Joint Experimentation on Scalable Parallel Processors

Dan M. Davis

ddavis@isi.edu

Information Sciences Institute

University of Southern California

The work described herein was funded by and conducted pursuant to direction from Joint Experimentation, US Joint Forces Command and computational resources were provided by the Maui High Performance Computing Center and the Aeronautical Systems Center of the HPCMP.

Outline

- Thesis
- Technical Background
- Accomplishments
- Opportunities for Advancement
- Summary

JESPP – Scalable Simulations

- This project provides virtually limitless scale to military simulations of conflicts
- US DoD needs simulations for
  - Analysis – “What tactics work best?”
  - Evaluation – “Does this sensor help?”
  - Training – “How can one prepare for war?”
- Previous simulations were limited to a few thousand entities; real cities have millions of people and vehicles

Thesis:
"JESPP Shows that High Performance Computing Works and Should be Used"

- There is good evidence from JFCOM experience that high performance computing is:
  - Useful
  - Available
  - Affordable
  - Implementable
- There are good examples that both:
  - Show the efficacy of the solution
  - Present a template for easy, effective implementation

Three Major Points

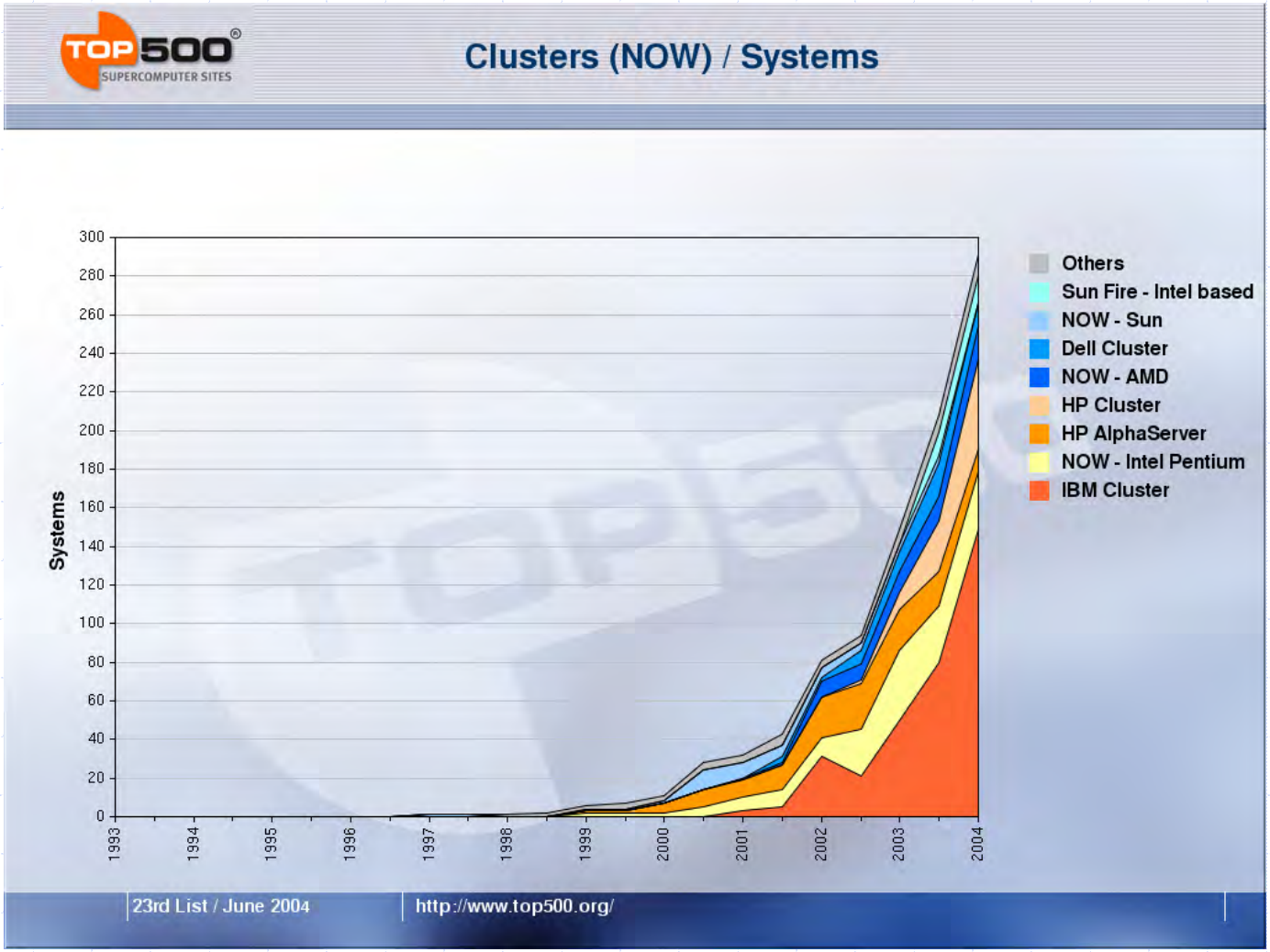
- DoD analysts did not have to be and should not be unnecessarily constrained by lack of computing power
- Linux cluster technology is affordable
- Effective utilization is based on:
  - Commonly available sys-admin skills
  - Learnable parallel processing skills

Common View of High Performance Computing?

