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StreamWorks: Continuous Pattern Detection on Streaming Data

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U.S. DEPARTMENT OF ENERGY

What is StreamWorks?

The Promise of Patterns

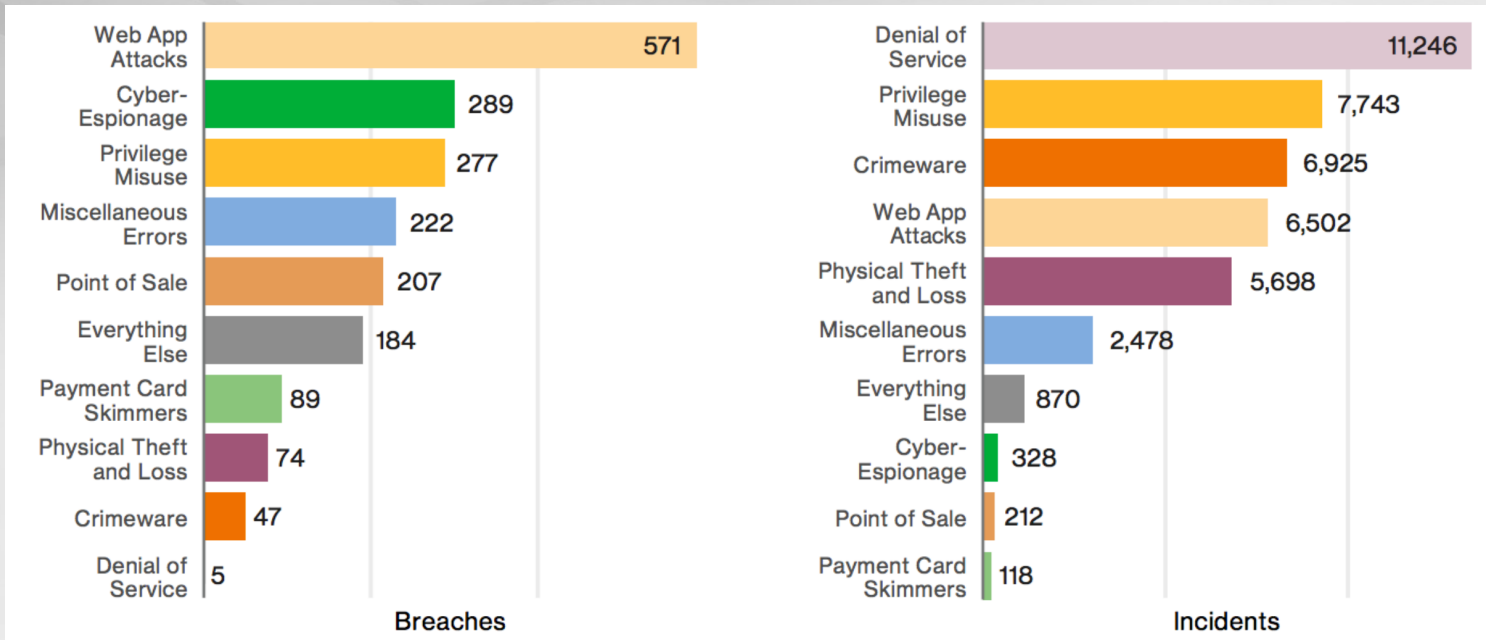


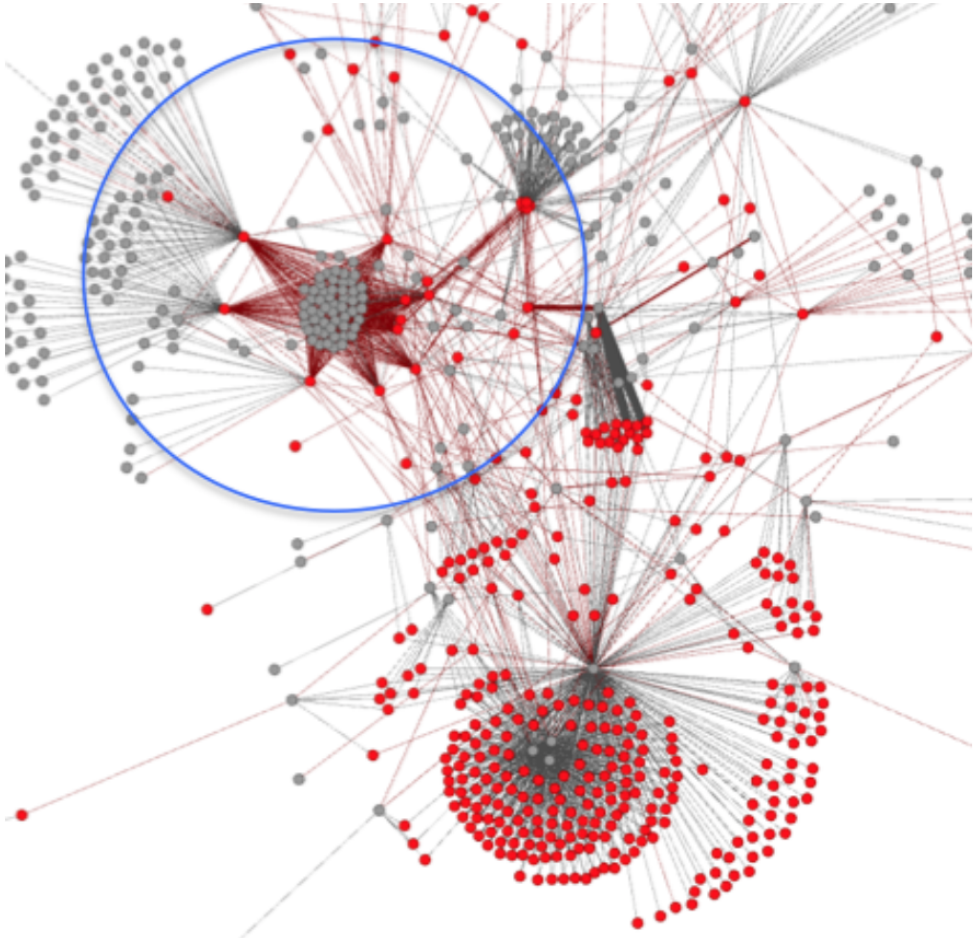
Figure 33: Percentage and count of breaches per pattern (n=1,935)

Figure 34: Percentage and count of incidents per pattern (n=42,068)

Source: Verizon 2017 Data Breach Investigations Report

- The **median number of days to detect security breaches** was **146 days** in 2015 – FireEye/Mandiant Report
- In its "Data Breach Investigations Report" in 2014, Verizon analyzed 100,000 security incidents from past decade and concluded **90% attacks fell in 10 attack patterns**

Graphs and Patterns



Red nodes are **Services**

Gray nodes are **Clients**

Users with similar role demonstrate same pattern of service usage

Tell me as soon as it happens!

- **How do you read email**?
  - Read every email as soon as it comes in (**Continuous Processing**)
  - Read every 4 hours (**Periodic or Batched Processing**)

- **Unfortunately, being late is not better than never in all cases**
  - **Cyber**: Data leaving your network or a malware spread in action
  - **Finance**: Price dips intraday, your late order buys high end of the day ☺

