USC Viterbi
School of Engineering

Commodity Cluster Symposium

Scoping, Specifying and Satisfying the Need for Large-Scale Distributed Data Management

Computational Sciences

ISI Information Sciences Institute

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Overview

Review Joint Experimentation

Scoping the Data

Specifying the Data

Managing the Data

Joint Experimentation Data Requirements

Larger Scale

- Global scale vs. theatre

Higher Fidelity

- Greater complexity in models of entities (sensors, people, vehicles, etc.)

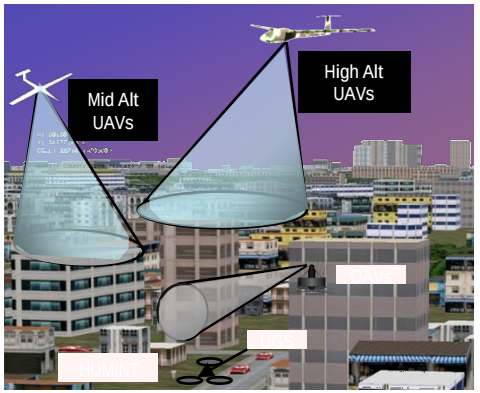
Urban Operations

- Millions of civilians

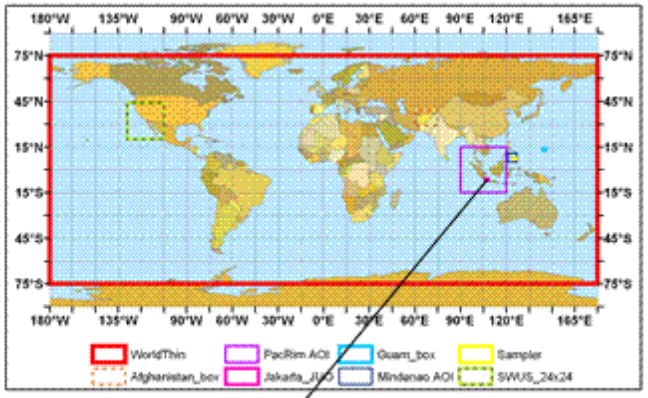
All of the above produce dramatic increases in data relative to the previously experienced events.

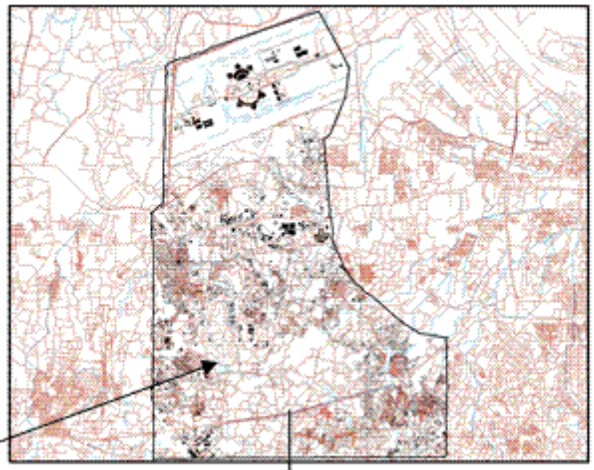
Joint Urban Operations: Urban Resolve Experiments

- Data needs driven by the
  - Joint Advanced
  - Warfighting Project (JAWP)
    - Large urban battle space
    - 100-200K entities (current)
    - 2 million entities (soon)
- Support for the Warfighters
  - Developing future military tactics and doctrine

