Mining Anomalies in Network-Wide Flow Data

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Network Anomaly Diagnosis

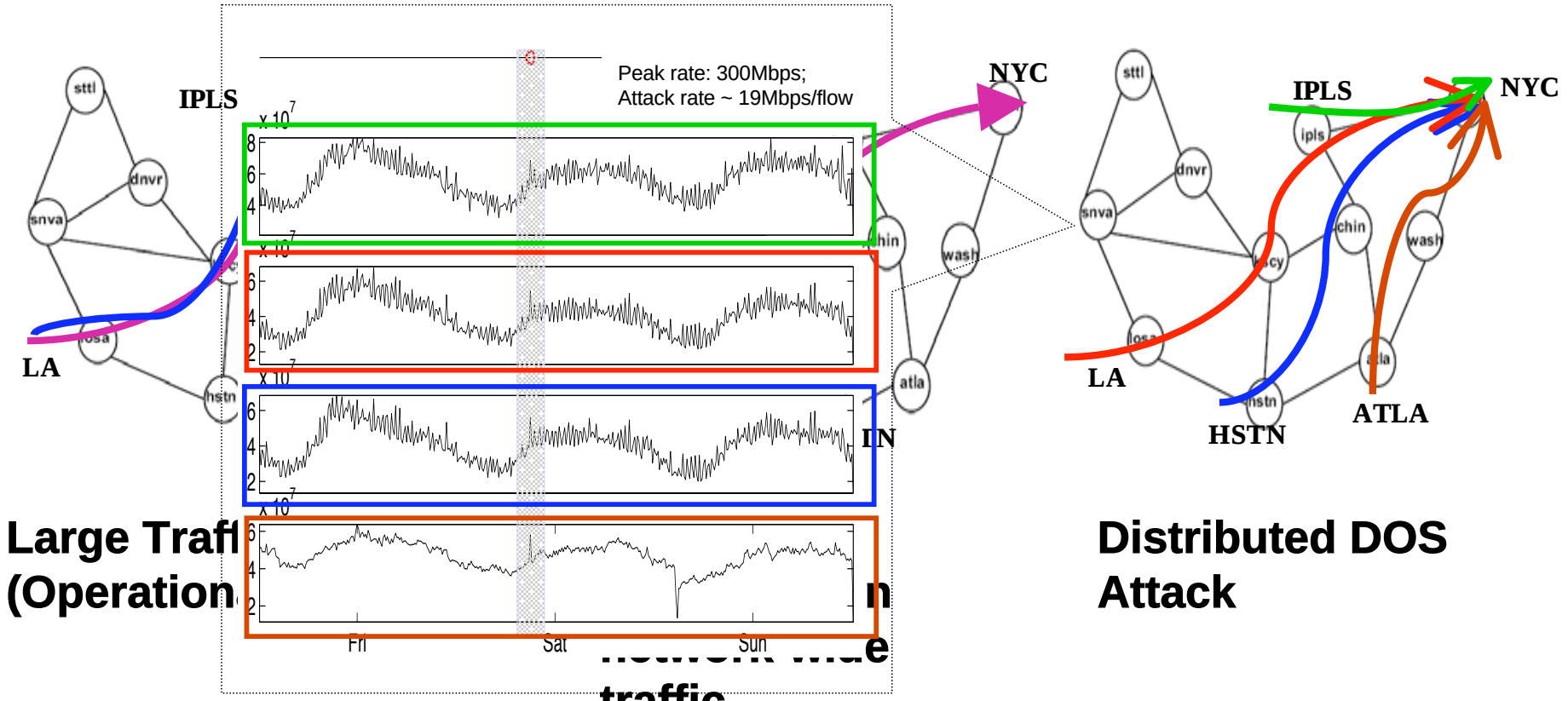
- Am I being attacked?
- Is someone scanning my network?
- Are there worms spreading?
- A sudden traffic shift?
- An equipment outage?
- Something never seen before?

