Anomaly Detection in Backbone Networks: Building A Security Service Upon An Innovative Tool

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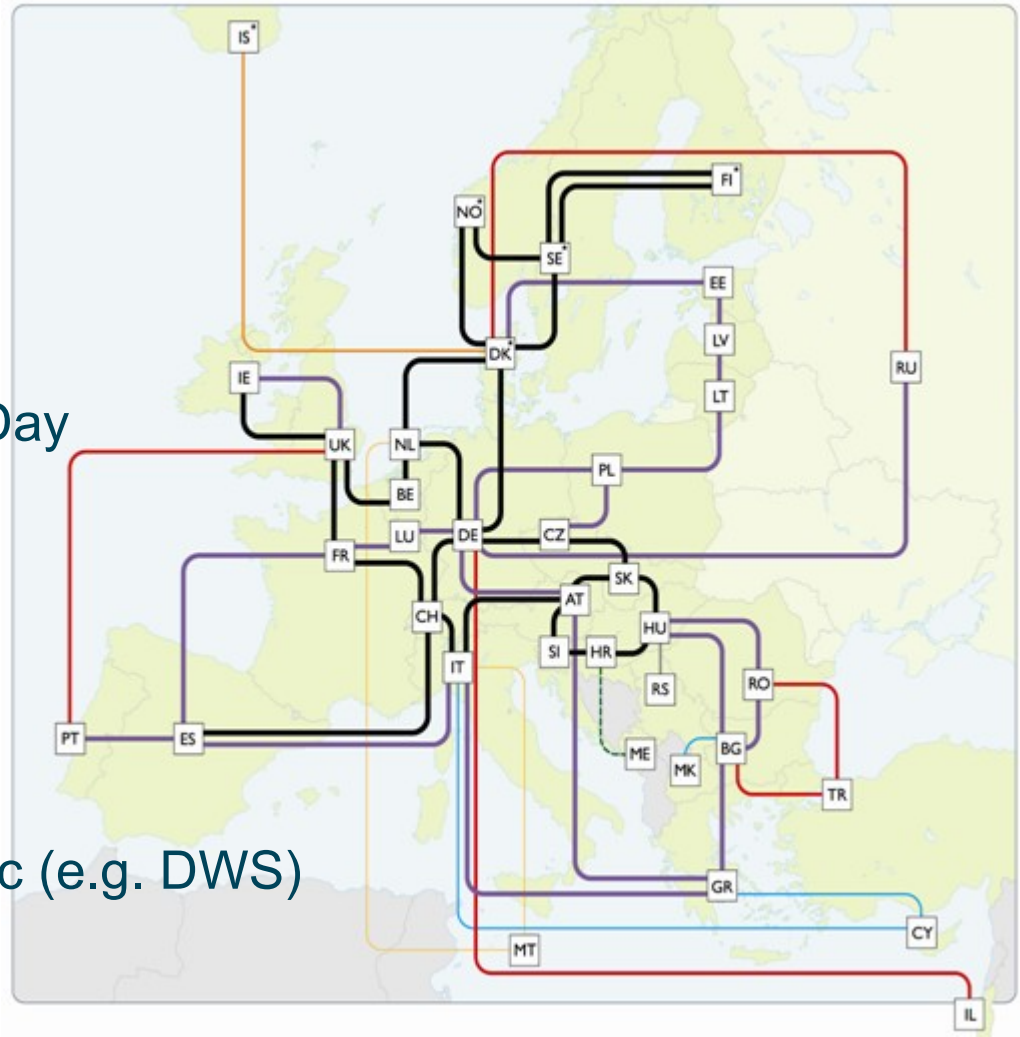
Content

- Introduction: The network and the service scenario
- The Tools
  - The benchmarking process
  - Deployment and initial usage of the selected tool
  - Some recent enhancements (Apriori)
- Network Security Service
  - The Objectives
  - The Service Details
  - Current Status
  - Event Workflow
- Conclusion

The Network Scenario

- …. A Transit Network with Global Visibility
- Up to 60 Gbit/s in peak times
- +/- 10 Million Speaking Hosts Per Day
- Unusual “research” Traffic
  - Large FTP Transfers
  - SSH Traffic
  - Grid Traffic
  - Bandwidth Testing Traffic
- Mixed with “ordinary” Internet Traffic (e.g. DWS)



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The Service Elements

1- Periodic Summary Reporting

- Observe global security anomalies trends at the GÉANT “boundary”
  - What are the most common attack types?
  - What the potentially more harmful?
  - Are some Networks heavy security anomalies sources or targets?
  - Why? Can something be done about it?