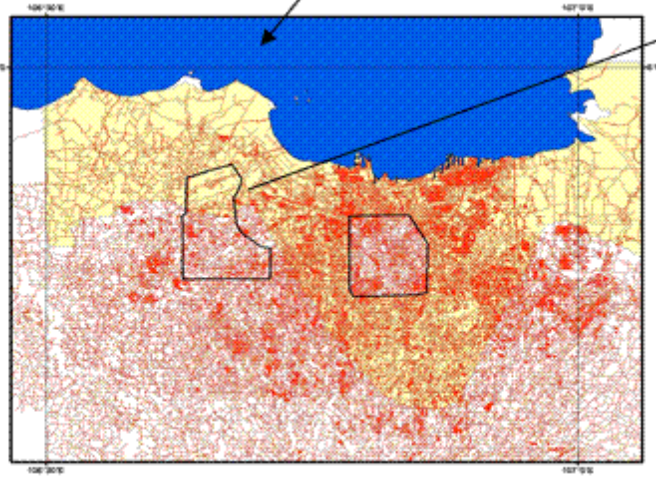


Terrain Large, but NOT Significant Data Issue





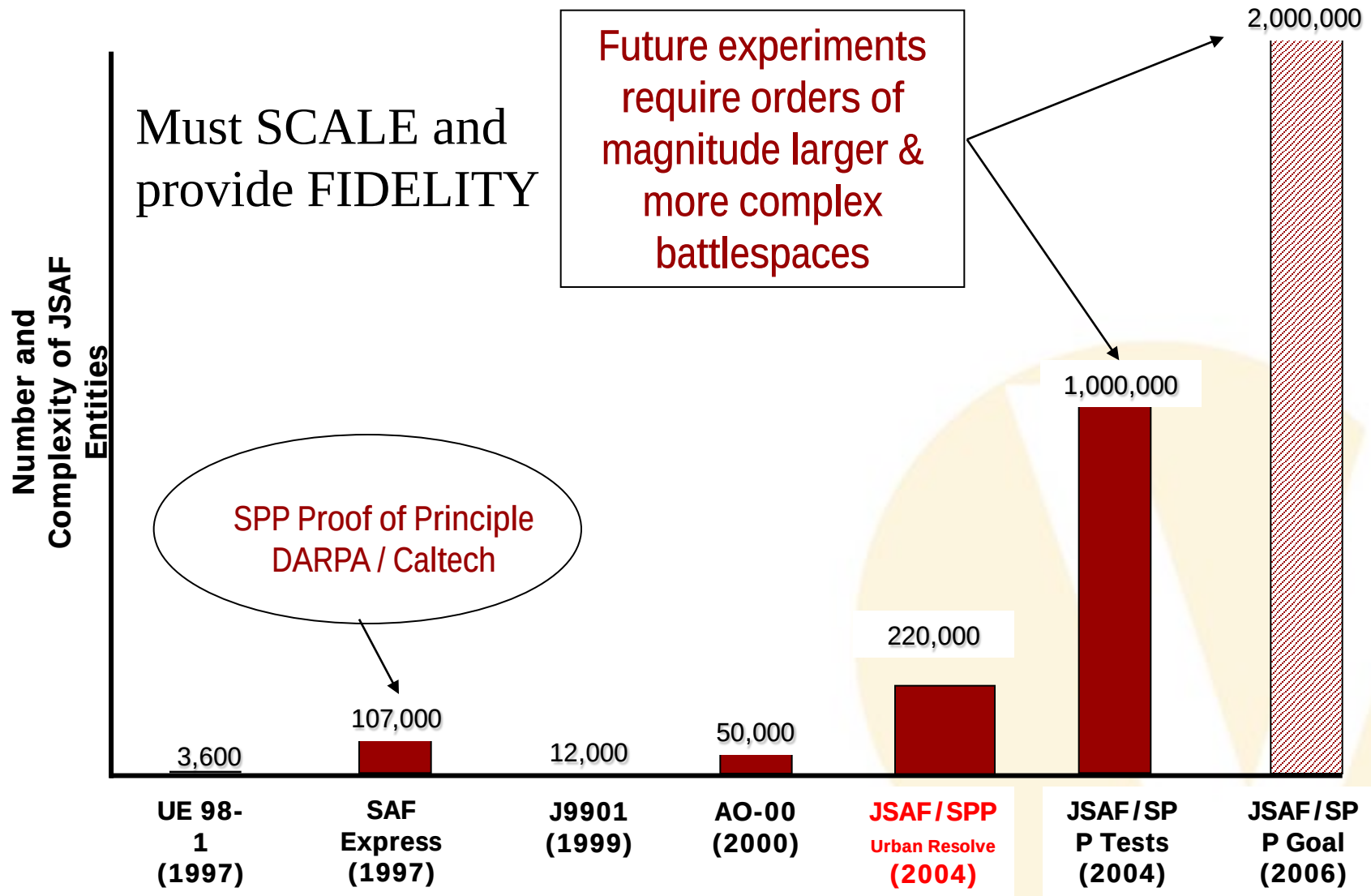
• Geo-Specific Terrain in Western AOI



•1.8 million Buildings & Structures

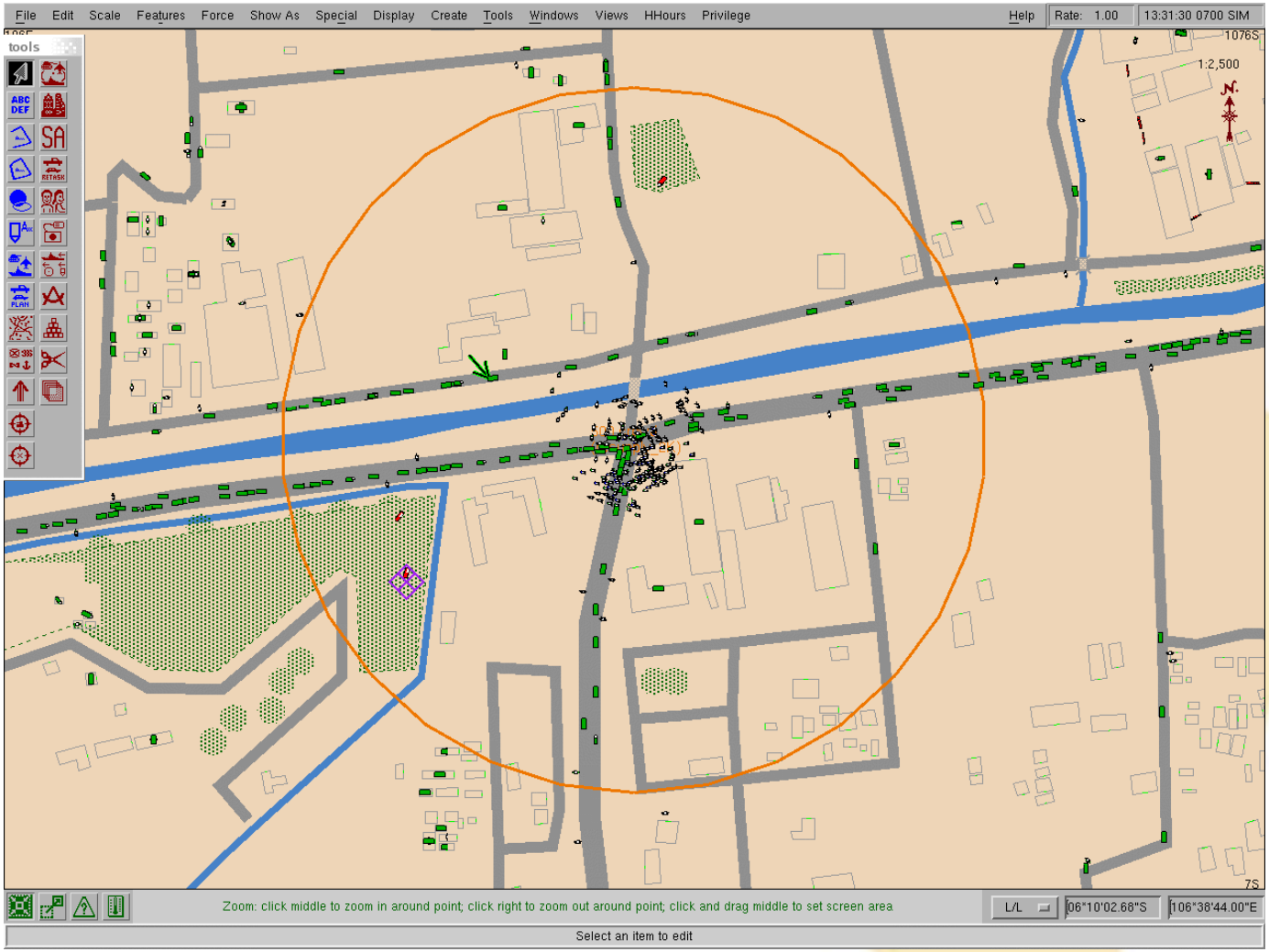
•47,000 Buildings & Structures in AOI

Growing Entity Count



3D Stealth View

Plan View Display

