CYBER SECURITY DIVISION
2013 PRINCIPAL INVESTIGATORS' MEETING

Metrics Suite for Enterprise-Level Attack Graphs

Center for Secure Information Systems
George Mason University
Steven Noel, PhD

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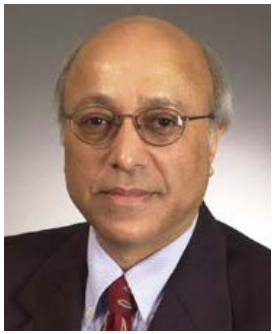
Homeland Security
Science and Technology

Team Profile

Fairfax, VA

GMU Center for Secure Information Systems



Academic Research Center

Northport, NY

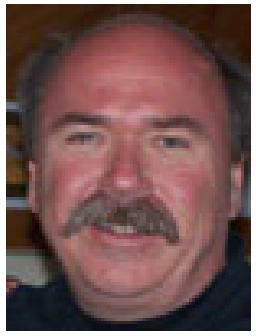
Secure Decisions



Information Visualization

Bethesda, MD

ProInfo

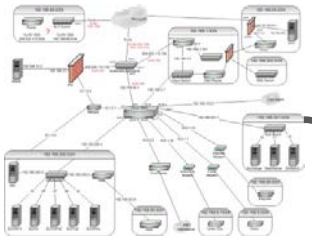
Technology Transfer

Customer Need

- Understand impact of combined topology, policy, and vulnerabilities on security posture
  - Prioritize critical problems
  - Compare options for risk mitigation
  - Measure security trends over time
- Attack graphs via Cauldron show all multi-step vulnerability paths through enterprise networks
- Lacks quantitative scores that capture overall security state at a point in time
- Metrics that can be compared
  - Over time
  - Across organizations
- Simple, practical, efficient, well organized, and clear

