Network Security Visualization Research

Kulsoom Abdullah PhD

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Outline

- PhD Thesis work
- Post-PhD work

Why Information Visualization & Network Security

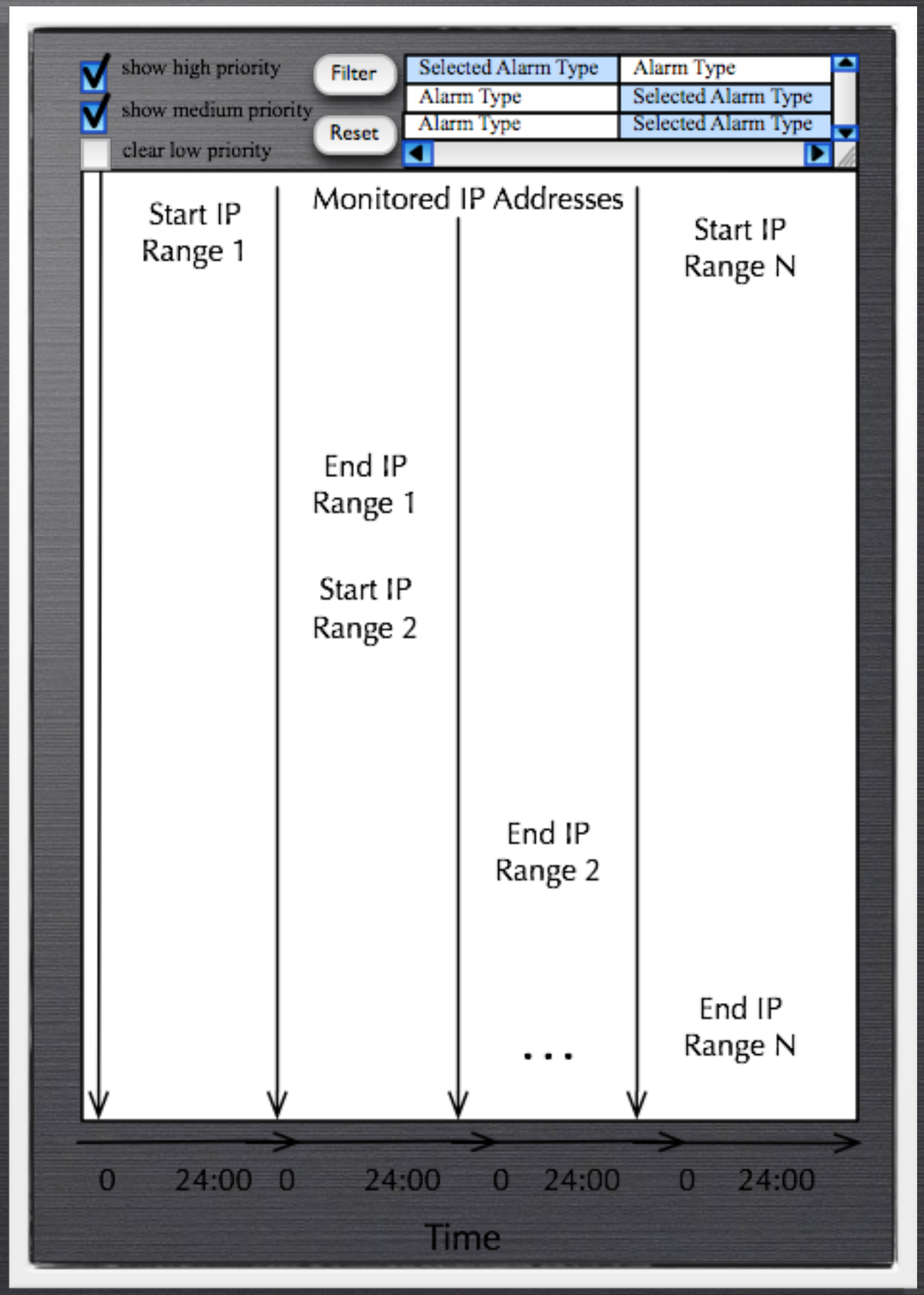
- Network traffic capacity is greater than systems can process
- Network attacks have not decreased, current security tools are insufficient
- Information visualization techniques used in network security research have initial success and future promise
- Text logs and machine learning algorithms are complemented and information is represented more densely.

