

Human-Machine Efficiency

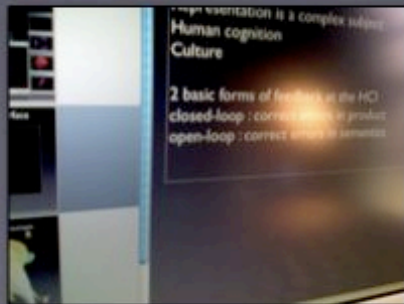
Over-Learned: **Feedback**

non-volitional feedback



haptic

volitional feedback



visual / aural

Human-Machine Efficiency

Over-Learned: **Feedback**

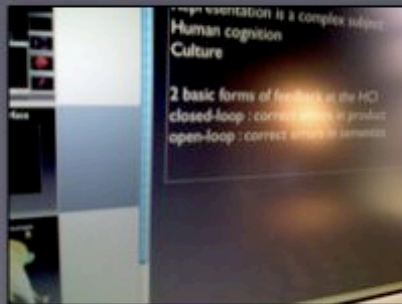
non-volitional feedback



correct errors in **production**

haptic

volitional feedback



visual / aural

Human-Machine Efficiency

Over-Learned: **Feedback**

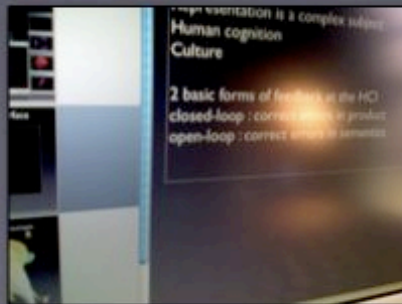
non-volitional feedback



haptic

} correct errors in **production**

volitional feedback



visual / aural

} correct errors in **semantics**

Human-Machine Efficiency

Over-Learned: **Feedback** - haptic vs visual/aural

Haptic Feedback

Visual / Aural Feedback

Sequential access



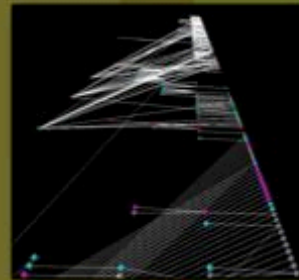
iFeel™



Sidewinder™
Force Feedback



Falcon™



joystick



mouse

Random access



keyboard



data/gesture glove



multi-touch



voice control

Human-Machine Efficiency

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Sequential access



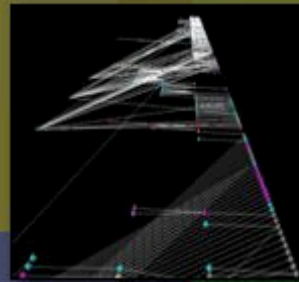
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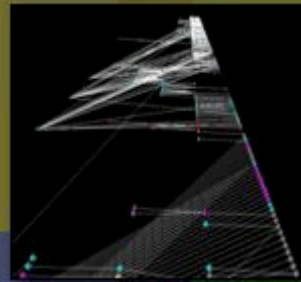
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joystick



mouse

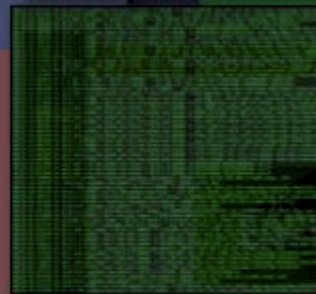
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voice control

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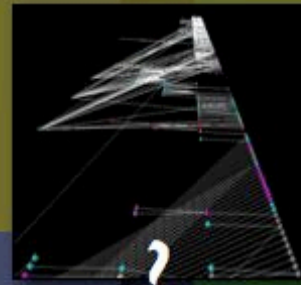
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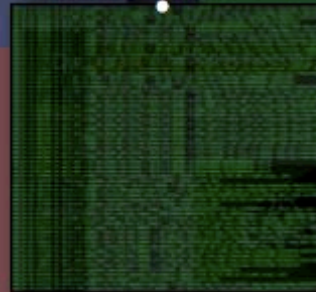
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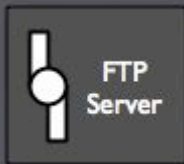


voice control

Human-Machine Efficiency

Under-Learned: **Representation**

arbitrary



PCAP

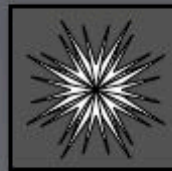
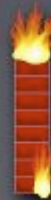
TXH 1138



association



metaphor



representational



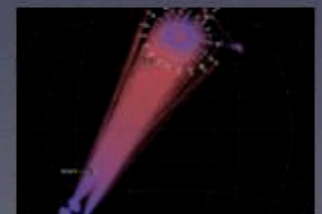
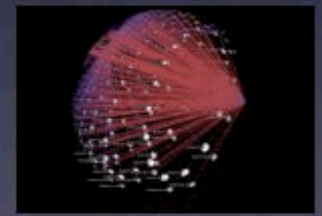
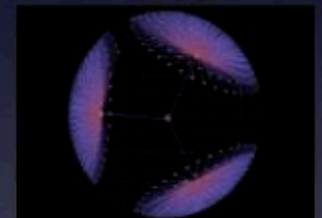
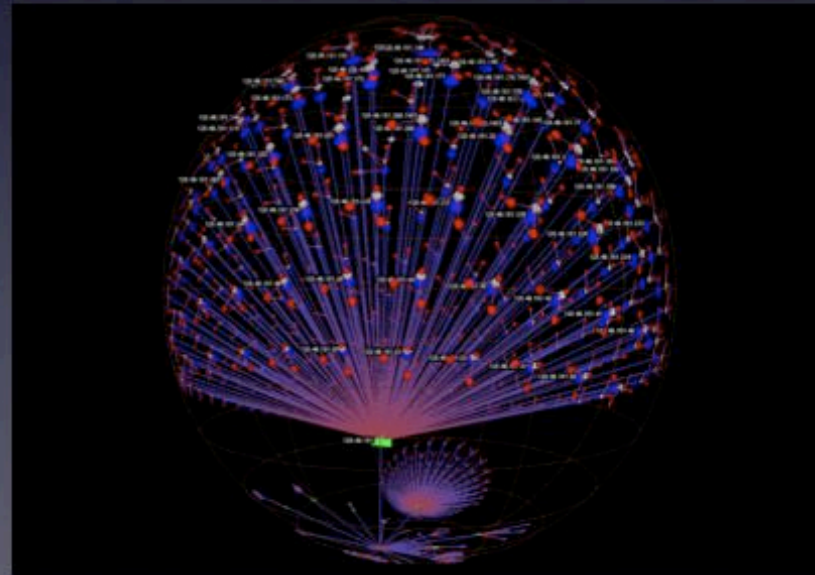
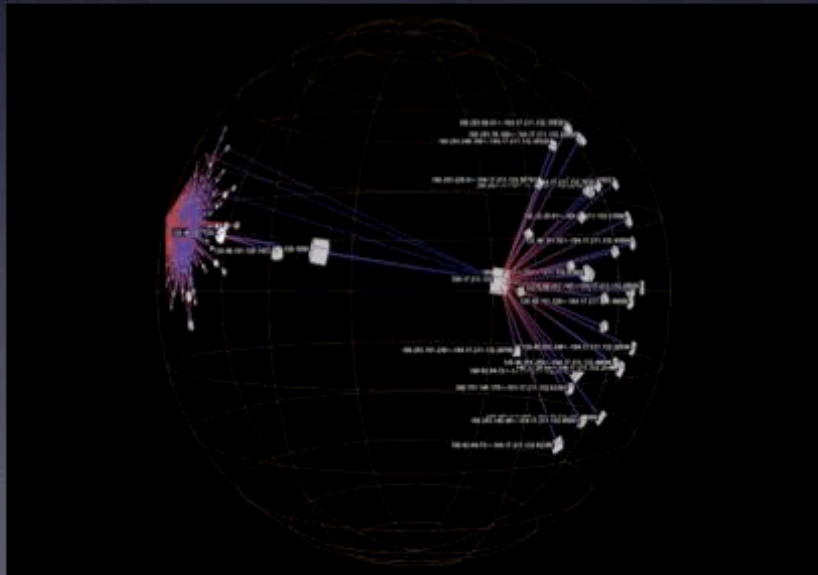
indexical



Culture/Domain Specificity

Flow in hyperbolic space

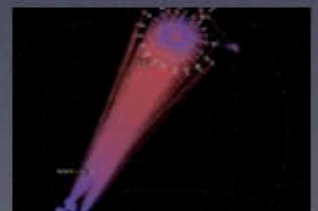
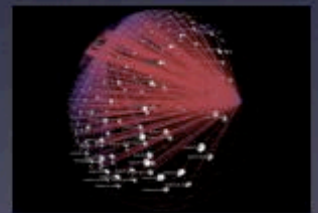
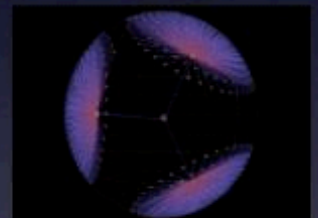
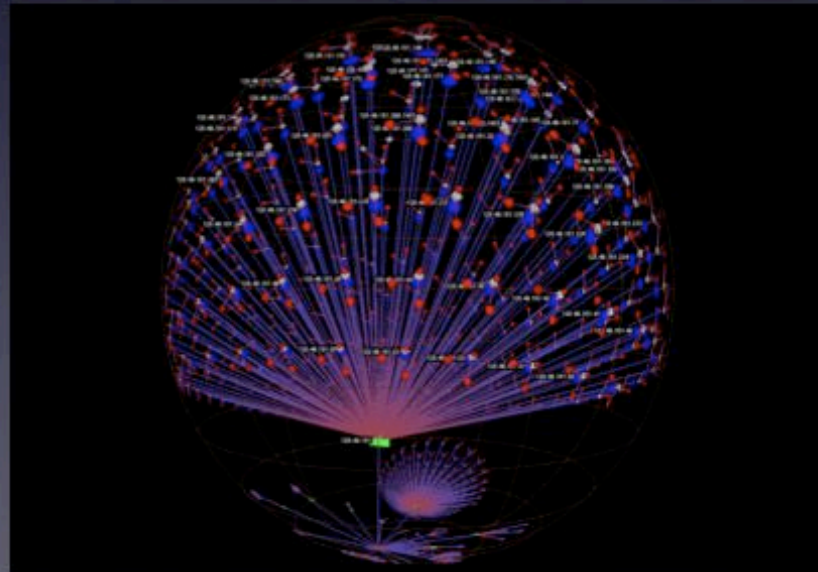
- 3 month SSC project in 2002
- discover and apply network visualization tools
- **Hyperviewer**: quasi-hierarchical hyperbolic space
- **'fish-eye'** 3-d
- Created by Stanford researcher **Tamara Munzner**

