Analyzing Flow Using Encounter Complexes

Leigh Metcalf, netsa-contact AT cert.org

Flocon, Charleston
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Clustering for Data Reduction

Instead of examining 5,000 flows over a time period…

Examine 12 clusters instead.

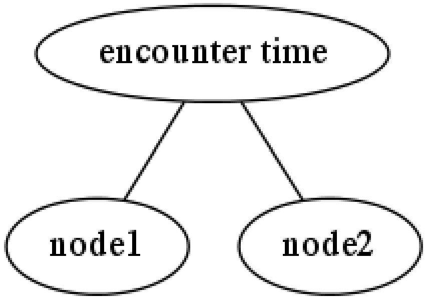
A 99.76% reduction

Previous Work

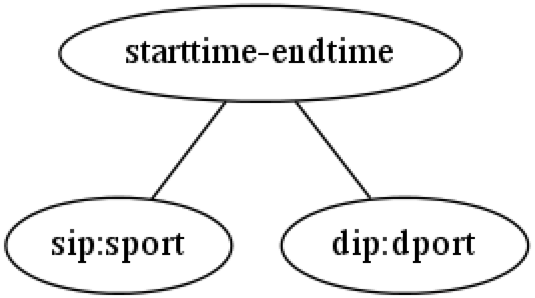
- Network Flow Clustering has been used for:
  - Trojan Detection
    - http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6405737&tag=1
  - Detecting Spoofed Flows
    - http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4239059
  - Finding Botnets
    - http://dl.acm.org/citation.cfm?id=1496721
- Encounter Complexes have been used for:
  - Recovering Spatial Information
    - http://dl.acm.org/citation.cfm?id=1374668

Encounter Trace

Defined as:



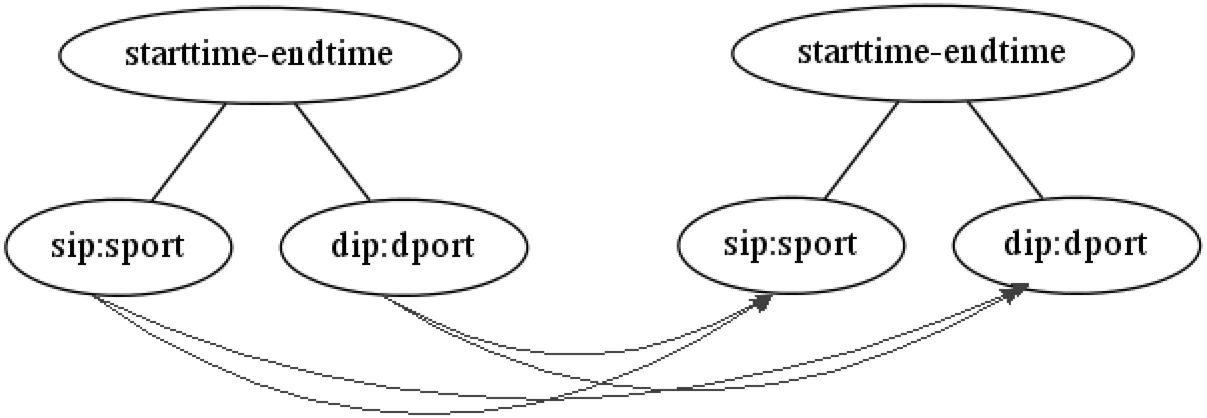
For Flow:



Encounter Complex

Two encounters have an edge between them if:

- They share an endpoint
- The endtime of one is within δ seconds of each other



Encounter Complex

Example of a complex:

```
2009/04/20T11:35:19.529 2009/04/20T11:35:28.935
        10.1.60.203:60515 10.1.60.25:25
2009/04/20T11:36:28.822 2009/04/20T11:36:28.822
        10.1.60.203:51727 10.1.60.25:25
```

Encounter Complex

Example of a complex:

```
2009/04/20T11:35:19.439 2009/04/20T11:35:19.445
          10.1.60.203:50398 10.1.60.187:80
2009/04/20T11:35:19.440 2009/04/20T11:35:19.445
          10.1.60.187:80 10.1.60.203:50398
```