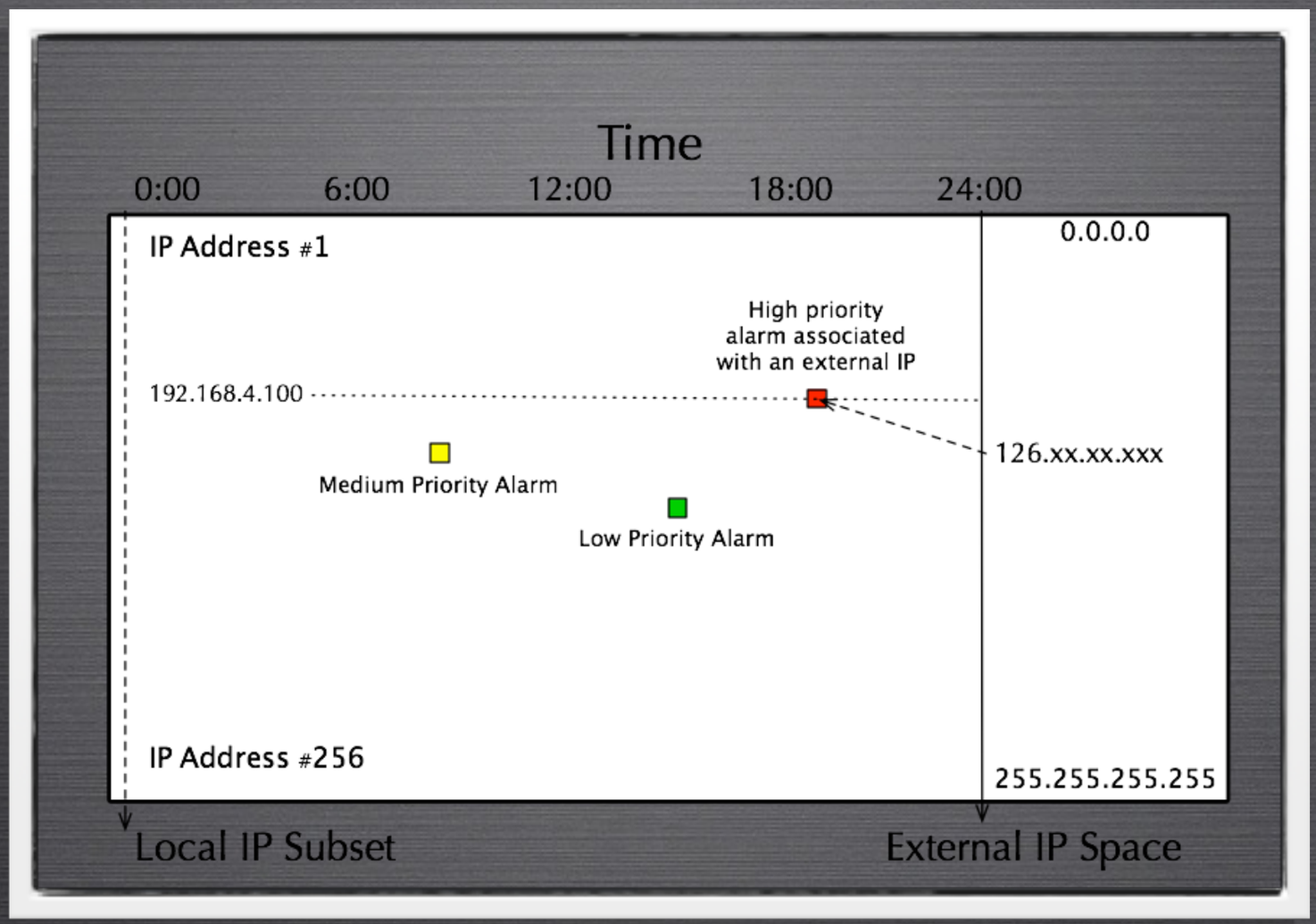
Network data & graph scaling issues

- Graph occlusion
  - Avoid overlap and occlusion in the visualizations
- Scaling data parameters ranges
  - For networking, port numbers & IP addresses need scaling
    - 65535 TCP and UDP ports
    - 4 billion possible IP addresses
- Time scaling
  - Needs to be either small or large depending on activity
    - small for quick activities: fast network scans, DoS, fast propagating worms
    - large for slow network scans, overall trends in a network