2- Punctual Anomaly Notification

- Specific events can be reported to NREN CERTs…
  - …that the NREN may not have noted due to lack of monitoring…
  - …or noted but lacking metadata for root cause analysis

Pre-requisite: anomaly detectability in GÉANT backbone

- Both service elements require anomaly “detectability” in the GÉANT backbone
  - With Sampled NetFlow only => no dedicated probes!
- Already proved with NfSen plugins (Molina: TNC 08)
- Decision to look at commercial tools for:
  - Support
  - Quick evolution to detecting new threats
  - Anomaly origin/destination analysis

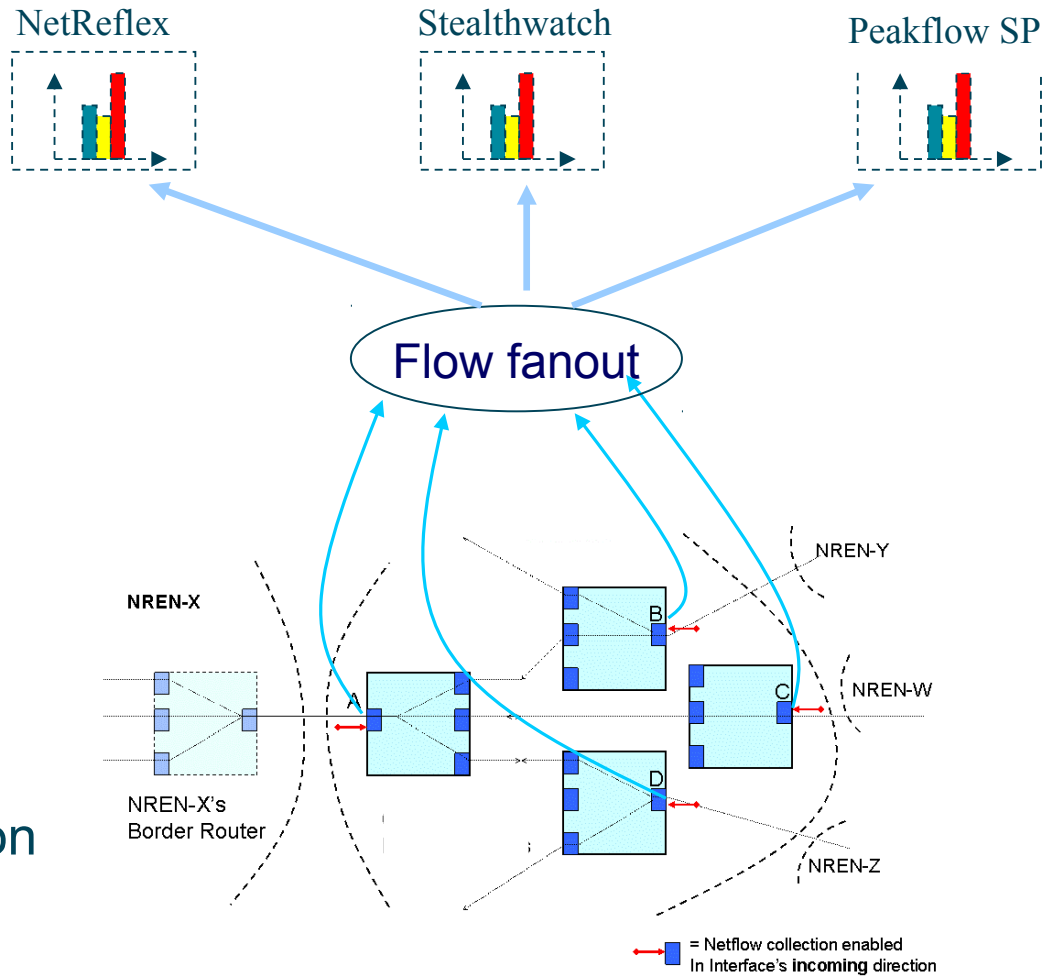
The benchmarked tools

- Three Distinct Tools
  - Netreflex – Guavus
    - Fuses BGP & ISIS Data
    - Creates an 18 x 18 Router Matrix
  - Peakflow SP – Arbor
    - Uses BGP & SNMP Data
    - Originally designed to pick large scale (D)DoS attacks
  - Stealthwatch – Lancope
    - Per Host Behavioural Analysis
    - Requires 1 anomaly end point to be part of prefix list