Not Encounter Complexes

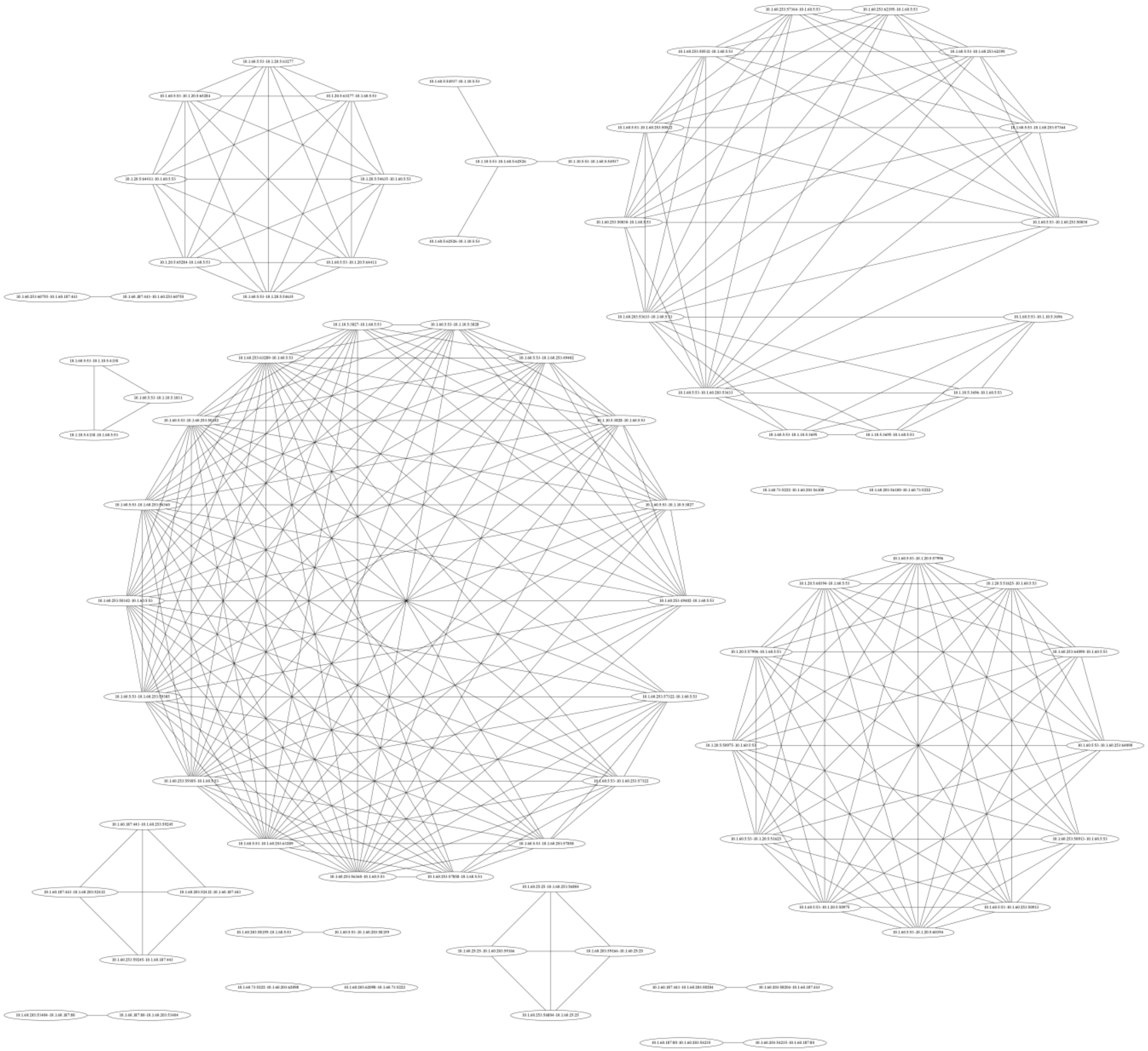
Example 1: The time is too far apart

```
2009/04/20T11:35:19.463 2009/04/20T11:35:19.519
        10.1.60.203:49592 10.1.60.187:443
2009/04/20T13:00:13.738 2009/04/20T13:00:13.738
        10.1.60.187:443 10.1.60.253:56074
```

Example 2: No matching trace found

```
2009/04/20T11:35:19.529 2009/04/20T11:35:28.935
        10.1.60.203:60515 10.1.60.25:25
```

Visualizing This – Is Useless



Analysis

- Graph clusters
  - Each component within the complex is a set of related encounter traces
  - For example:
    - 12 components within one flow when δ=8
  - Degree Analysis
    - What is the encounter with the most connections?
  - Local Clustering Coefficient
    - How dense is my graph