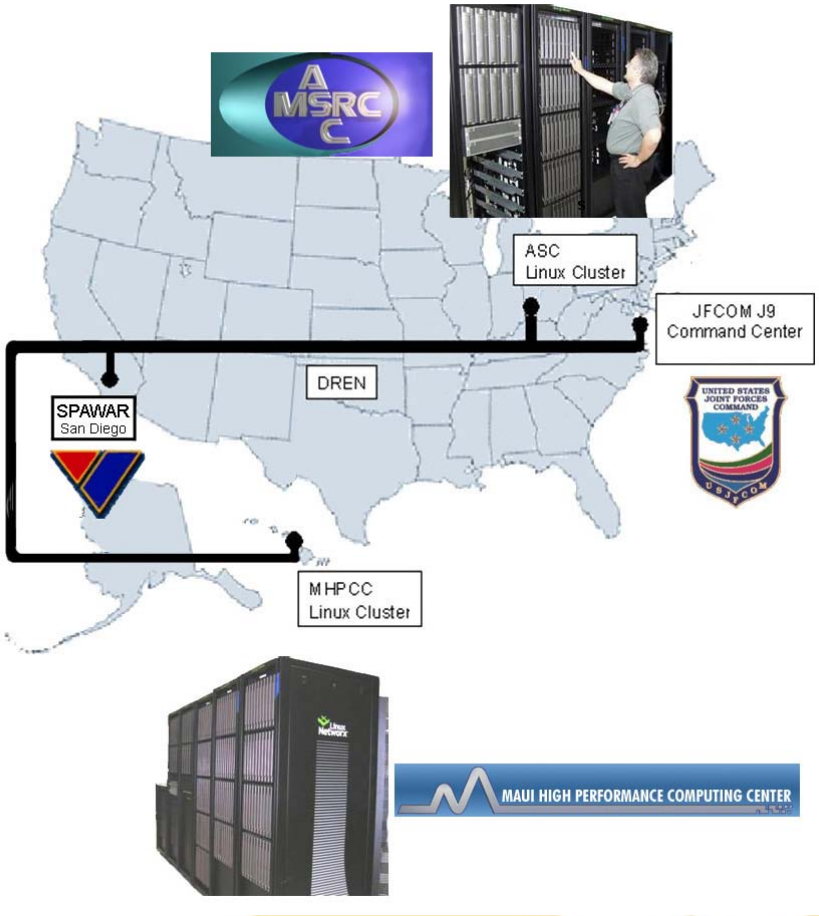


Technical Successes

- 1 Million Entities
  - Clutter and operational
  - December, 2002
- Consistent and stable service scheduled and delivered
- Using DREN, both Classified and Unclass
- Technology adopted by CENTCOM
  - Fielded to Baghdad
- JSAF Experiments Demonstrated to:
  - Reps. Ford, Thornberry, and Forbes