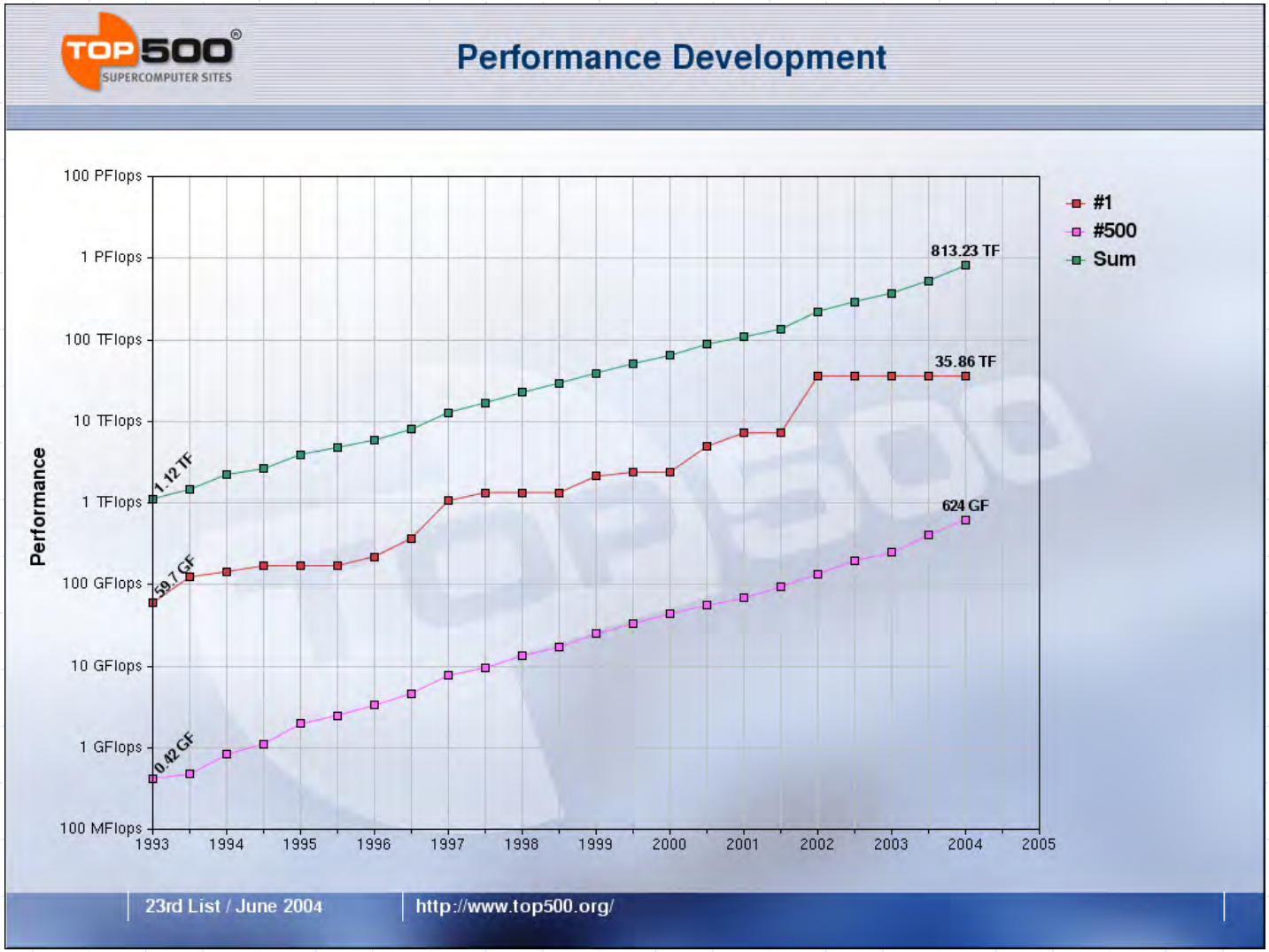
High Performance Computing

- Popular in government and academia since World War II
- Two major types
  - Vector/single processor machines –
    - The “X”iacs (Eniac, Illiac, Univac, ...)
    - Cray, *et alii*
  - Parallel Computers
    - Proprietary – Intel Delta, IBM Px to SGI Origin
    - Linux Clusters – Beowulf to Large Linux Clusters
- Top 500 List – HTTP://www.top500.org