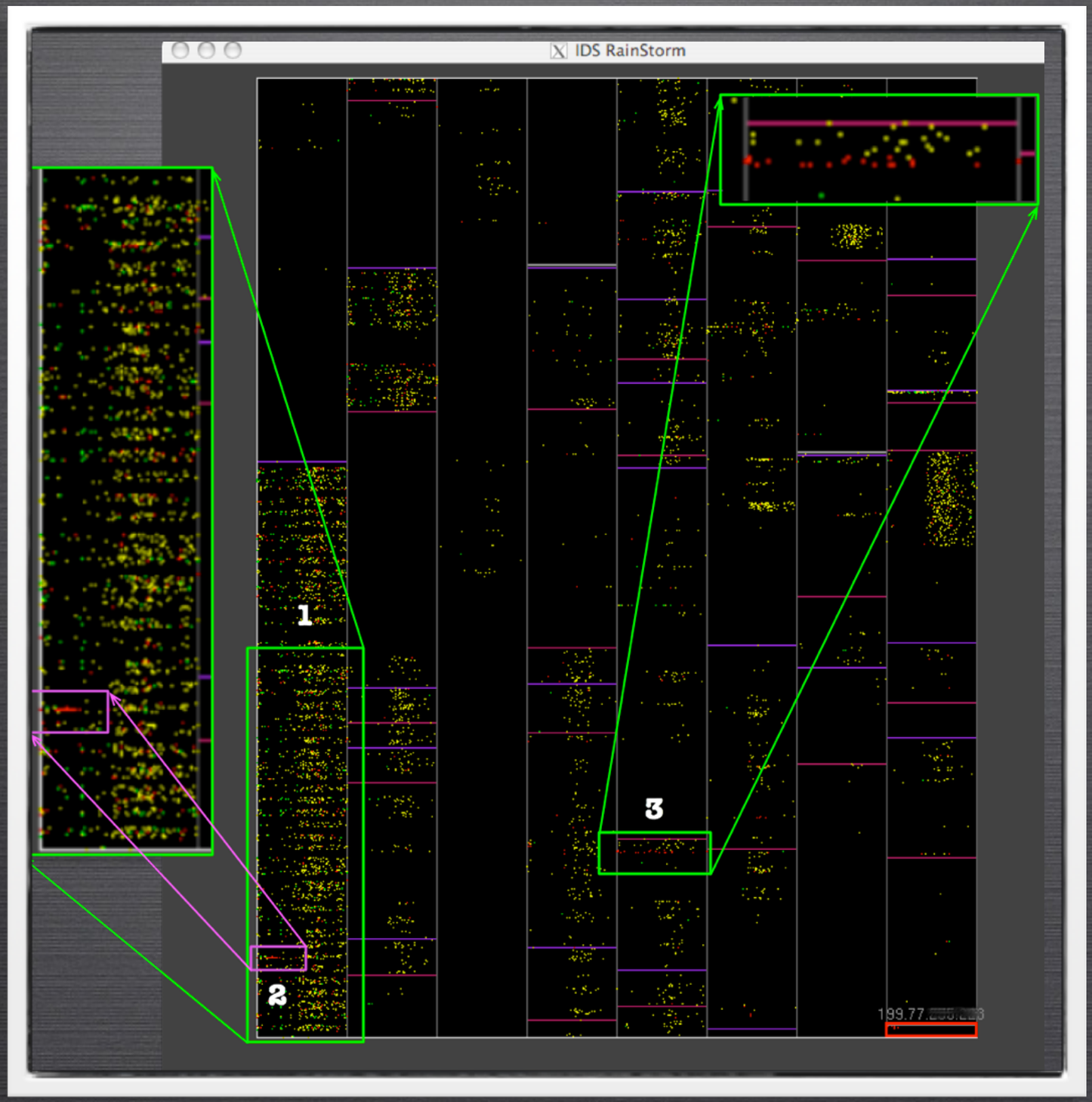
IDS Rainstorm Main View

- This design scales all of the GT IP addresses
- 2.5 Class B addresses plotted along 8 vertical axis
- 20 IPs represented on each line
- Color represents severity
- Time: 24 hours of Stealthwatch IDS alarms shown
  - Most logs are archived into 24 hours
- Filtering on alarm type & priority

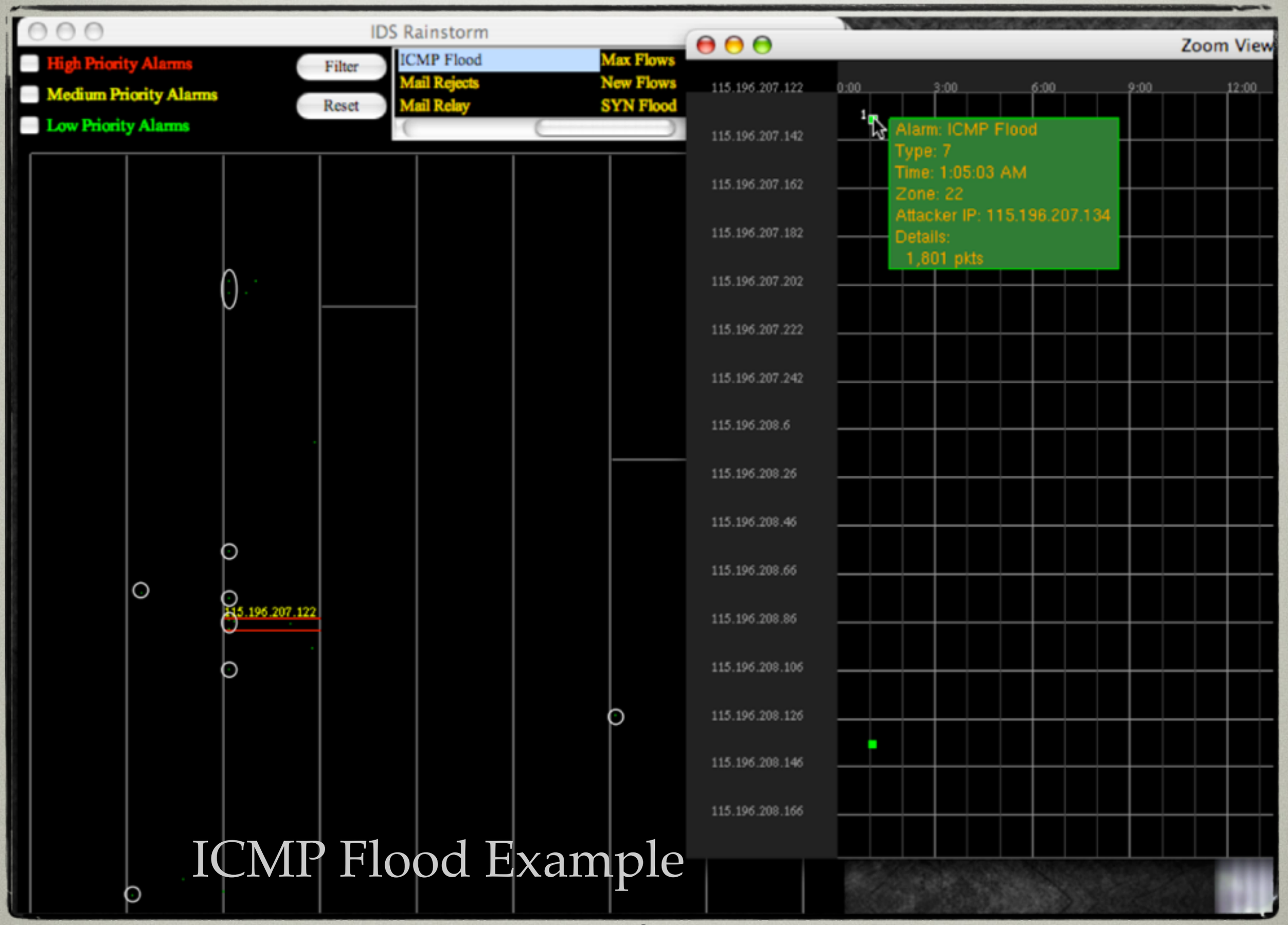



Time
0:00
6:00
12:00
18:00
24:00
IP Address #1
0.0.0.0
High priority
alarm associated
with an external IP
192.168.4.100
126.xx.xx.xxx
Medium Priority Alarm
Low Priority Alarm
IP Address #256
255.255.255.255
Local IP Subset
External IP Space