Approach for Continuous Pattern Detection

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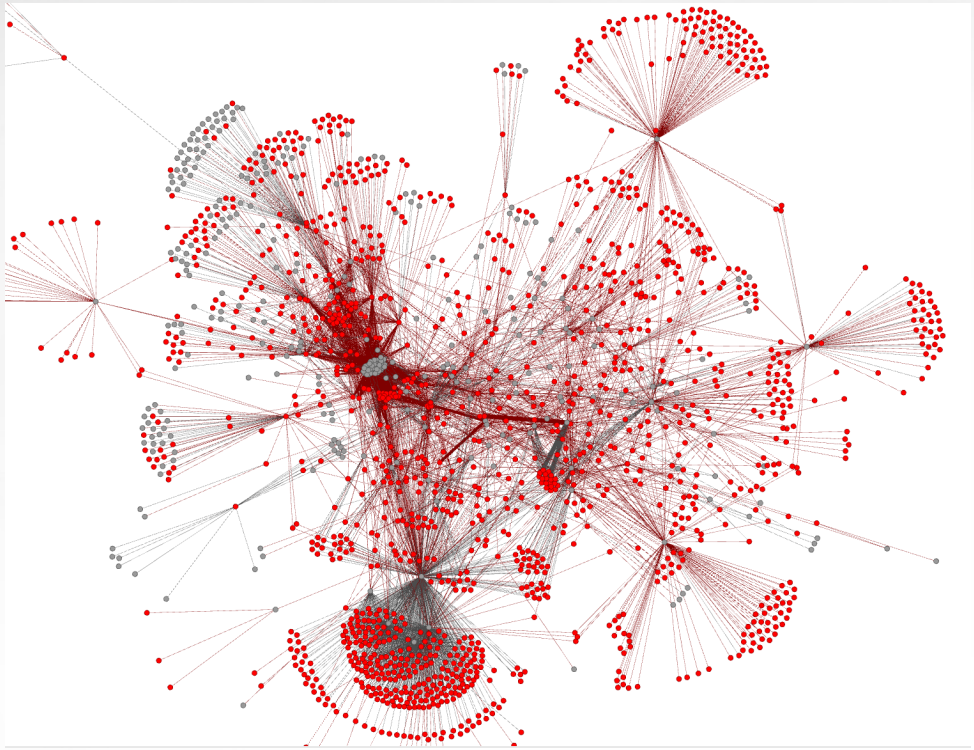
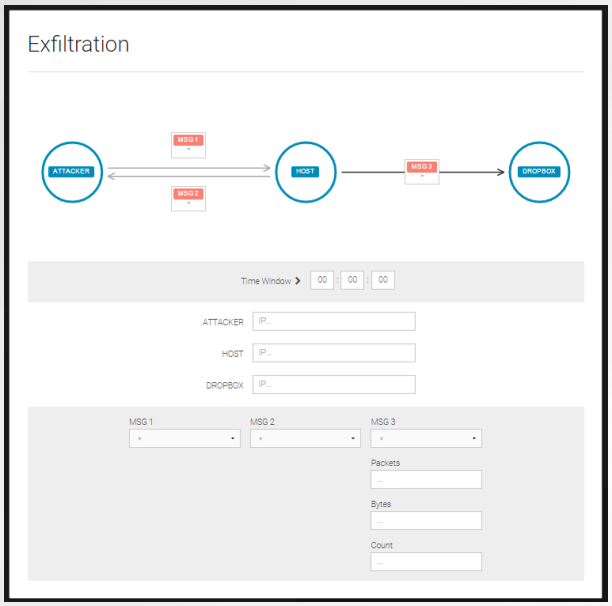
- **Incremental Querying is key to Performance**
  - We turn streaming data into a graph model
- **Guiding our insight**
  - We interviewed tens of analysts and system defenders, and asked about the top patterns they would like to detect
- **Pattern Queries in Action**
  - “Tell me when a chain of 3 logins are detected with increasing privileges?”



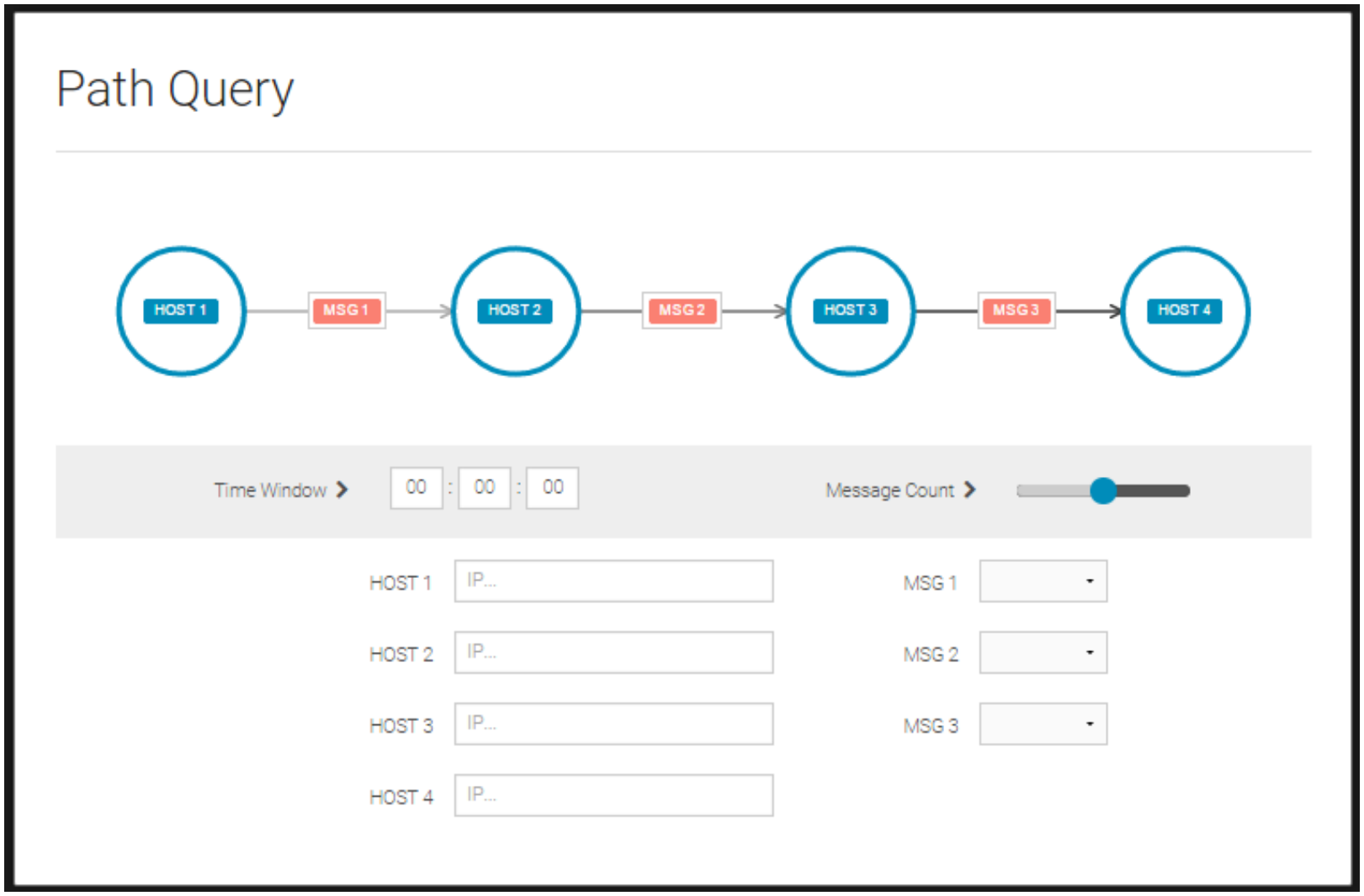
And last, but not the least …

- **One more "Driver"**
- **Visual Querying**: Real users should not need to learn a new query language to use the system.