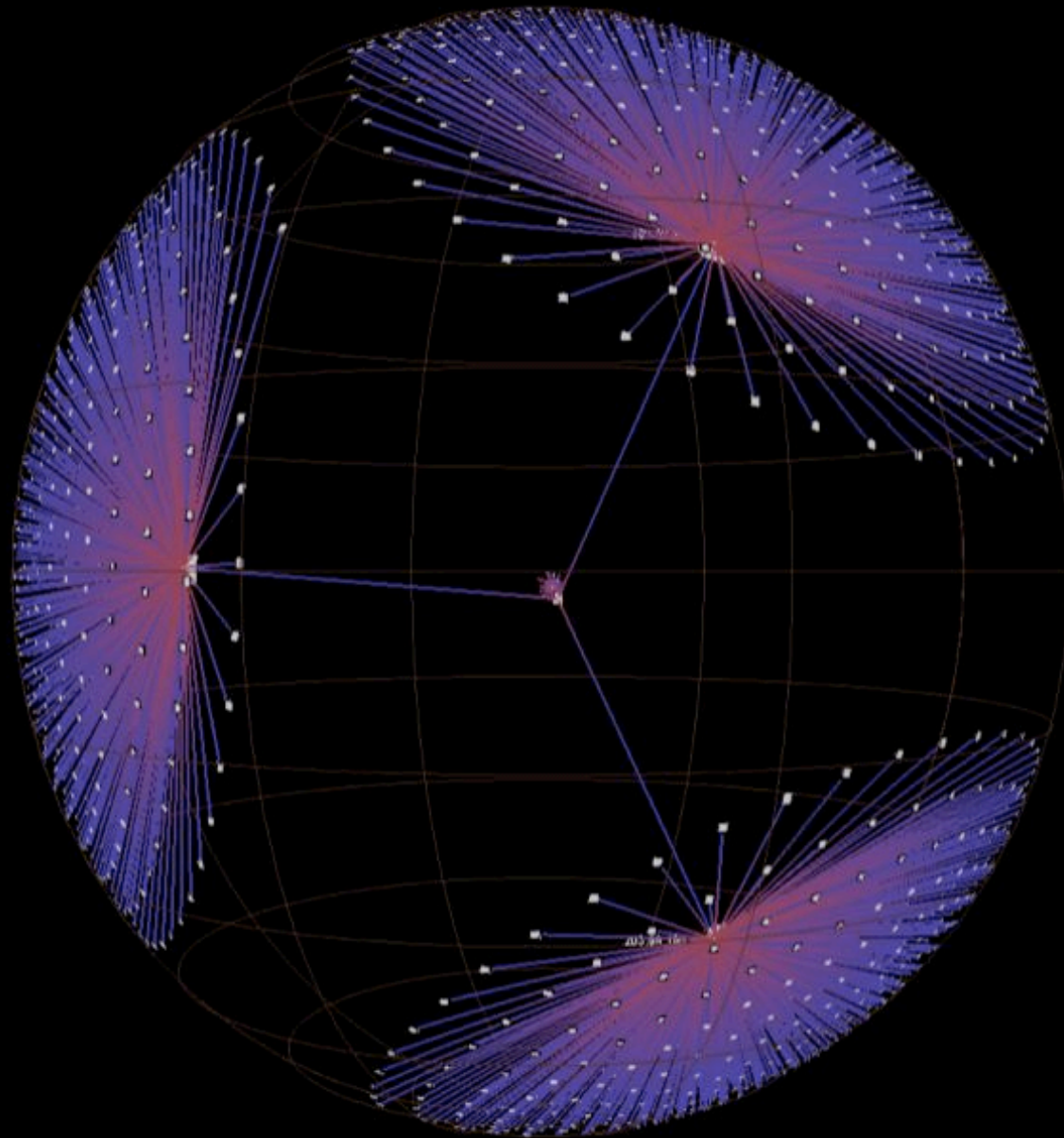


Flow in hyperbolic space

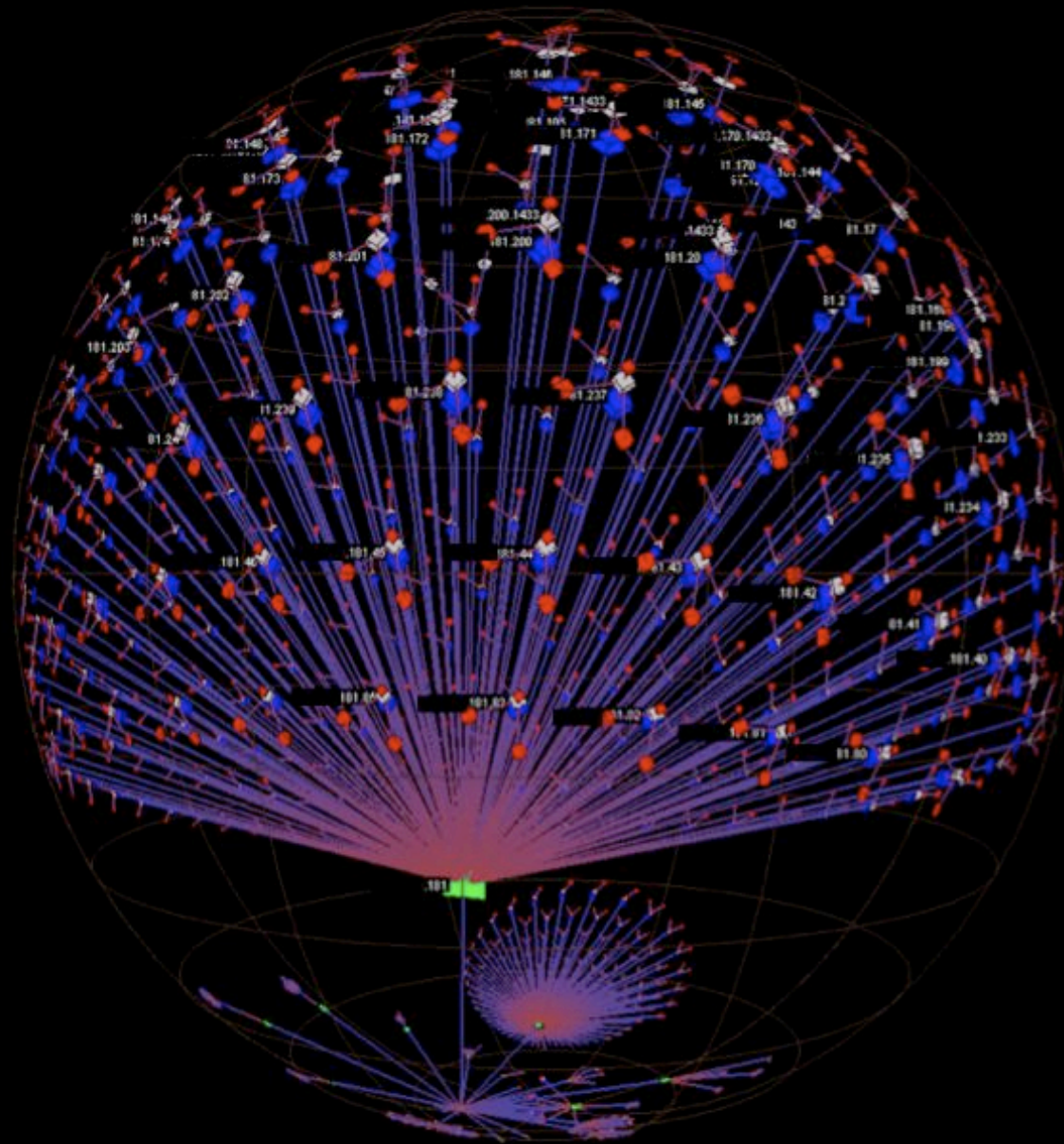
- Easily adapted to a forced-hierarchy view of flow
- **Open source** C++ library and UI
- Experimented with visual methods

- colors
- graph cycles
- scaling
- text labels
- **graph size**
- search automation

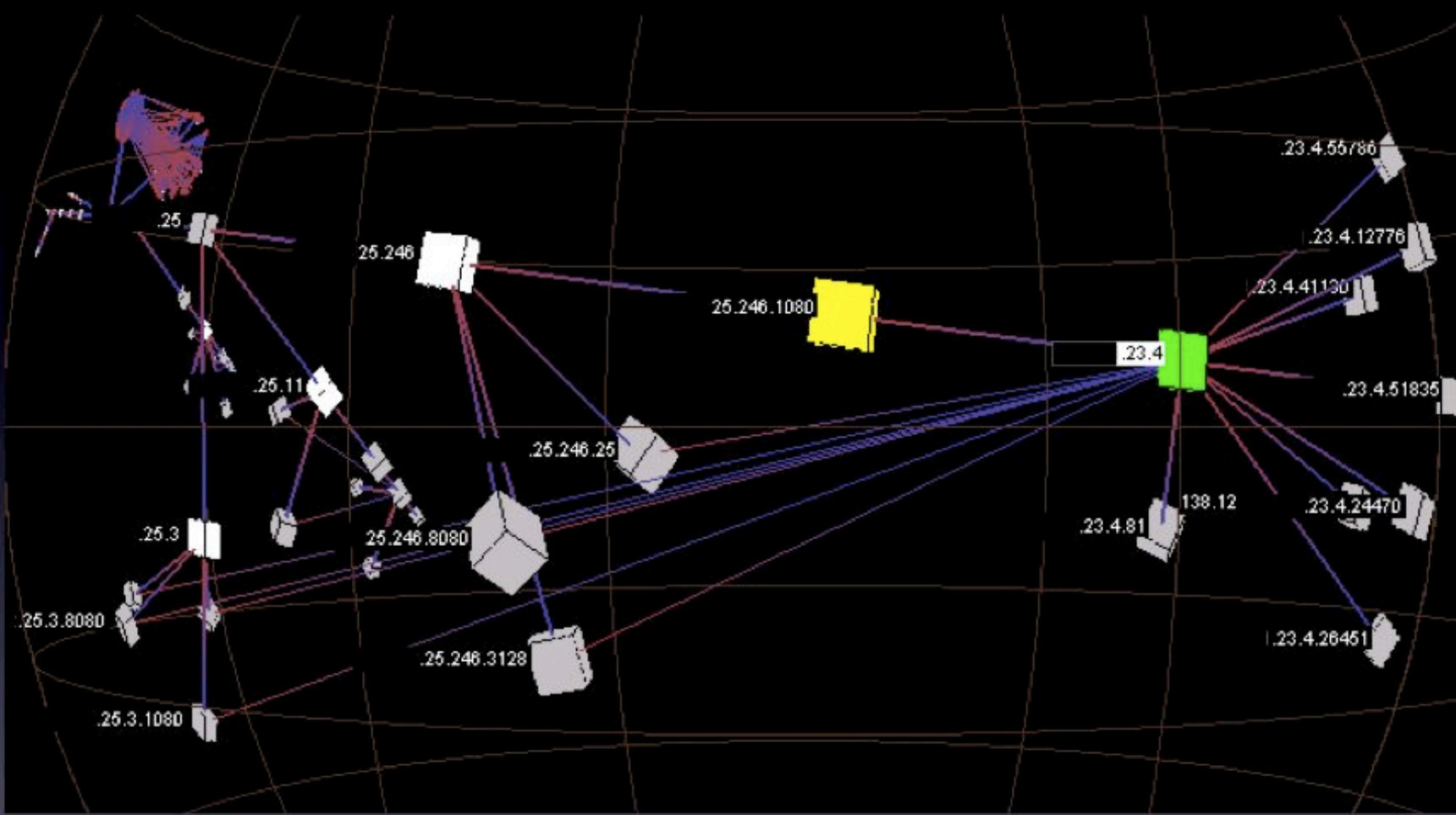




Symmetry in port access from 3 separate clients.



src/dst ports colored red/blue



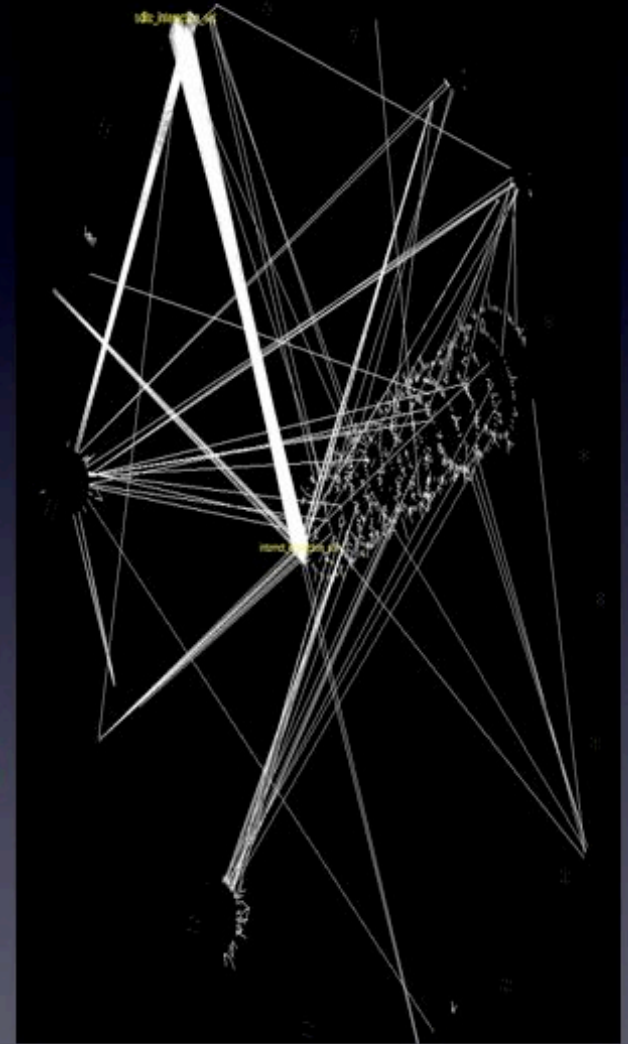
Hierarchy showing client subnet and server ports

Shapes Vector

- Acquired by DARPA in 2002
- Developed by Australian DSTO
(Defence Science Technology Organisation)
- JTF-GNO pilot program from 2003-2006

What is it?

- **Intelligent Agents** gather information and produce inferences
- Gathers information from multiple sources
 - pcap, **flow**, Snort, syslog, etc
- IAs performs automated data correlation & **knowledge extraction**
- Integrates **visual** and **command-line** analysis
- Integrated visualization makes use of **human vision**
- Supports **visual analysis** and decision-making



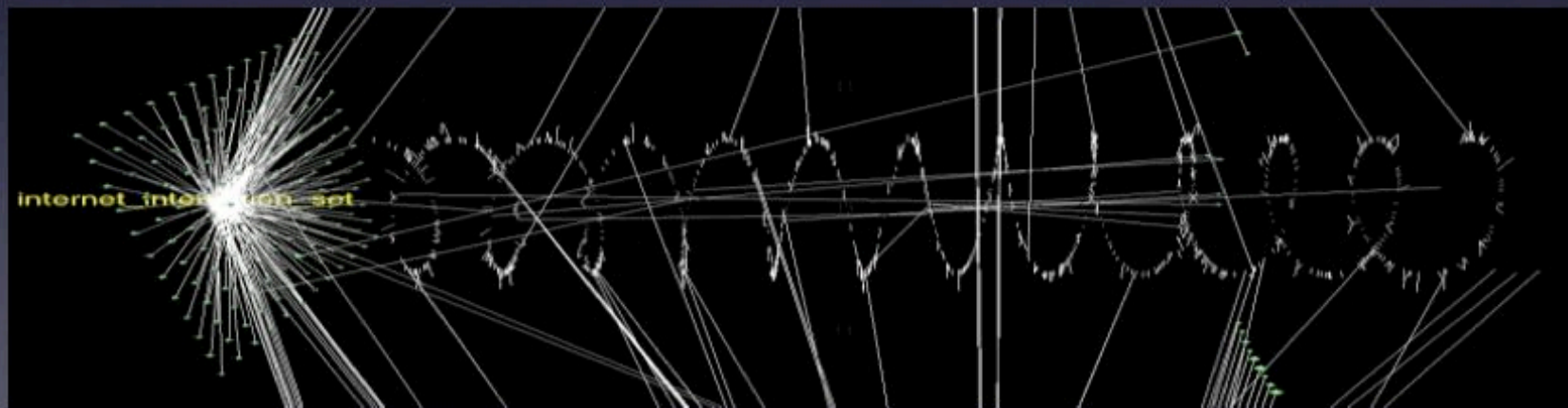
Shapes Vector

Contextual spatial, temporal, **social**, topological

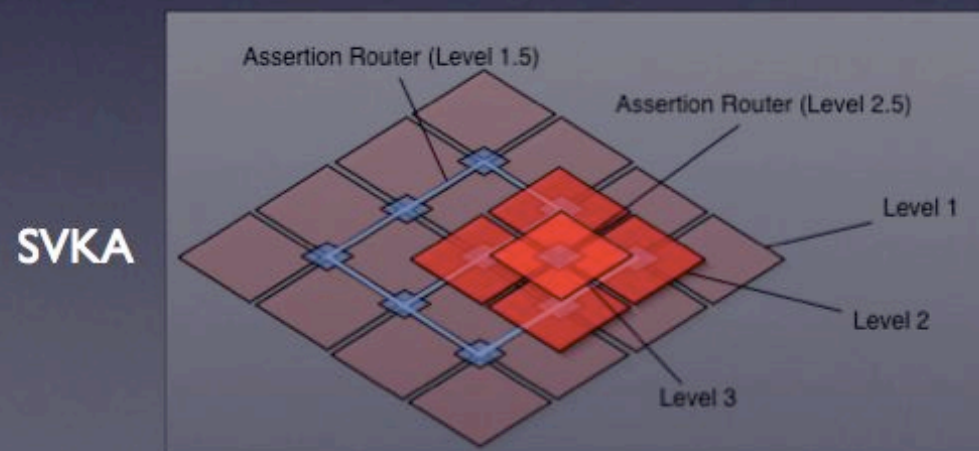
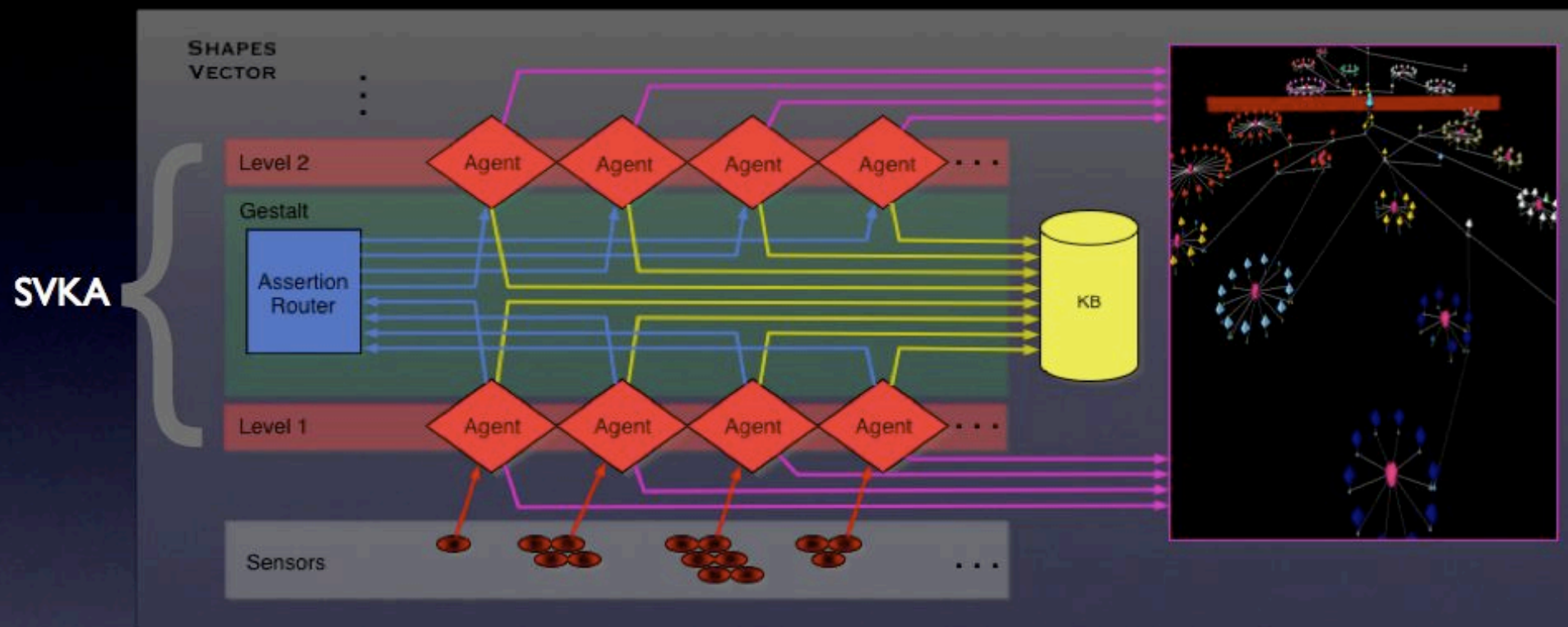
Spatial physical geography or **metaphor**