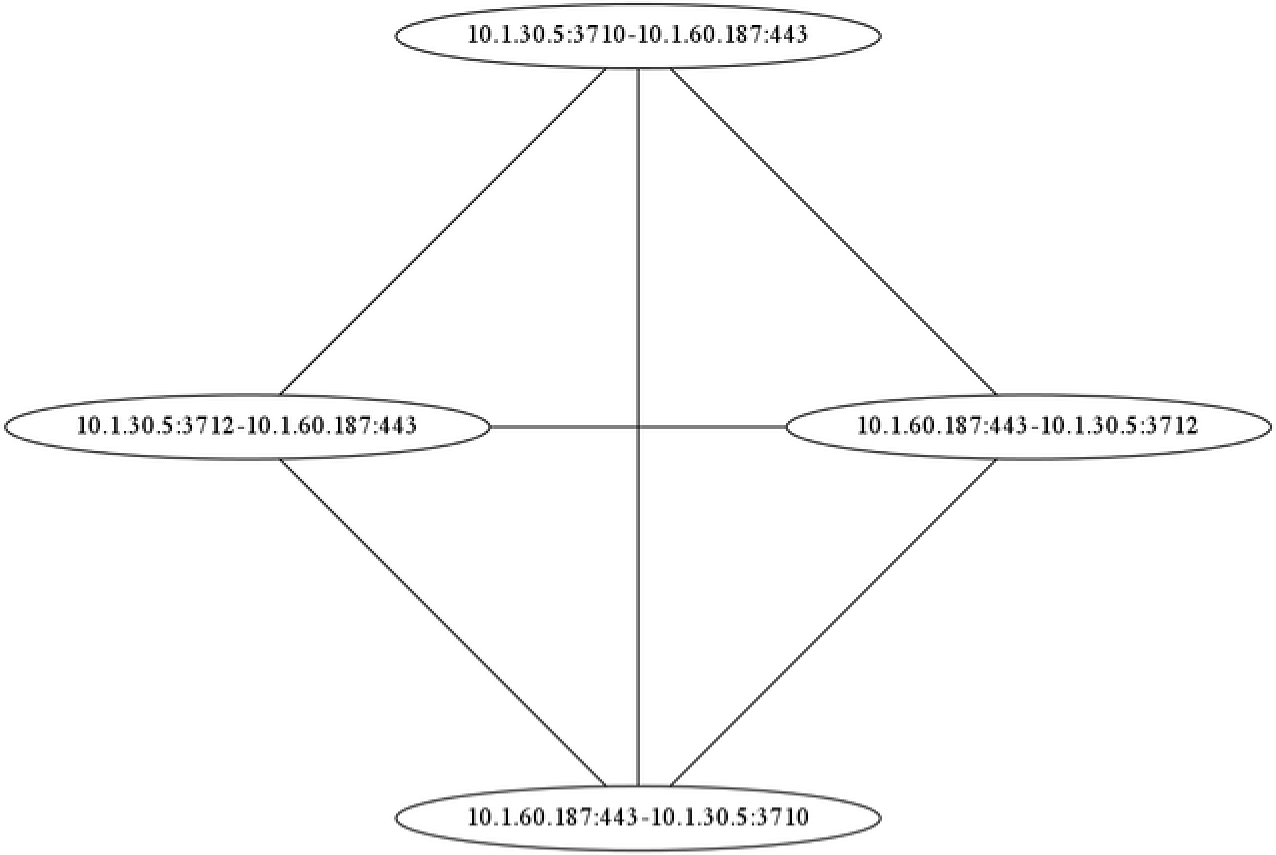
Analysis

Analyzing the largest component created from flow:

- 4,313 vertices, 636,761 edges, 635,631 cycles
- This means we have 4,313 encounter traces, or at worst case, 8,616 flows
- Vertex with highest degree (1,130) is found at:
  - 10.2.195.248:48776 10.1.60.25:25
- Local Clustering Coefficient:
  - Tightly clustered: 0.999994
- Examining the neighbors, it looks like 10.2.195.248:48776 is being very friendly

Analysis

This is what an HTTPS session can look like:



Analysis

This is some of the data from the previous graph:

10.1.60.187:443-10.1.30.5:3710 10.1.60.187:443-10.1.30.5:3712

10.1.60.187:443-10.1.30.5:3710 10.1.30.5:3710-10.1.60.187:443

10.1.60.187:443-10.1.30.5:3710 10.1.30.5:3712-10.1.60.187:443

10.1.60.187:443-10.1.30.5:3712 10.1.60.187:443-10.1.30.5:3710

Analysis

δ makes a difference

- When δ = 1, the graph has 60 components
- When δ = 8, the graph has 12 components
- $G_1 \subseteq G_8$

Increasing δ pulls in more edges

Analysis

Alternative Analysis:

What about those edges which didn’t get an edge in the graph?

In general, these are one-sided conversations.

For example, this appears to be an unanswered ping:

2009/04/21T13:57:21.541 2009/04/21T13:58:02.968 10.1.60.187:0 10.1.100.8:0

Future Work

- Graph fingerprinting
  - Create a graph that looks like a connection with http://www.cnn.com
  - Allow graph edit distance or Jaccard distance to determine similarity with the fingerprint
- Add size of flow as an edge weight to the graphs
- Multigraphs
- Time Series Analysis with Graphs
- A SiLK plugin

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Questions/comments?