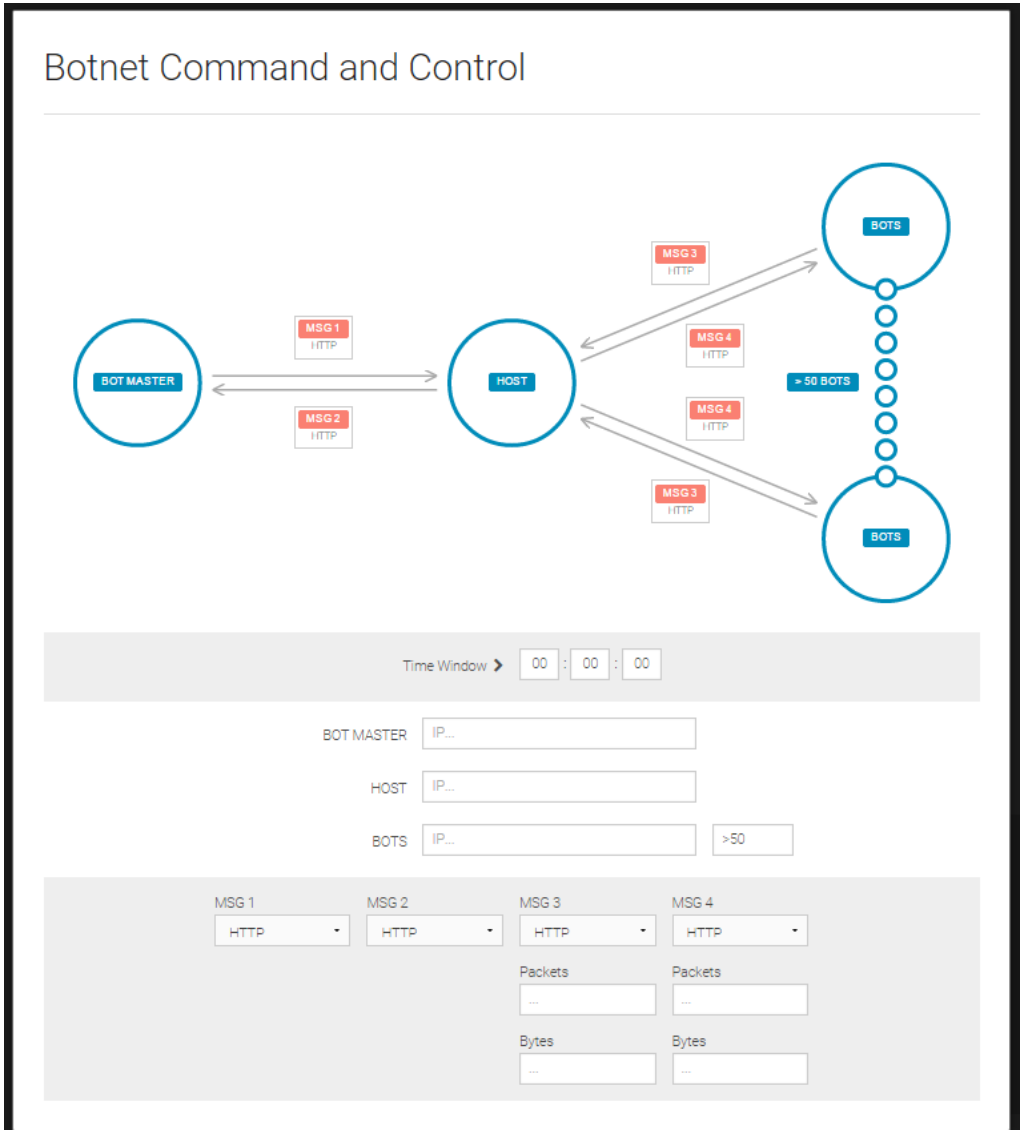


```
SELECT ?control ?target ?dropbox ?xfil WHERE {
 # Control Message from C2 to target
  ?control ?ctrlmsg ?target .
  ?ctrlmsg :FTIME ?ftime1 .
  ?ctrlmsg :STIME ?stime1 .
  ?ctrlmsg :DPKTS ?pkts1 .
  ?ctrlmsg :DOCTETS ?octets1 .
  FILTER (?pkts1 < 3 && ?octets1 < 300)

  # xFil occurs within the next hour to ?dropbox
  { SELECT ?target ?dropbox (SUM(?octets) AS ?xfil)
    WHERE {
      ?target ?flow ?dropbox .
      ?flow :DOCTETS ?octets .
      ?flow :STIME ?stime .
      FILTER (?stime > ?ftime1
              && ?stime - ?ftime1 < 3600)
    } GROUP BY ?target ?dropbox
      HAVING (SUM(?octets) > 200000)
  }

  # xFil did NOT happen from target in previous
  # hour (target usually does not send lots of
  # data to external hosts).
  { SELECT ?target
    { SELECT ?target (SUM(?octets) as ?outRate)
      WHERE {
        ?target ?flow ?dst .
        ?flow :DOCTETS ?octets .
        ?flow :STIME ?stime .
        FILTER (?stime < ?stime1
                && ?stime1 - ?stime < 3600)
      } GROUP BY ?target ?dst
    } GROUP BY ?target
      HAVING (MAX(?outRate) < 100000)
  }
}
```