Temporal **sequences** in time, correlated

Visual use **visual language** to depict objects & events



Architecture



- **Agents** can be written in many languages - must conform to the SV ontology and knowledge architecture (SVKA) specification
- **Sensors** can be built to wrap many information sources - must produce SV ontology
- **SV ontology** is a knowledge description language for network defense

Shapes Vector - Visual Language

- Easily defined visual mappings
- No applied theory of visual language

shape/color/scale



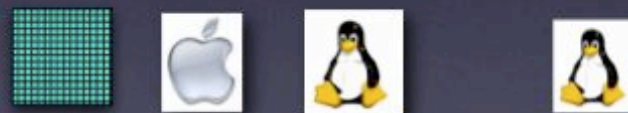
texture/icon



connection / topology



movement



packet events, information exchange, attribute changes, attribute values, host id, software, processes, machine purpose, network topology, social topology, intrusion events, event type, event priority, client vs server, routing, ...

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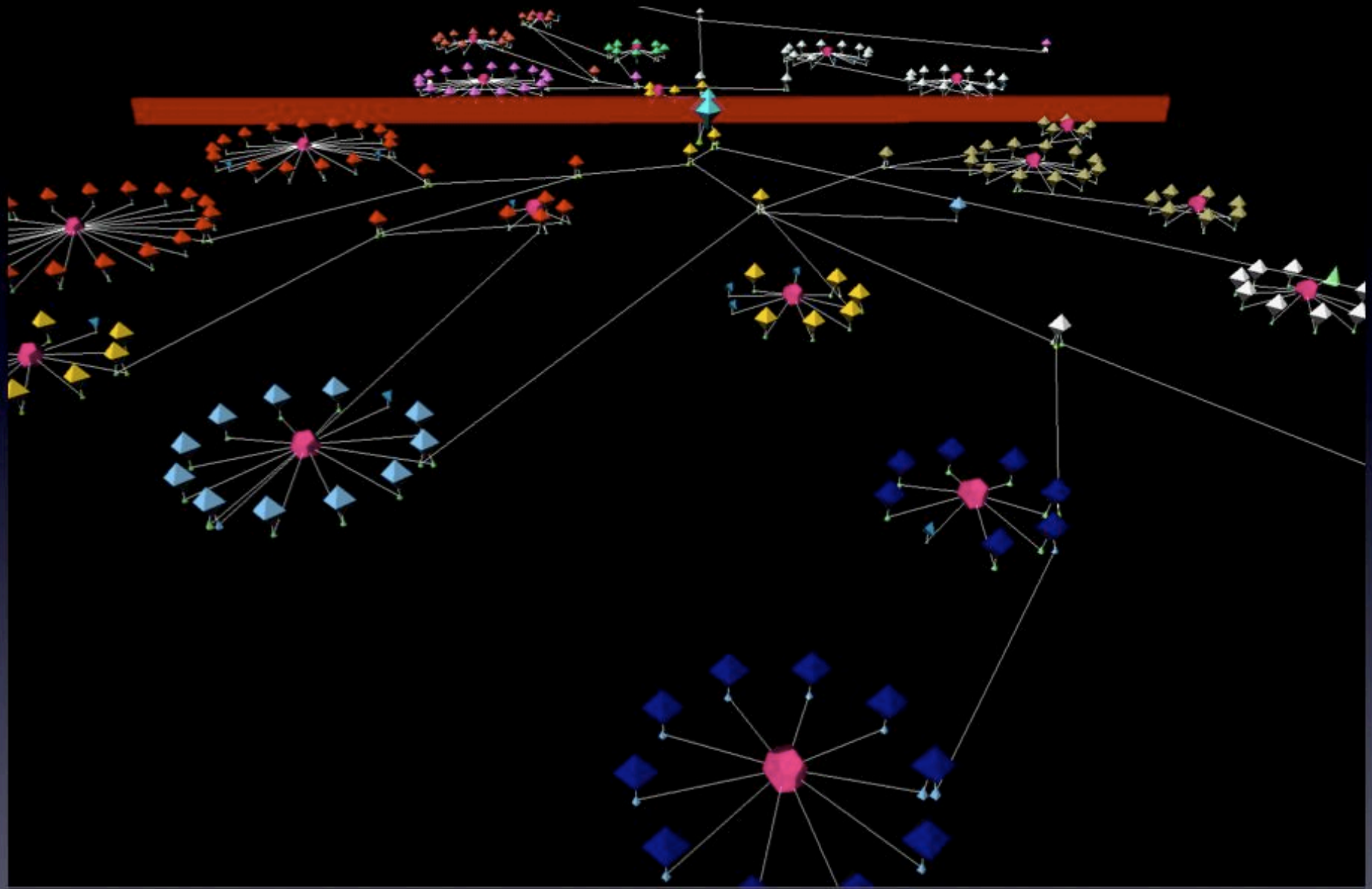
connection / topology



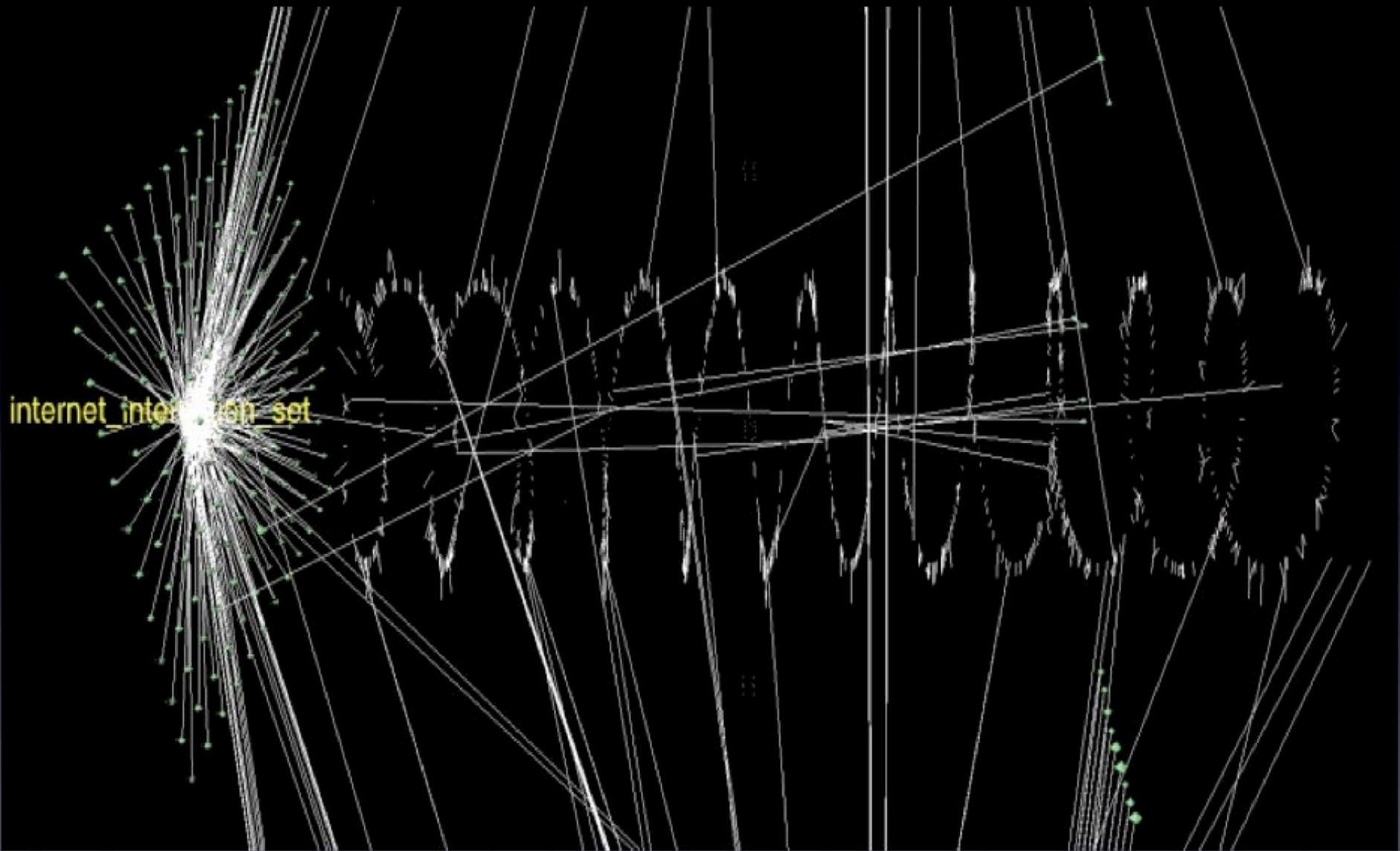
movement



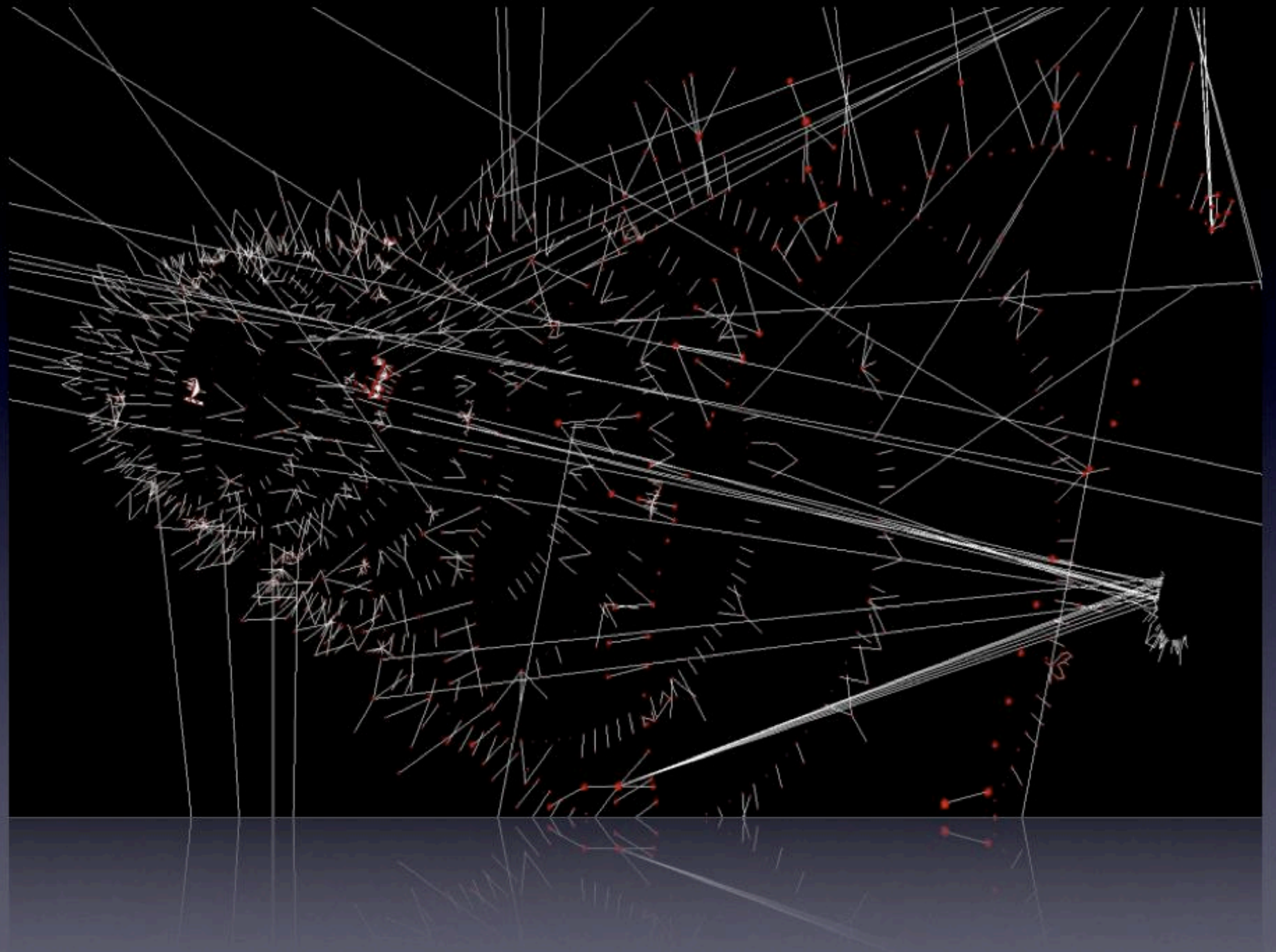
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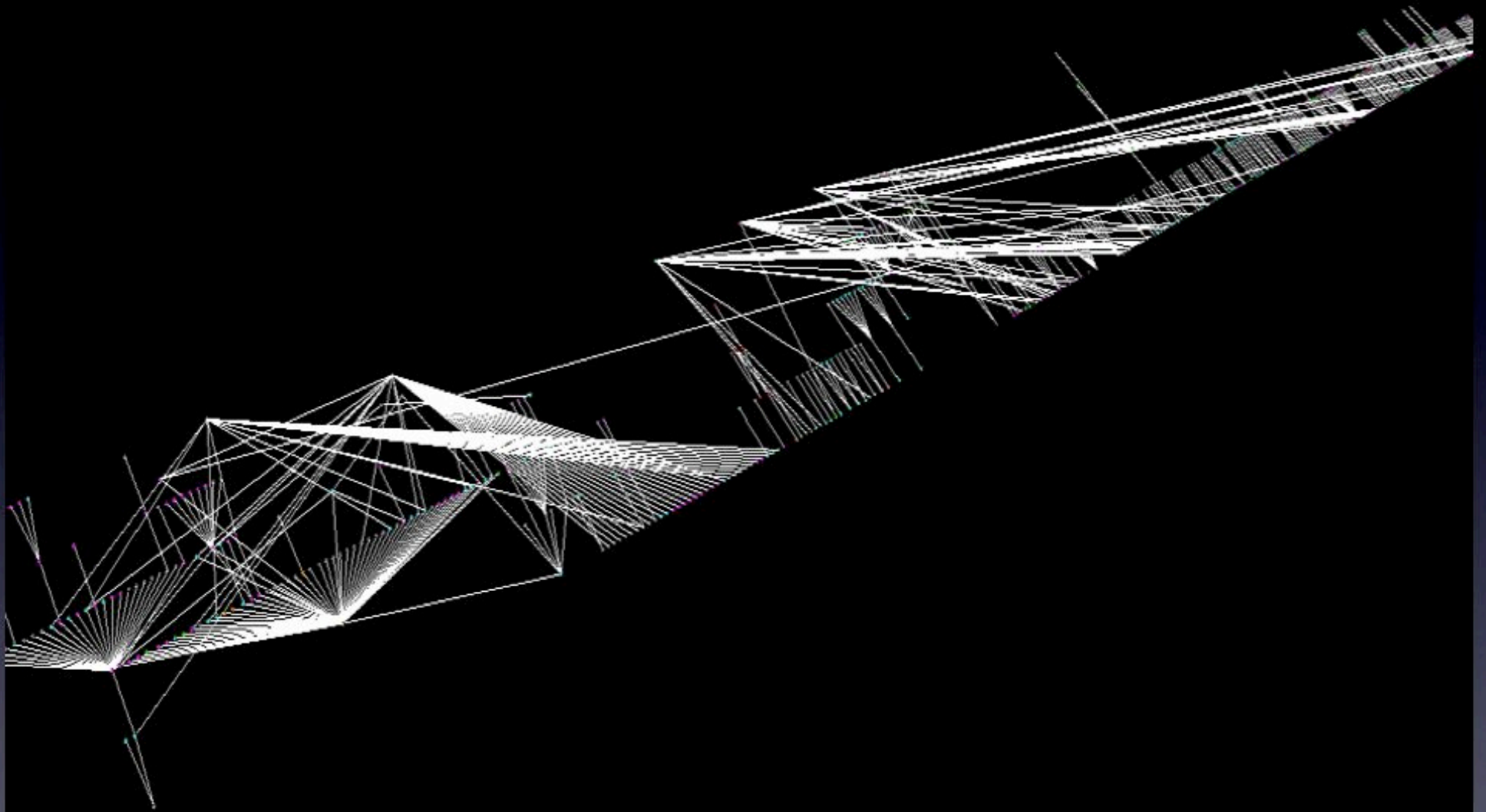


