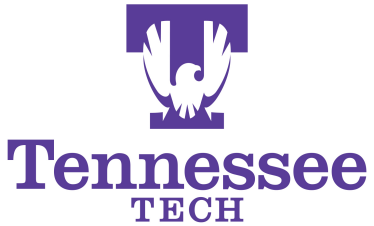
FLAIRS 2019 – Main Track



DETECTING THE INCEPTION OF A NETWORK LAYER DOS ATTACK WITH A GRAPH-BASED APPROACH

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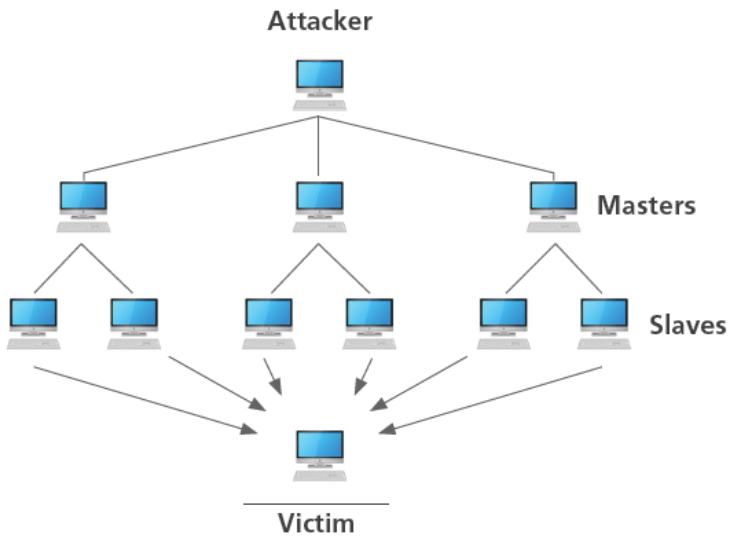
- Introduction
- Methodology
- Dataset
- Experiments & Results
- Discussion & Future Work

Denial of Service (DOS) Attack



[10]

- **Denial of Service (DOS) attack** : malicious act with the goal of interrupting the access to a computer network.
- **Motivation**: include but are not limited to revenge, prestige, politics, or money [1].
- **Goal**: overflow server/network with messages that have invalid return addresses → overwork the targeted network [2].

Motivation

- **Imagine a world in which DoS attacks do not exist**
  - *Saves companies time and money*
  - *Allows user access to their contents without interruption*

However, the majority of the techniques used to identify DoS are too late… the damage has already occurred

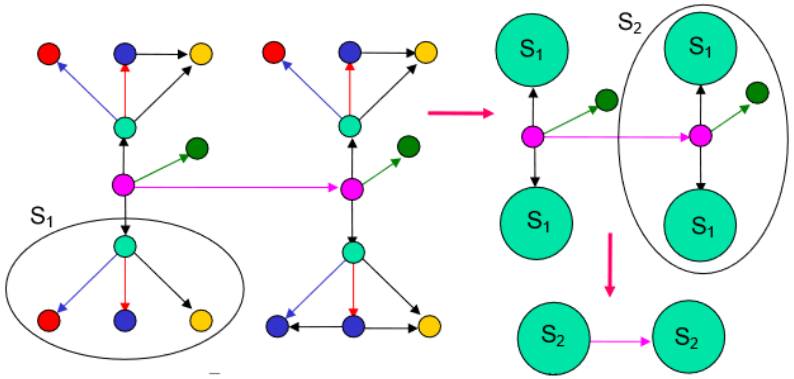
- **How do we exterminate DoS attacks?**
  - *Locate DoS attacks at its inception*
  - *Take action to prevent further damage*
- **Goal:**
  - ***Identify the DoS attack earlier in the process***