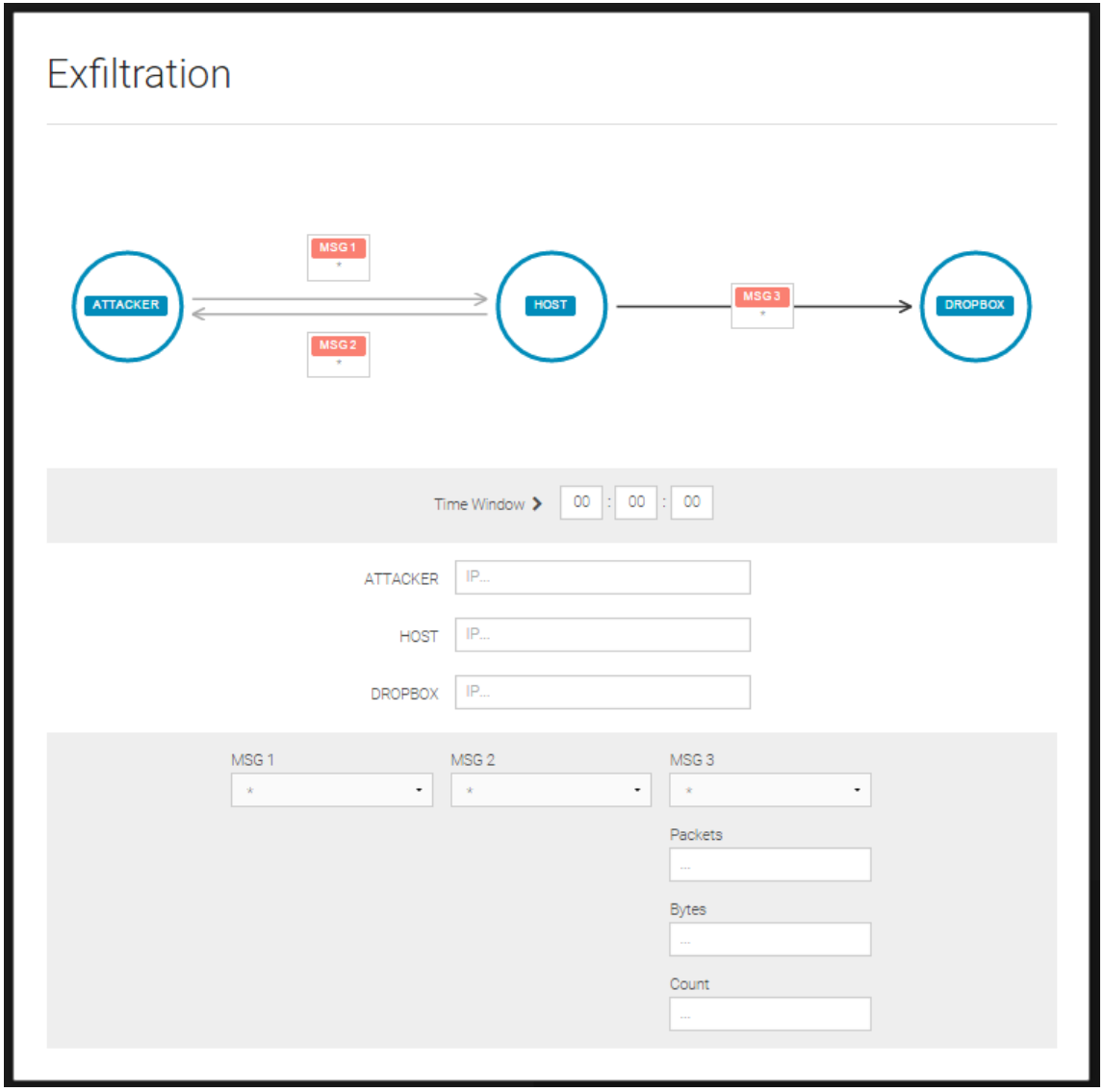
Querying for Chains of Activity



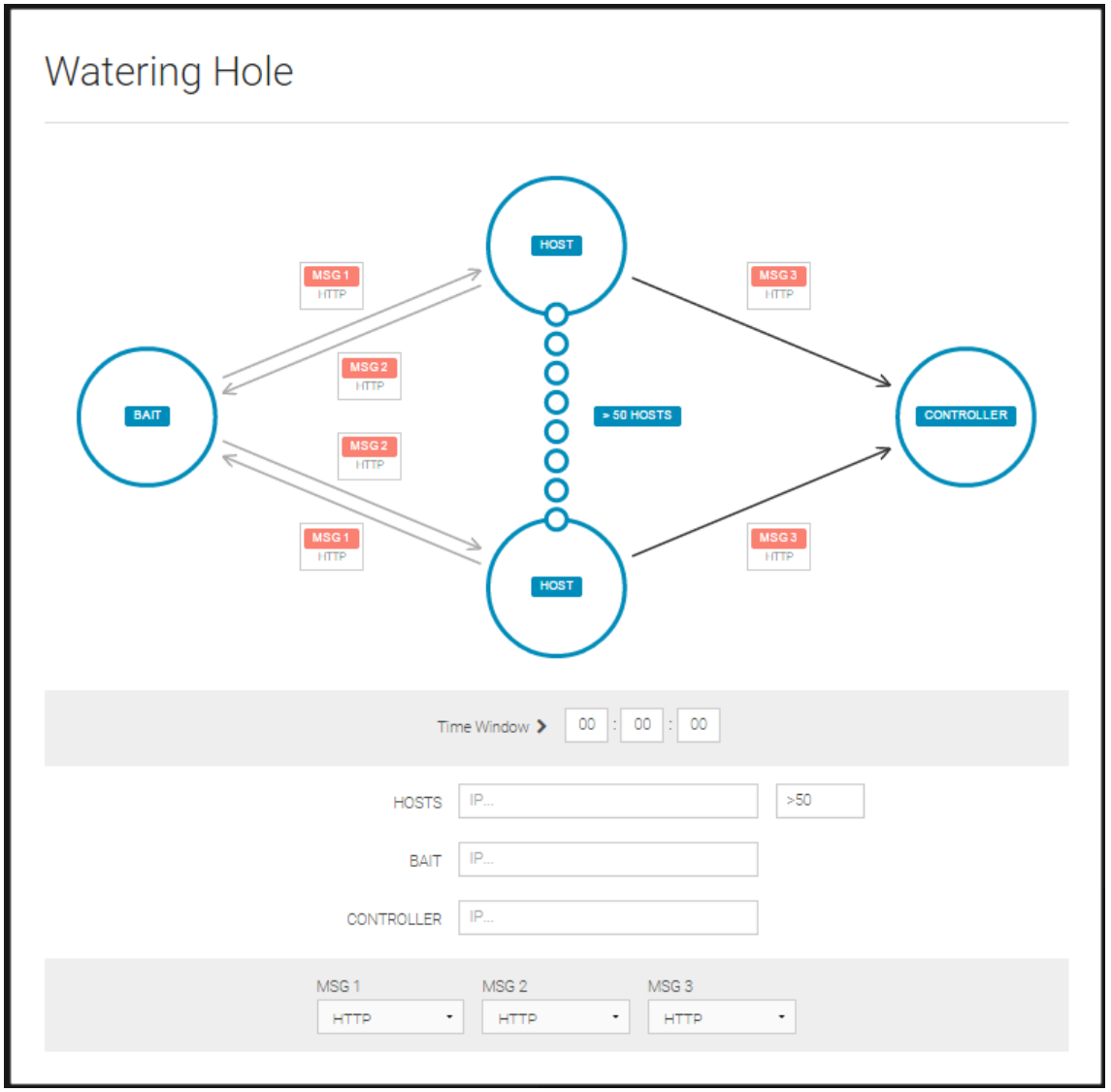
Botnet Command and Control



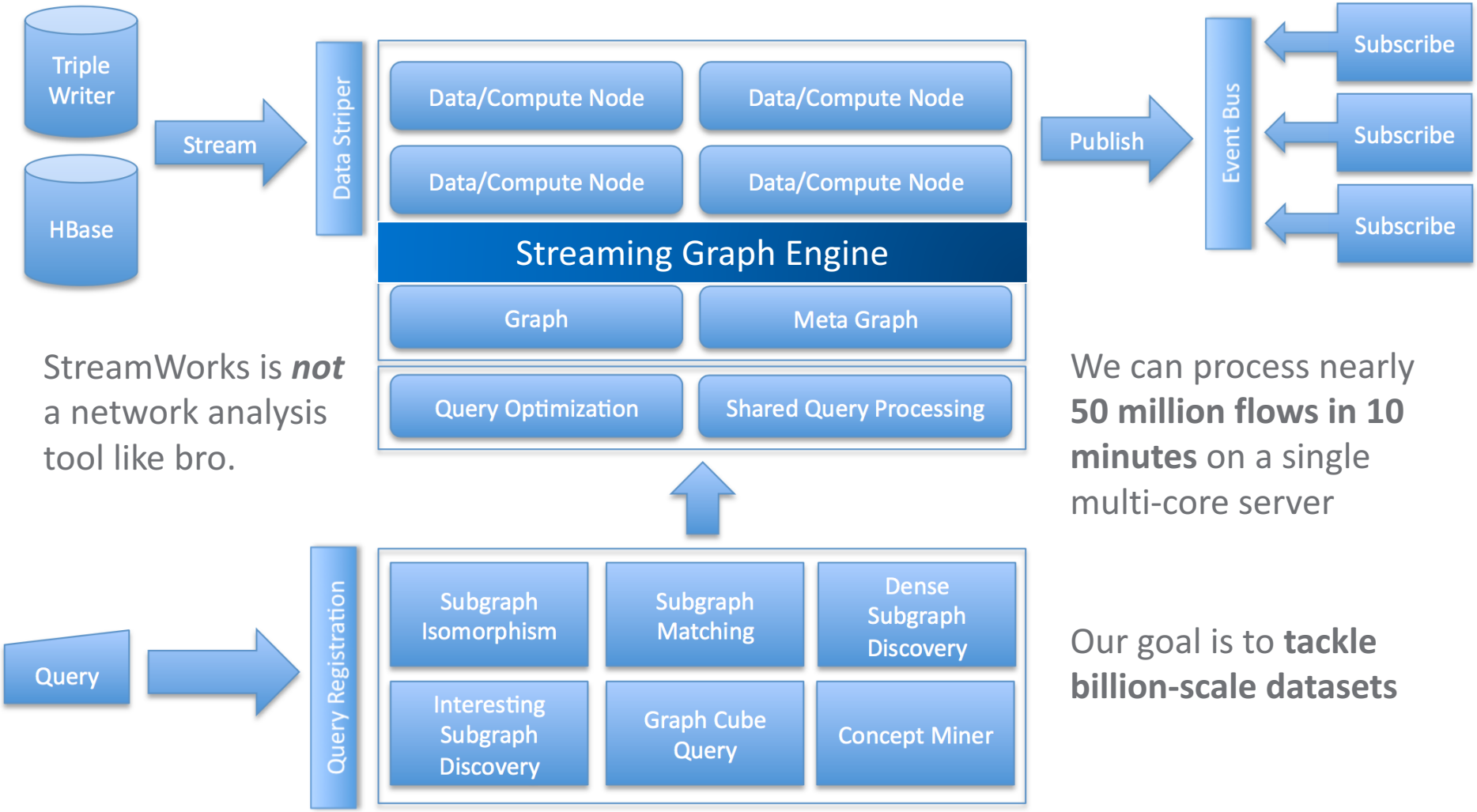
Exfiltration



Watering Hole



The StreamWorks Architecture



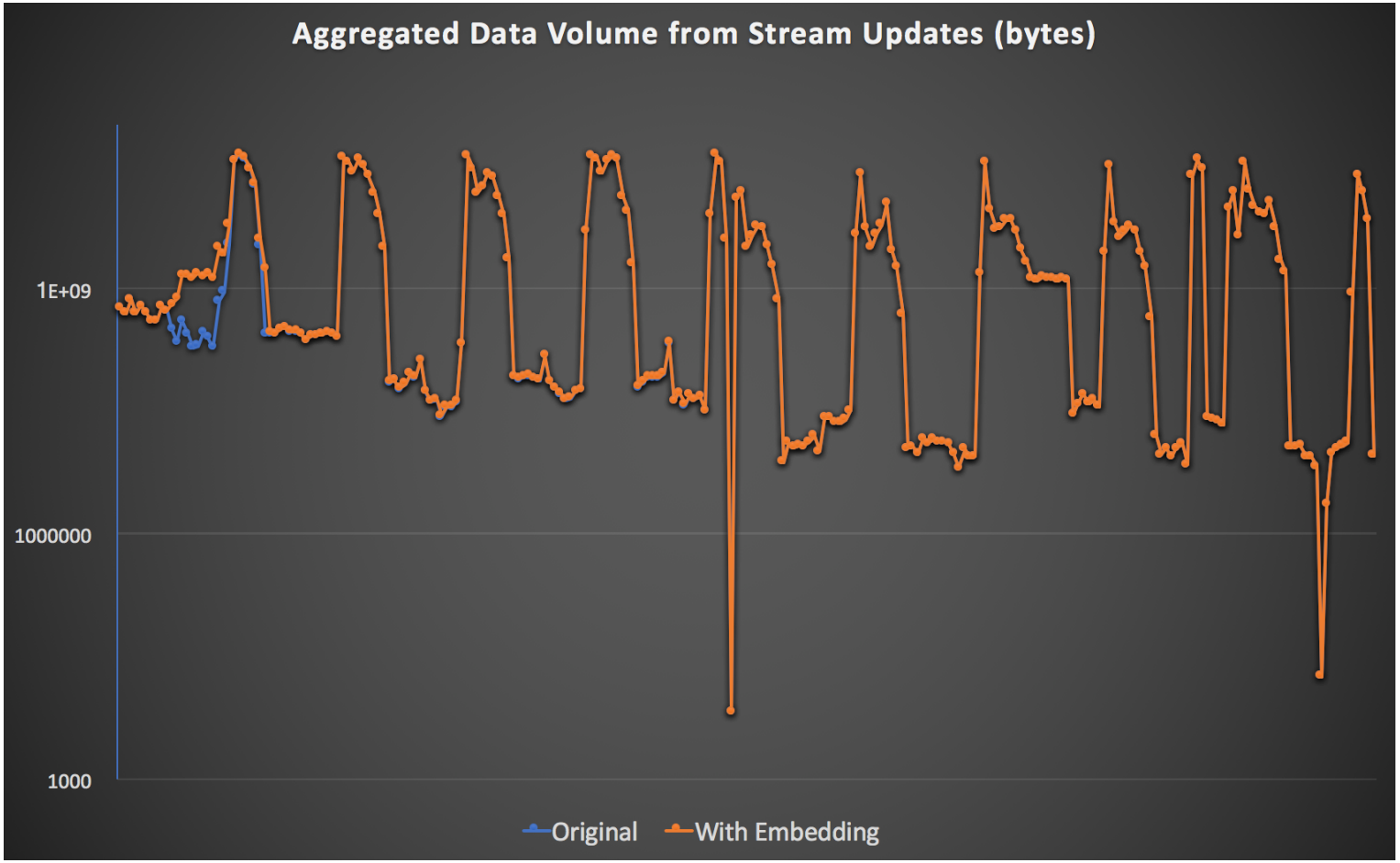
StreamWorks is ***not*** a network analysis tool like bro.

