CERIAS

The Center for Education and Research in Information Assurance and Security

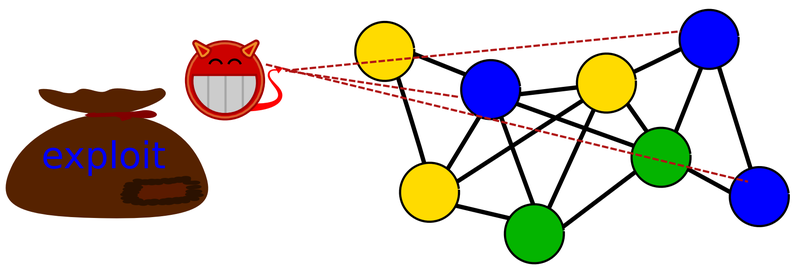
Increasing Network Resiliency by Optimally Assigning Diverse Variants to Routing Nodes

Andrew Newell, Daniel Obenshain, Tom Tantillo, Cristina Nita-Rotaru, and Yair Amir

Motivation

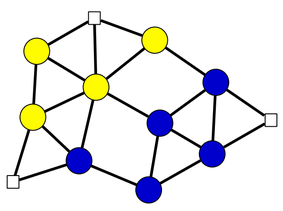
- Exploits target specific vulnerabilities
  - Operating system
  - Administrator
  - Routing code
- **Homogeneous networks** potential total compromised

- **Diverse networks** more likely portion of network survives

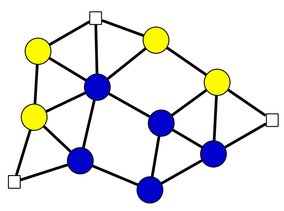


Goal

- Given topology and diverse variants
  - # diverse variants < # nodes
  - Each variant independent probability of compromise
  - Resilient routing protocol
- Assign variants to nodes to maximize connected clients



Yellow: 1
Blue: 1



Yellow: 2
Blue: 3

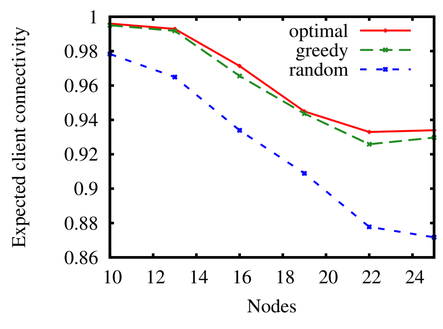
Diversity Assignment Problem

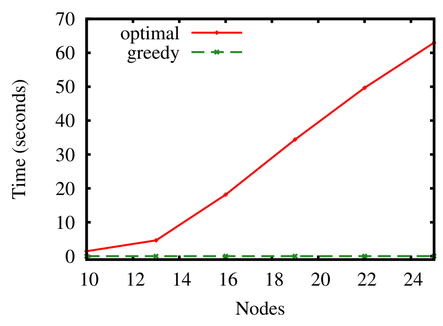
$$\text{argmax}_A[\overbrace{\sum_{e \in C} P(e) * \underbrace{f(A,e)}_{\text{Client connectivity}}}^{\text{Expected client connectivity}}]$$

A	assignment of variants to nodes
e	compromise event
C	all compromise events
$f(A,e)$	$\frac{\#\text{ client-pairs connected}}{\#\text{ client-pairs}}$

Solution Techniques

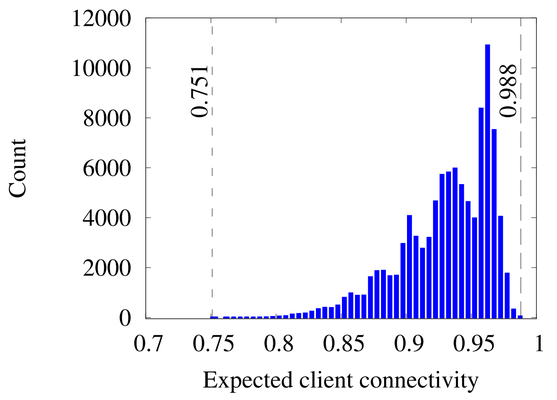
- Problem is NP-Hard
- Mixed Integer Programming (optimal)
  - Heuristics prune large amount of search space
  - IBM's CPLEX solver does well in realistic scenarios
- Greedy algorithm (approximate)
  - Assigns iteratively to maximize immediate results
  - Achieves nearly optimal solution

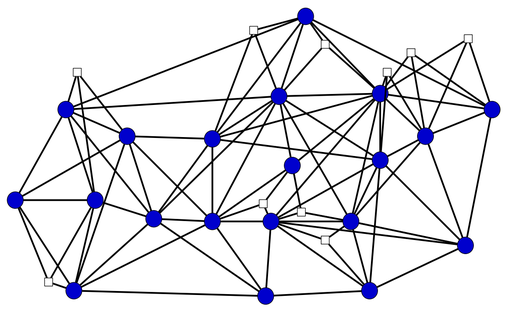




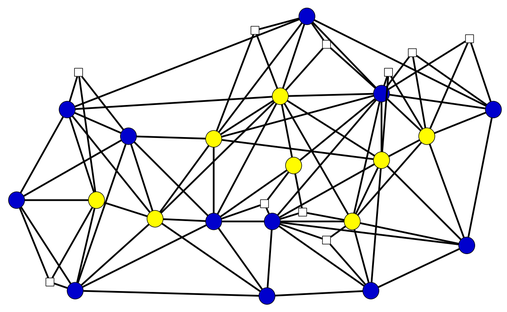
Case Study

- LTN cloud service provider topology
- Three representative variants that fail with 10% (blue), 15% (yellow), and 20% (red)
- Random assignments are quite poor
- Increasing diversity increases resilience

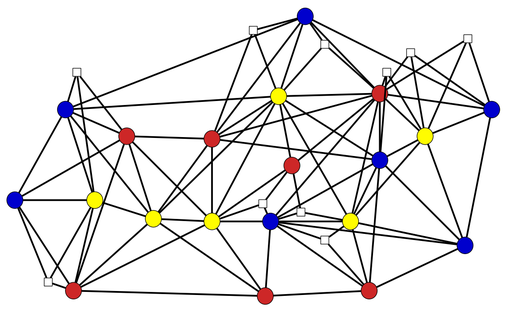




1 variant (homogeneous)
90% Exp. client conn.



2 variants
98.5% Exp. client conn.



3 variants
99.7% Exp. client conn.

CERIAS

PURDUE UNIVERSITY