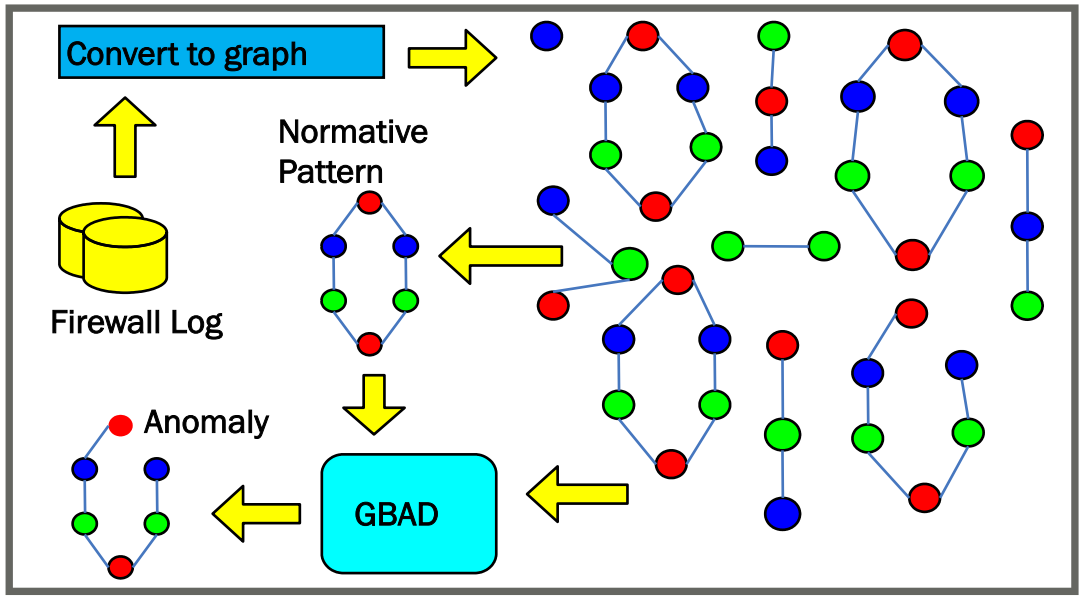
Contribution

- Use graph-based approach for detecting DoS Attack.
- Detect DoS attack at it’s inception (quicker than the installed IDS in company’s network).

Graph-Based Anomaly Detection

- Find normative pattern $\boldsymbol{S}$ (highly compressing pattern using MDL principal)
- Find closely-matching instances $\boldsymbol{S_A}$ of $\boldsymbol{S}$
  - *Missing nodes/edges (gathered along the way)*
  - *Additional nodes/edges (search a bit further)*
  - *Modified labels among structural matches*
- $\boldsymbol{P_r(SA) = \frac{\#\, particular\ SA}{\#\, all\ SA's}}$
- $\boldsymbol{Anom.score = Pr(SA) * D(SA, S)}$
- GBAD (www.gbad.info)

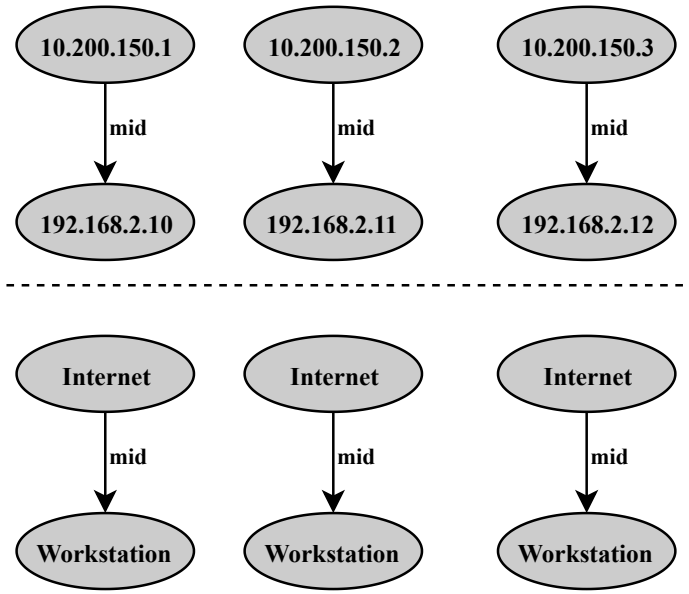




Dataset

- **Visual Analytics Science and Technology (VAST) 2011**, mini challenge 2
- Multiple logs (firewall, IDS, etc) from All Freight Corporation's computer network
- Only firewall log used for this work
- Although there were three days of data, the DoS attack occurs at 11:39:51 am on day one on an external web server.
- DoS attack carried by 5 devices: **10.200.150.<201, 206, 207, 208 and 209>**
- IDS log did not flag the DoS attack until 11:43:29 (3 minute and 39 seconds delay)

Data Preparation



- Parsed the firewall log into graphs.
- Devices on network grouped by type instead of IP (helps establish clear pattern).
- Connections (edges) labeled by volume of traffic (e.g., “mid” and “high”).
- Individual graphs correspond to different time intervals.