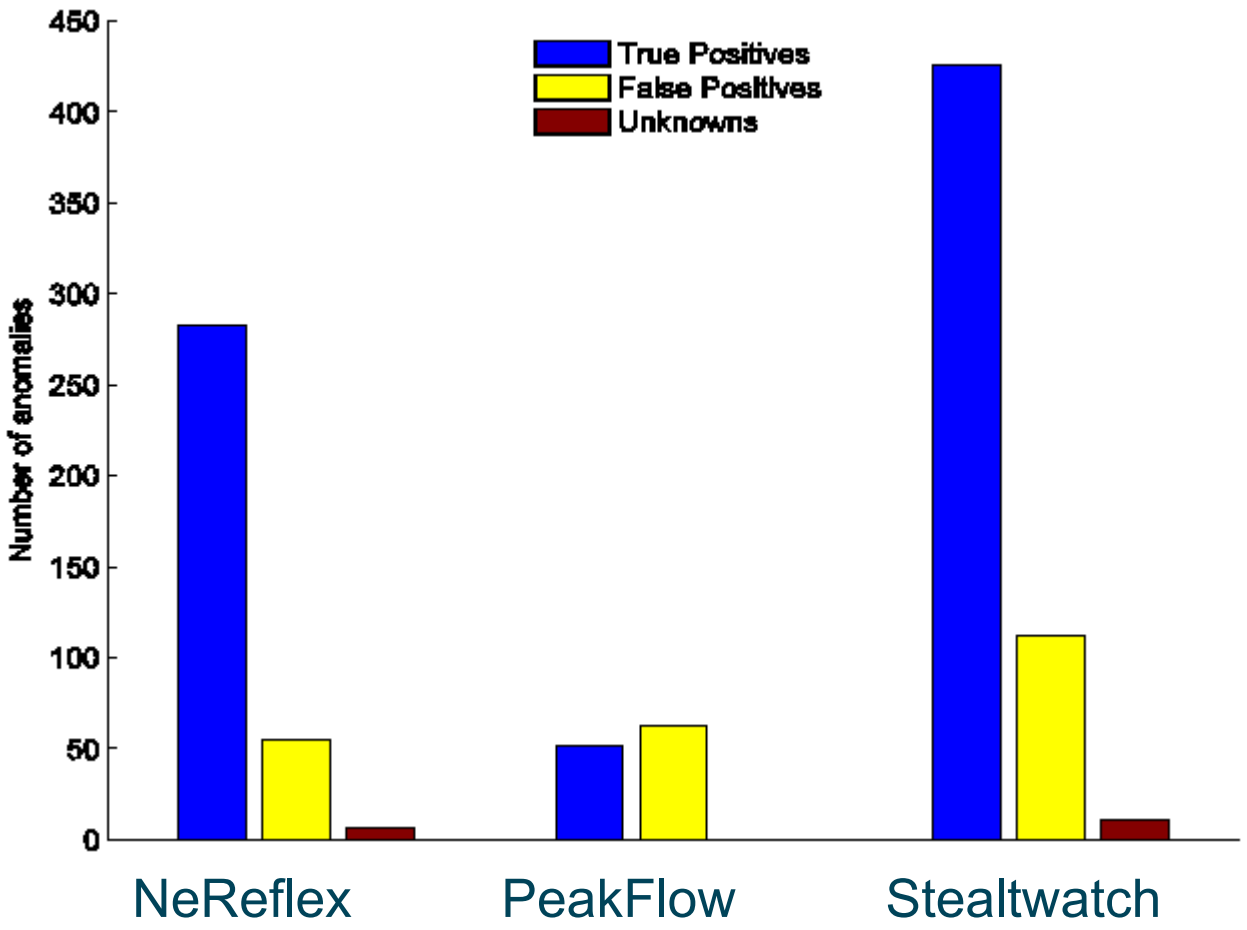
The benchmarking process

- Same data fed to tools
  - 13 days of cross comparison
  - 1066 anomalies in total
- Each anomaly
  - Cross checked with NfSen and raw NetFlow
  - Classified as True or False positive
- Some events forwarded to CERTs