Topological layout using visual demarcations
(e.g. firewall, network segment, physical layout)

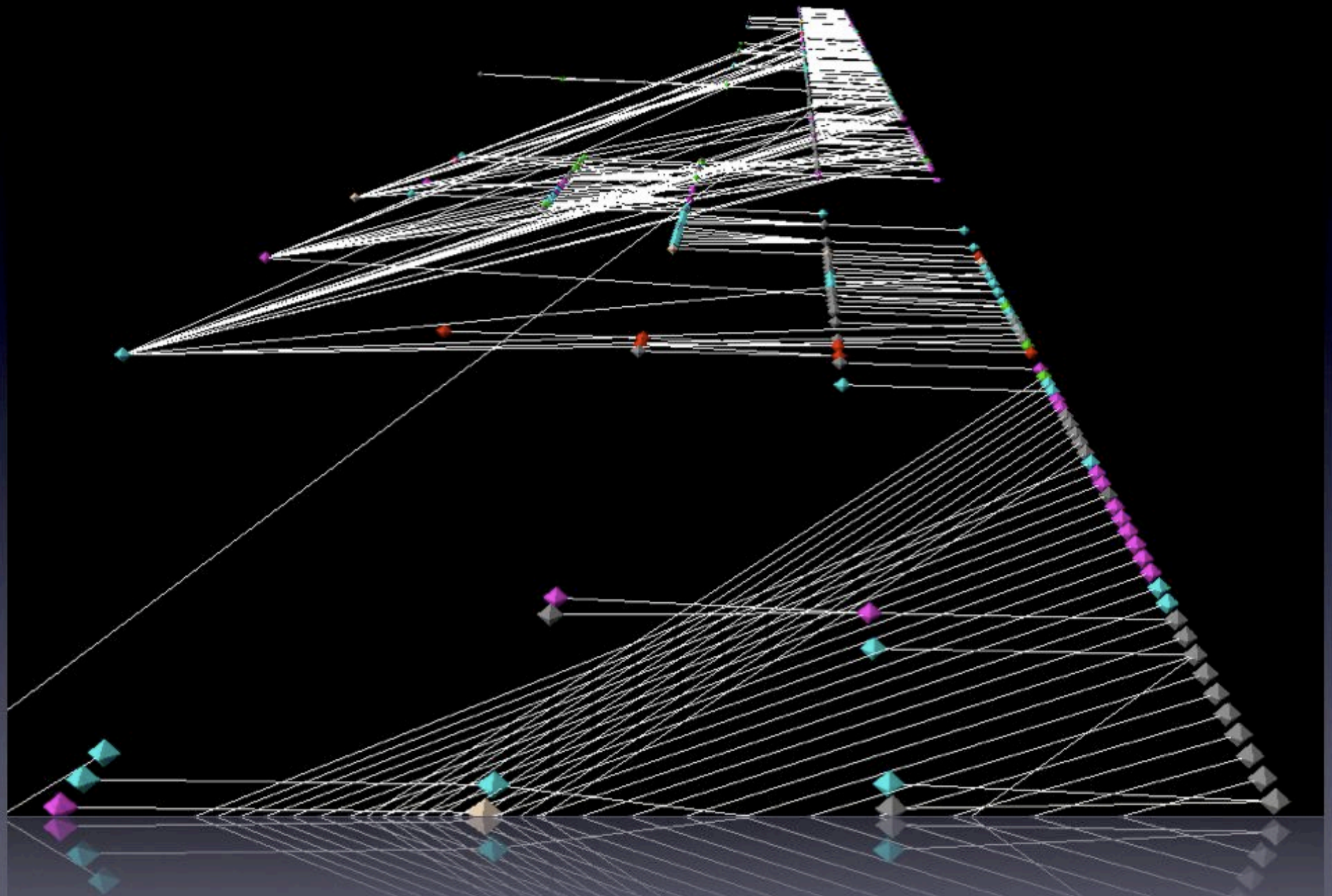


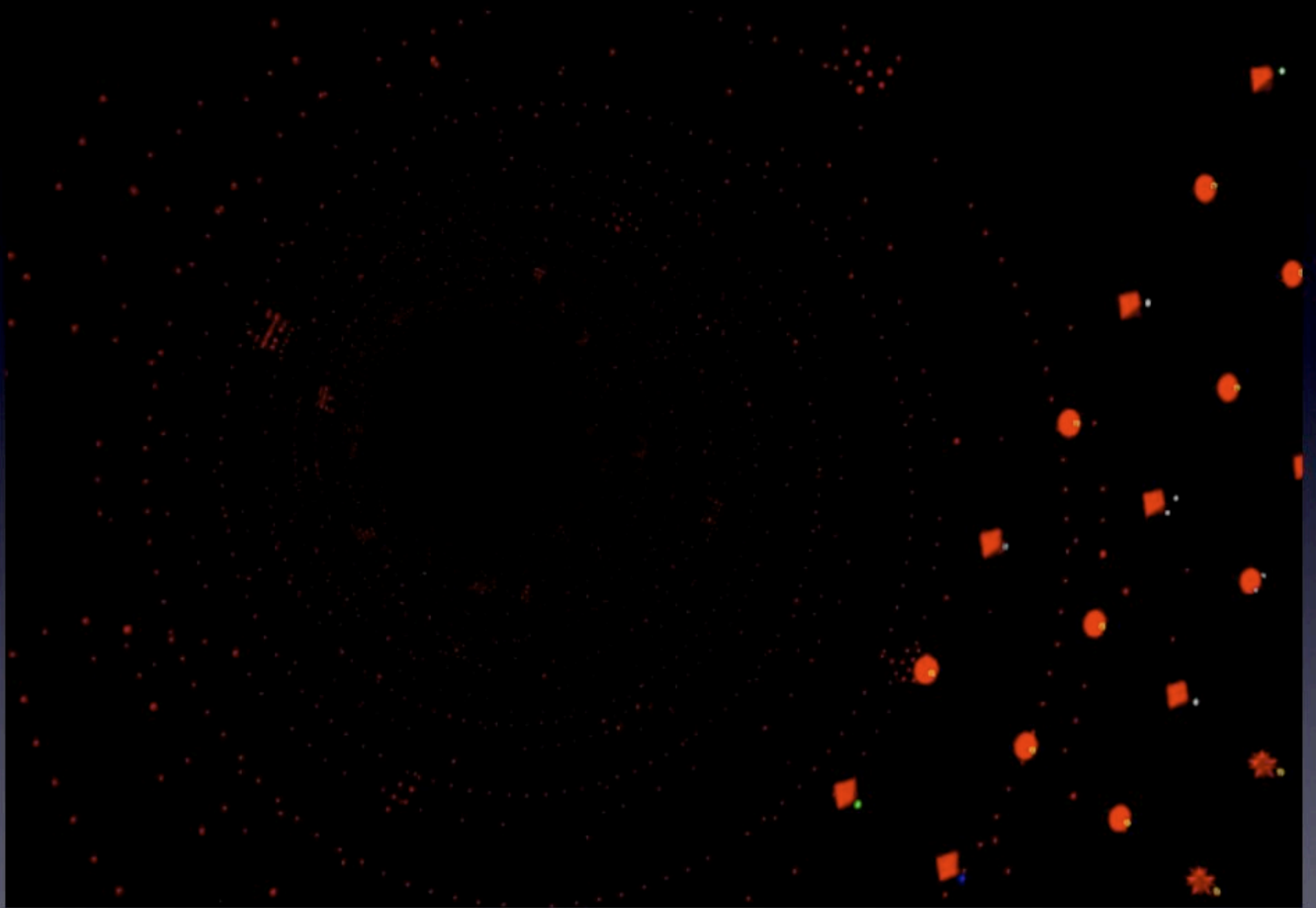
Automated layout to arrange hundreds of sub-graphs in a non-overlapping manner.



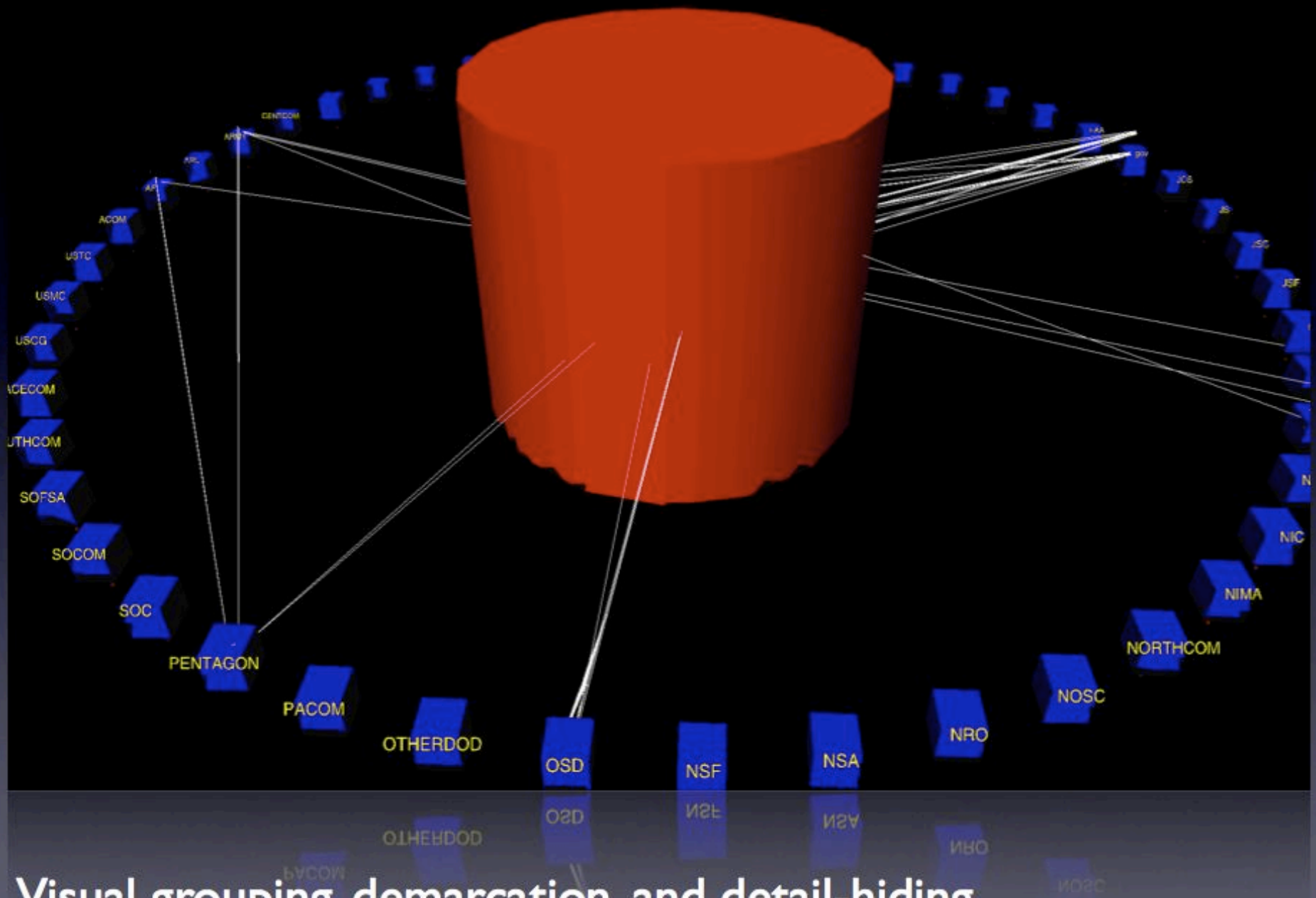


Topological layout discovered using hints in the data
(e.g. TTL)