Zoom View

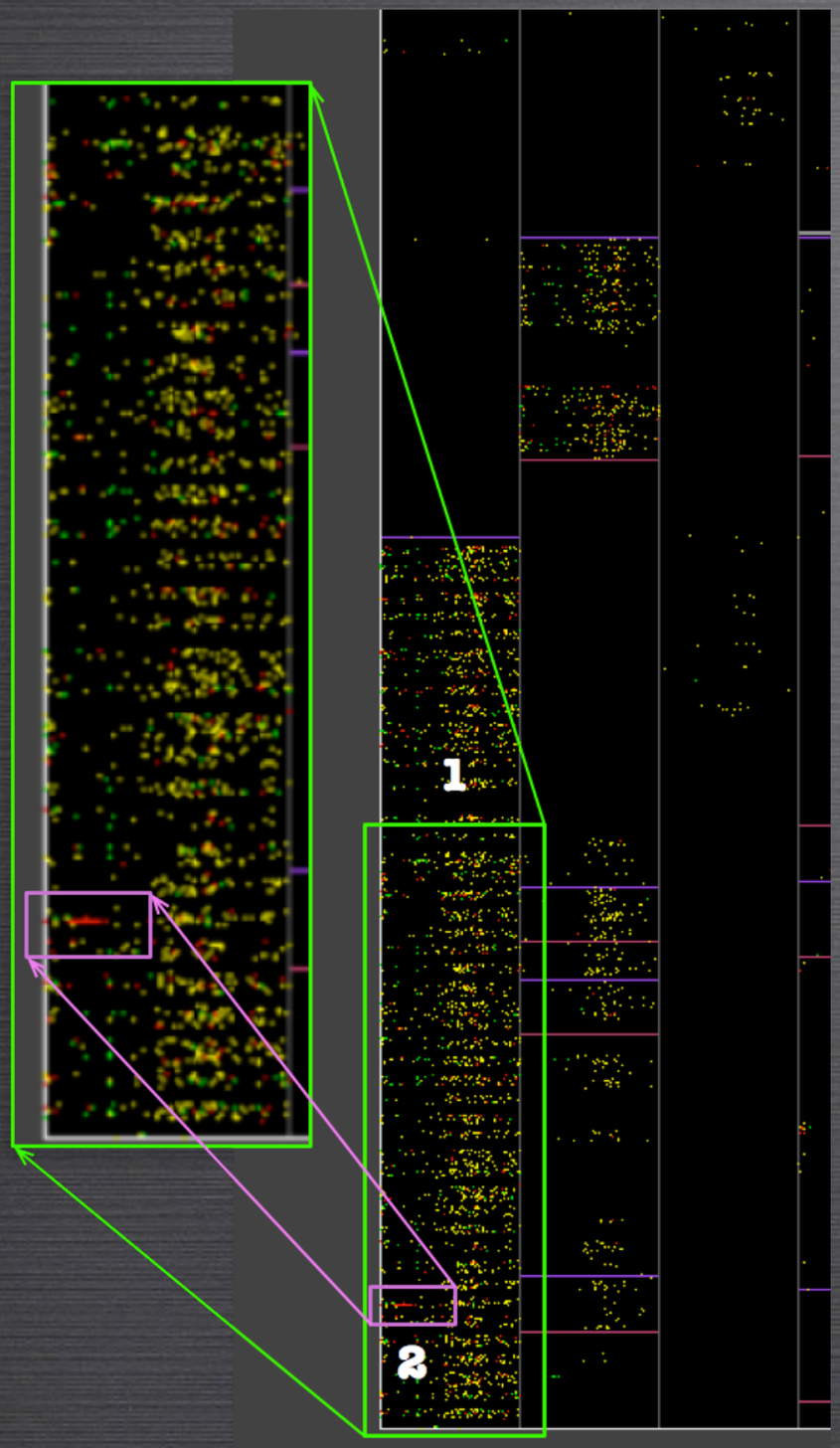


Examples

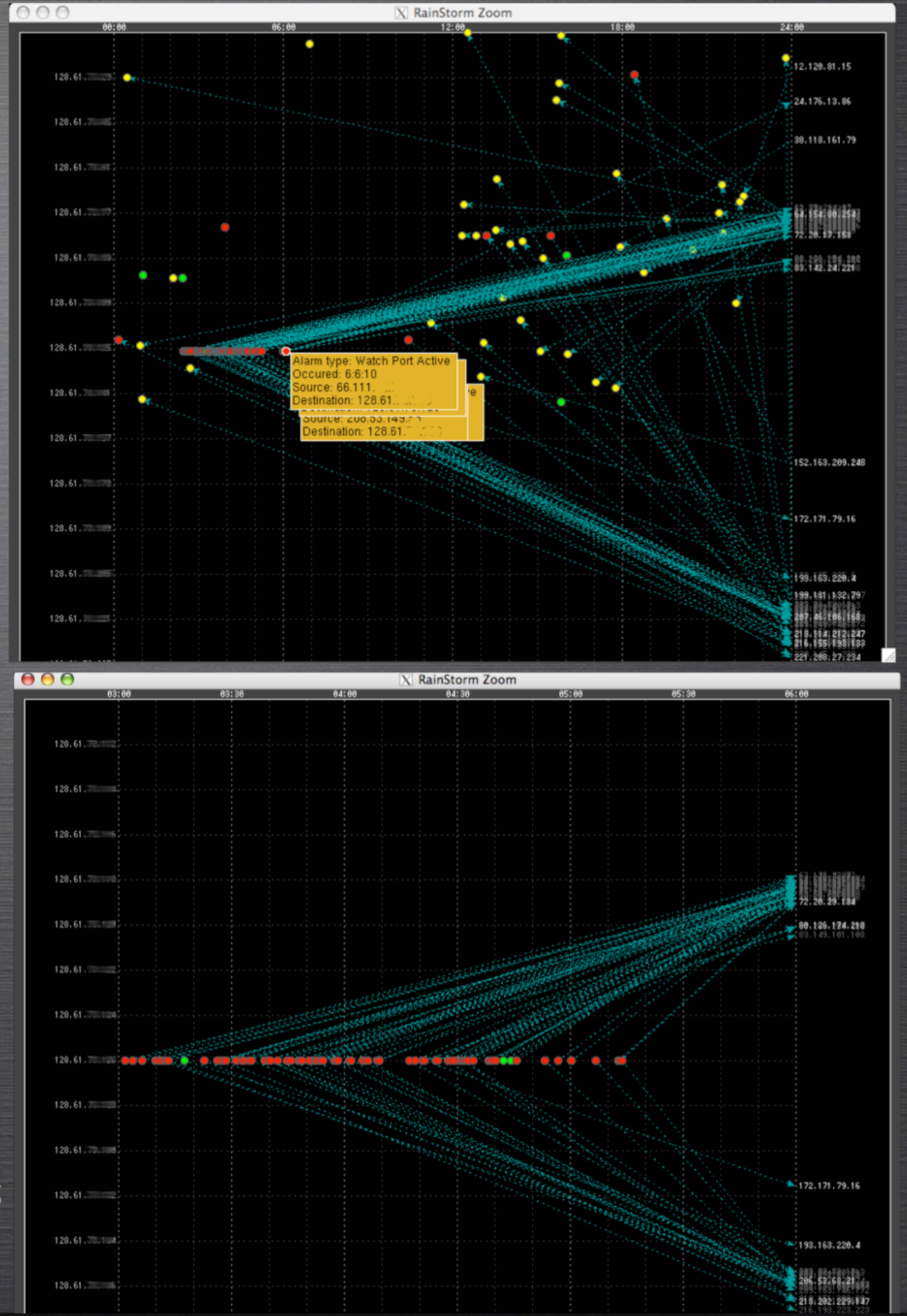


ICMP Flood Example

Worm



Watch port active alarms in dorm space. Port watch was on a known exploit.



Results-User Study

- All stated that time was saved compared to using traditional IDS logs, it was simple and intuitive to use & functioned well
- Seeing patterns and sequence & connections between host
- Some did not return to the alarm text log & some did return to the log for more detail
- Not all alarm parameters are visually encoded
  - Avoid overlap and occlusion in the visualizations
  - Time scaling - Needs to be either small or large depending on activity
    - small for quick activities: fast network scans, DoS, fast propagating worms
    - large for slow network scans, overall trends in a network

Publications

- **K. Abdullah**, G. Conti and R. Beyah. "*A Visualization Framework for Self-monitoring of Web-based Information Disclosure*" IEEE International Conference on Communications (ICC), May 2008. (Post PhD) http://bit.ly/1WfUbu1

- **K. Abdullah**, G. Conti and E. Sobiesk. "*Self-monitoring of Web-based Information Disclosure*" Workshop on Privacy in the Electronic Society (WPES); October 2007. http://bit.ly/1WfUB3L Cited in: G. Conti; Googling Security [http://amzn.to/1NcestF], Addison Wesley; November 2008. (Post PhD)