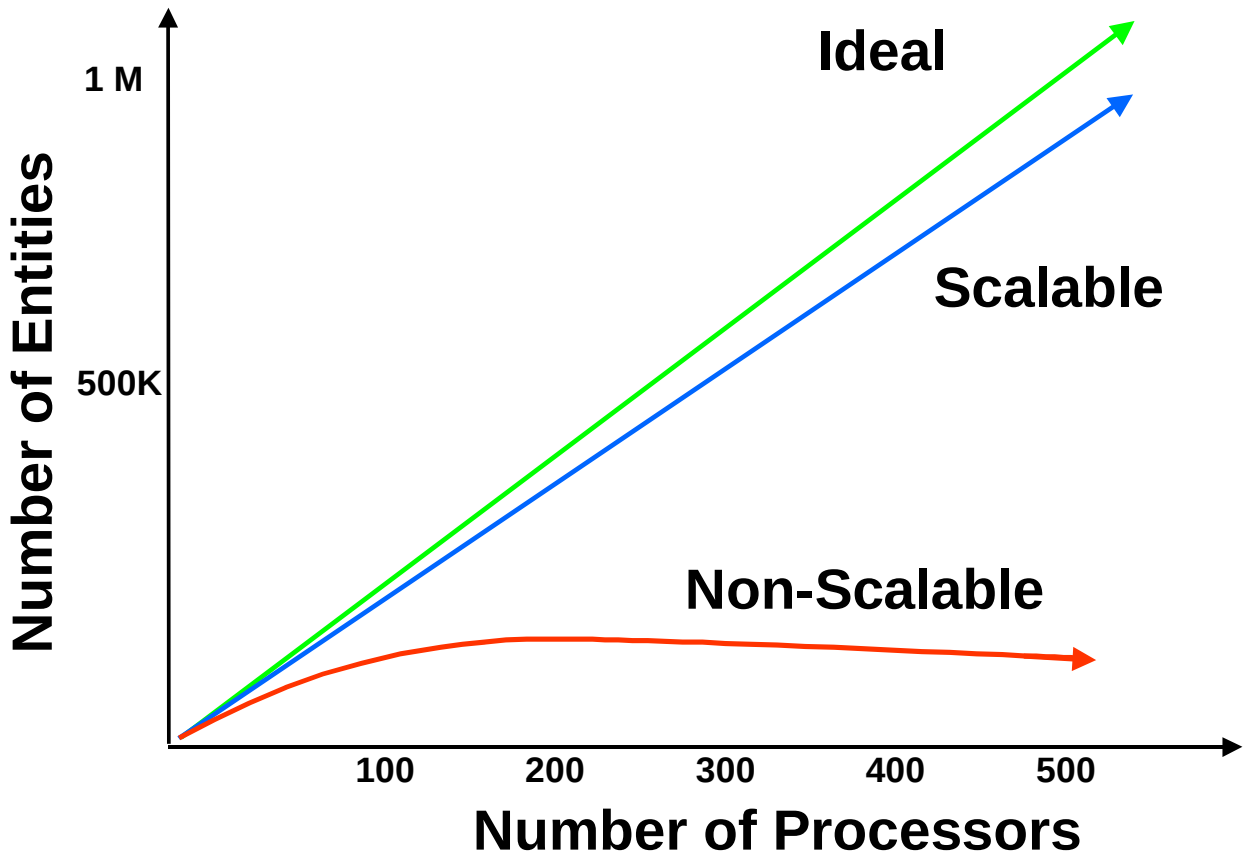
Installed Clusters



Performance Trends



The Concept of Scalability

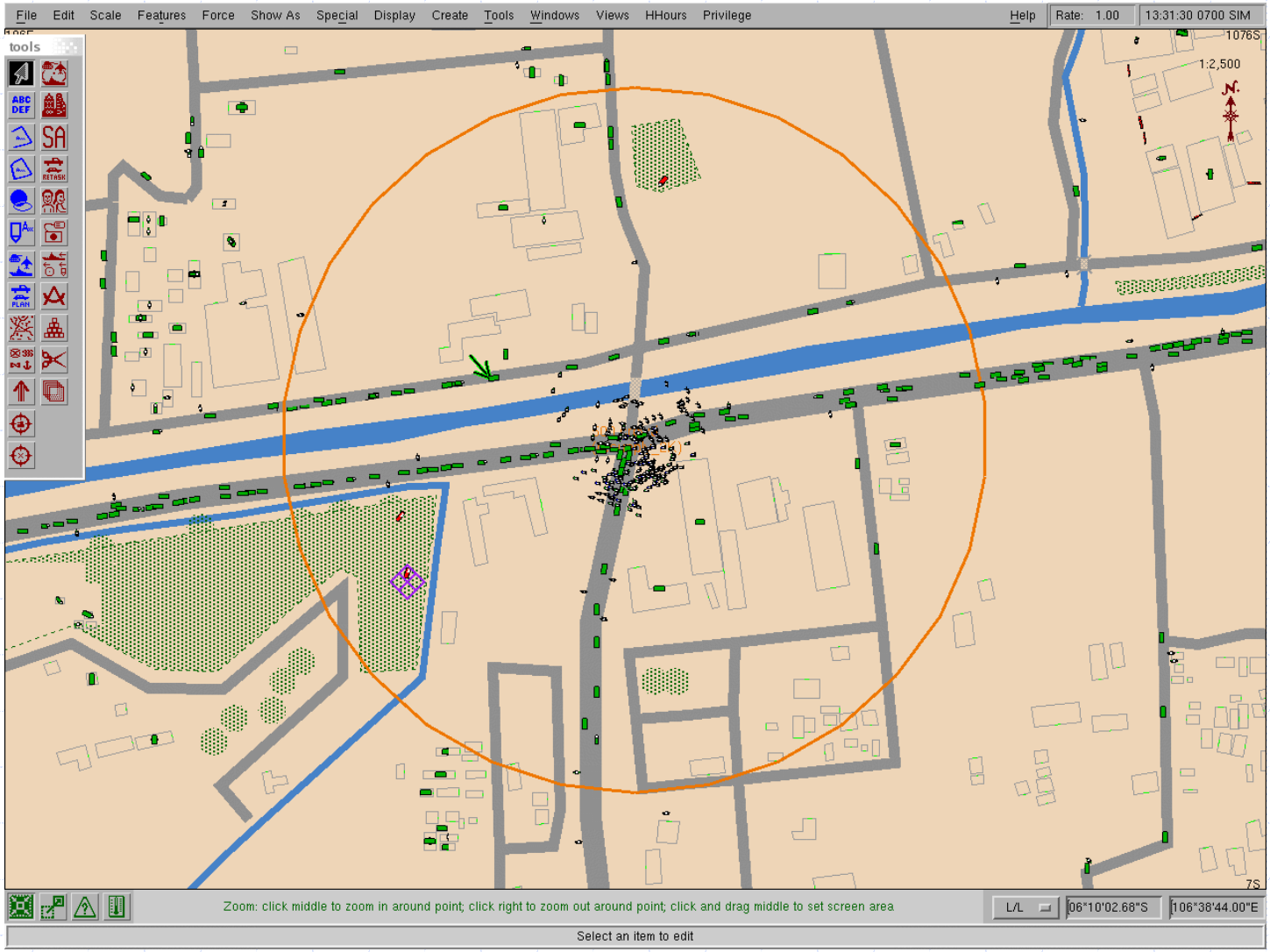


Many codes are not well designed to take advantage of multiple processors, especially > 32.

The red line is not apocryphal, with many parallel codes “falling over” at 16 or so nodes.

The blue line has been achieved by JESPP routers up to at least 1,500 CPUs.