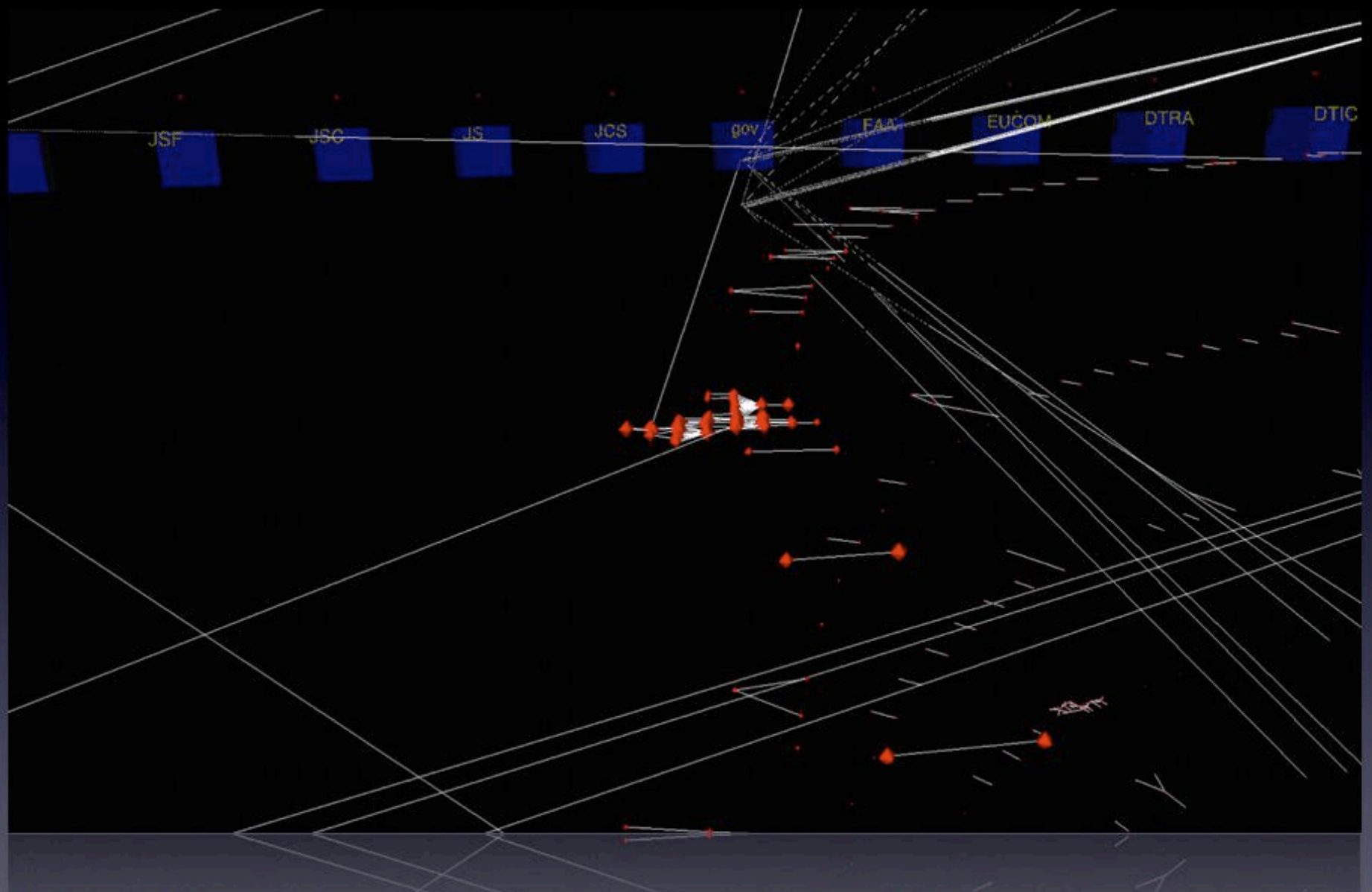




Color, shape, texture, icon, location, arrangement



Visual grouping, demarcation, and detail-hiding



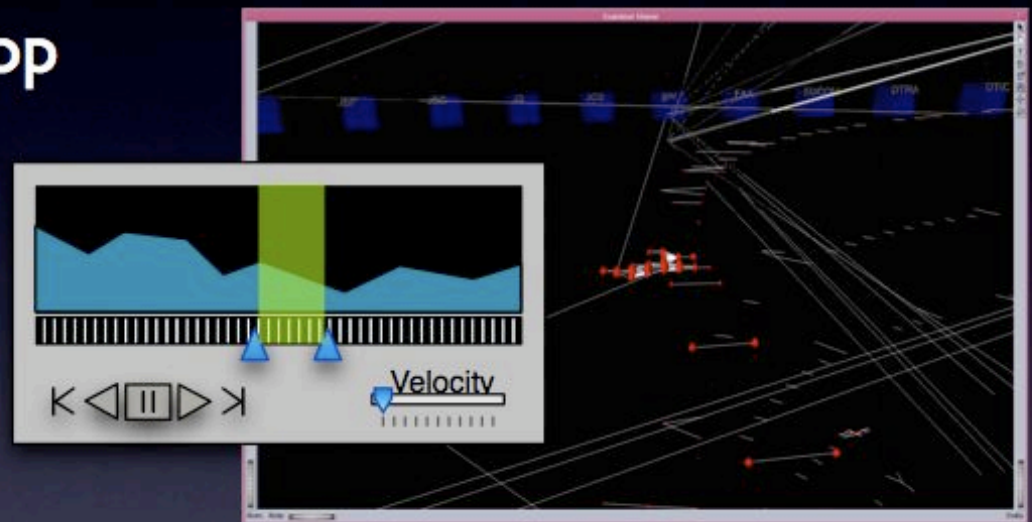
Expansive vantage points for network analysis

Shapes Vector Flow Viewer

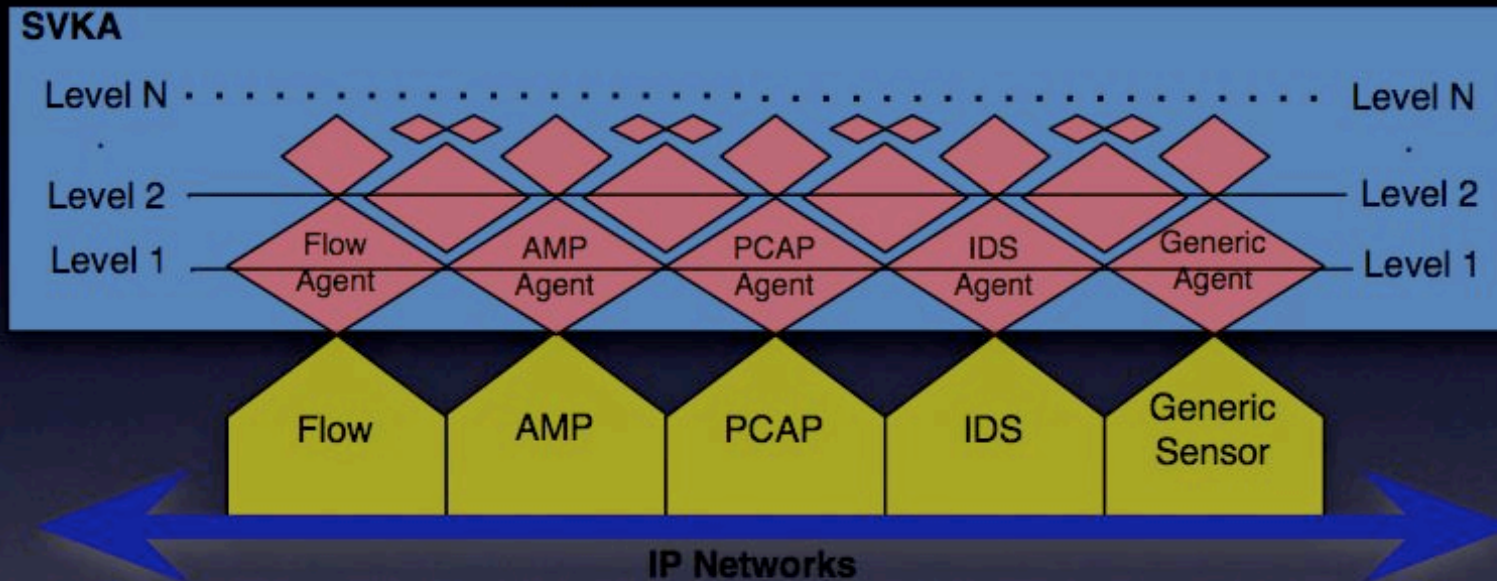
- JTF-GNO funded effort to implement SV
 - Use SV architecture and components
 - DARPA demo system > operational system
 - New scripts, sensors, agents, and GUI
- Results
 - A visual **augmentation** of CLI
 - Produces a view of **social topology**
 - **Intuitive** view of gobs of data
 - static **topology** and event **replay**
 - Links statistical views and topology view

Flow Viewer GUI

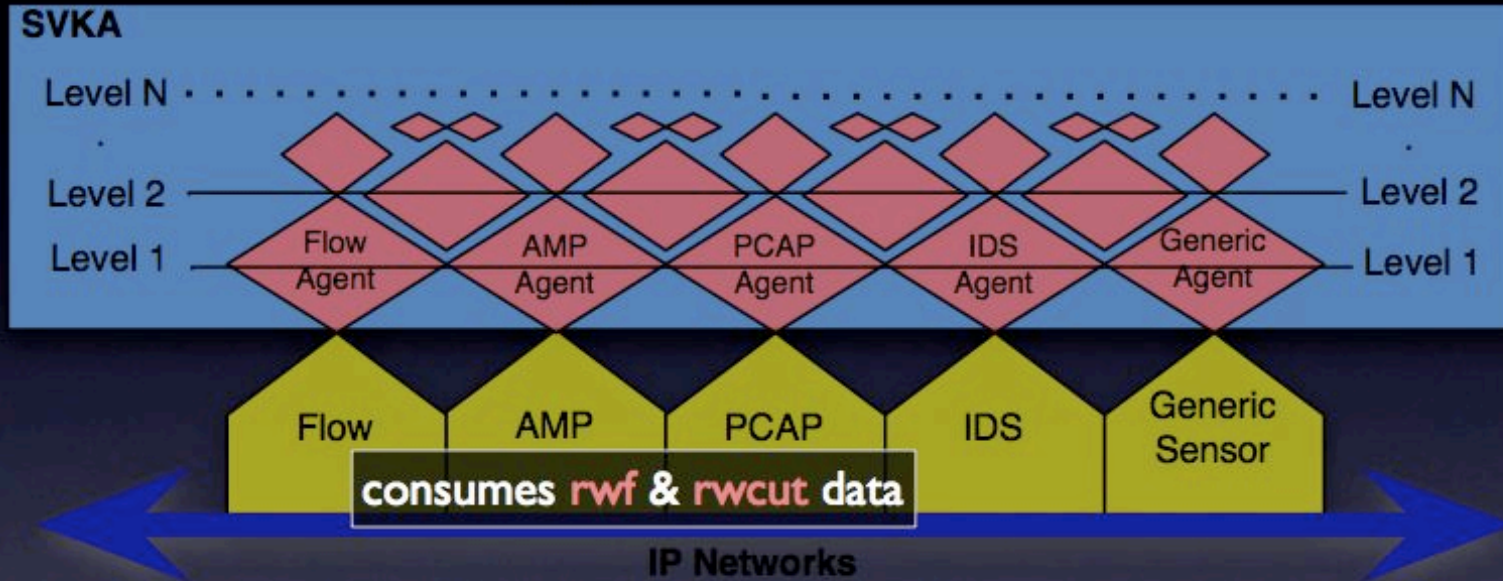
- multiple stats views linked to visuals
- playback specific ranges & loop
- adjust replay **velocity**
- time-skip
- IP and attribute **hotlists**
- dynamic **filtering** controls
 - **GUI** managed **rwfilter**
 - filter using **SV ontology**
- integration between **flow, AMP, IDS, & PCAP**