We can process nearly **50 million flows in 10 minutes** on a single multi-core server

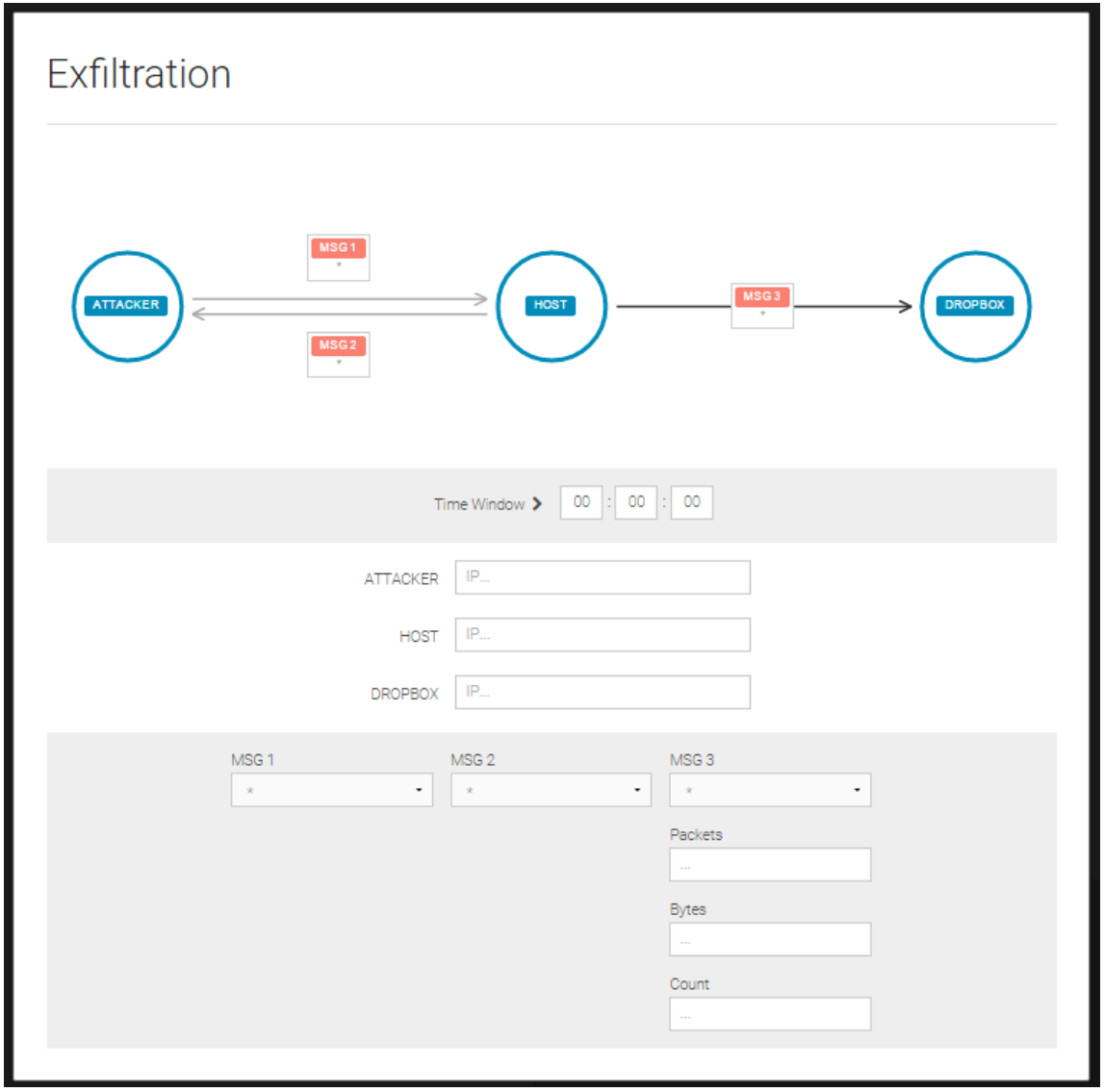
Our goal is to **tackle billion-scale datasets**

Finding the Needle in a Haystack

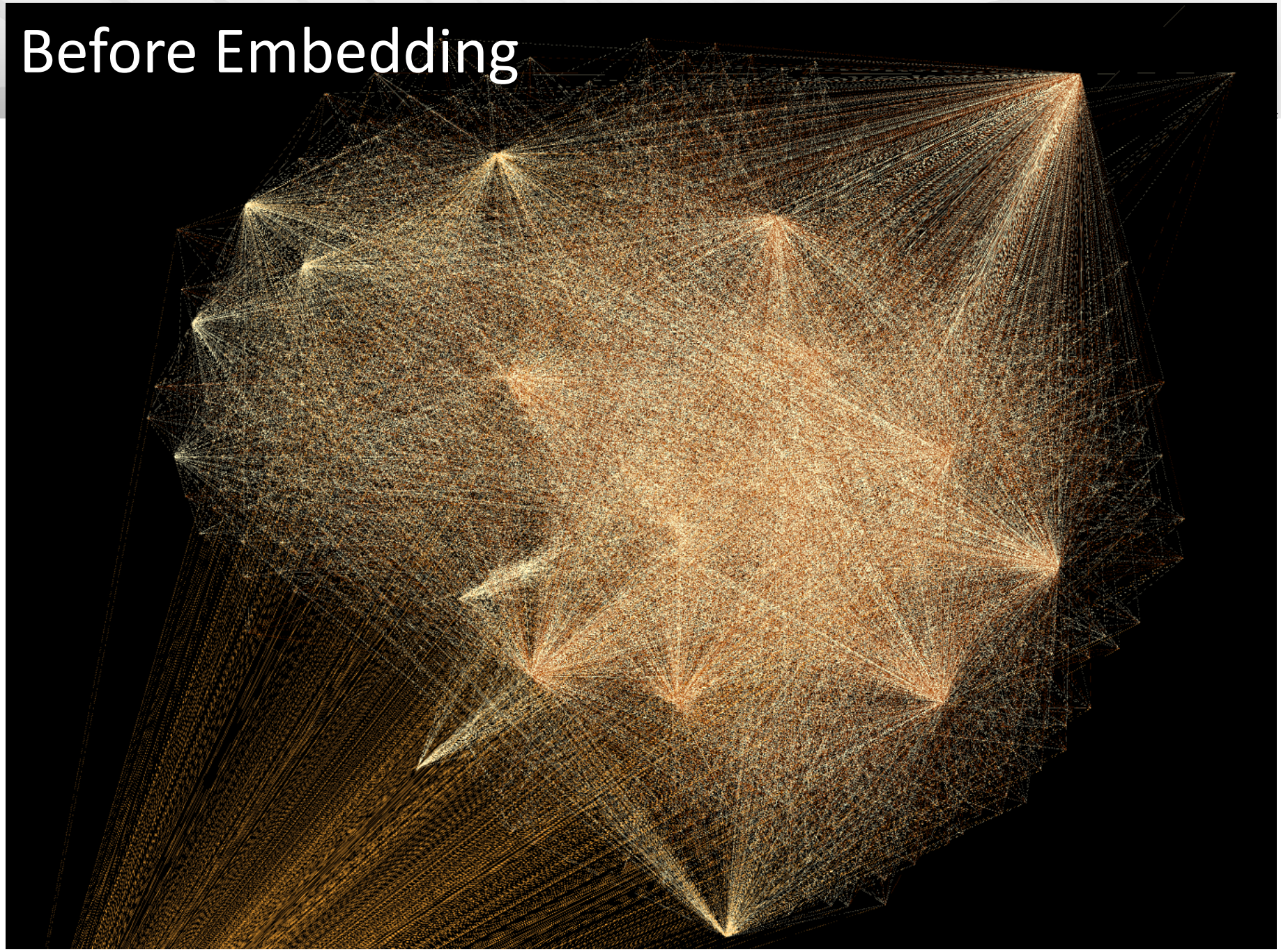
- Embedded multiple embeddings of exfiltration into a large-scale dataset