A Plan View Display

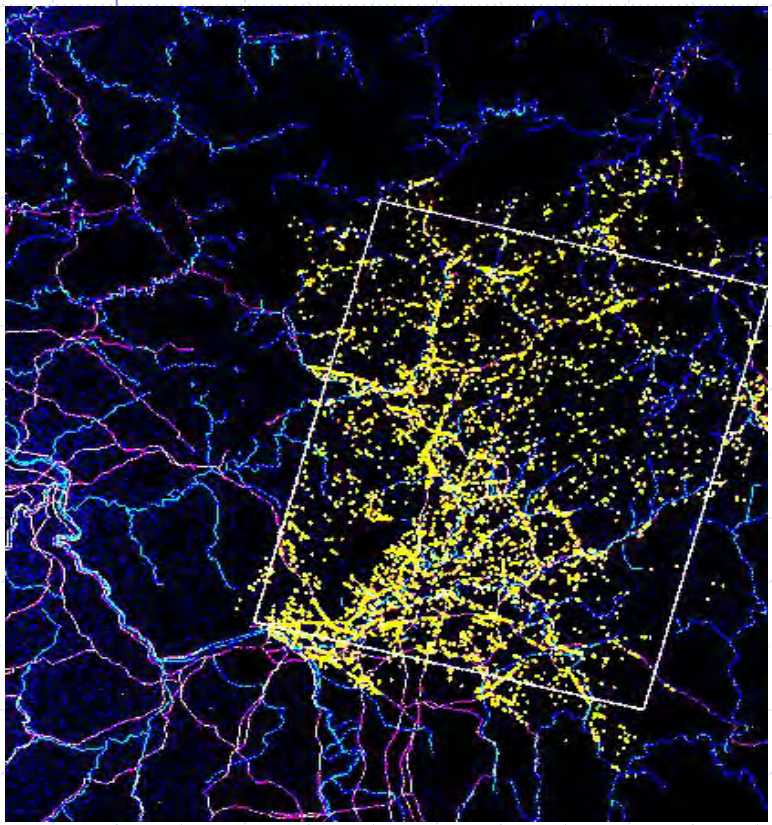


An Example of Non-scalability

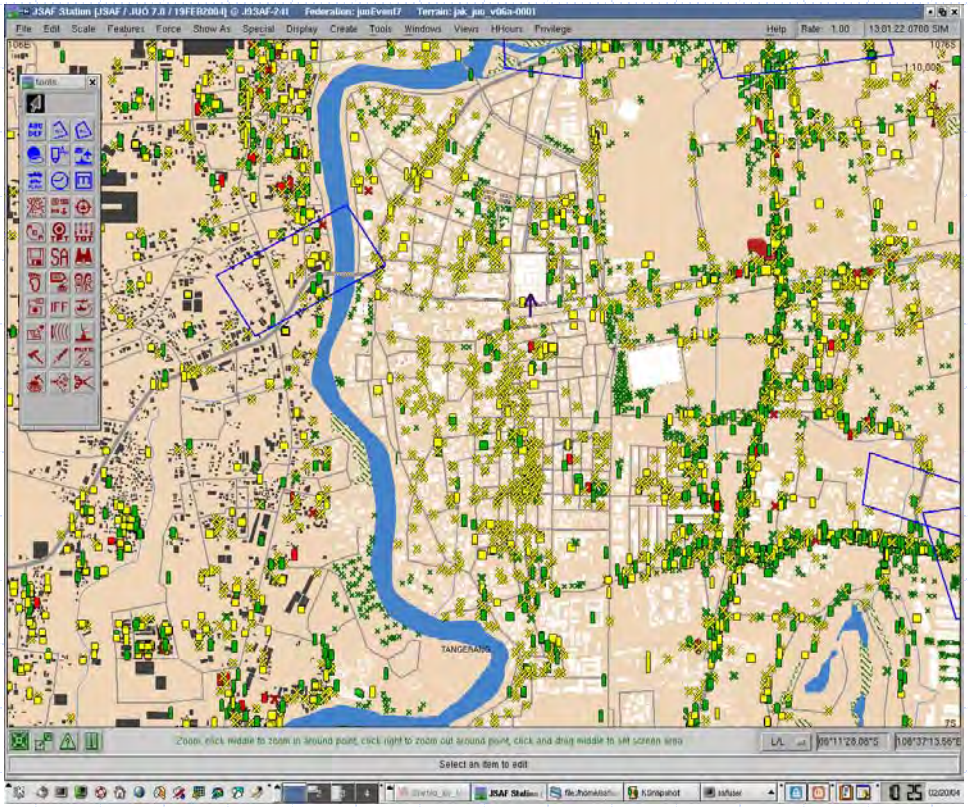
- The SAF family of simulations
- STOW and workstations on a LAN
- The SF Express Project
- Challenges
- Achievements
- Impact