A **general, unsupervised** method for reliably **detecting** and **classifying** network anomalies is needed

My Talk in One Slide

- A *general* system to *detect & classify* anomalies at ISPs and large enterprises
- **Central Message:** *Network-wide analysis* of NetFlow data can expose many anomalies
  - Detect both operational & malicious incidents
- I am here to seek **your feedback** ☺

Network-Wide Traffic Analysis



Large Traffi
(Operation

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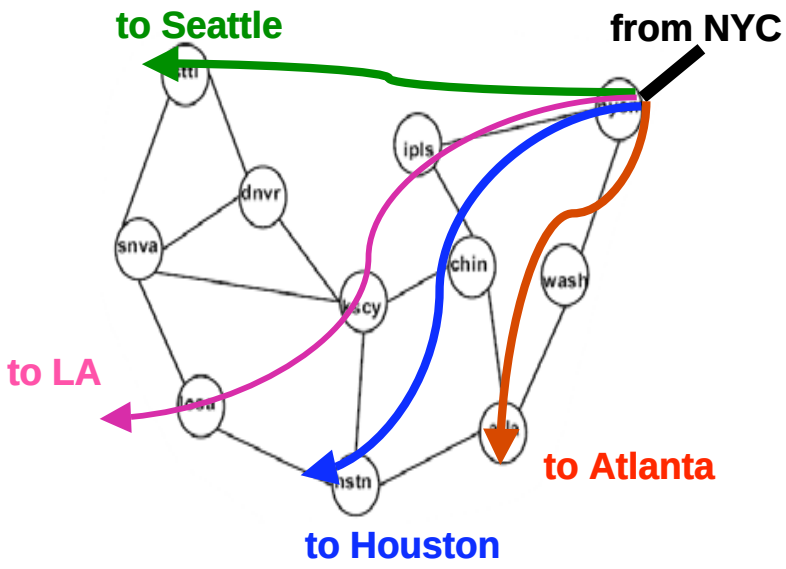
network wide traffic

Distributed DOS Attack

Collecting Network-Wide Traffic



- Assemble network's **traffic matrix**
- Traffic entering at the *origin* and leaving at the *destination*
- Use routing to aggregate NetFlow data into *OD flows*

Networks Evaluated

Abilene research network (Internet2)