- **K. Abdullah**, J. A. Copeland. "*High alarm count issues in IDS RainStorm*" ACM Conference on Computer and Communications Security's Workshop on Visualization and Data Mining for Computer Security (VizSEC); November 2006. http://bit.ly/1KioKbz

- **K. Abdullah**, C. Lee, G. Conti and J. Copeland. "*Processing Data to Construct Practical Visualizations for Network Security*" Information Assurance Newsletter, Information Assurance Technology Analysis Center, United States Department of Defense, Summer 2006. http://bit.ly/1Snimrt

- G. Conti, **K. Abdullah**, J. Grizzard, J. Stasko, J. Copeland, M. Ahamad, H. Owen and C. Lee, "*Countering Security Analyst and Network Administrator Overload Through Alert and Packet Visualization*" IEEE Computer Graphics and Applications (CG&A), March 2006. http://bit.ly/1ZqpgeD

- **K. Abdullah**, C. Lee, G. Conti, J. Copeland and J. Stasko, "*IDS RainStorm: Visualizing IDS Alarms*" IEEE Symposium on Information Visualization's Workshop on Visualization for Computer Security (VizSEC); October 2005. http://bit.ly/1n1Heb8 Cited in: G. Conti; Security Data Visualization, No Starch Press; September 2007 http://amzn.to/1UVZPjY