  - Former Speaker Newt Gingrich
  - Sen Hillary Clinton
  - Gen Abizaid
  - DDR&E
  - DDS&T

Computing Infrastructure

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



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JFCOM Net Diagram (Notional)

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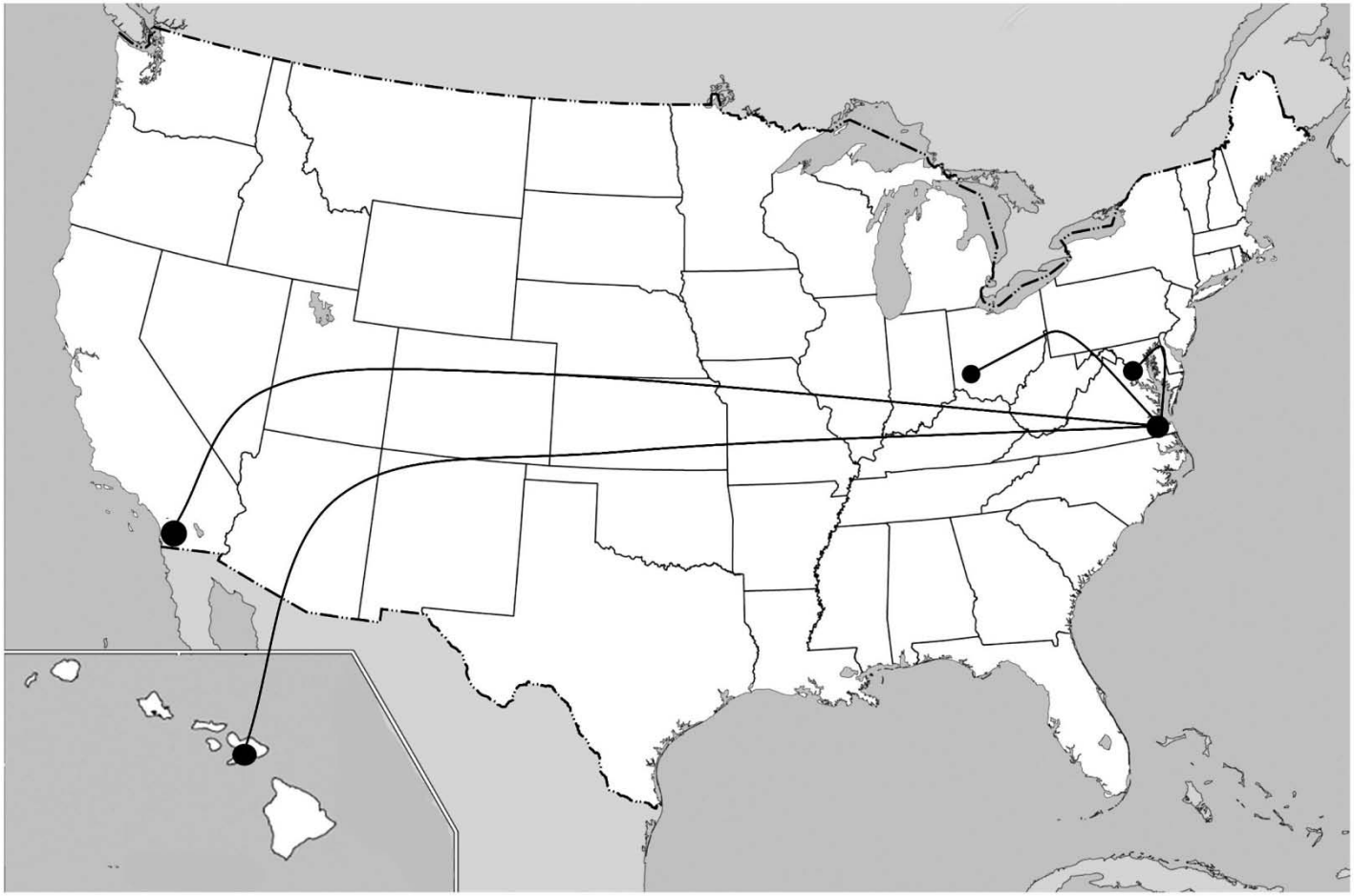