Approach: Attack Graph Metrics

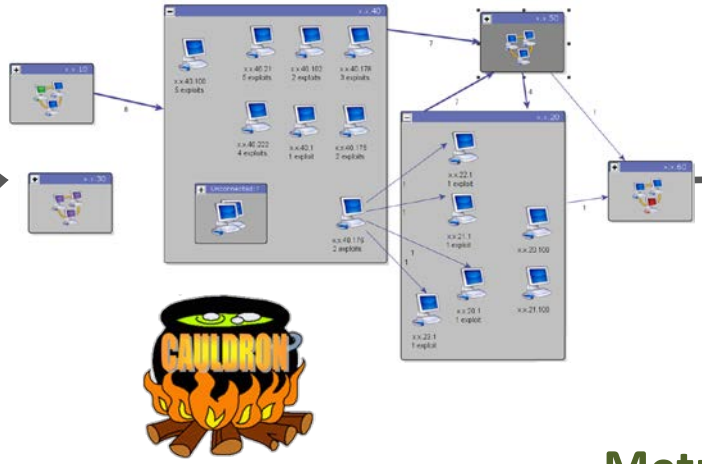
Network Topology



Firewall Rules

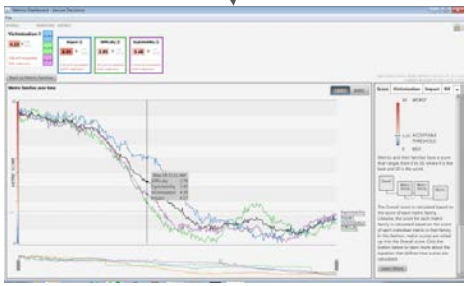
Host Vulnerabilities

Attack Graph Analysis

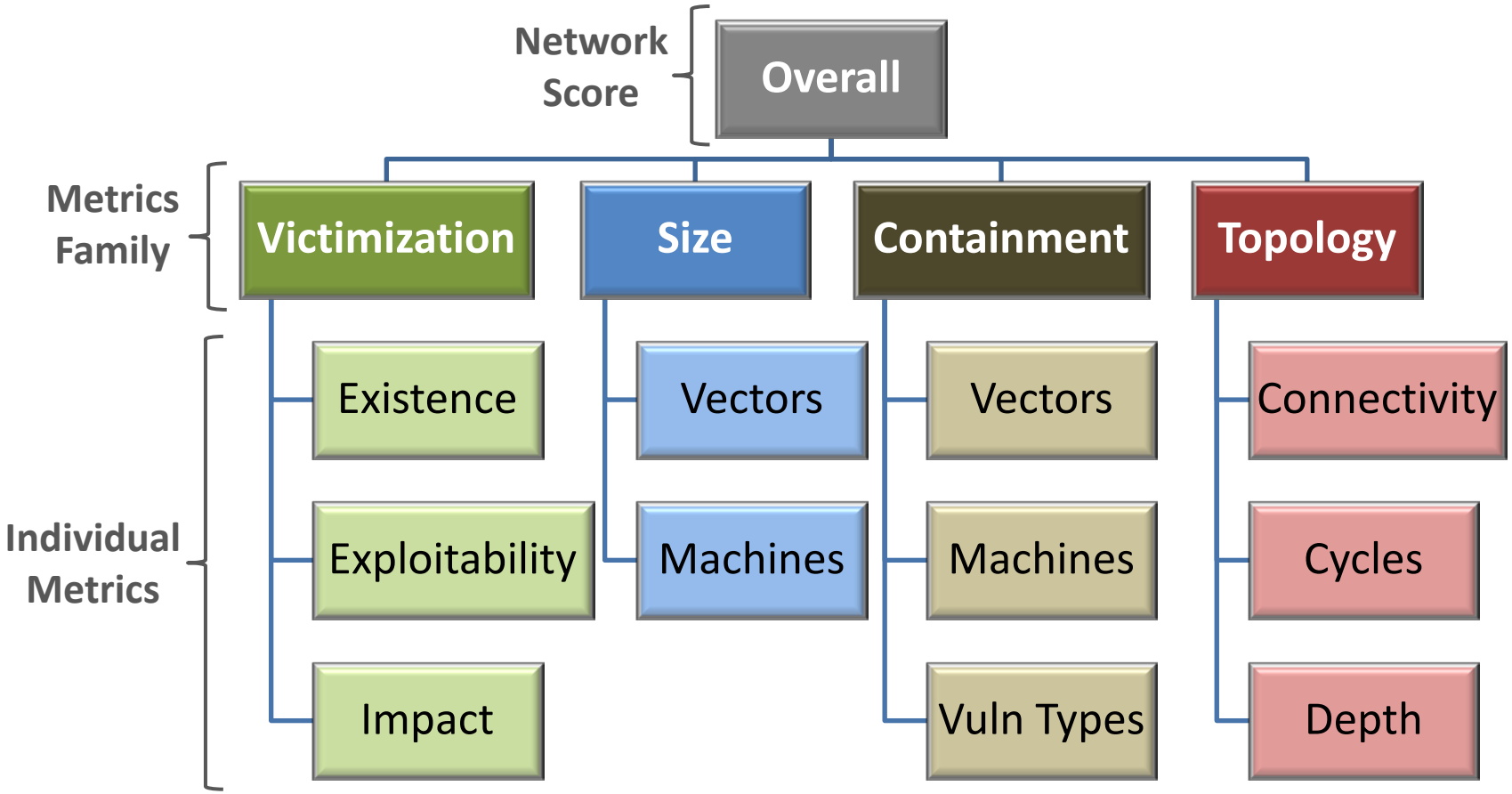


Metrics Engine

Metrics Dashboard



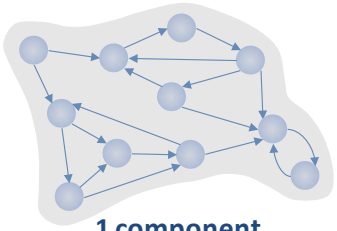
Approach: Metrics Hierarchy



Approach: Topology Family

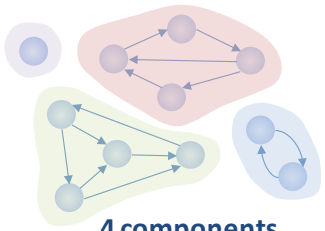
Connectivity

Relative number of (weakly) connected components



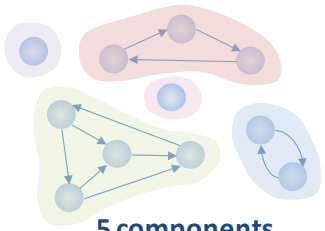
1 component

$$\text{Metric} = 10\left(1-\frac{1-1}{11-1}\right) = 10$$



4 components

$$\text{Metric} = 10\left(1-\frac{4-1}{11-1}\right) = 7$$

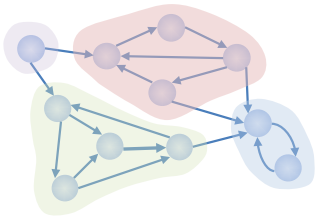


5 components

$$\text{Metric} = 10\left(1-\frac{5-1}{11-1}\right) = 6$$