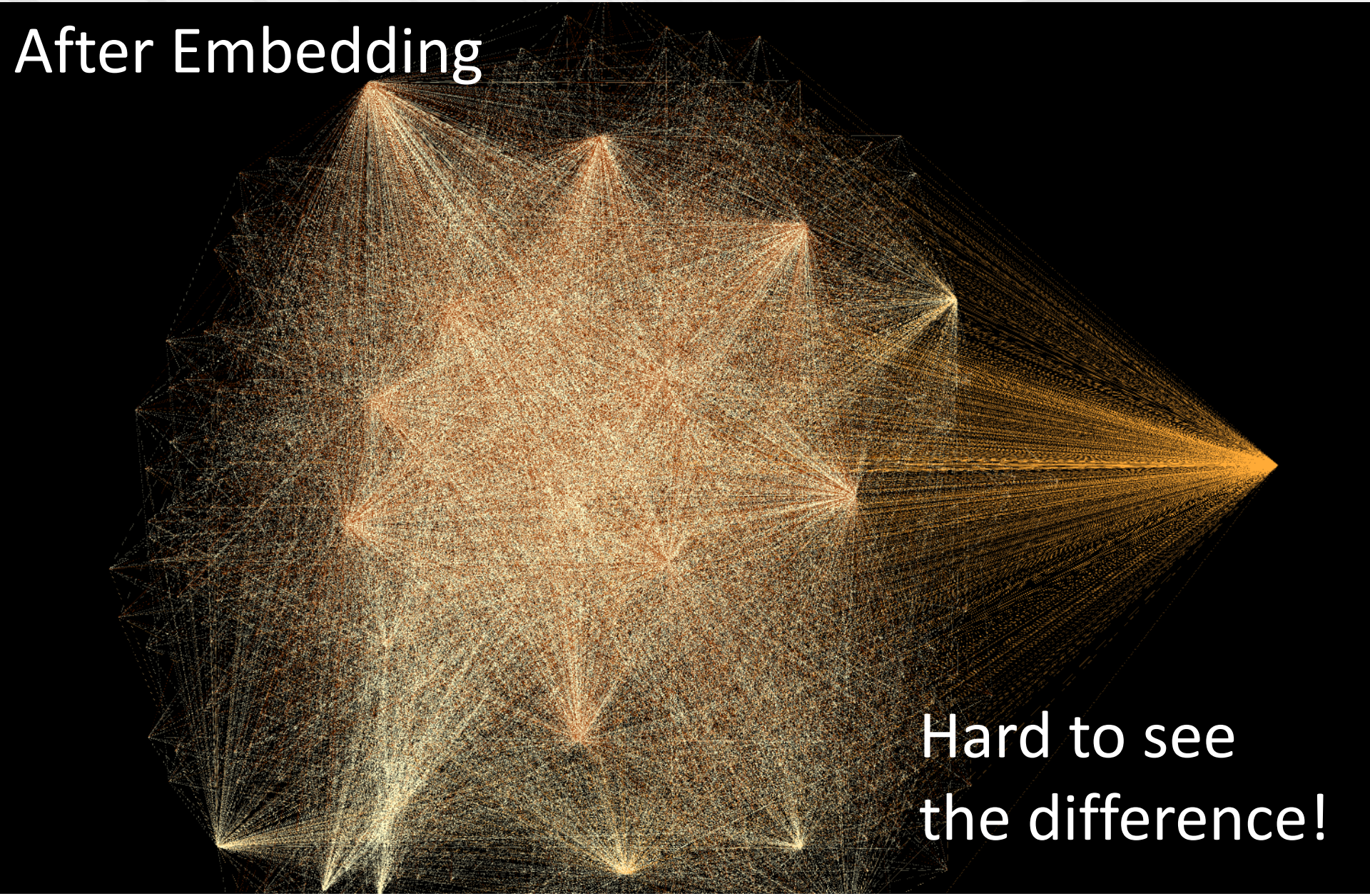
Exfiltration



Before Embedding



After Embedding



Visualization of Matching Patterns

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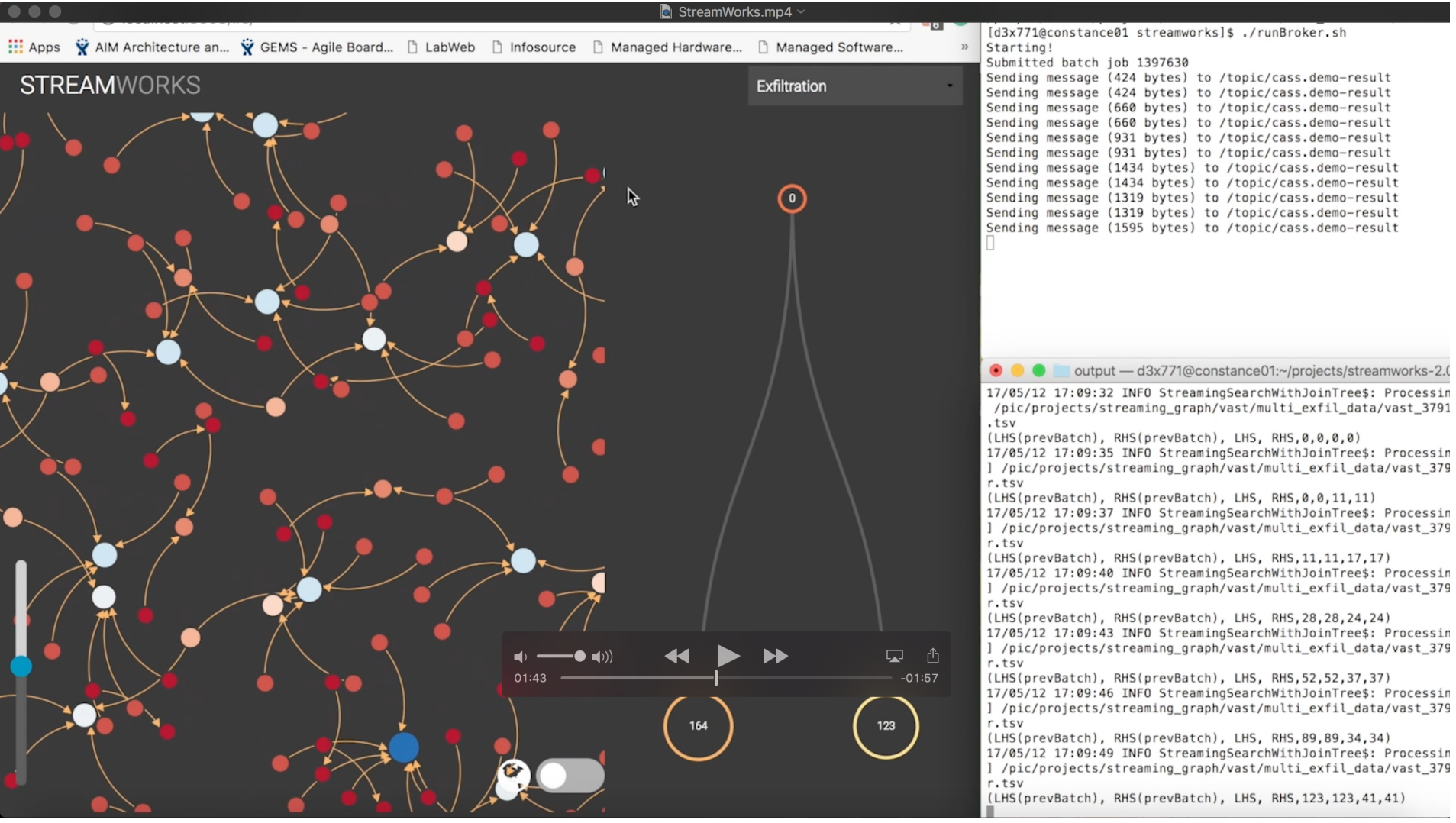