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JFCOM Mesh Diagram (Notional)

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Urban Resolve Participants

JFCOM – Suffolk Virginia (Tidewater Area)
TEC – Ft. Belvoir Virginia
DTRA – Ft. Belvoir Virginia
SPAWAR – San Diego California
US Army – Ft. Knox, Kentucky
US Army – Ft. Leavenworth Kansas

ASC MSRC – WPAFB, Ohio
MHPCC – Maui Hawai'i

Growth and the Impending Data Armageddon

- JFCOM has IMMEDIATE need for more entities (10X)
- Memory on Nodes and in Tertiary Storage very limited
  - TeraByte a week with existing practice
  - Keeping only 20% of current data
  - Need 10X more entities
  - Need 10X behavior improvement
  - Net growth needed: almost three orders of magnitude
- Now doing face validity
- Need more quantitative, statistical approach
  - Caltech – Dr. Thomas Gottschalk
  - NPS – Profs Sanchez and Lucas
- Data mining efforts now commencing

Two Key Challenges

- Collect the “fire hoses” of data generated by large-scale distributed sensor rich environments
  - Without interfering with communication
  - Without interfering with simulator performance
- Maximally exploit the collected data efficiently
  - Without overwhelming users
  - Without losing critical content
- Goal:
  - Unified distributed logging/analysis infrastructure, helps users and the computing/networking infrastructure managers

Limitation of the Original System – Does not scale

- **Two separate data analysis systems**
  - **One for near-real time during the event**
  - **Another one for post event processing**
- **For near-real time**
  - **Too much data access over wide-area network**
- **For post event processing**
  - **1-2 weeks to stage data to centralized data store**
  - **Discards Green entities (80%)**

Handling Dynamic Data

Data is NOT static during runs, but users need to access
- Logger continuously inserts new data from the simulation

Need distributed query to combine remote data sources
- Distributed logger inserts data into SDG data store at each site

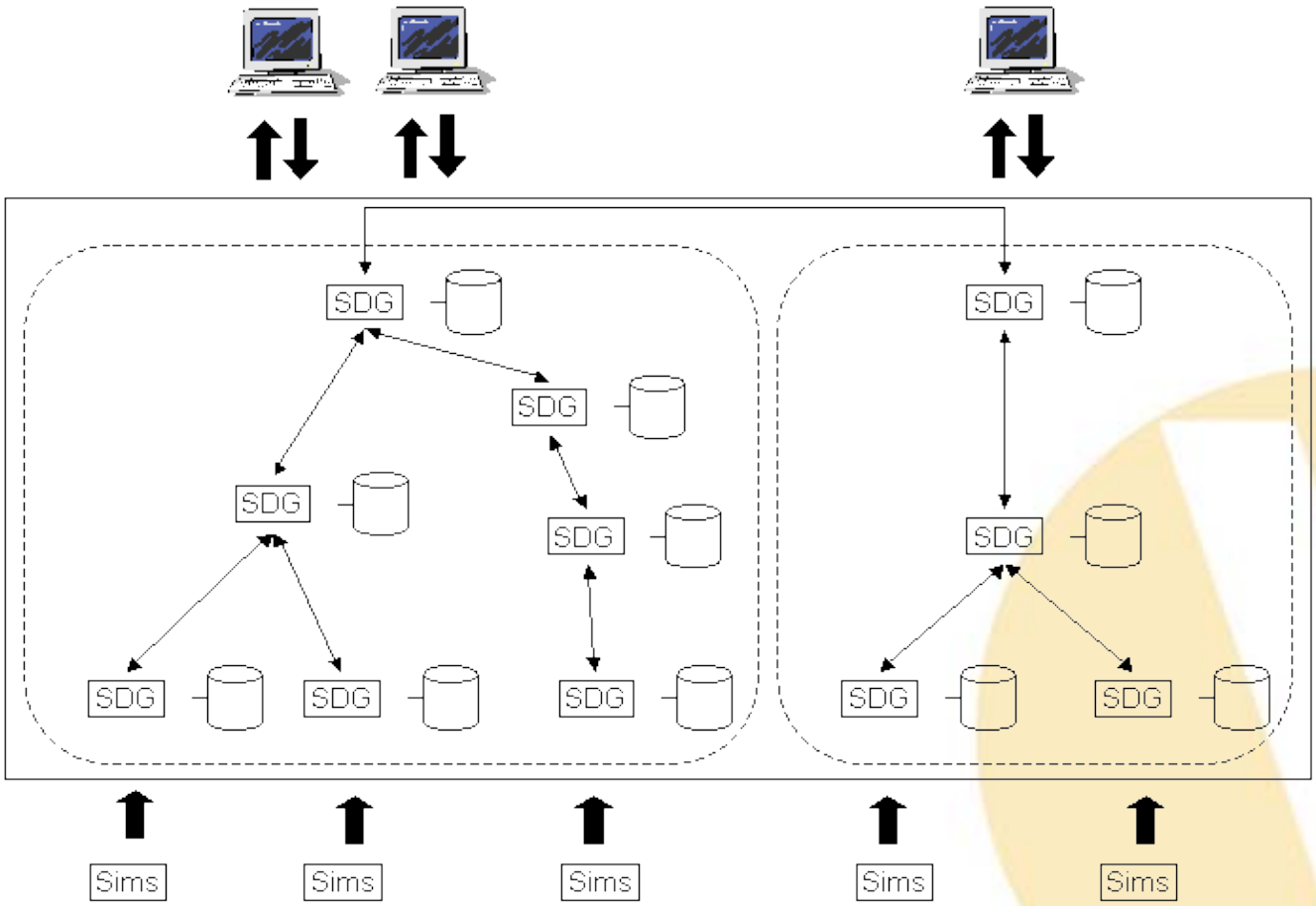
Problems
- Local cache invalid with respect to inserts
- Cannot preposition data to optimize queries