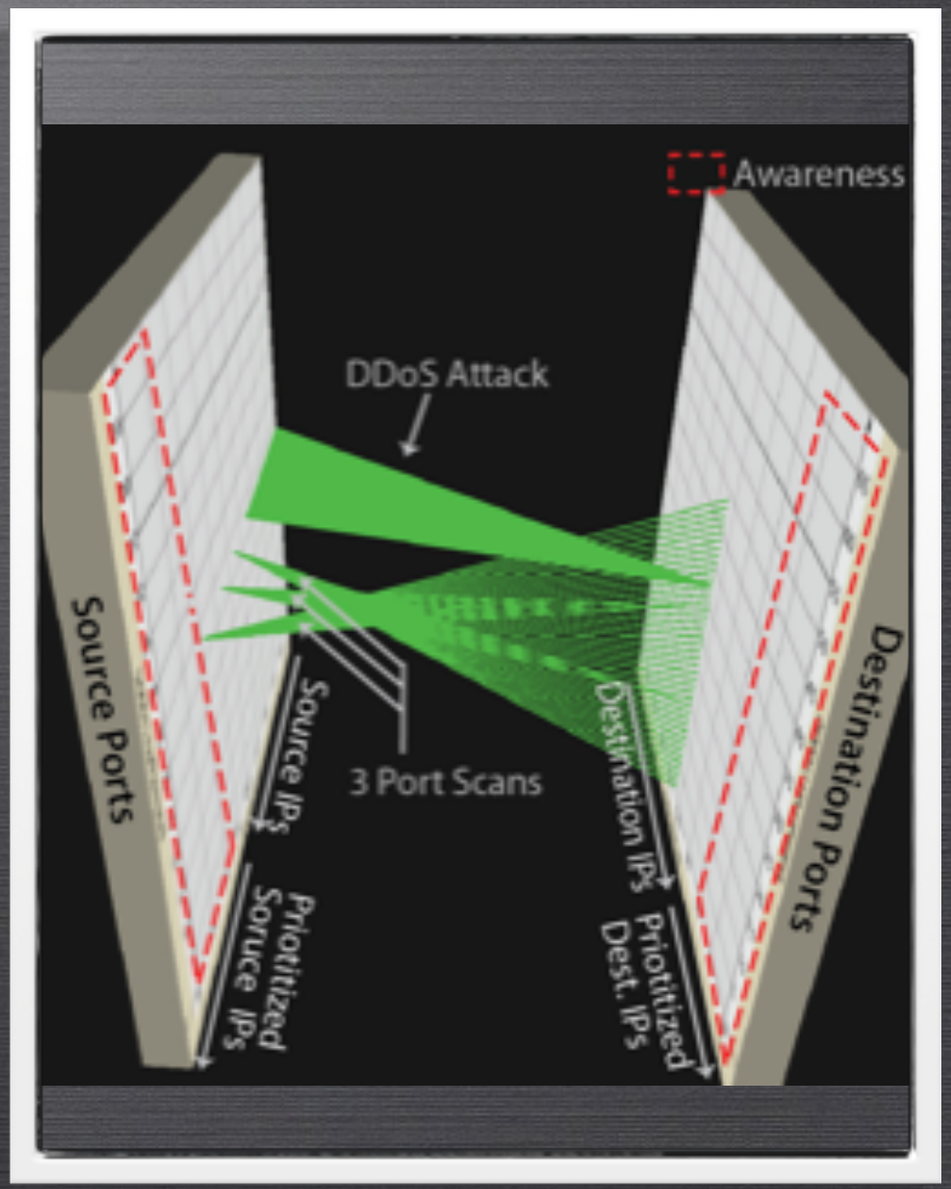
- **K. Abdullah**, C. Lee, G. Conti and J. Copeland, "*Visualizing Network Data for Intrusion Detection*" IEEE Information Assurance Workshop (IAW); June 2005. http://bit.ly/1lg5m8P

- G. Conti and **K. Abdullah**,"*Passive Visual Fingerprinting of Network Attack Tools*" ACM Conference on Computer and Communications Security's Workshop on Visualization and Data Mining for Computer Security (VizSEC); October 2004. http://bit.ly/1PwRaR1