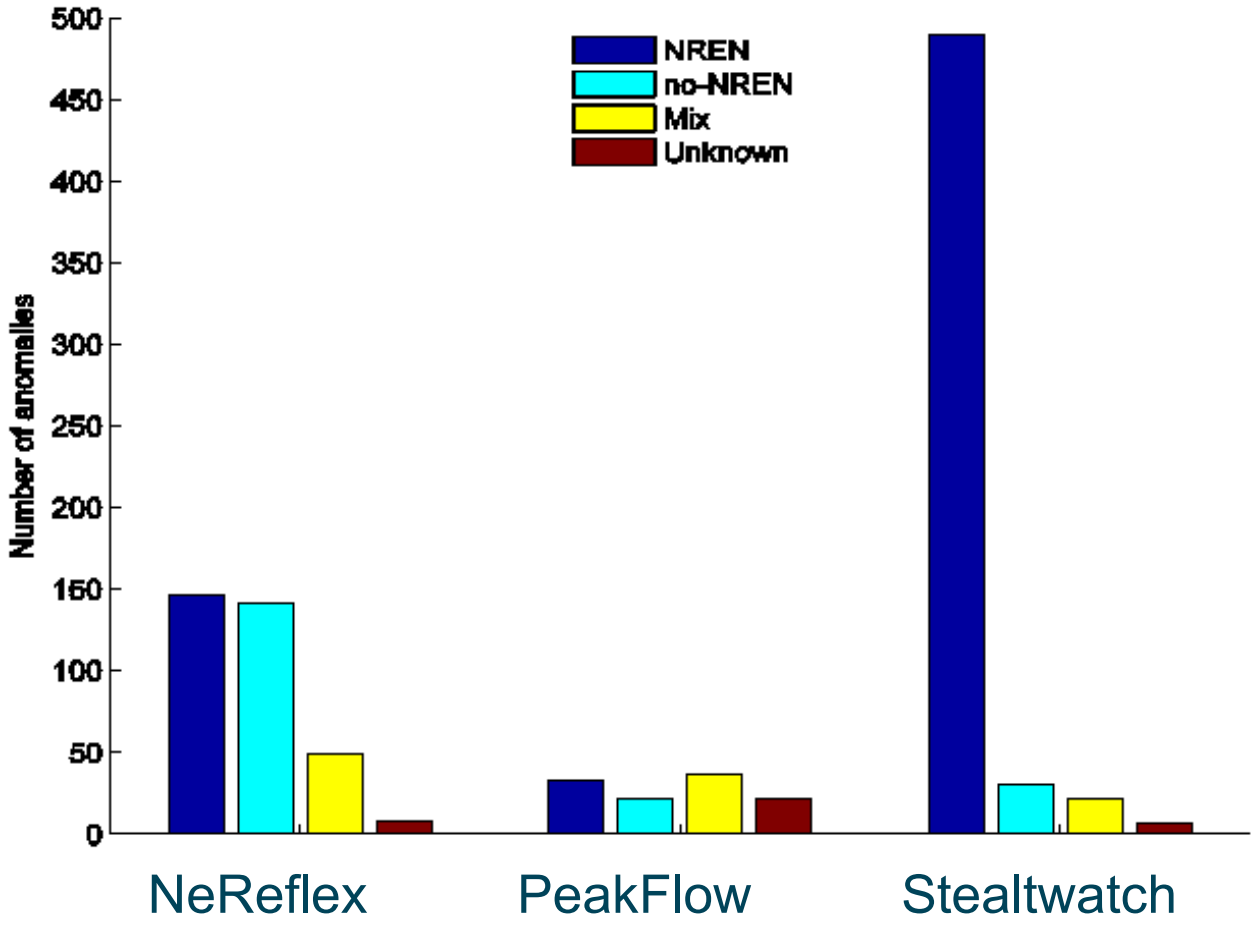
  for further Confirmation & Discussion



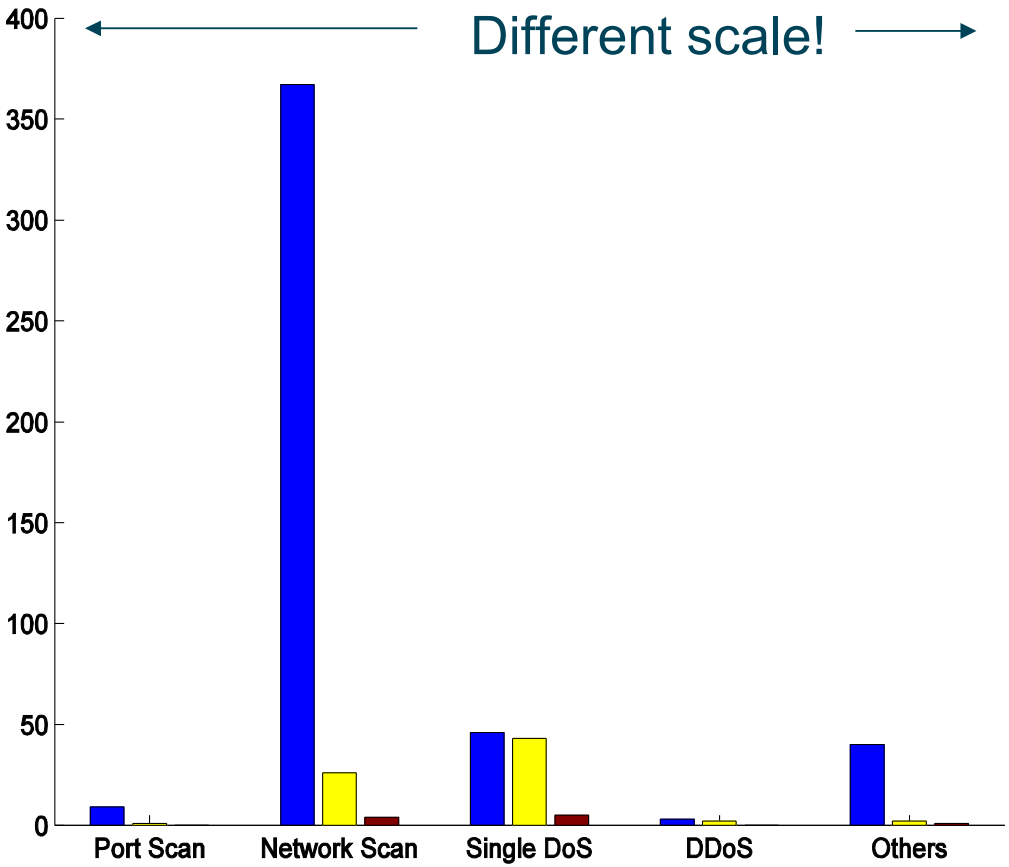
The benchmarking results: True and False Positives