ISI Strategy: explore trade-offs
- Compute on demand for better efficiency
- Compute on insert for faster queries
- Variable fidelity: periodic updates
- Dynamic pre-computation:
  - detect frequent queries

Handling Distributed Data

- Analyze data in place
  - Data is generated on distributed nodes
  - Leave data where it is generated
- Distribute data access so data appears to be at a single site
- Take advantage of HPC hardware capabilities
  - Large capacity data storage
  - High bandwidth network
  - Data archival
- Exploit JSAF query characteristics
  - Limited number of joins
  - Counting/aggregation type queries
  - Size of data product is several orders of magnitude less than raw data size

Notional Diagram of Scalable Data Grid



Multidimensional Analysis: Sensor/Target Scoreboard

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Aggregate(Top) Level

TARGETS / AGGREGATES	Civilian School Bus	Civilian SUV	Civilian Medium Car	Civilian Medium Truck	Civilian Small Car	Civilian Large Truck	Civilian Small Truck	Civilian Large Car	Civilian Bus	Civilian Limo	MEL	UAZ469B	BTR80	Total
High Altitude[1]	463	237	234	240	266	389	230	254	266	218	121	4	3	2925
Medium Altitude[1]	12	6	4	7	7	4	8	4	4	5	3	0	0	64
Totals	475	243	238	247	273	393	238	258	270	223	124	4	3	2989

- Summarizes sensor contact reports
  - Positive and negative sensor detections
- Displays two dimensional views of the data
- Provides three levels of drill-down
  - Sensor platform type vs. target class
  - Sensor platforms vs. sensor modes
  - List of contact reports

Platform/Mode Level

TARGET TYPE	MEL			
MODE(S) / PLATFORM	SPOT_IR	STRIP_IR	MTI	Total
30 Lacrosse*	20	63	0	83
38 Lacrosse*	0	0	27	27
47 Lacrosse*	0	0	11	11
Total	20	63	38	121

Sensor Mode(s): **SPOT_IR** STRIP_IR **MTI**

Multidimensional Analysis

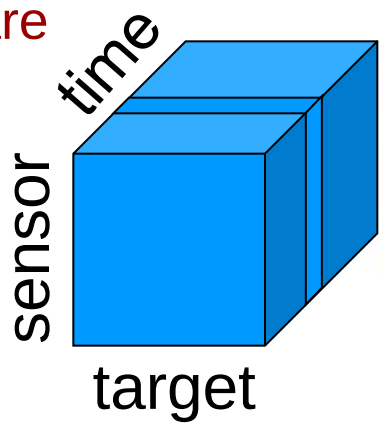
Raw data has other dimensions of potential interest

- Detection status
- Time, location
- Terrain type, entity density
- Weather condition