- 11 PoPs, 121 OD flows, anonymized, 1/100 sampling, 5 min bins

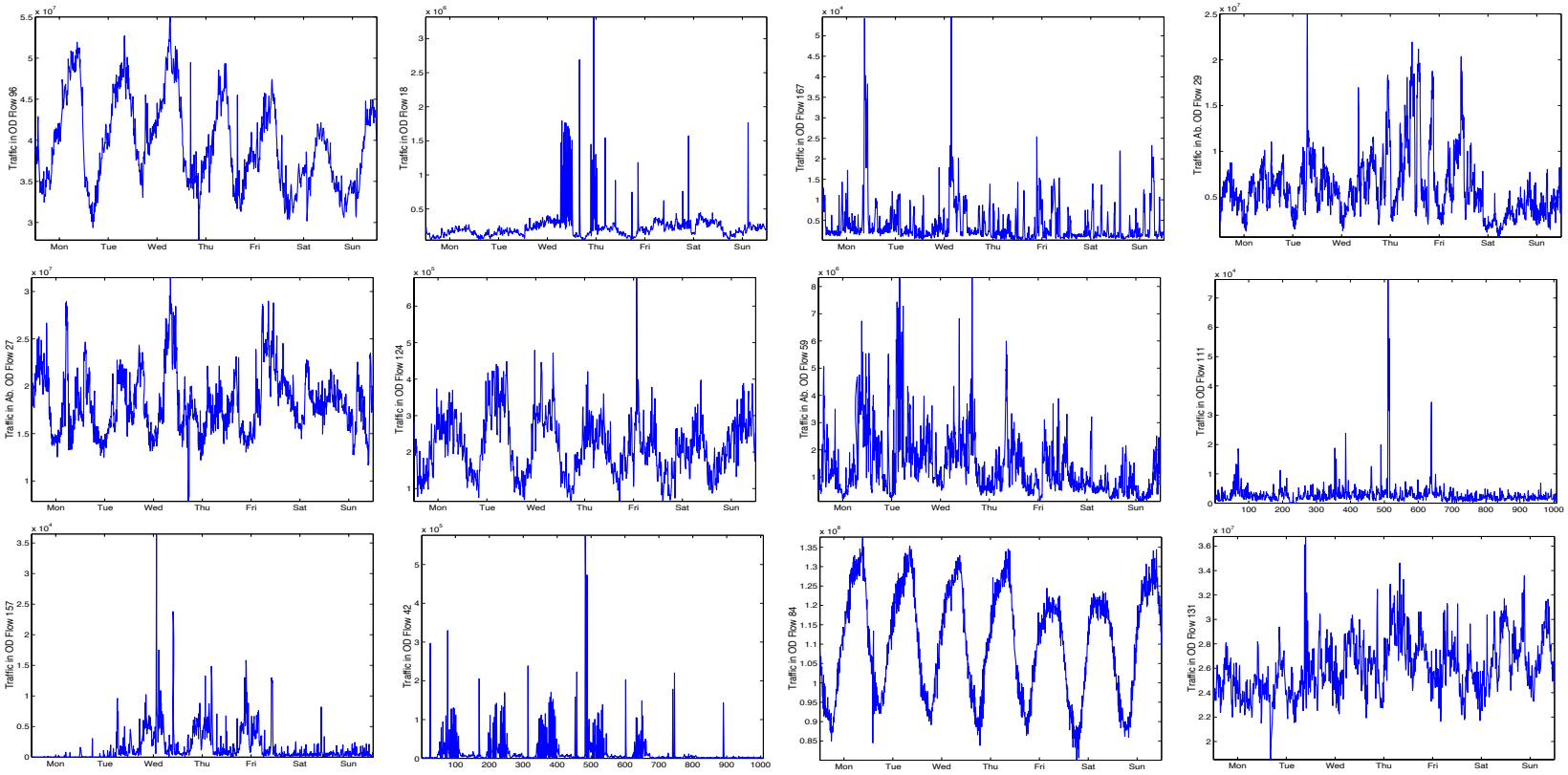
Géant Europe research network (Dante)

- 22 PoPs, 484 OD flows, not anonymized, 1/1000 sampling, 10 min bins

Sprint European commercial network

- 13 PoPs, 169 OD flows, not anonymized, aggregated, 1/250 sampling, 10 min bins

But, This is Difficult to Analyze!