Visualization of matching patterns

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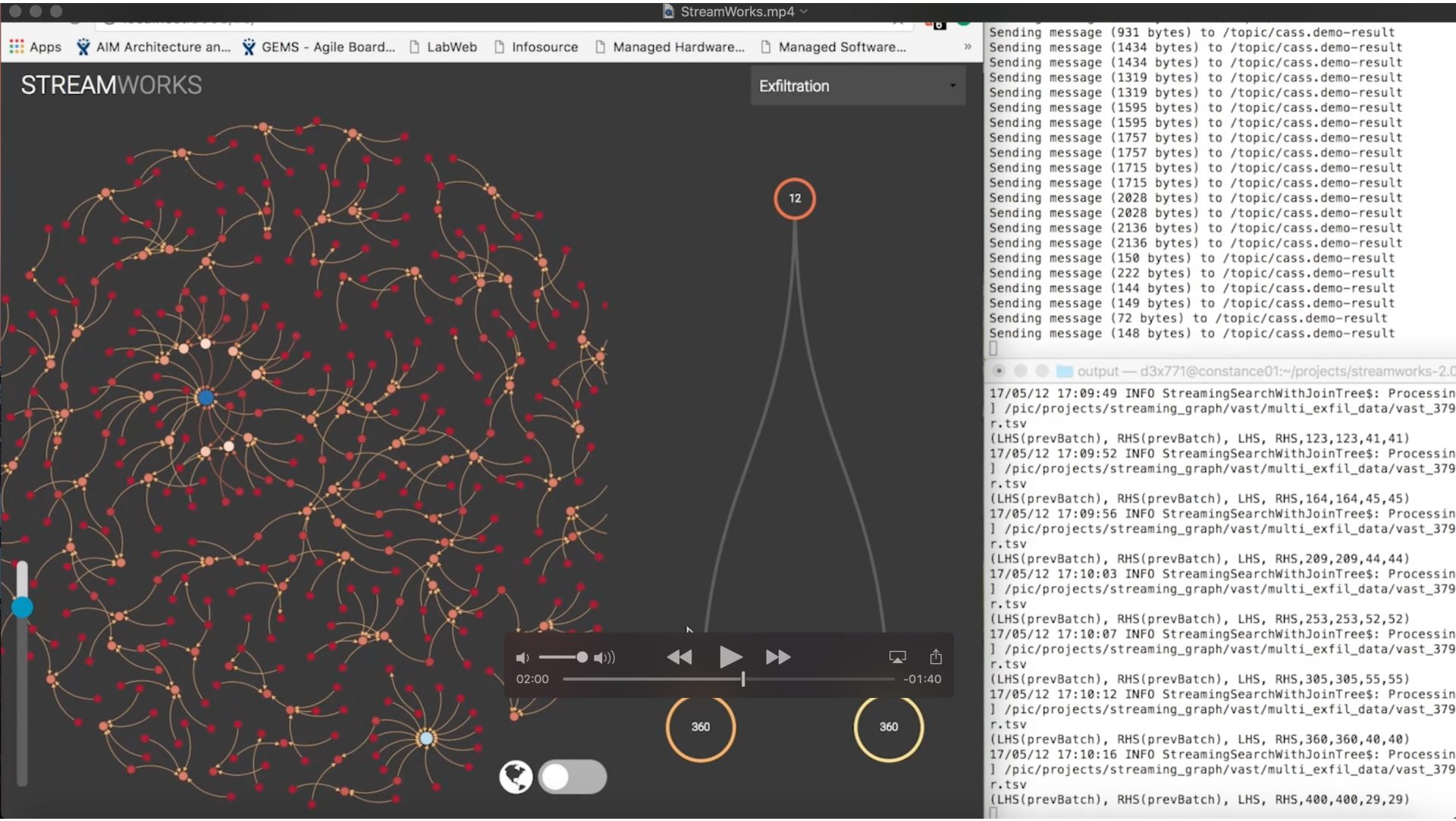
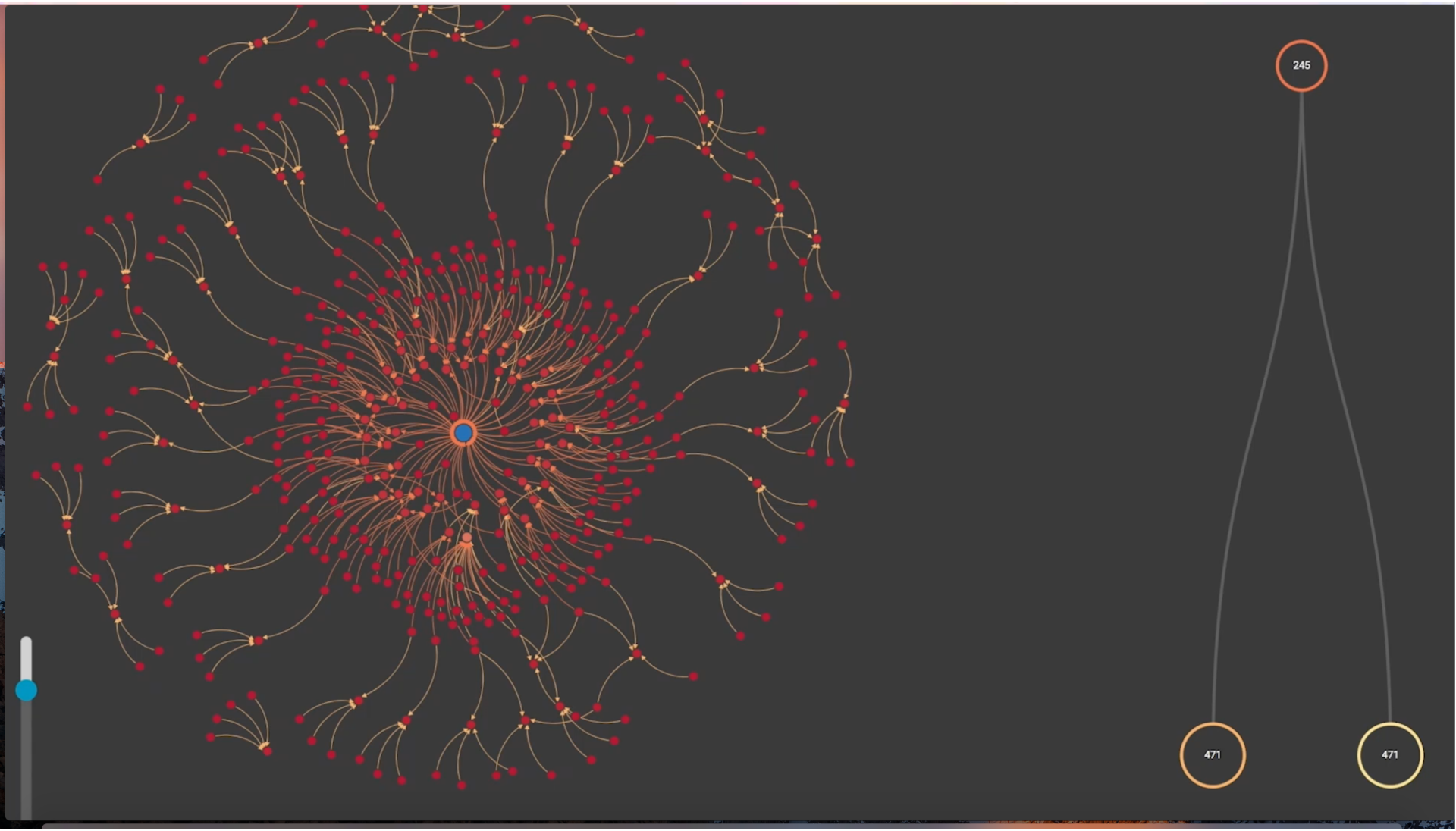