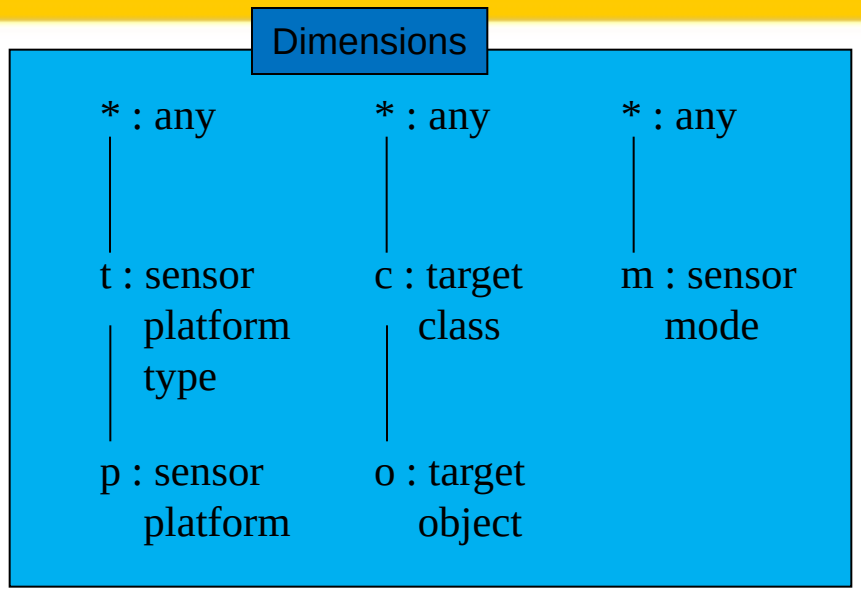
Each dimension can be aggregated at multiple levels

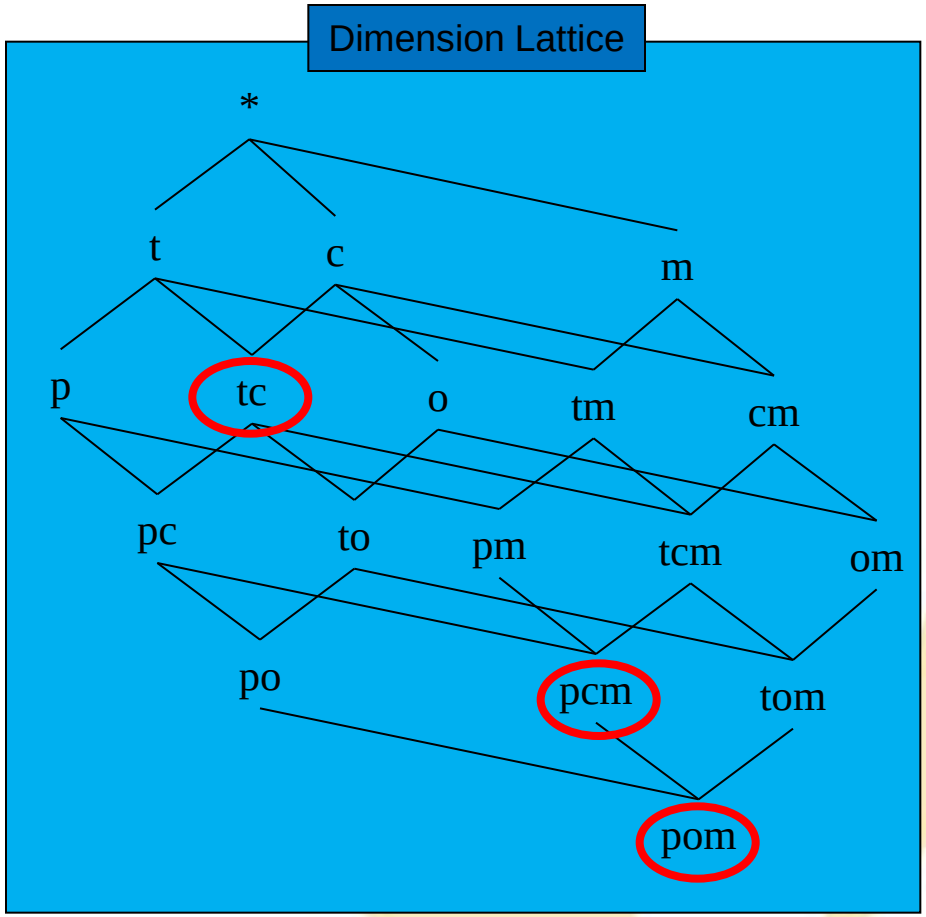
- Time: minutes, hours, days
- Location: country, grid square