Experimental setup

- 0 sec interval resulted in too many graphs with a small graph to vertex ratio (≈1:8) resulting in insignificant patterns.
- Similarly, 8-second intervals generalized the data too much (graph to vertex ratio 1:26), resulting in uninteresting and larger normative patterns.
- **5-sec intervals (middle ground) was chosen for the testing process**

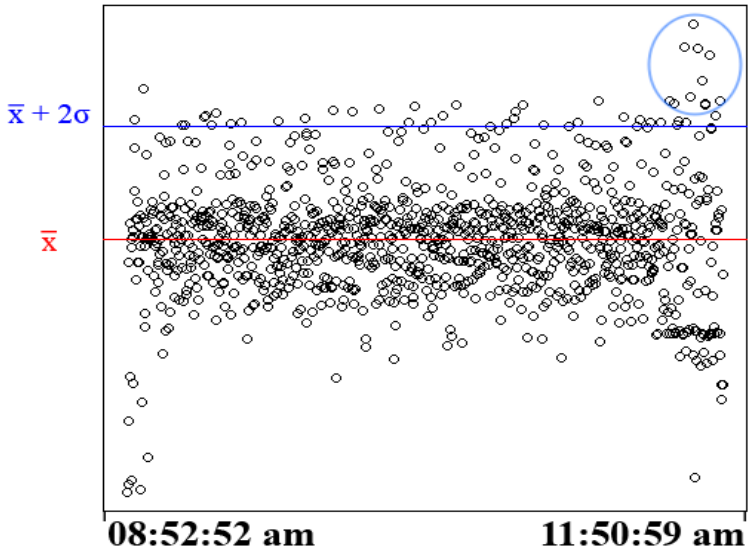


Fig: Number of connection from internet to web server

Single Graph Interval	# of Vertices	# of Edges	# XP/file	# of Graphs		
				Normal	DoS	Total
0 Sec	68,267	59,588	8,478	7,801	677	8,478
1.25 Sec	49,197	45,007	4,629	4,295	344	4,629
2.5 Sec	42,032	39,957	3,201	2,962	239	3,210
5 Sec	33,544	34,543	1,691	1,580	111	1,691
8 Sec	29,607	32,282	1,140	1,066	74	1,140

Table: Graph topology based on time intervals and graph counts

Results

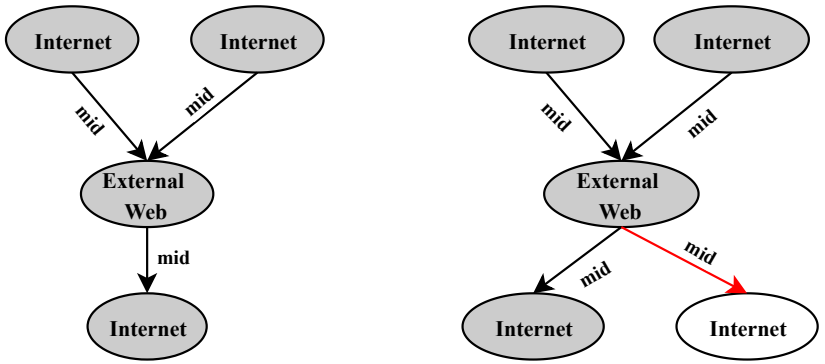


Fig: Normative Pattern I and anomalous addition (extra node and edge)

Graph Interval	Anom. Graph Reported	Attack Source Reported	Detection Delay	Runtime
0 Sec	6.35%	5	31	482
1.25 Sec	4.2%	4	612	289
2.5 Sec	18.4%	3	31	257
5 Sec	**96.4%**	**5**	**23**	**118**
8 Sec	1.35%	0	4	102

Table: Performance of on different graph topology

	Predicted (DoS)	Predicted (Normal)
Actual (DoS)	107 (TP)	4 (FN)
Actual (Normal)	0 (FP)	1580 (TN)