Visualization of Matching Patterns



Visualization of Matching Patterns

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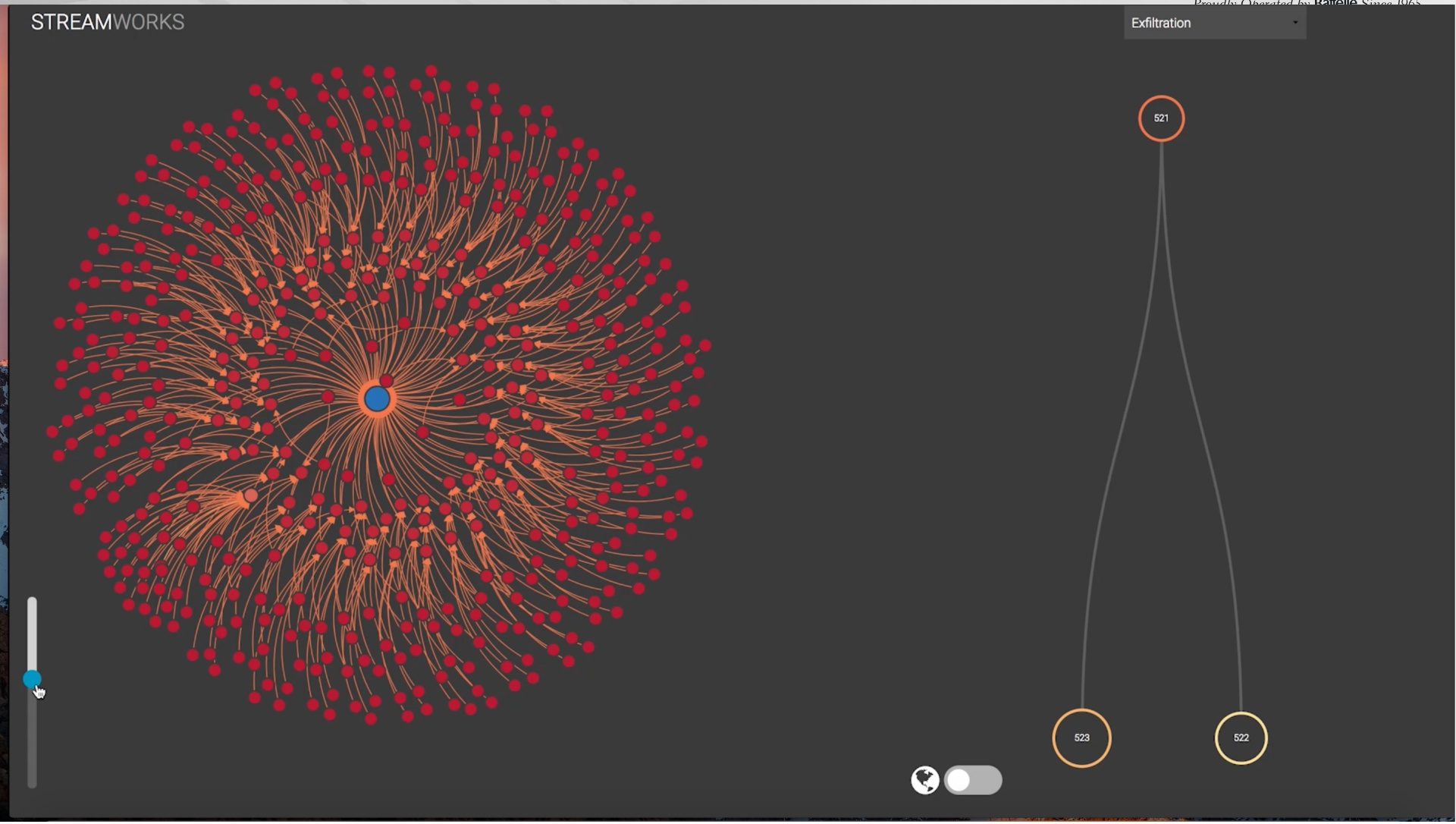

Providing a geographical perspective

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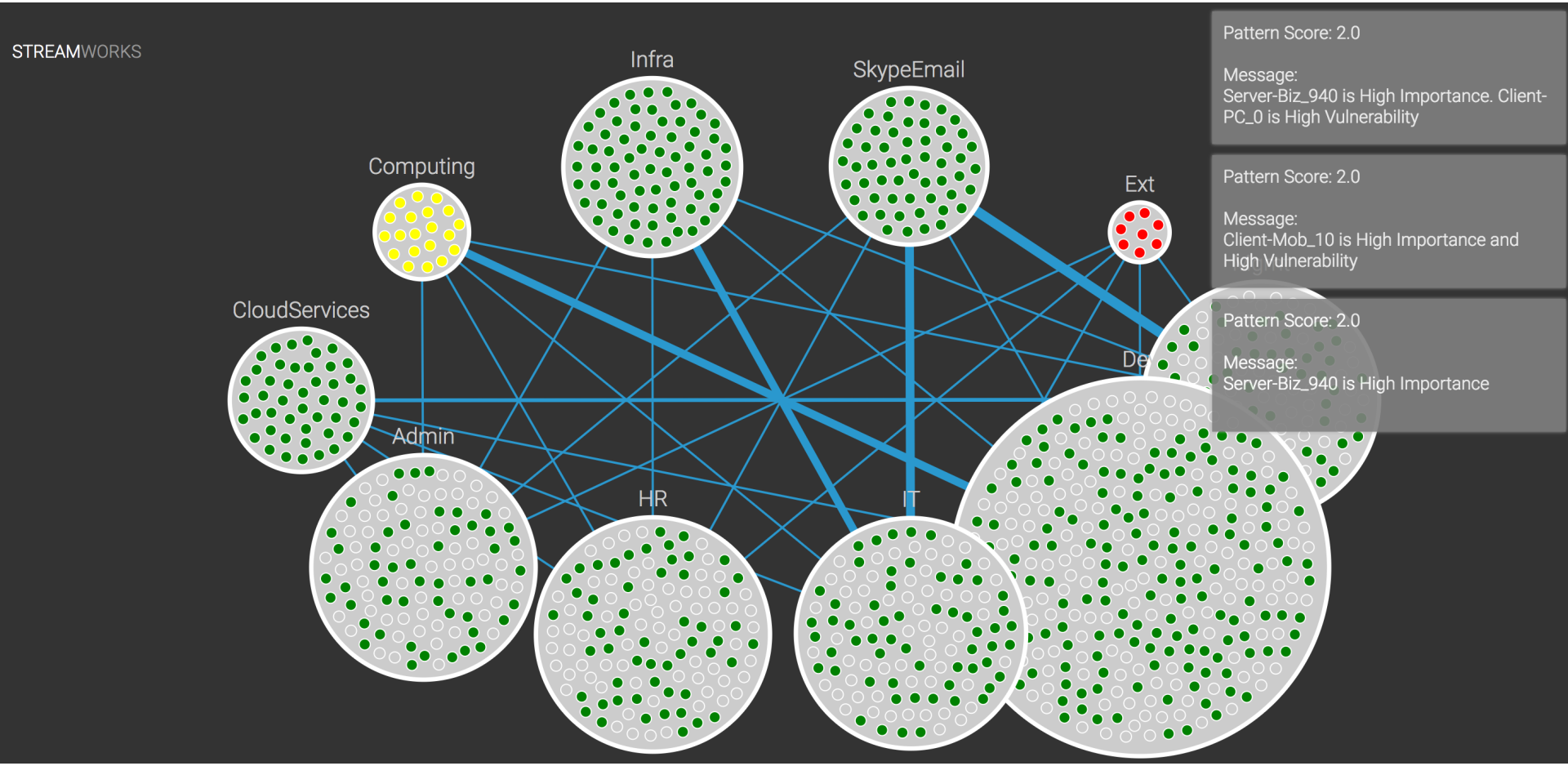
Another example of Geo-View

Tell Me Why!

- Too many matches is a problem
- Rank and Explain through background knowledge and behavioral patterns learnt from data



Competition

Product	Streaming	Graph Search	Visual Analytics
StreamWorks	✔	✔	✔
SQRRL Enterprise	✖	✔	✔
Apache Spark	✔	✖	✖
Neo4J	✖	✔	✖

- **We obtained 10-100x improvement in runtime on an internet backbone traffic flow dataset.**
- **Filed US Patent on graph based pattern matching technology**

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TTP
TRANSITION TO PRACTICE

THANK YOU!

StreamWorks

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Homeland Security
Science and Technology

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