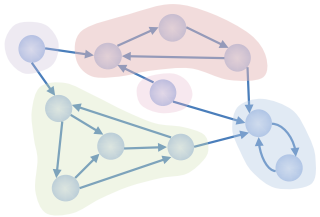
Cycles

Relative number of (strongly) connected components



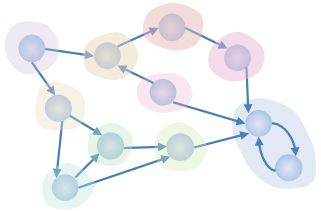
4 components

$$\text{Metric} = 10\left(1-\frac{4-1}{11-1}\right) = 7$$



5 components

$$\text{Metric} = 10\left(1-\frac{5-1}{11-1}\right) = 6$$

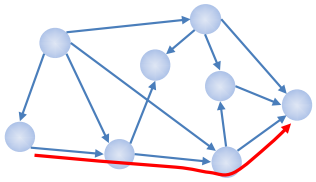


10 components

$$\text{Metric} = 10\left(1-\frac{10-1}{11-1}\right) = 1$$

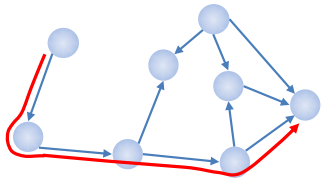
Depth

Minimum of all-pairs shortest path



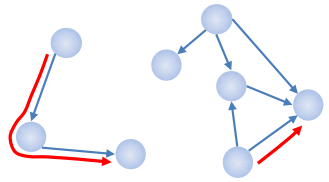
Shortest path 3/8

$$\text{Metric} = 10\left(1-\frac{3}{8-1}\right) = 5.7$$



Shortest path 4/8

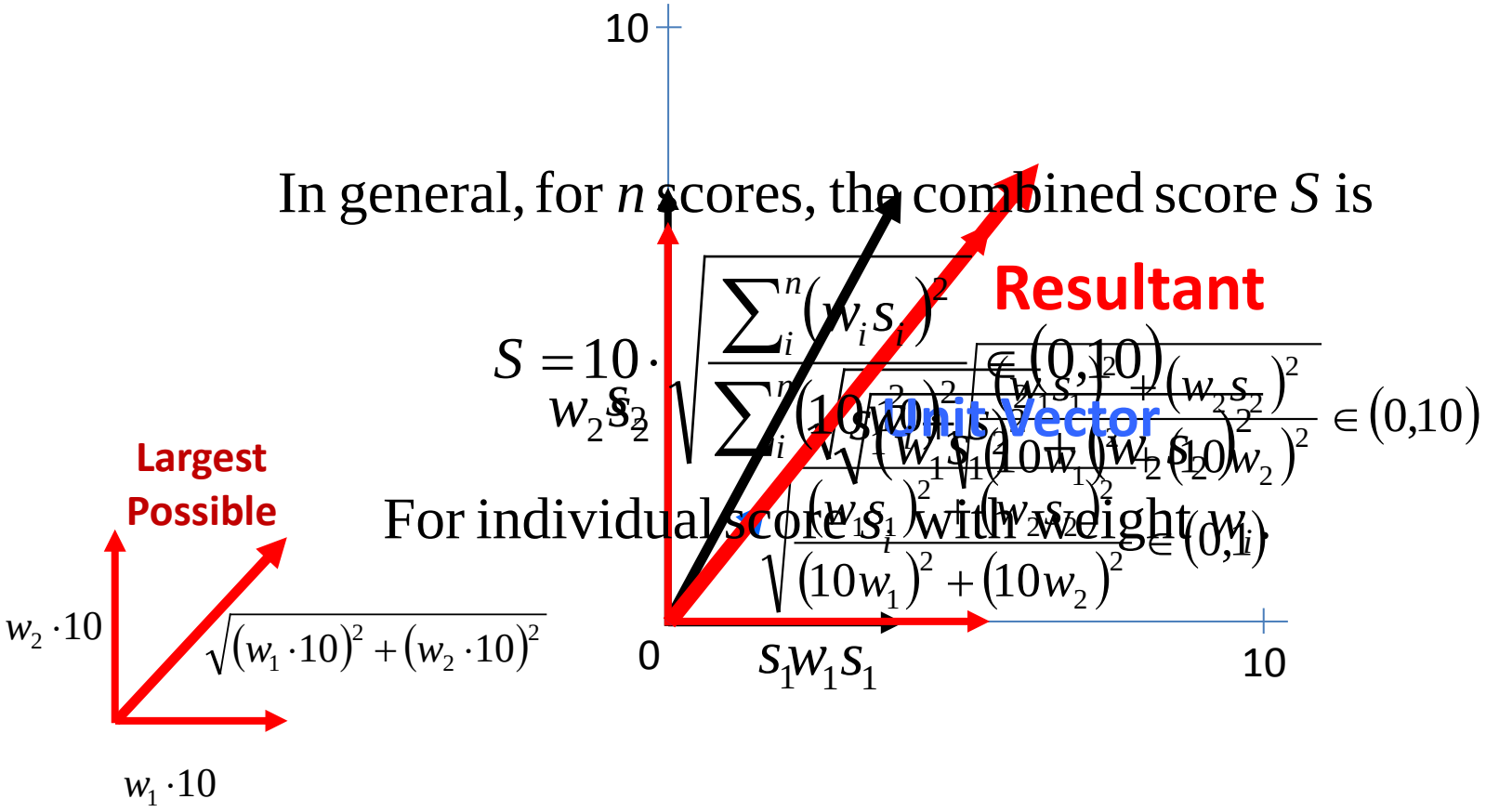
$$\text{Metric} = 10\left(1-\frac{4}{8-1}\right) = 4.3$$