Table: Confusion matrix for 5 second graph using normative pattern shown in the left

Results

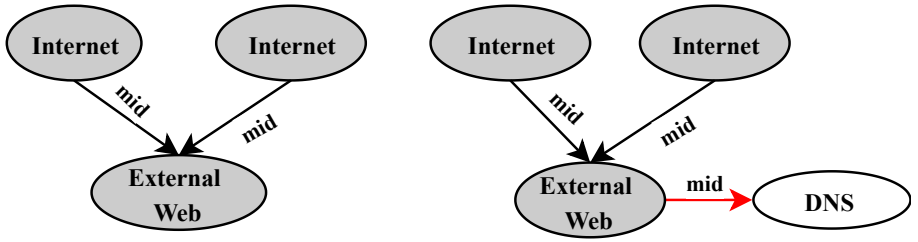


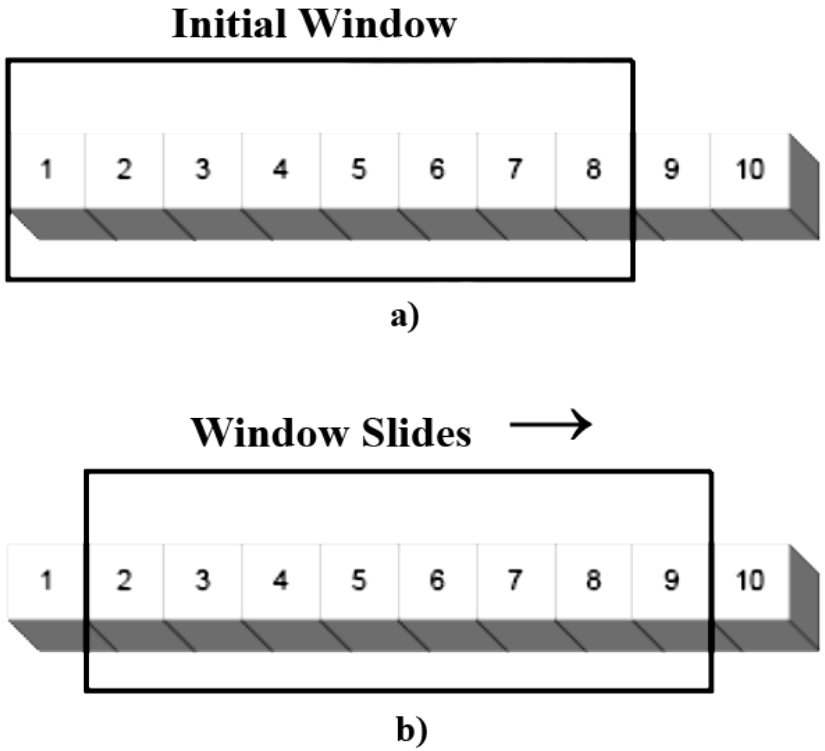
Fig: Normative Pattern II and anomalous addition (extra node and edge)

- To reduce the DoS attack detection delay.
- Use another subgraph shown above (left side) as a normative pattern.
- **Two** anomalous instances (right) were found.
- **Anomalous pattern** - unusual for the web server on All Freight's computer network to communicate to the DNS servers.
- The anomaly topology was discovered at 11:39:56 am.
- The first flag was raised 5 seconds after the DoS attack begins (DoS attack starts at 11:39:51 am).

Discussion

- **We argue that these anomalies are justifiable and logical**
- The goal of DoS attack is to squander network resources.
- It is done by sending a high amount of traffic (which is reflected by the first normative pattern)
- The direct repercussion of a high amount of traffic:
  - *Create factious return addresses*
  - *Web servers must perform a DNS quarry to find address it does not know*
  - *This was flagged as an anomaly using the second normative pattern.*

Conclusion & Future Work



- Installed IDS picked DoS attack after 3 minute and 39 seconds.
- However, the proposed graph-based approach raised the first flag in 5 seconds after the DoS attack begins.
- Issues
  - *Took ~100 seconds to run the algorithms*
  - *Need to be able to run in real-time, scalability*
- Possibilities
  - *Sliding window protocol, break down the dataset into smaller chunks instead of analyzing all data at once*
  - *Process graphs in parallel*

Acknowledgements

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Questions?