SLAMEM Sensor Federate

Provides Platforms & Sensors for HITL and Constructive Trials



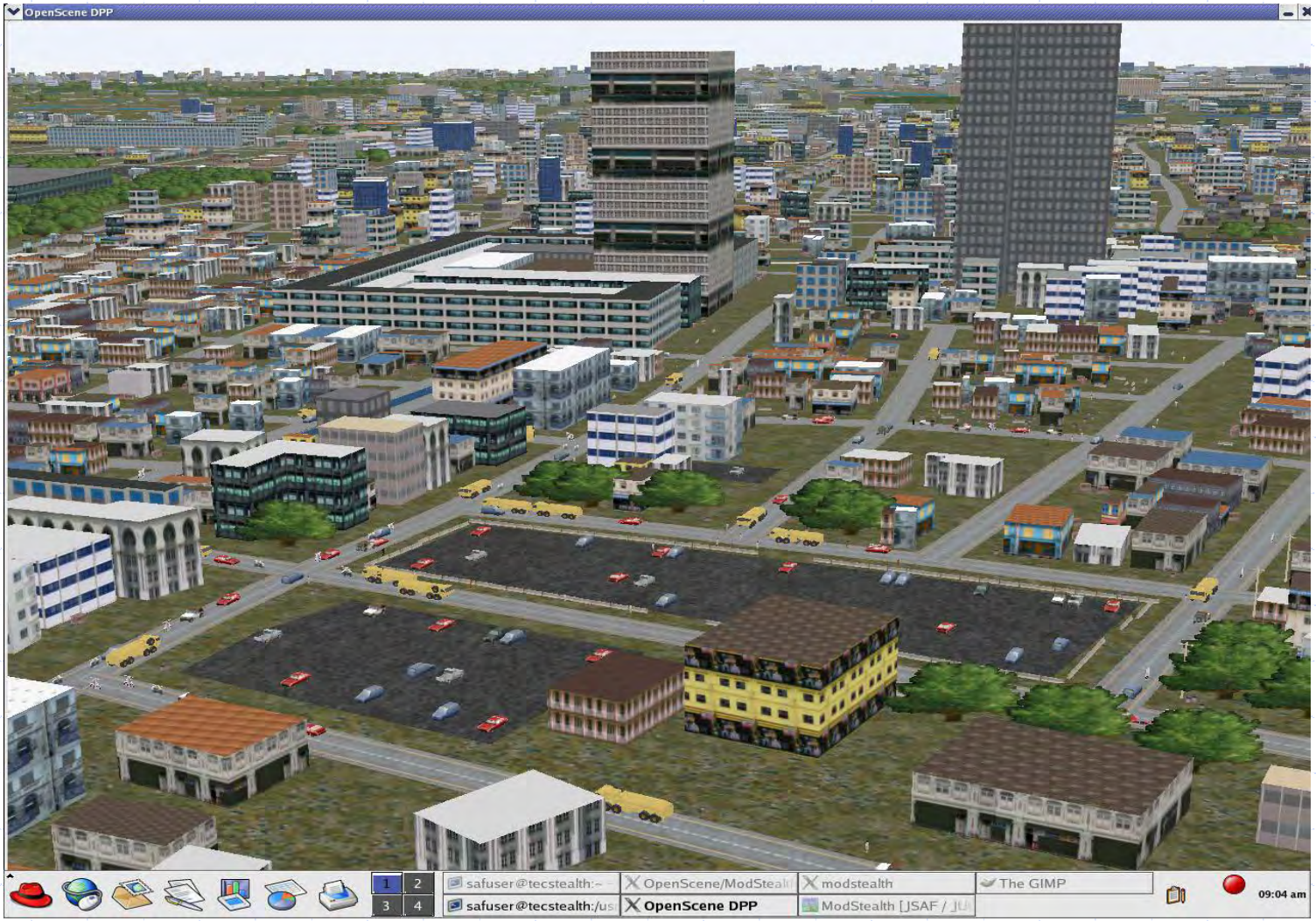
JSTARS



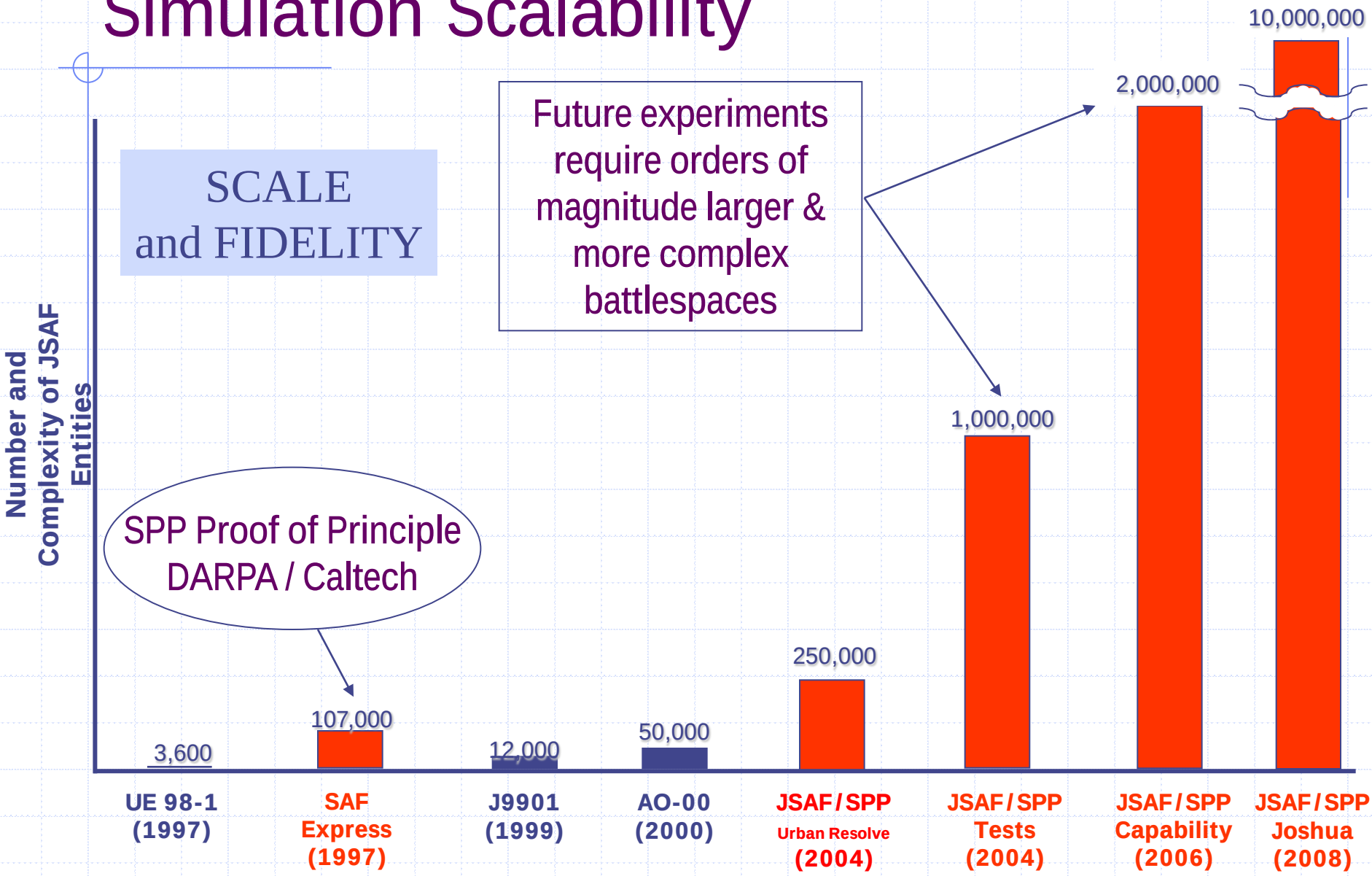
JSAF PVD

Urban Setting for Experiments

How to fight an asymmetric enemy in 2015



Growing Need for Simulation Scalability



Joint Experimentation Goals

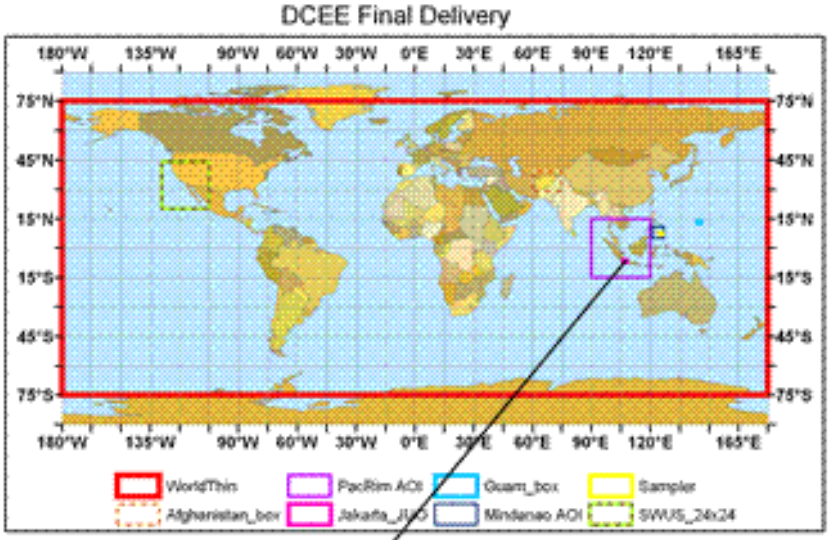
- Joint Experimentation
  - Develop/experiment with joint concepts
  - Look at future joint warfighting
  - Analyze joint training and solutions
  - Improve joint forces' capabilities to warfighters
- JUO and HITL
  - Joint Urban Operations
  - Human in the Loop

“Stealth” View of Clutter Crowd

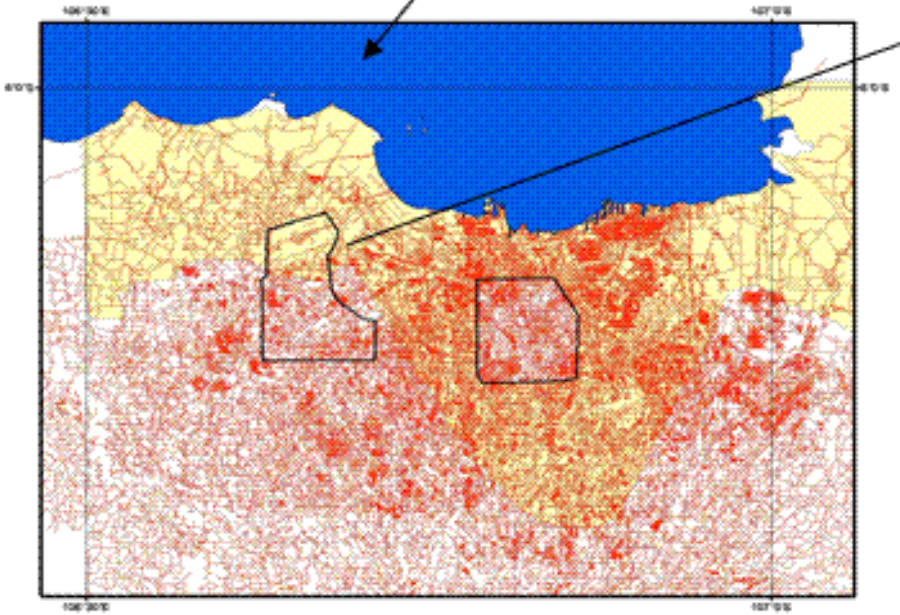
What the DoD Needs

- Global-scale terrain
  - DTED – Level 1 for entire globe
  - Detailed inserts
- Higher resolution
  - More entities
  - Better behaviors
- Requires dramatic increase over the computing power previously available to JFCOM via LANs