Post PHD Network Visualization Research

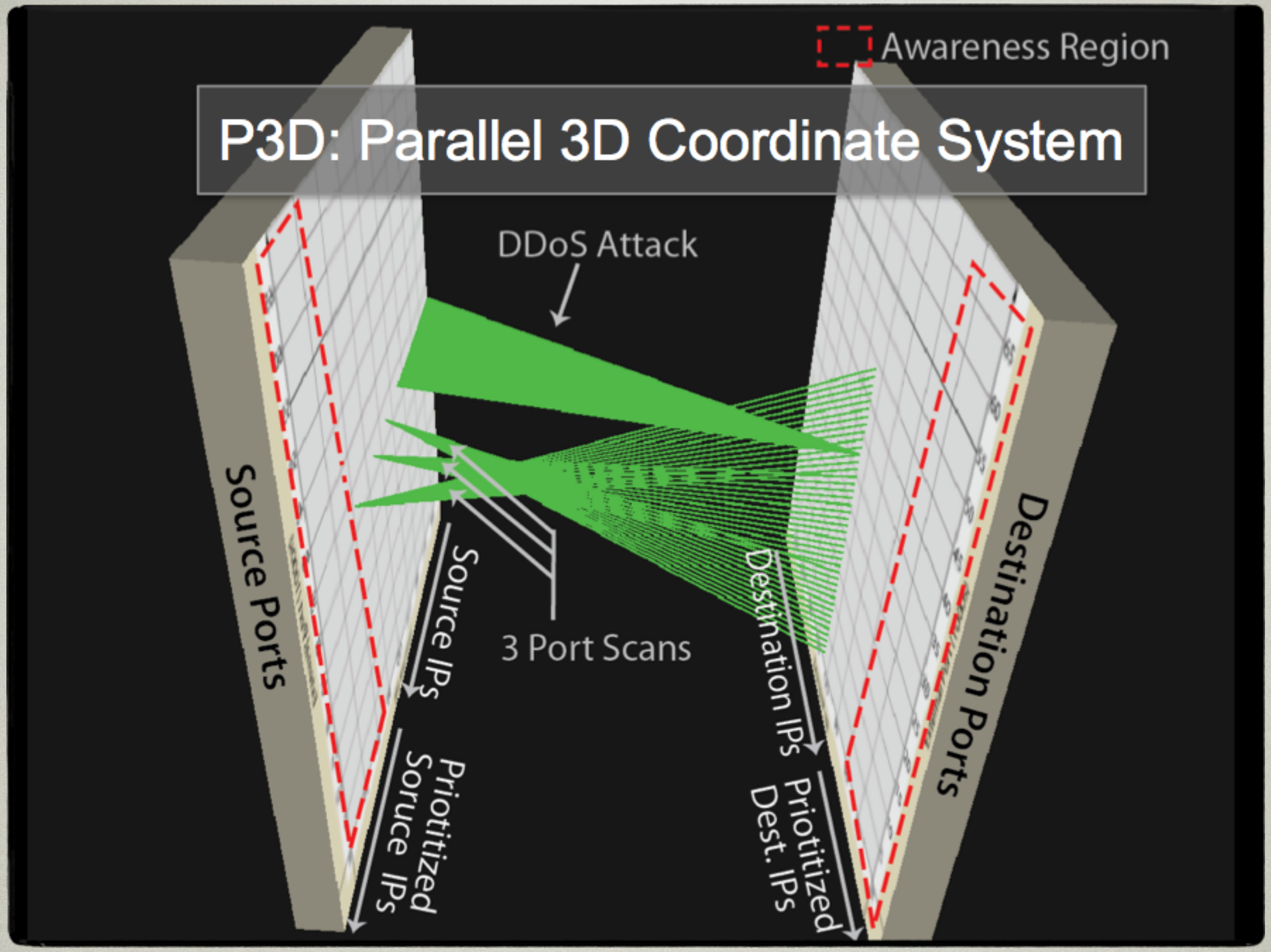
3D Network Security Visualization

3D Network Security Visualization

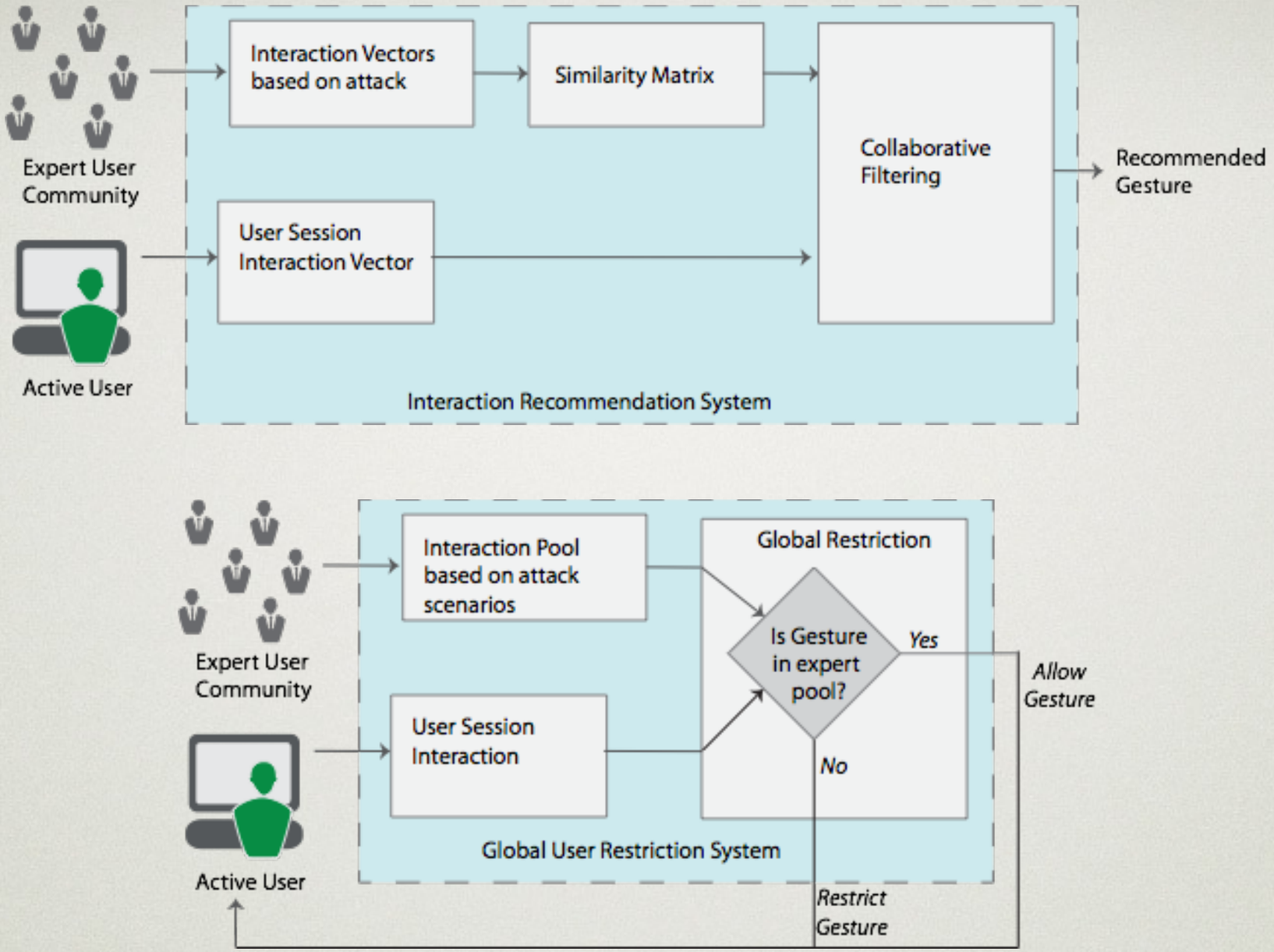


Troy Nunnally, CAP & CSC at GATECH

- 3D Shows more information vs 2D
- 3D can be difficult to for Novices to navigate



T. Nunnally, P. Chi, K. Abdullah, A. S. Uluagac, and R. A. Beyah, "P3D: A Parallel 3D Coordinate System for Advanced Network Scans", IEEE International Conference on Communications (ICC), Budapest, Hungary, September 2013



Collaborative Filtering & Global Restriction

1 Compute the active user's and expert users' frequency of interactions

$$c_{if} = \sum_{k=0} n_{ij}$$

c_{if} is the frequency of each interaction c_i in a sessions. all sessions for user uj