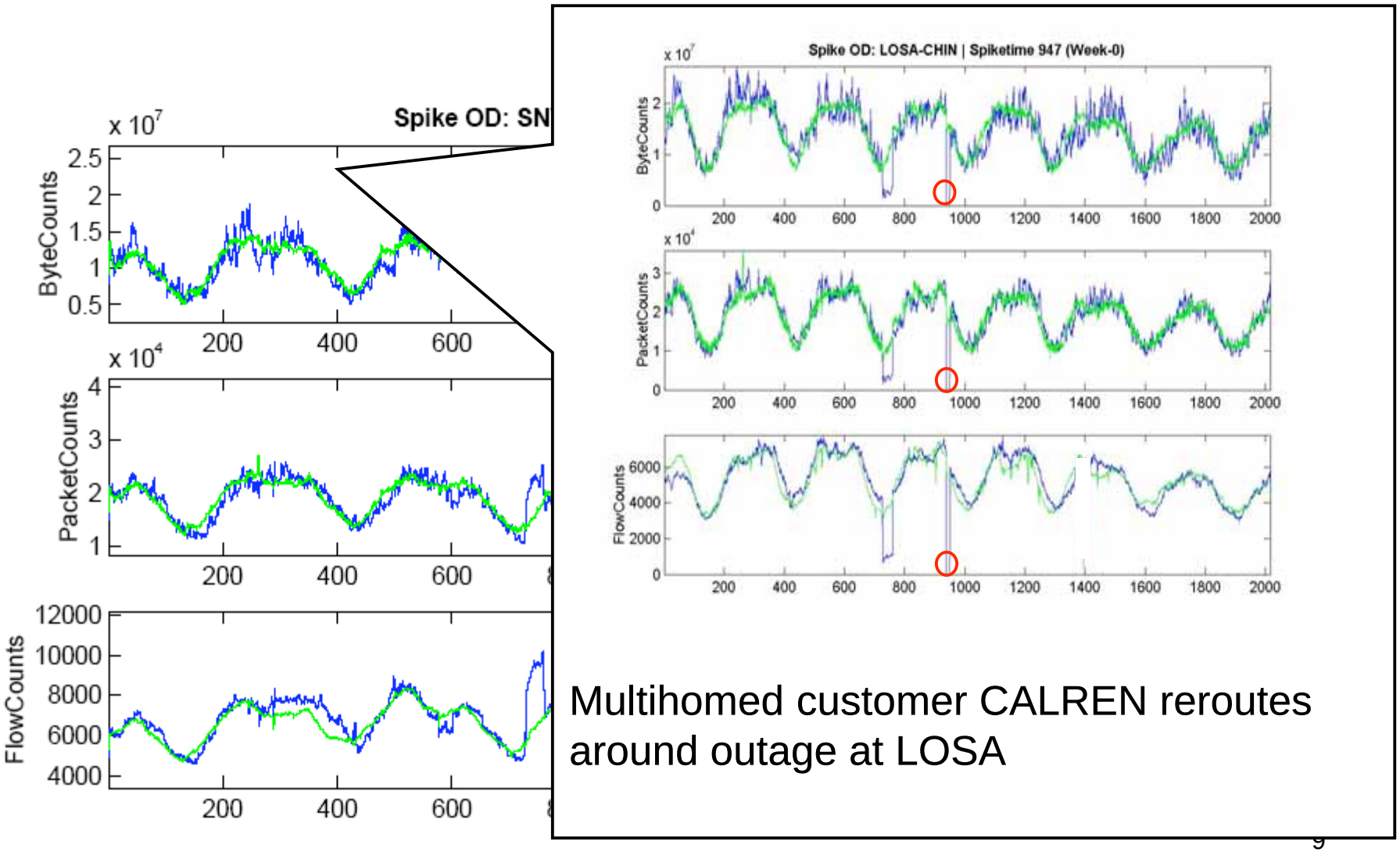


How do we extract **anomalies** and **normal behavior** from noisy, **high-dimensional** data?

The Subspace Method [LCD:SIGCOMM '04]

- An approach to separate normal & anomalous network-wide traffic
- Designate temporal patterns most common to all the traffic flows as the **normal patterns**
- Remaining temporal patterns form the **anomalous patterns**
- Detect anomalies by statistical thresholds on anomalous patterns