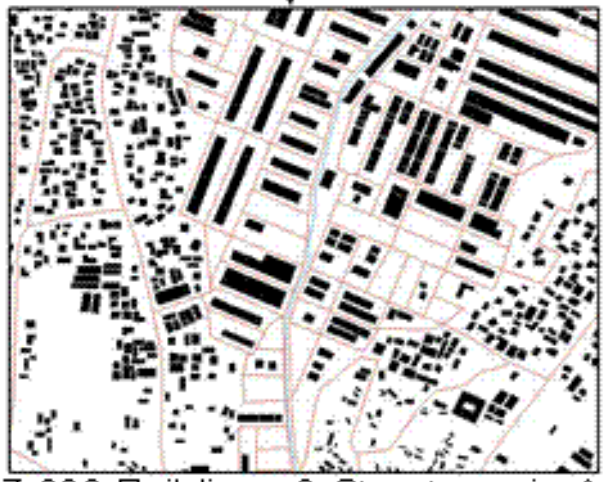
Multi-Resolution Synthetic Environment



• Geo-Specific Terrain in Western AOI

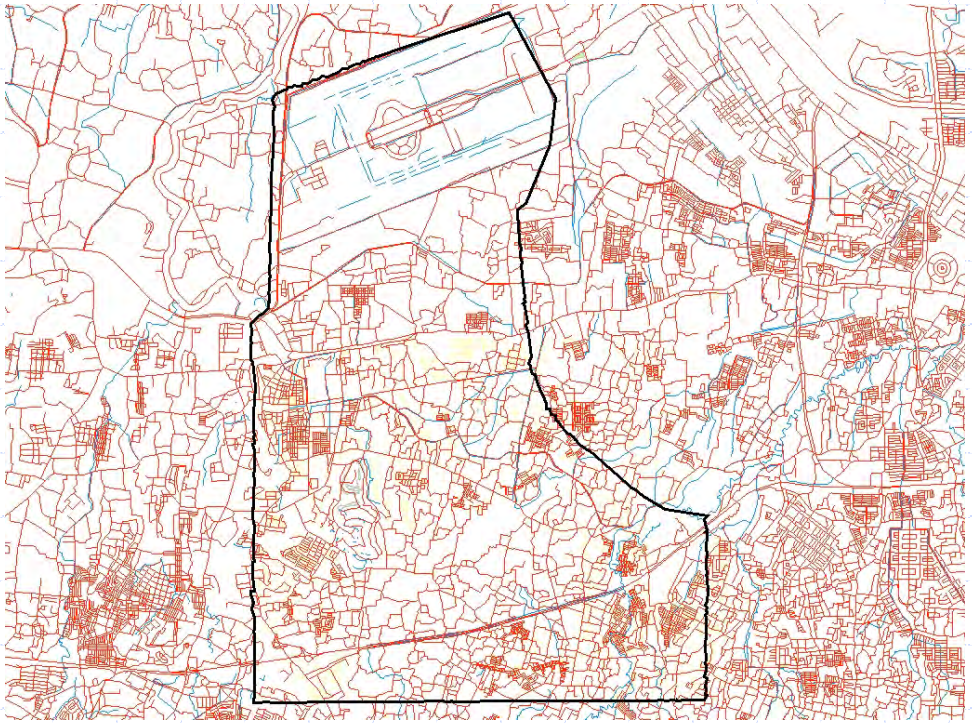


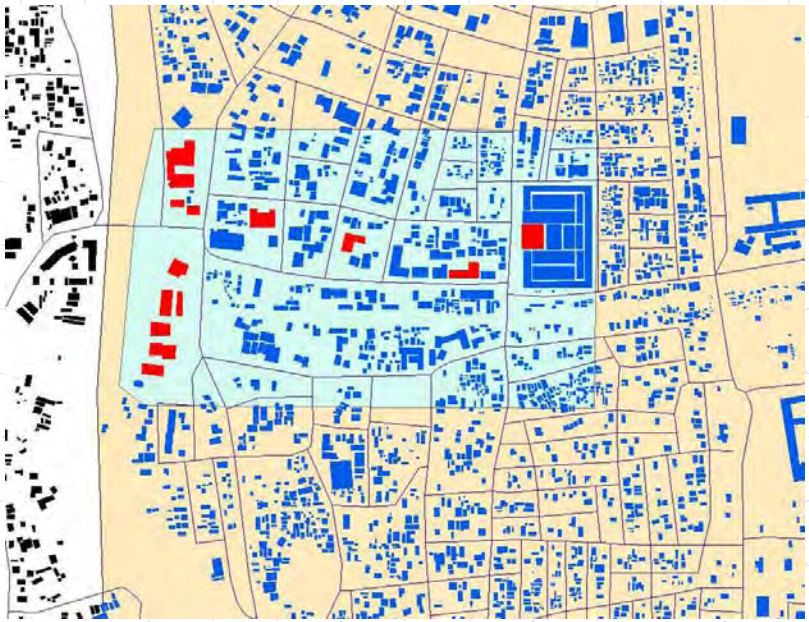
•1.8 million Buildings & Structures



•47,000 Buildings & Structures in AOI

BFC_	Count	VALUE
12	1	Police Station
37	1	Fire Station
35	2	Post Office
46	2	Transportation
83	3	Power Generation
84	4	Filtration Plant
129	10	Airport Terminal
29	16	Aircraft Maintenance Shop
45	20	Industrial
51	25	Market
118	25	Community Centre
30	27	Hangar
43	30	Communication
98	48	Shed
114	54	Non-Christian Place of Worship
61	58	Courthouse
54	61	Service / Refueling Station
128	66	Library
53	165	Bank
95	212	Hotel
7	325	House of Worship
5	352	Government Administration Building
101	355	Municipal Hall
9	373	Museum
21	386	Garage
15	427	School
1	436	Fabrication Structures
127	453	Theater
122	456	Shopping Centre
60	628	University / College
24	689	Warehouse
6	715	Hospital
28	772	Administration Building
42	809	Institution
116	815	Factory
133	1126	Commercial Building
2	1484	Government Building
57	1626	Restaurant
17	4232	Multi Unit Dwelling
47	4504	Commercial / Recreational
16	24015	House
	45808	TOTAL