Collapse and expand multiple dimensions for viewing



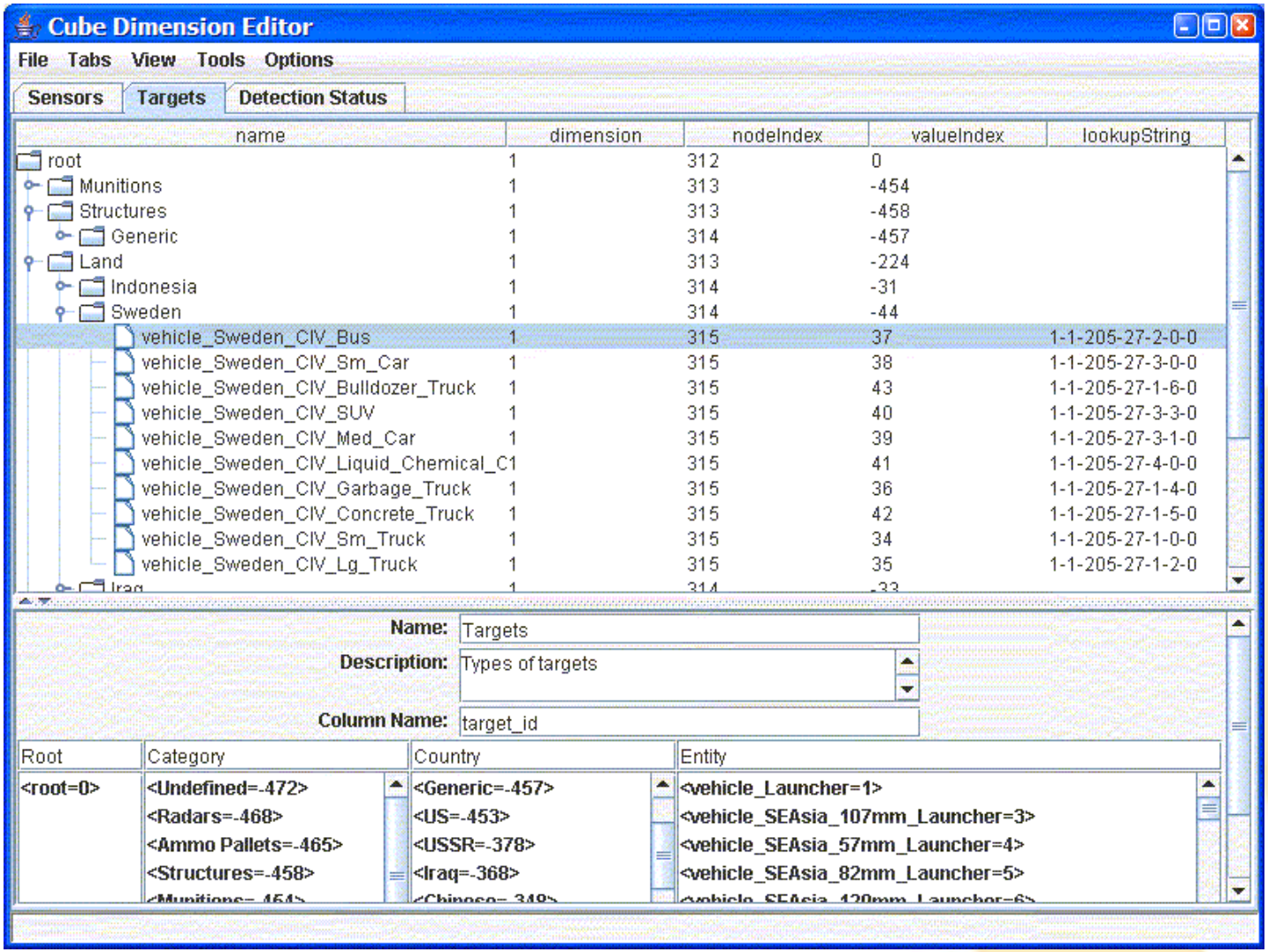
Multidimensional Analysis





- Sensor/Target Scoreboard drill-downs in the context multidimensional analysis
- Data classified along 3 dimensions
- Drill-down to 3 nodes in the dimensional lattice

Cube Dimension Editor



SDG: Broader Applicability?

- Scalable Data Grid: a distributed data management application/middleware that effectively:
  - Collects and stores high volumes of data at very high data rates from geographically distributed sources
  - Accesses, queries and analyzes the distributed data
  - Utilizes the distributed computing resources on HPC
  - Provides a multidimensional framework for viewing the data
- Potential application areas
  - Large scale distributed simulations
  - Instrumented live training exercises
  - High volume instrumented physics research and experiments
  - Virtually any distributed data environment using HPC resources

Summary

New capabilities for JFCOM Joint Experiments

- Global scale
- Higher fidelity
- Orders of magnitude more entities

They were the most effective due to:

- HPCMP provision of clusters at MHPCC and ASC-MSRC
- Development under the watchful eye of parallel architects
- Support by experienced staff at the centers
- Assistance of PET personnel (Pratt & Amburn)

"And now, a message from our sponsor."

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