2 Store each interaction frequency into a vector Vi for active user

65535

Total number of interactions (zoom, pan, etc.) = number of dimensions in V_i

3 Create a Similarity Matrix *M*

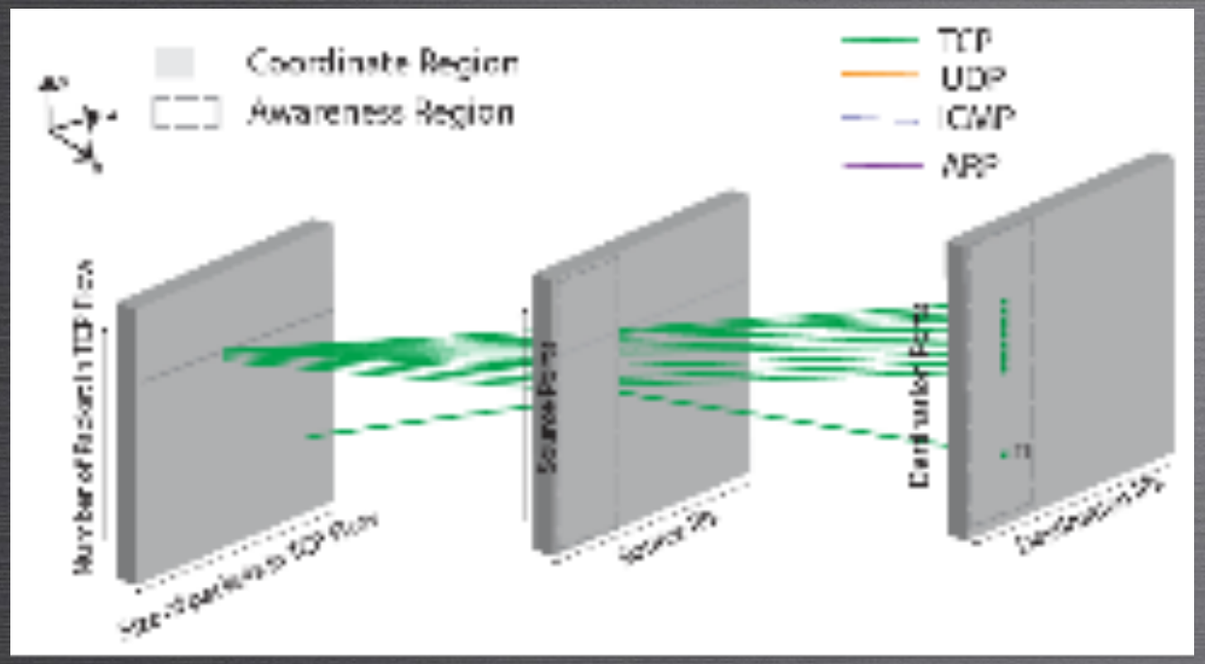
$$M_{ik} = cos(V_i, V_k) = \frac{V_i \cdot V_k}{\|V_i\| * \|V_k\|}$$

V_i – *Active* users
V_k - Expert users
M – similarity matrix
M_{ik} - each pair of interactions *i* and *k*

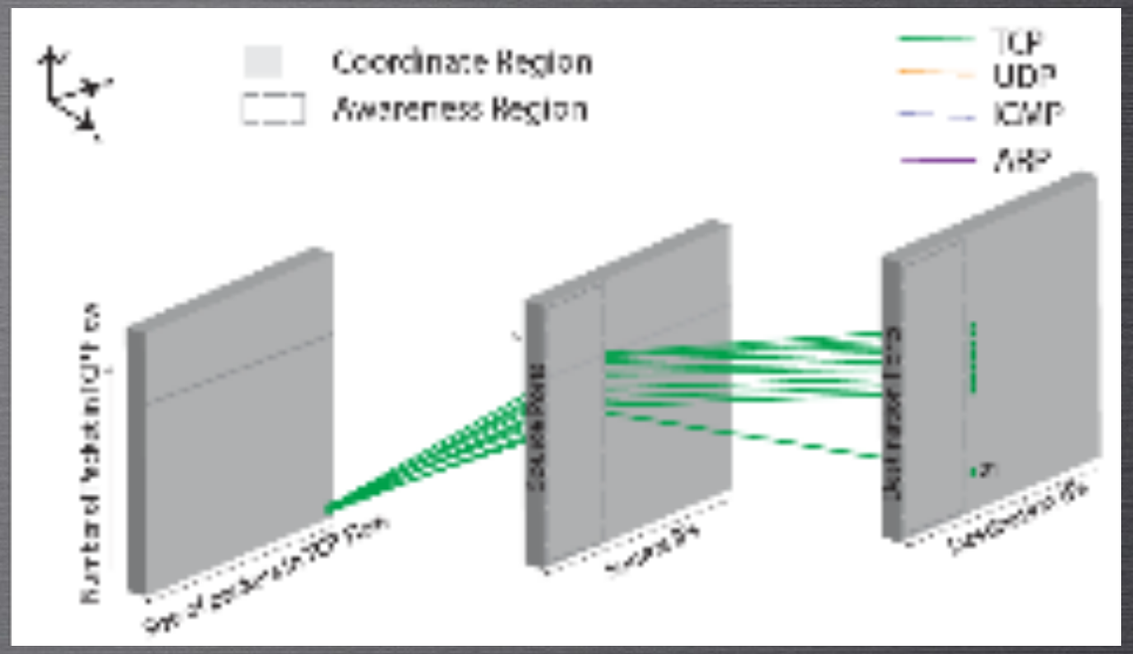
4 Compute the user's expected interaction as list L

Maximum values denotes interactions with highest similarity between V_i and V_k.

T. Nunnally, K. Abdullah, A. S. Uluagac, and R. A. Beyah, "NAVSEC : A Recommender System for 3D Network Security Visualizations", IEEE Symposium on Information Visualization's Workshop on Visualization for Computer Security (VizSEC), Atlanta, GA, USA, October 2013.



P3D Multiple concurrent FTP scan



P3D Multiple concurrent FTP scan

Stealthy Port Scanning Use-Case

Future P3D work

- Implementation and evaluation of more advance use-case scenarios (i.e., introduce benign traffic)
- T. Nunnally, K. Abdullah, A. S. Uluagac, J. A. Copeland & R. A. Beyah, "*InterSec: An Interaction System for Network Security Applications*", IEEE Symposium on Information Visualization's Workshop on Visualization for Computer Security (VizSEC) 2014. http://bit.ly/1P58Hpd
- User Testing
  - 3D, Stereoscopic view, Navigation Assistance
- Natural User Interface
  - Kinect, WII