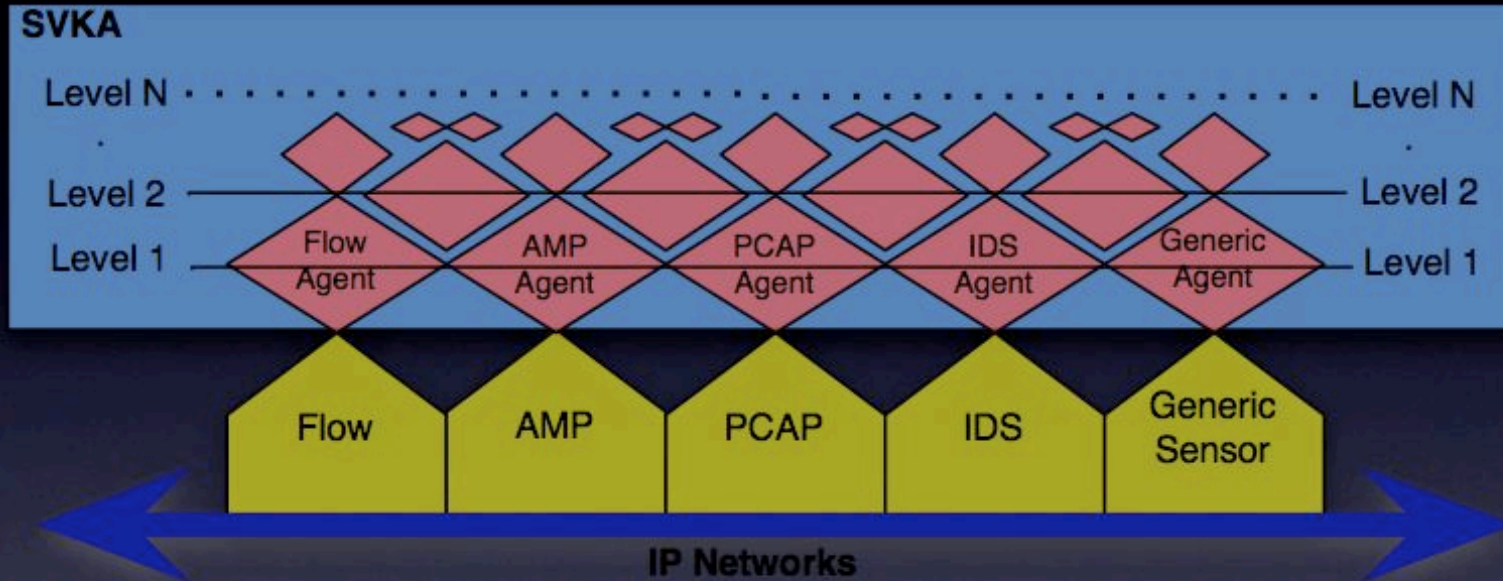
Flow Viewer Sensors



Flow Viewer Sensors

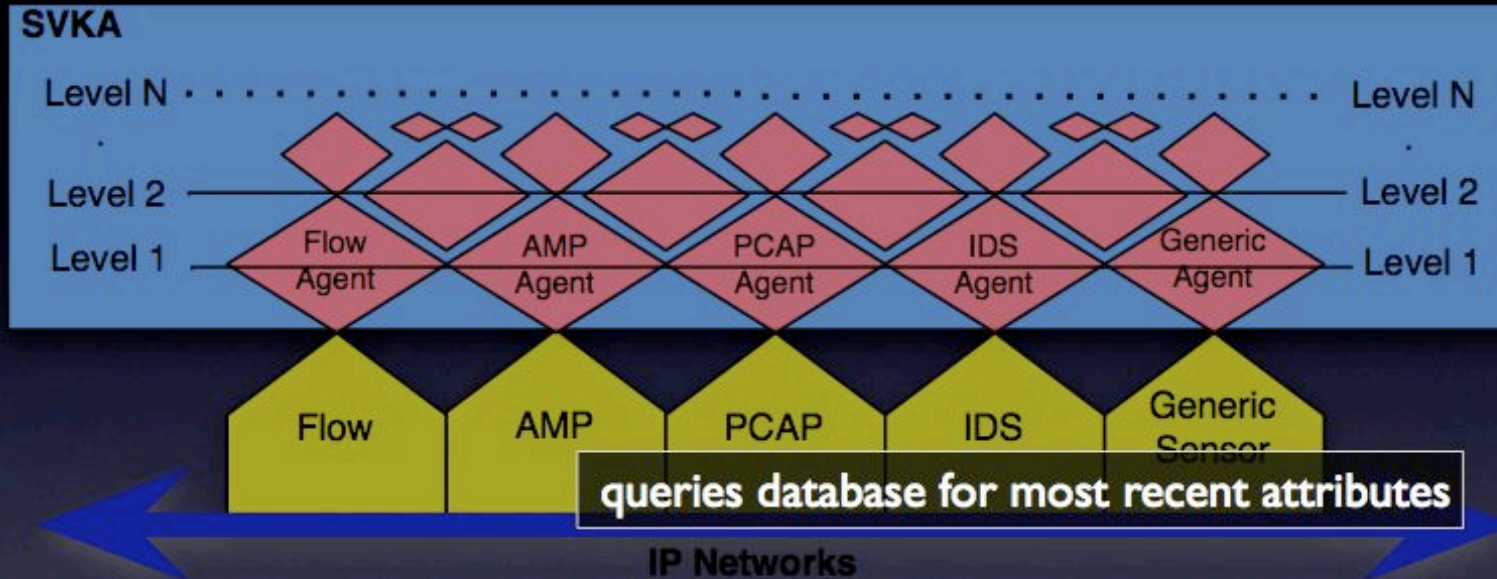


Flow Viewer Sensors



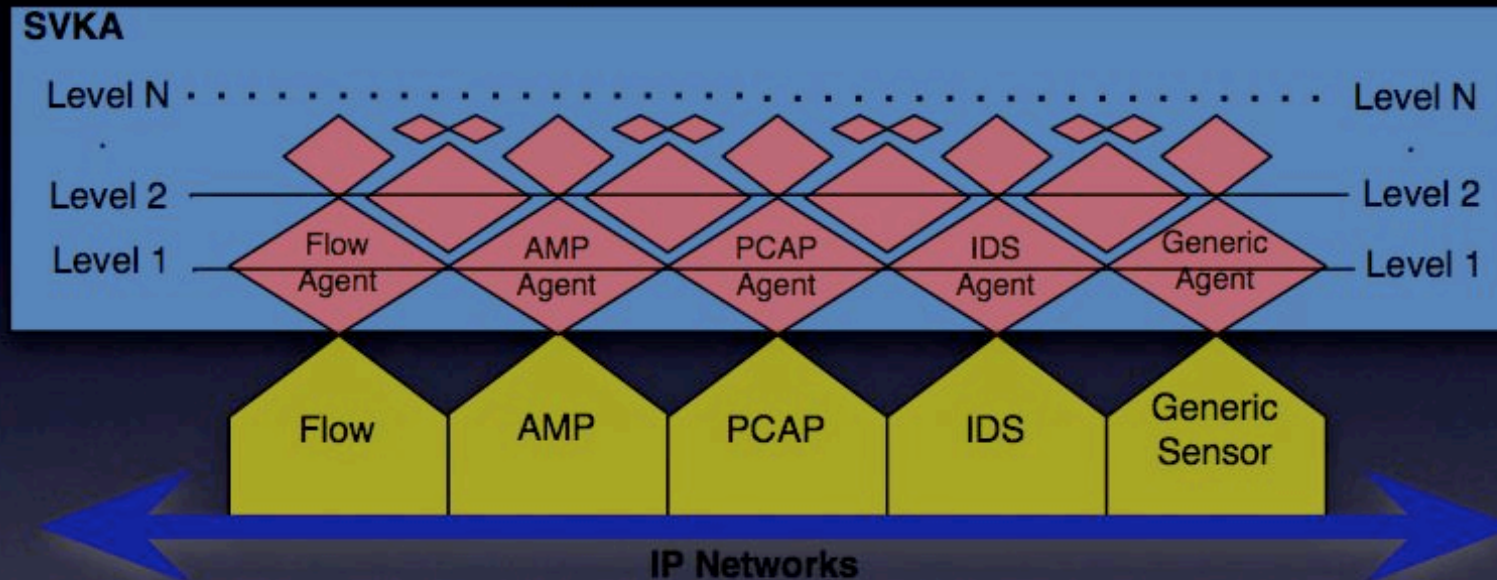
Flow Agent consumes *rwf* & *rwcut* data

Flow Viewer Sensors



Flow Agent consumes *rwf* & *rwcut* data

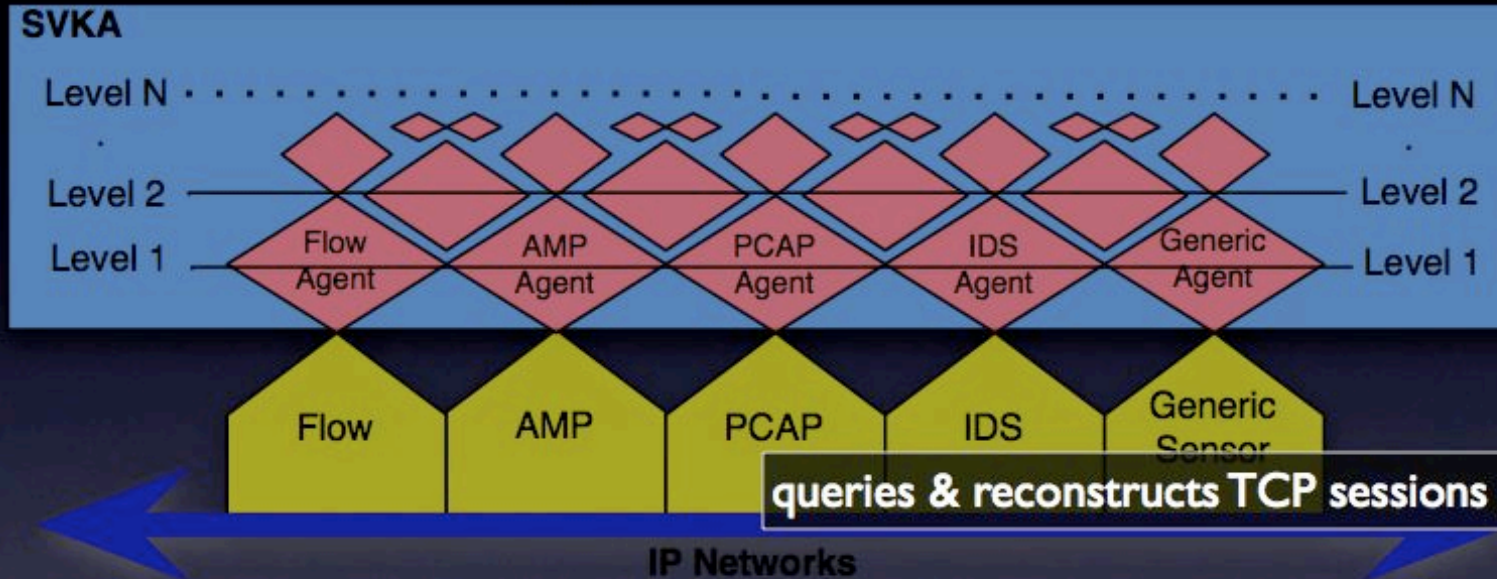
Flow Viewer Sensors



Flow Agent consumes *rwf* & *rwcut* data

AMP Agent queries database for most recent attributes

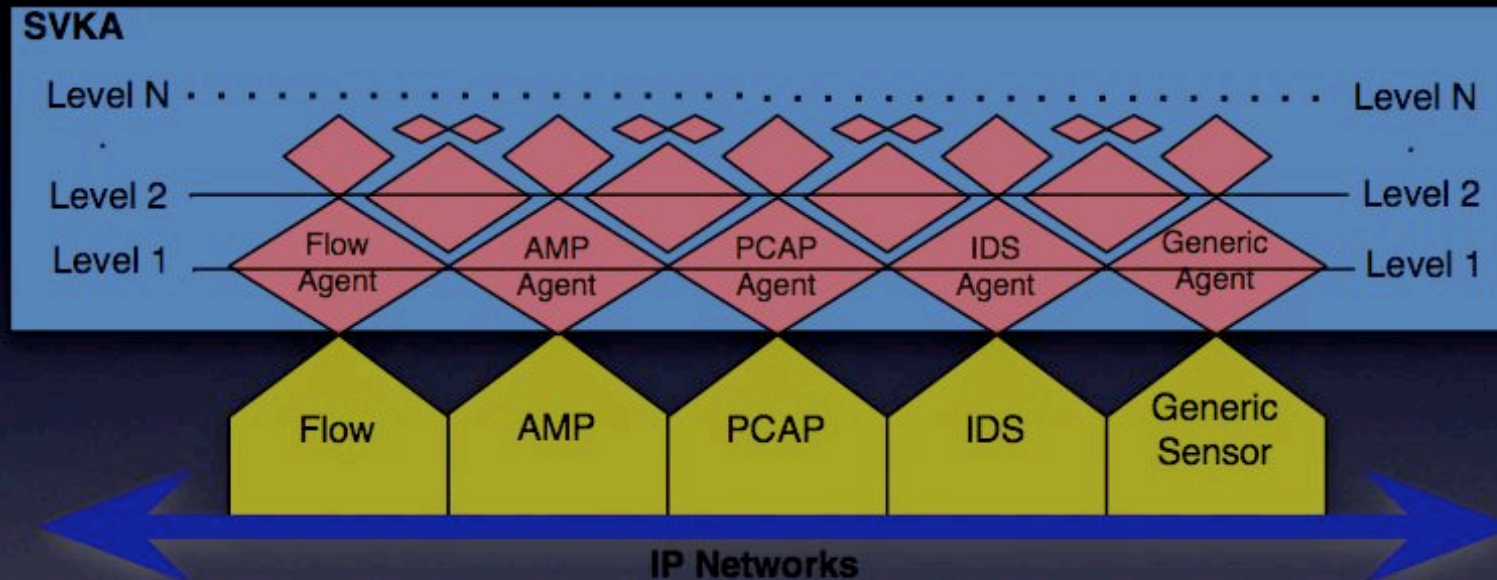
Flow Viewer Sensors



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Flow Viewer Sensors

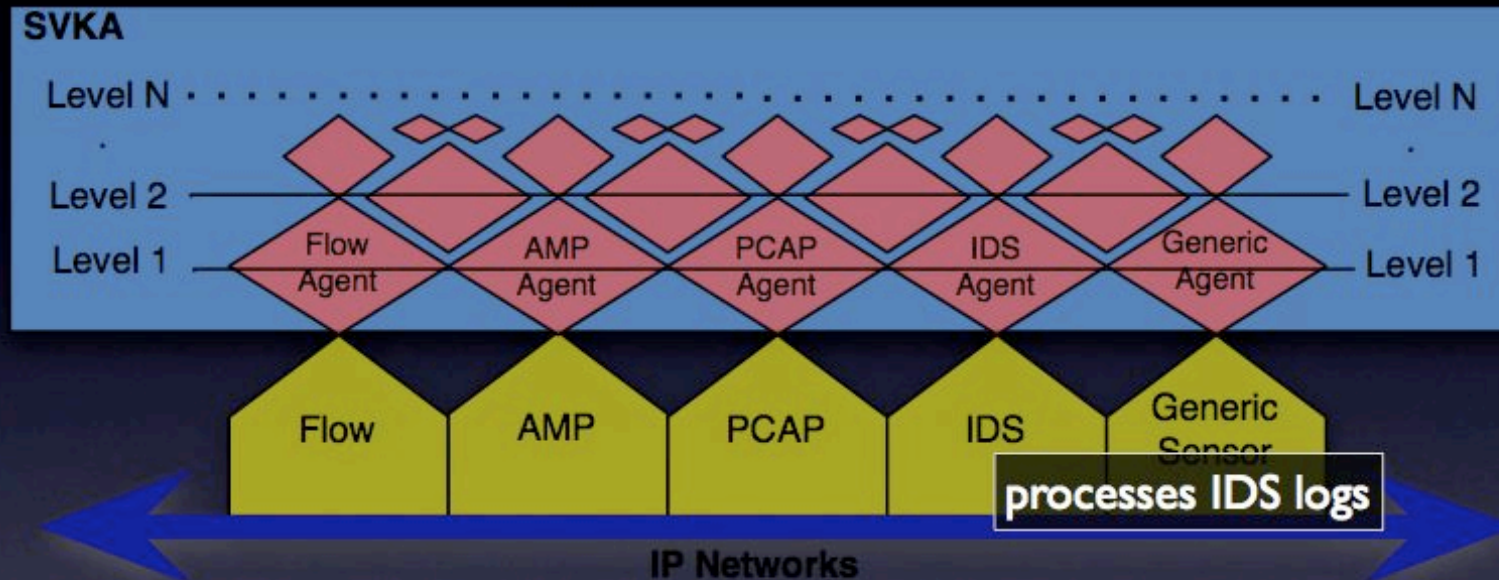


Flow Agent consumes *rwf* & *rwcut* data

AMP Agent queries database for most recent attributes

PCAP Agents queries & reconstructs TCP sessions

Flow Viewer Sensors

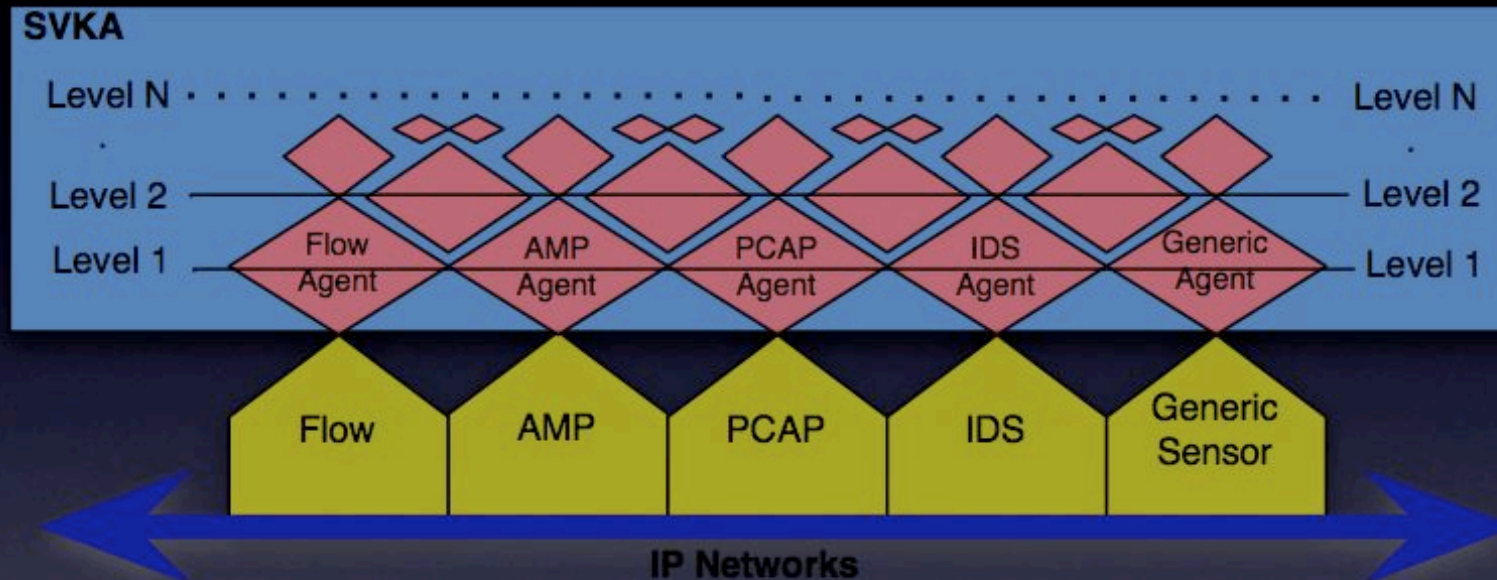


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PCAP Agents queries & reconstructs TCP sessions