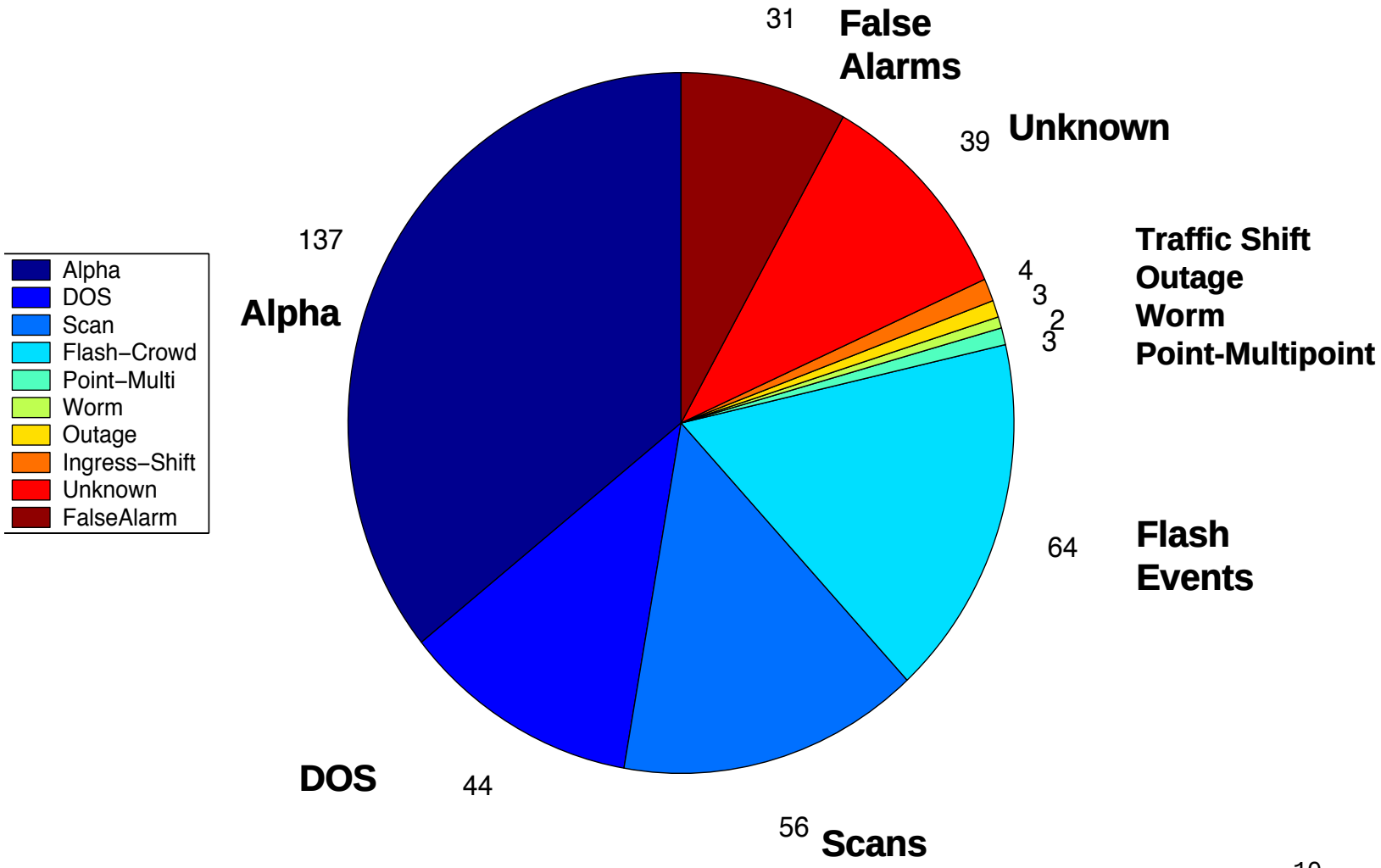
An example operational anomaly



Multihomed customer CALREN reroutes around outage at LOSA

Summary of Anomaly Types Found

[LCD:IMC04]