Shortests paths 2/3 and 1/5

$$\text{Metric} = \frac{10}{2\cdot 8}\left[3\cdot\left(1-\frac{2}{3-1}\right)+5\cdot\left(1-\frac{1}{5-1}\right)\right] = 2.3$$

Approach: Combining Metrics



In general, for n scores, the combined score S is

$$S = 10 \cdot \frac{\sqrt{\sum_i^n (w_i s_i)^2}}{\sqrt{\sum_i^n (10 w_i)^2}} \in (0,10)$$

For individual score s_i with weight w_i

$$\frac{w_i s_i}{\sqrt{(10w_1)^2 + (10w_2)^2}} \in (0,1)$$

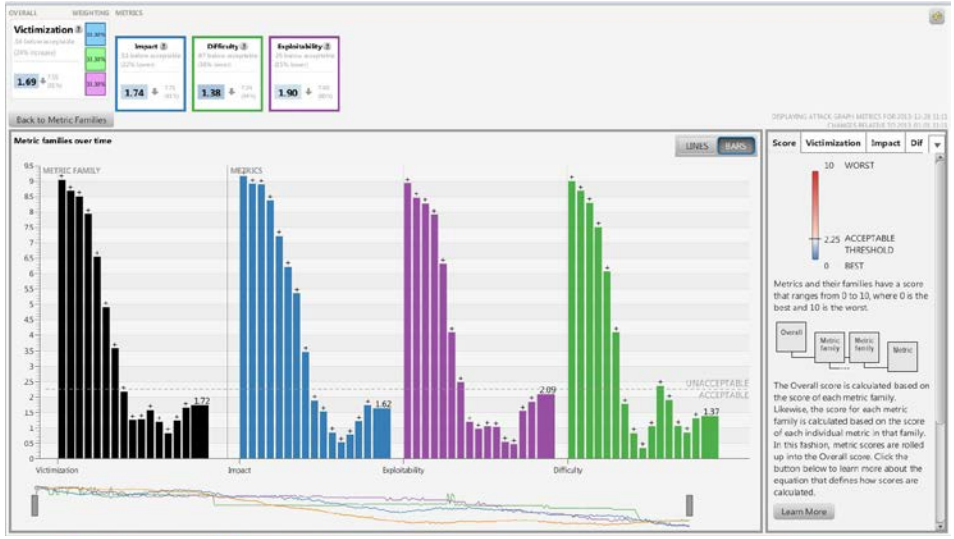
Approach: Metrics Dashboard

Line Graph

Historical Details

Bar Graph

Summary Trends



Benefits

- Numeric measures are simple to understand, organized into families of related metrics
- Quickly determine if the situation is improving over time
- Tedious error-prone work is automated
- All metrics linear complexity with respect to graph size
- Practical for large networks
- Comparable across different organizations and networks
- Huge volumes of disparate data reduced to concise business intelligence

Competition

- Metrics
  - There are many metrics but for the most part they are qualitative
  - Quantitative measures such as CVSS and SANS Top 10 vulnerabilities lack context of specific network environment
- There is no automated tool in the market place

Current Status

- Type III (one year)
- Q1: requirements, design, interfaces, mockups
- Q2: Prototype implementation, user feedback
- Q3-Q4: Production implementation
- 9 development sprints
- 70+ customer briefings
- Customer evaluations
- Final software packaging, documentation, reporting

Next Steps

- Cauldron commercialization through Mason Tech Transfer (GMIP) and ProInfo/CyVision partnership
- Cauldron deployed in a variety of customer settings
- Significant IP, protected by patents and copyrights
- Available under GSA scheduling
- Marketing through direct sales and a network of resellers, strategic partners, and OEM relationships
- Strategic partners for services and complementary technologies
- Cauldron+Metrics (C+M) as software, C+M as service

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