Clusters in Maui and Ohio

MHPCC

ASC MSRC

Technical Successes

- 1 Million Entities
  - Clutter and operational
  - December, 2002
- Consistent and stable service schedule
- See I/ITSEC & WinterSim Papers by:
  - R.F. Lucas and D.M.Davis
  - T.D. Gottschalk B. Barrett and P. Amburn
  - W. Helfinstine *et al.*
  - Tran, Yao and Curiel
  - *et alii*

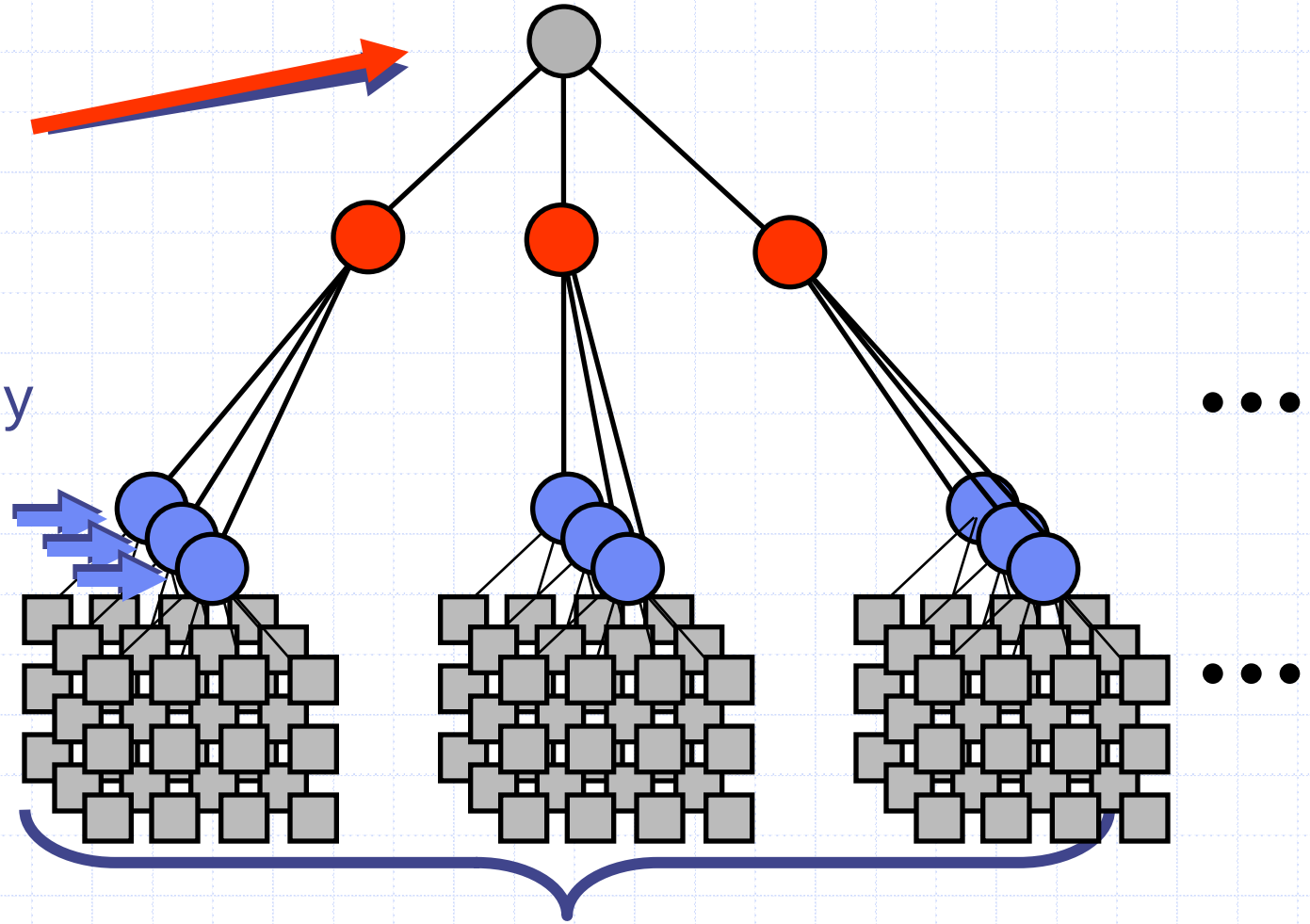
Urban = Lots of People

- Realistic Urban “clutter”: Civilian vehicles, people, ...
  - Demonstrators, protestors, men, women, children, ...
  - Life-like human characters respond to real-time simulated scenarios in high-resolution environment
  - Move realistically, respond to simple commands,
  - Demographically correct, move in environment as directed
  - Respond to real-time commands to change activity