Automatically Classifying Anomalies

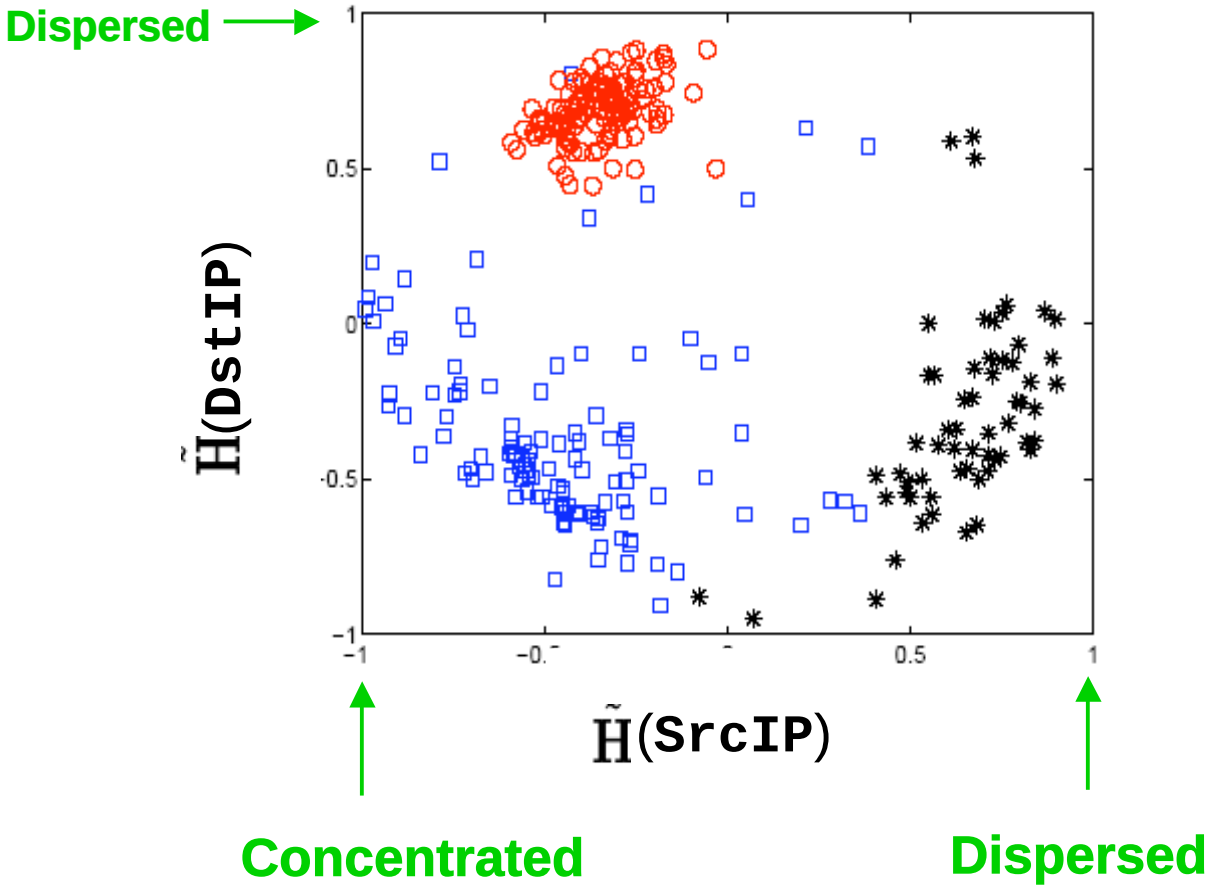
[LCD:SIGCOMM05]

- Goal: Classify anomalies without restricting yourself to a predefined set of anomalies

- Approach: Leverage 4-tuple header fields: **`SrcIP, SrcPort, DstIP, DstPort`**
  - In particular, measure *dispersion* in fields

- Then, apply off-the-shelf clustering methods

Example of Anomaly Clusters



Legend

Code Red Scanning

Single source DOS attack

Multi source DOS attack

Summary

- **Network-Wide Detection:**
  - Broad range of anomalies with low false alarms
  - In papers: Highly sensitive detection, even when anomaly is 1% of background traffic
- **Anomaly Classification:**
  - Feature clusters automatically classify anomalies
  - In papers: clusters expose new anomalies
- Network-wide data and header analysis are promising for general anomaly diagnosis

Next steps

- **Ongoing Work:** implementing algorithms in a prototype system

- For more information, see papers & slides at:
  http://cs-people.bu.edu/anukool/pubs.html

- Your feedback much needed & appreciated!
  - Data, deployment, …