Flow Viewer Sensors



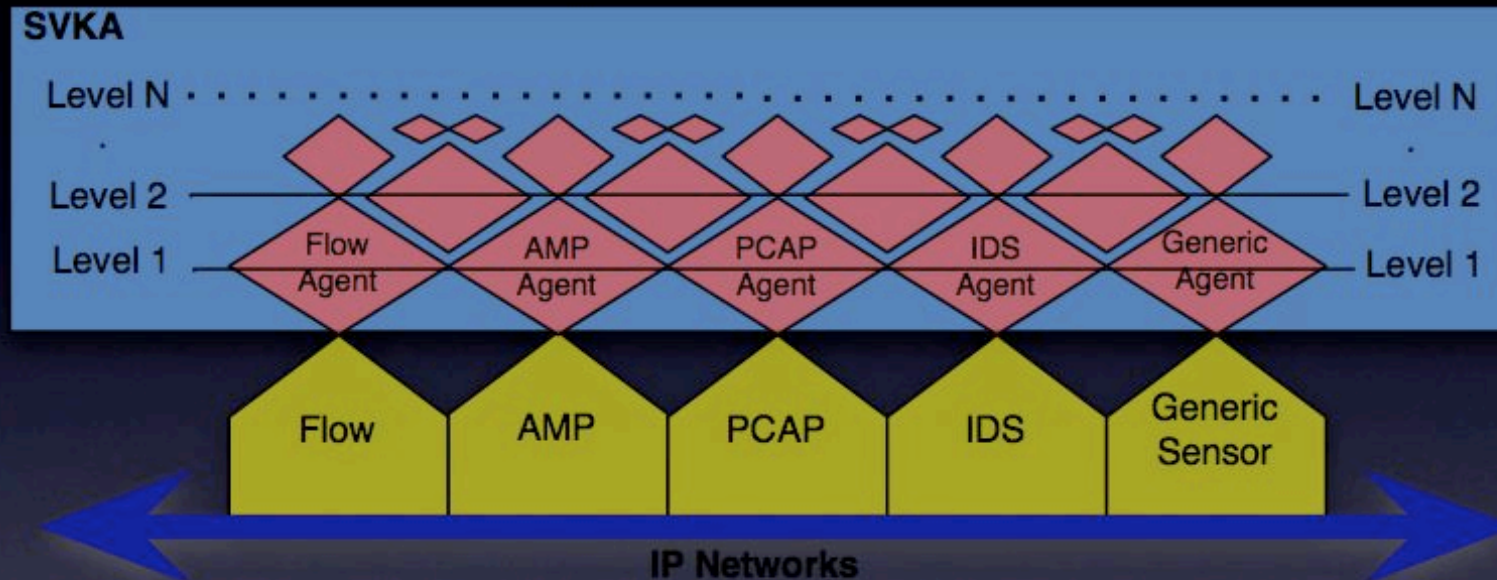
Flow Agent consumes *rwf* & *rwcut* data

AMP Agent queries database for most recent attributes

PCAP Agents queries & reconstructs TCP sessions

IDS Agents processes IDS logs

Flow Viewer Sensors



Flow Agent consumes *rwf* & *rwcut* data ✓

AMP Agent queries database for most recent attributes ✓

PCAP Agents queries & reconstructs TCP sessions

IDS Agents processes IDS logs

Flow Viewer Intelligent Agents

Flow Sensor

- Converts flow into **ontology**
- produces **facts**

AMP Agent

- uses **correlations** from Flow Agent
- query made on every unique **IP** seen
- produces visual **events**

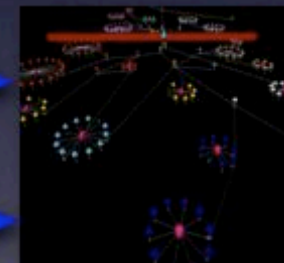
Flow
Sensor



Flow
Agent



AMP
Agent



Flow Agent

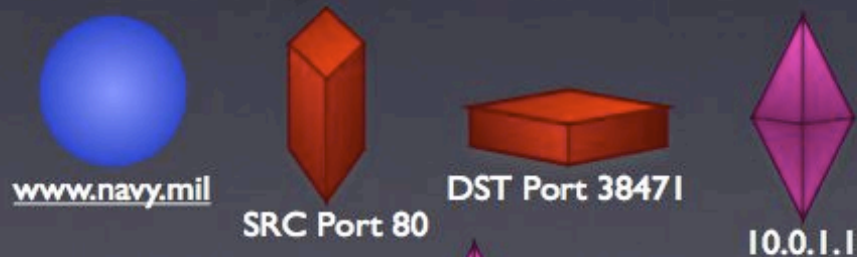
- **correlates** records
- **counts** and **corroborates**
- produces **inferences**
- produces visual **events**

Flow Viewer Visual Language

Leverage cultural knowledge



Use metaphors for abstract

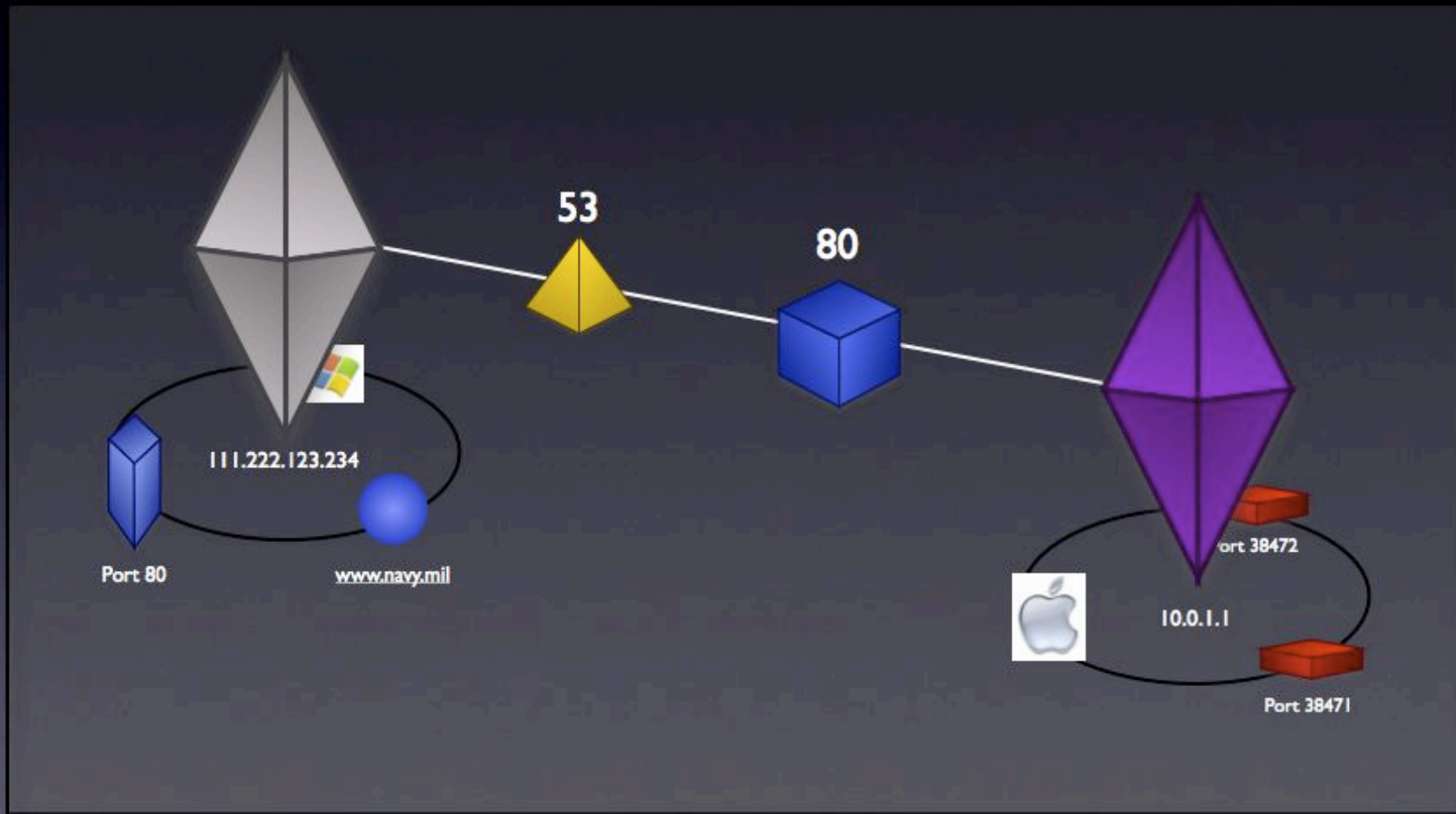


Scaling host or packet based on total packet/bytes

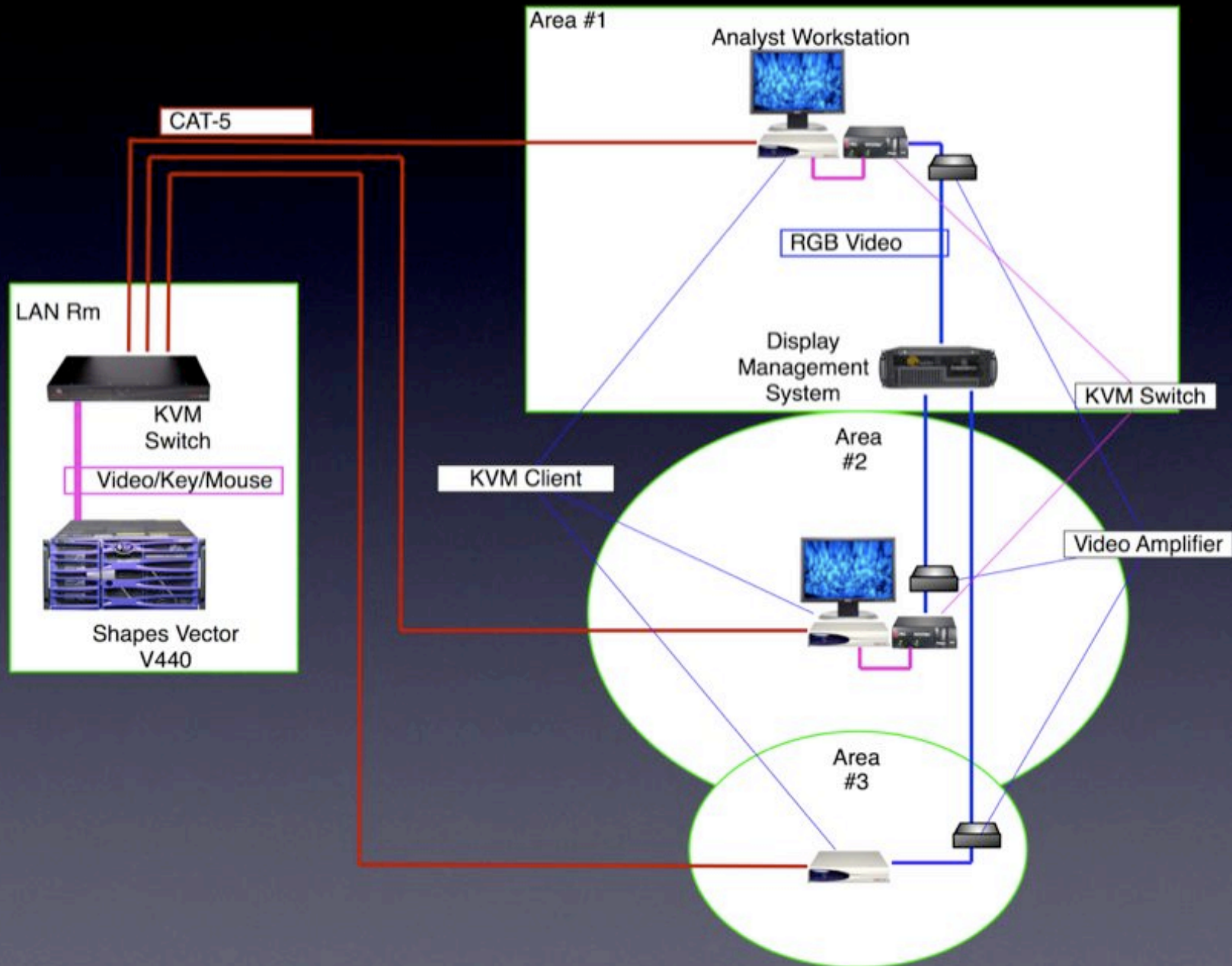
Color by ownership



Flow Viewer Visual Language



Test installation



Flow Viewer

Visualization

- **Tested** using:
 - 100-5000 nodes
 - 1M-3M flows
 - 10K-300K flows per hour
- Integrated **filtering** (rwfilter, SVKA filtering, visual filter)
- Visual ID
- **Queries**
- **Grouping** (e.g. domain, netblock, vulnerability)
- **Replay**-mode or Real-time
- Historic **visual context**
 - Replay 'on top of' known incident

Flow Viewer

data prep

Include

- Incoming & outgoing
- Hub & core-to-core traffic
- Wide port ranges
- Time-span wider than the activity (minutes to hours)
- Suspect IPs and ranges

