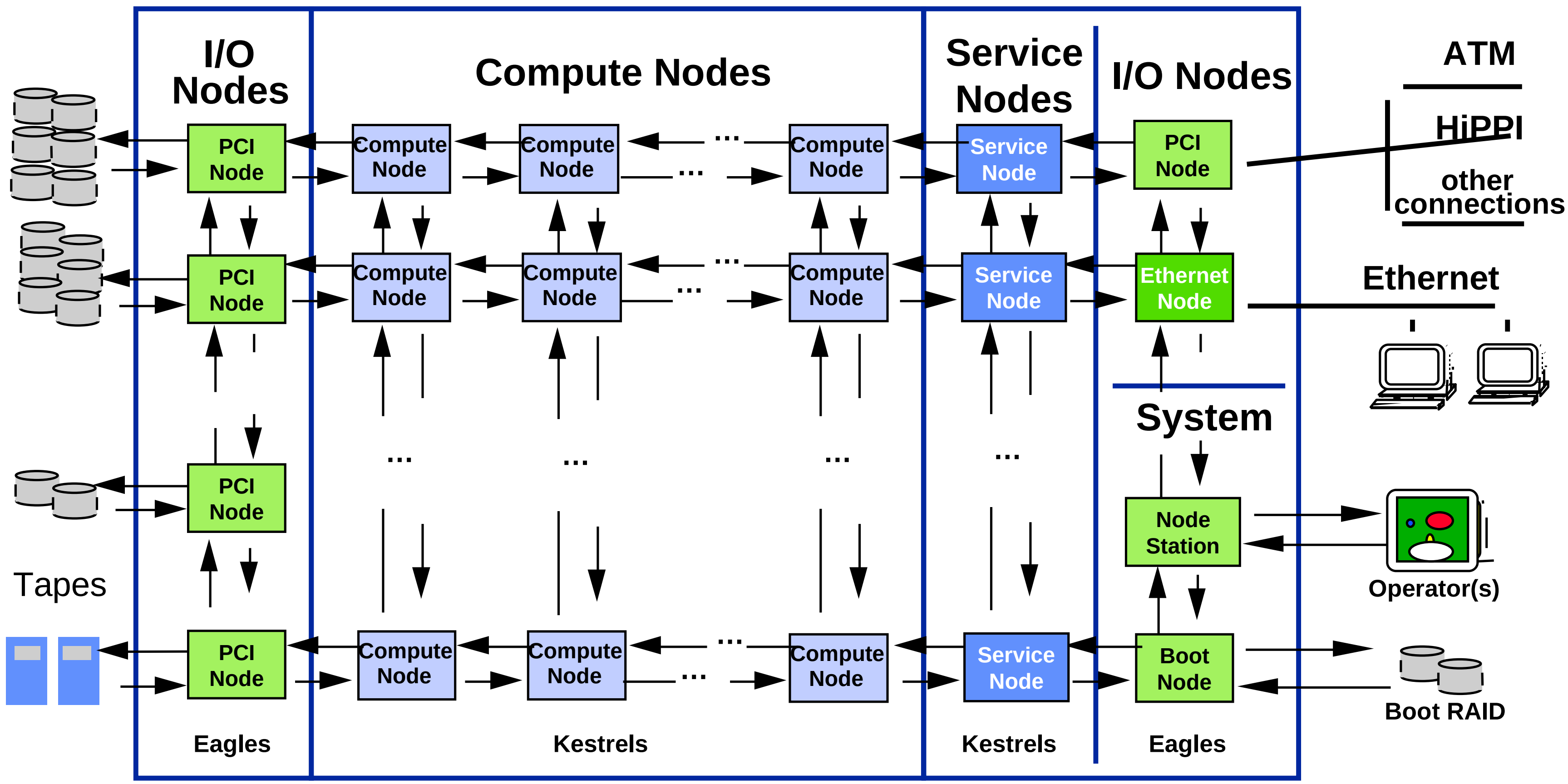
- **Integrate computing capabilities distributed throughout the complex**
- **Provide dramatically increased computing capacity at the lowest possible cost**

Strategies:

- **Quickly scale up and integrate computing assets**
- **Focus on services**
  - **distributed systems services, application-enabling tools, and system management services**
- **Adapt needed applications technologies**
- **Drive down the cost of simulation**
  - **Leverage high volume, commodity building blocks**

Proven Integrated Distributed Computing

TFLOPS Approach



Specialized servers and services

Closely integrated "system image"