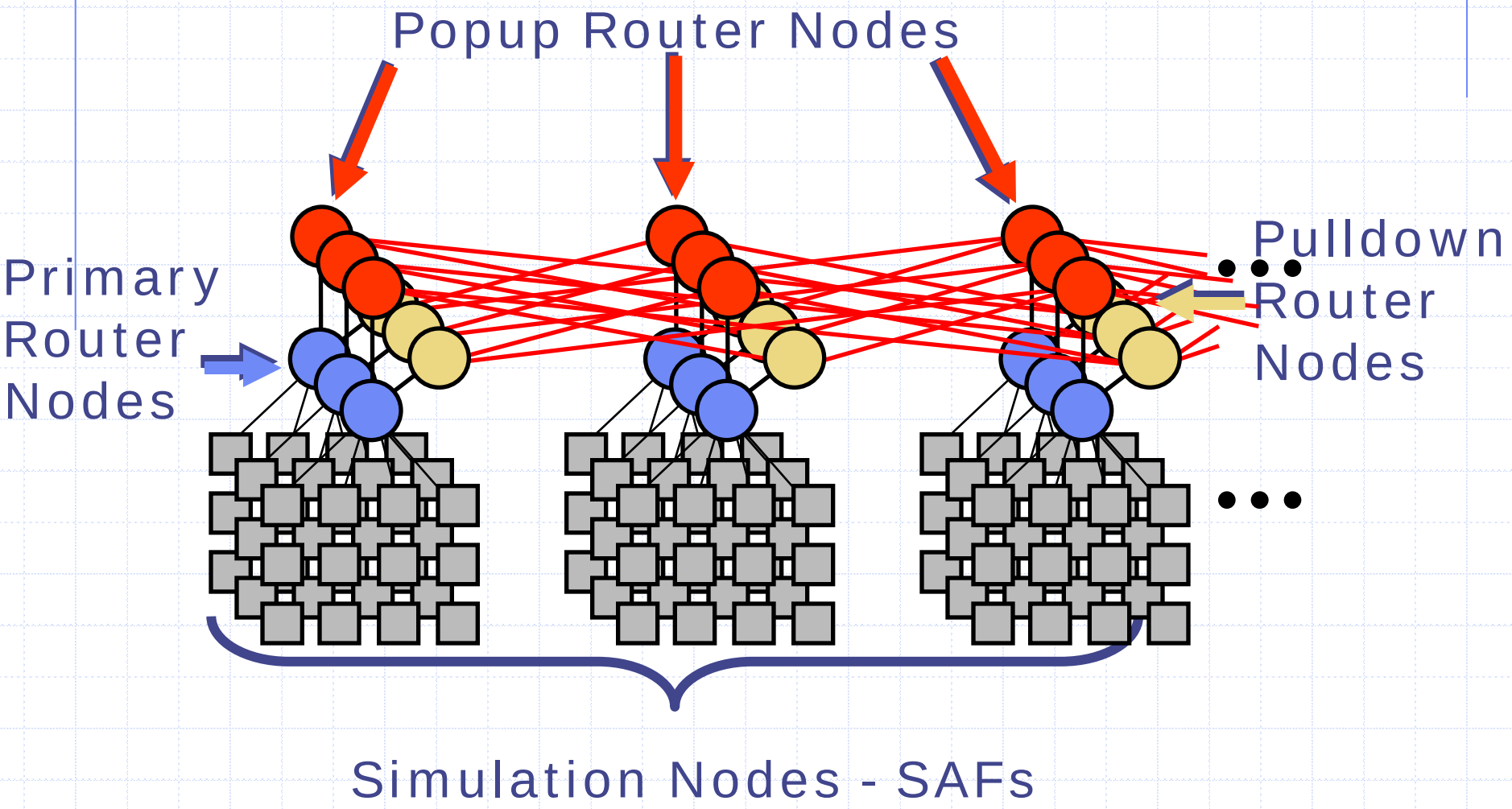
An Example of a Cluster Facility

- Deployed, spring ‘04
  - 2 Linux Clusters
  - 24x7support by HPCMP
- DREN Connectivity
  - Users in VA and CA
  - Application tolerates network latency
- Real-time interactive supercomputing

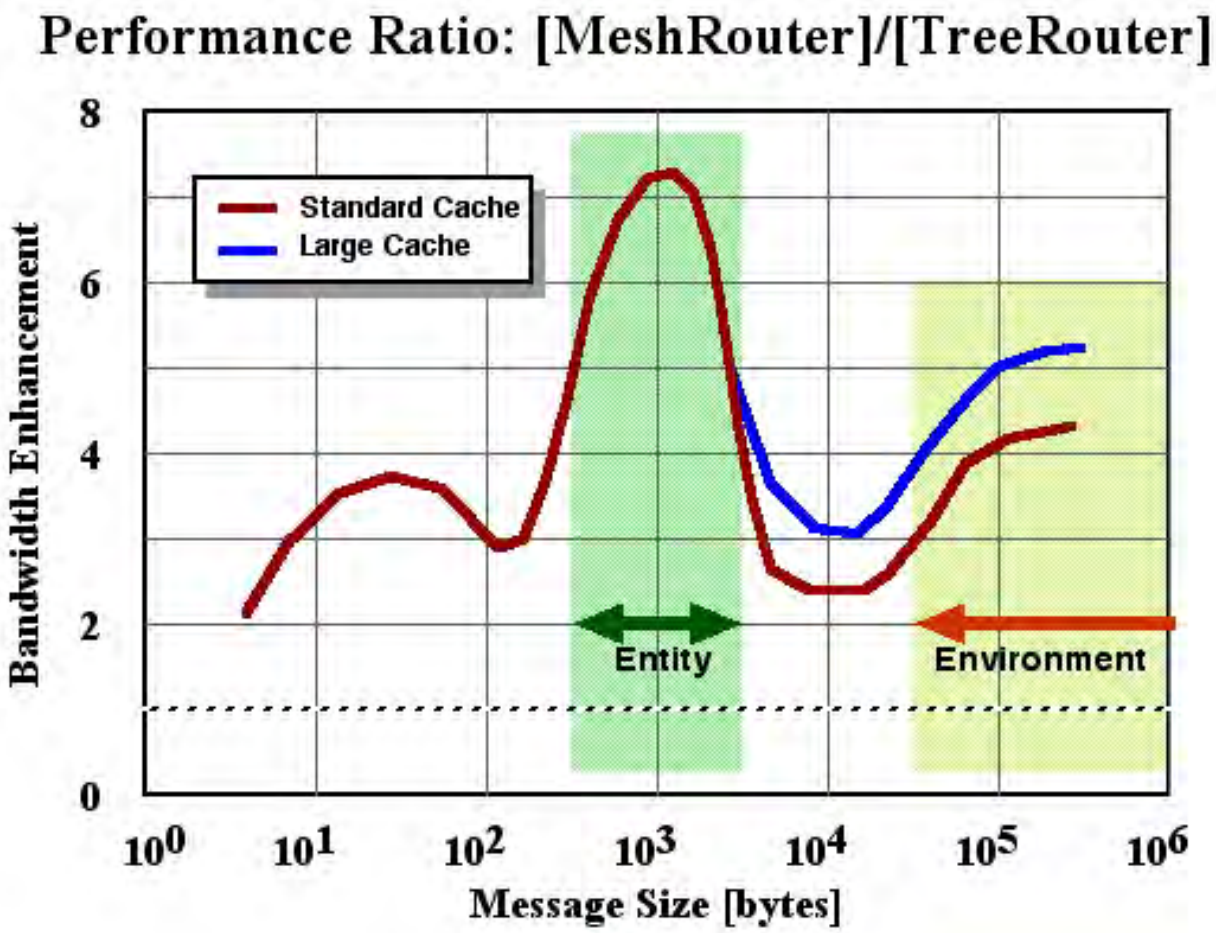
Tree Router Design



Scalable Mesh Router Design



Scalability in Router Program



Data Logging and Analysis

- High Performance Data Logging
  - High Performance computing produces
    - More data than can be easily handled
    - Capability to employ better data techniques
  - Enables new techniques
  - Need input from OR and DB communities
- See Papers by Graebener, Yao *et al.*
- Early experience

GPU Feasibility Experiment

- DARPA IPTO PCA project
- Characterize Line-Of-Sight bottleneck in Urban Resolve
- Can Graphics Processors alleviate bottleneck?
  - Leverage UNC work with Army's oneSAF
  - Research underway with latest generation GPUs

Summary

- New capabilities proved effective with JESPP
  - High performance computing
  - Linux Clusters
- While not daunting, they were best used:
  - Under the watchful eye of parallel architect
  - When supported by experienced staff
- Assistance is readily available
  - Hardware technology is NOT exotic
  - Software techniques are NOT opaque

Papers at: http://www.hpc-educ.org/JESPP/JESPP_Papers.html