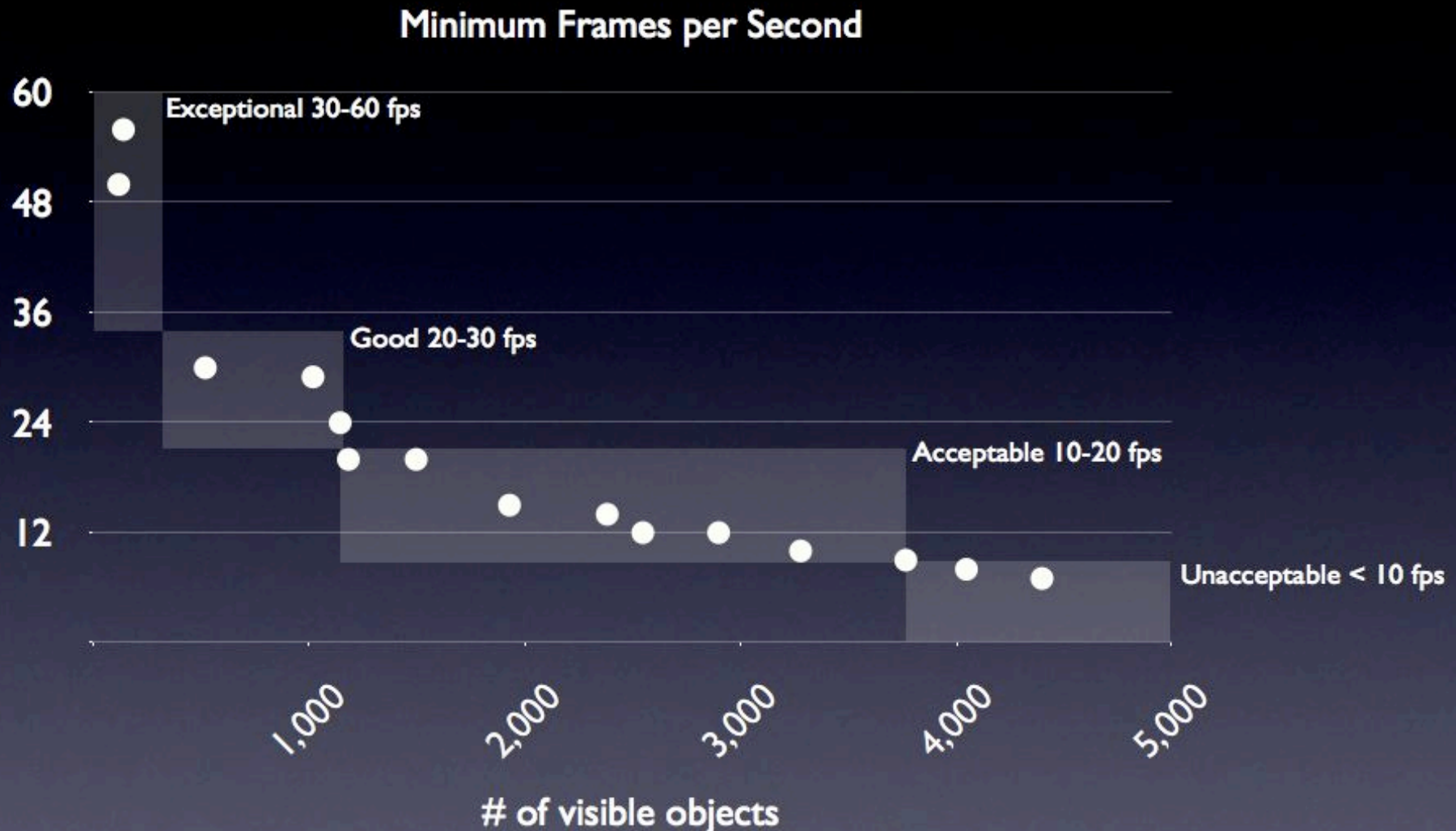
Filter

- Superfluous port traffic (e.g. 80, 53, 25)
- IPs that are unrelated to the incident

Sampling & Time

- Dense data
- Smear data across time resolution (~1 second)

Flow Viewer Performance



**Graphics performance on dual 1.5GHz SPARC SunFire v440 with Sun XVR 1200

Flow Viewer Performance

Real-time Performance	Real-time Records / Hour	Optimal playback rate
Optimal	10K-30K/hour	10X Real-time
Acceptable	40K-100K/hour	Real-time
Poor	100K-300K/hour	1/10 X Real-Time

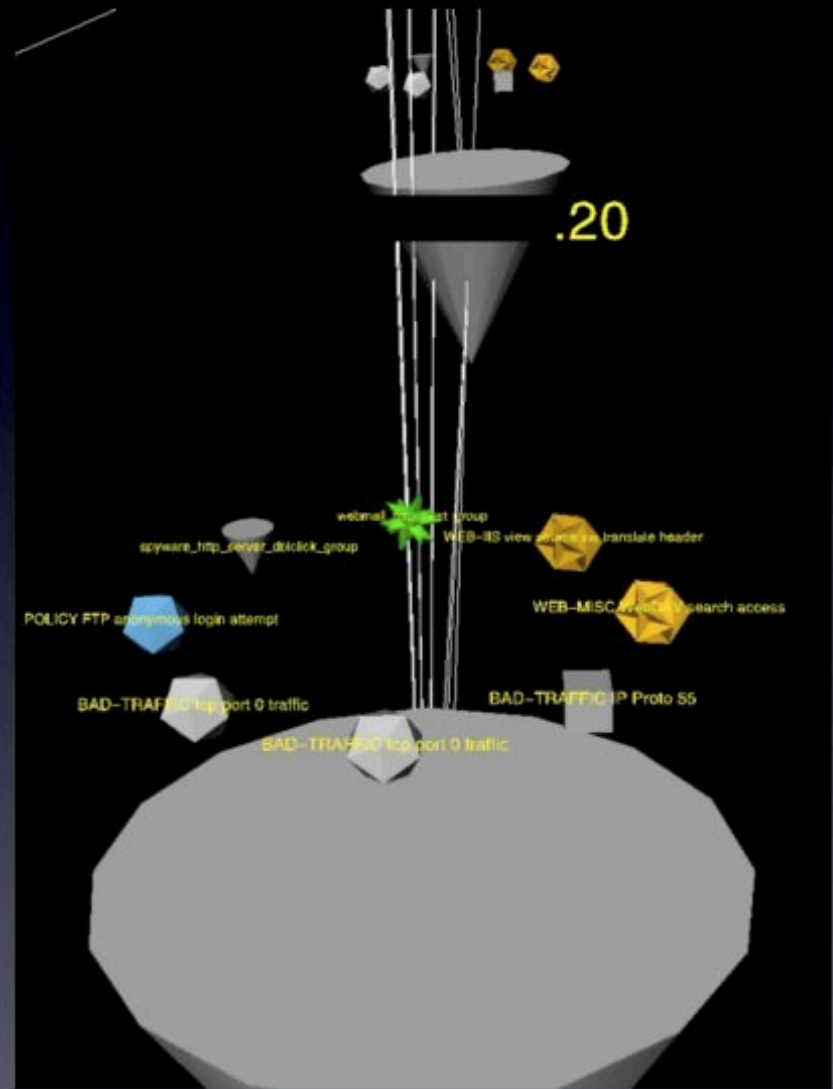
Sparse data sets can be viewed quickly
e.g. months of data in minutes

Dense data sets can be viewed slowly or filtered
e.g. seconds of data in minutes

Knowledge Depth vs Breadth

What trade-offs are we making?

- **UI Feedback?**
 - Haptic vs visual feedback
- **Data access?**
 - Random sequential access
- **Training?**
 - Under-learned vs over-learned
 - Tool complexity
- **Meaning?**
 - Visual semantic vs text
 - Intuitive/Iconic vs cryptic/coded



References

- [1] T. Abraham, Electronics, and Surveillance Research Laboratory (Australia). Information Technology Division. IDDM: Intrusion Detection Using Data Mining Techniques. DSTO Electronics and Surveillance Research Laboratory, 2001.
- [2] Mark Anderson, Dean Engelhardt, Damian Marriott, and Suneel Randhawa. Data processing and observation system, August 1 2006.
- [3] Mark Anderson, Dean Engelhardt, Damian Marriott, and Suneel Randhawa. Data view of a modelling system, April 11 2006.
- [4] H. H. Clark and W. G. Chase. On the process of comparing sentences against pictures. *Cognitive Psychology*, 3:472–517, 1972.
- [5] Herbert A. Colle and Gary B. Reid. The room effect: Metric spatial knowledge of local and separated regions. *Presence: Teleoperators and Virtual Environments*, 7(2):116–128, 1998.
- [6] Science Applications International Corporation. Intrusion Detection System System Protection Profile. National Security Agency, 9800 Savage Road, Fort Meade MD, 20755, version 1.4 edition, February 2002.
- [7] Stephen W. Draper and Donald A. Norman. *User Centered System Design: New Perspectives on Human-computer Interaction*. CRC, 1 edition, 1986.
- [8] D. Engelhardt and M. Anderson. A distributed multi-agent architecture for computer security situational awareness. *Information Fusion*, 2003. Proceedings of the Sixth International Conference of, 1, 2003.
- [9] Sunny Fugate. Visual language for tactical communication. In *Proceedings of the First Annual Visual and Iconic Language Conference*. SPAWAR Systems Center, San Diego, August 2007.
- [10] Sunny Fugate, Emily W. Medina, LorRaine Duffy, Dennis Magsombol, Omar Amezcua, Gary Rogers, and Marion Ceruti. Next-generation tactical-situation-assessment technology (tsat): Iconic language. In Sunny Fugate, editor, *Proceedings of the First Annual Visual and Iconic Language Conference*. SPAWAR Systems Center, August 2007.
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Images

- [Jeff Han's Multi-Touch Screen Interface](#), Jeff Kubina, Flickr.com, license: <http://creativecommons.org/licenses/by-sa/2.0/deed.en>
- [Atari joystick](#), duncan, Flickr.com, license: <http://creativecommons.org/licenses/by-nc/2.0/deed.en>
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SPAWAR
Systems Center
San Diego

Next Generation Tactical Situation Assessment Technology (NG-TSAT)



Objective: Next-generation Tactical Chat. Icon-based situation assessment (SA) language supported by wireless gesture-recognition gloves used in hostile or noisy (silence-mandated) environments

Description of Effort:

- 1. Linguistic Analysis:** Analysis of current C² chat logs to determine speech patterns and repetitive SA concepts/themes
- 2. Iconic Language Development:** Output of linguistic analysis determines candidate icons representing most prevalent SA “themes;” development of prototype C² iconic SA language
- 3. Wireless, Gesture-Recognition Gloves:** Develop wireless gloves that recognize C² icons/gestures which can transmit across network to distributed warfighters (replacing keyboard input when in MOPP)

Benefits of TSAT:

Compressed Chat (25% ↓ content; 50% ↓ reduction in production time) for rapid SA dissemination.
Gesture-recognition in very noisy, distributed ops, or in very austere environments (e.g., the moon)

Challenges:

1. No current method or theory for chat-meaning compression; currently done in prose; computer linguistic analysis of unstructured text still neoteric.
2. Wireless gesture recognition glove technology still in infant stages of development; focused on commercial animation support, not on disciplined language support

TRL: Chat: TRL 1-2; Gesture-recognition: TRL 1-4



Major Milestones FY06:

- Linguistic analysis discovery of common C² SA themes
- Development of icon/symbols for candidate SA themes
- Development of proof-of-concept wireless gesture-recognition glove

Period of Performance: 2007-2012

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Synaesthesia

Synaesthesia: "a neurological condition in which two or more senses are coupled."

"loud color" "sharp laugh" "bitter wind"

grapheme color synesthesia - letters or numbers are perceived as inherently **colored**

How many numbers contain the digit 6?

9910 9972 3292 7602 82 9054
5636 2710 1944 6330 6560 8101
5177 1955 7029 4083 4643 5710
4935 2256 1495 1025 8375 8518
80 797 2610 3008 8784 1854 2383
9728 4523 573 5914 7975 281
6664 2682 7689 7753 273 5597
799 9960 1437 4534 8601 4563
6734 647 9409 6543 4827 2398
1532

Is this easier?

9910 9972 3292 7602 82 9054 5636
2710 1944 6330 6560 8101 5177
1955 7029 4083 4643 5710 4935
2256 1495 1025 8375 8518 80 797
2610 3008 8784 1854 2383 9728
4523 573 5914 7975 281 6664 2682
7689 7753 273 5597 799 9960 1437
4534 8601 4563 6734 647 9409
6543 4827 2398 1532

Emulating Synaesthesia

These methods can be used achieve **sequence disambiguation** and

9910 9972 3292 7602 82 9054
5636 2710 1944 6330 6560 8101
5177 1955 7029 4083 4643 5710
4935 2256 1495 1025 8375 8518
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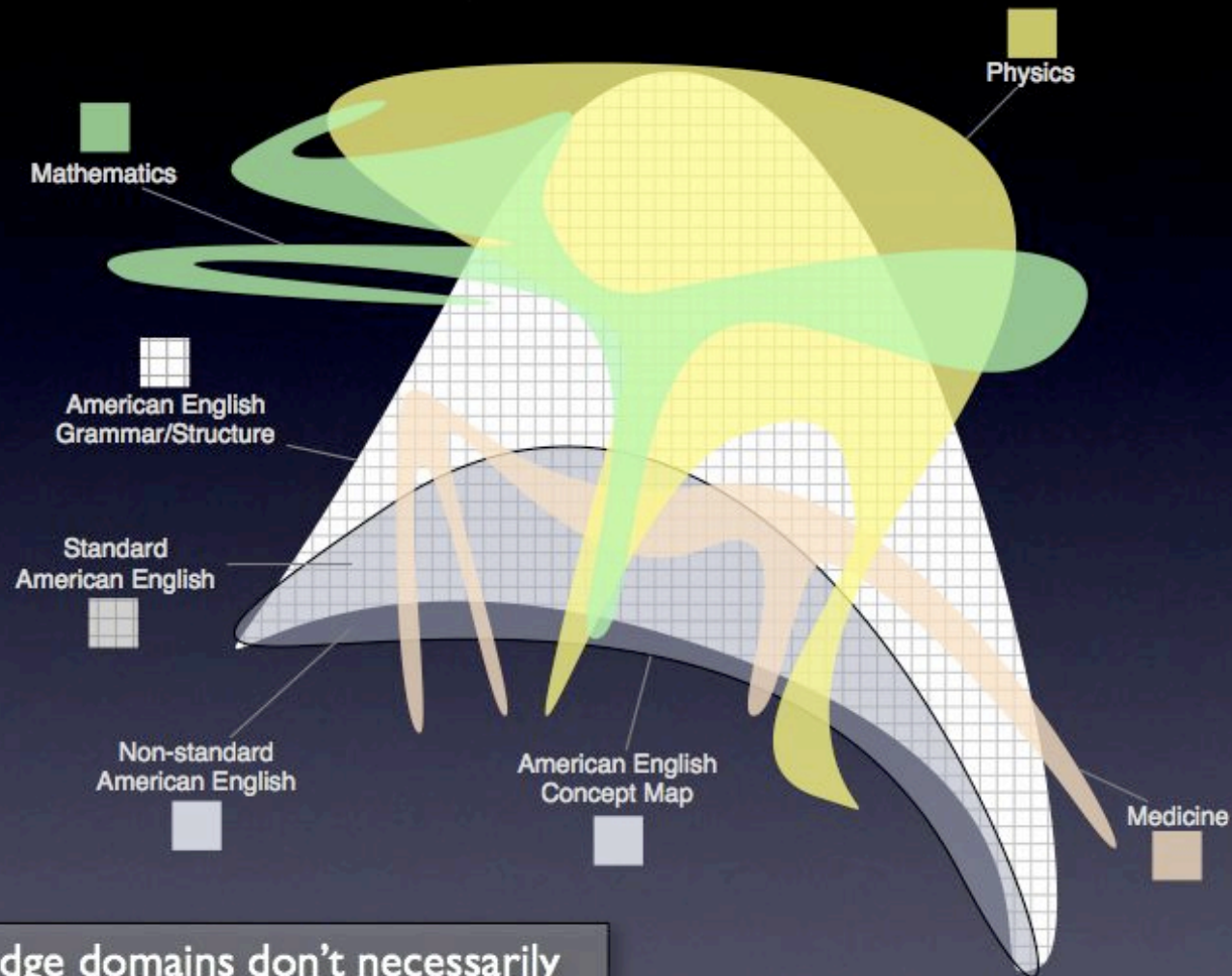
Emulating Synaesthesia

192.168.1.232
129.168.1.233

192.168.1.232
129.168.1.233

192.168.1.232
129.168.1.233

Language Domains



Cultures and knowledge domains don't necessarily use the same lexicon or even the same grammar!

How does the CND lexicon map to common language?
Technical language? Military/tactical language?