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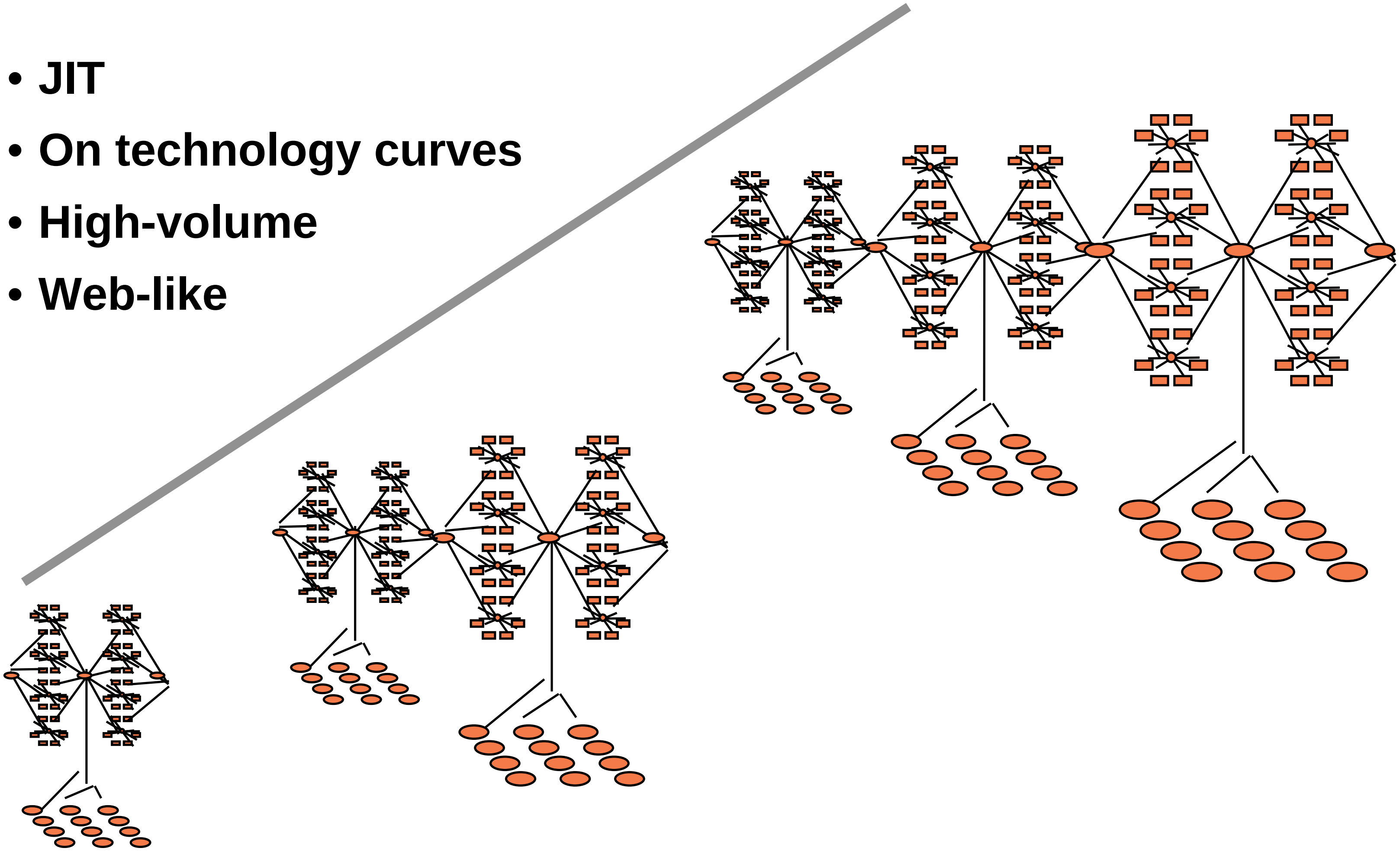
Start with something tractable and that we know scales

Extend to large scale distributed computing

- Prototype
- Deploy and expand needed partitions
- geographical separate parts
  - eventually a single resource
- Heterogeneous
- Varying users
- Evolve/Preserve

Incremental Growth Strategy

- JIT
- On technology curves
- High-volume
- Web-like



CPlant Prototype

- Scalable, recursive design
- Methods to connect, run, and and maintain nodes
- Separate, scalable system-support

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