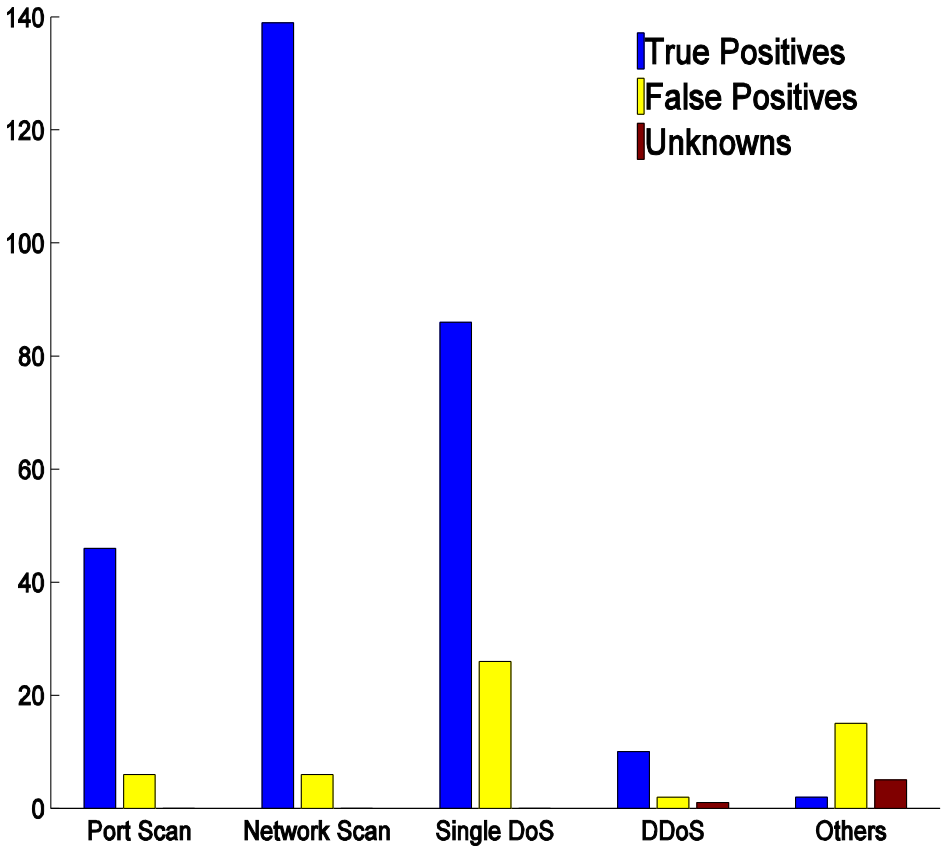
The benchmarking results: source of anomalies



NetReflex vs Stealthwatch: more details



Stealthwatch



Netreflex

Tool Selection - Netreflex

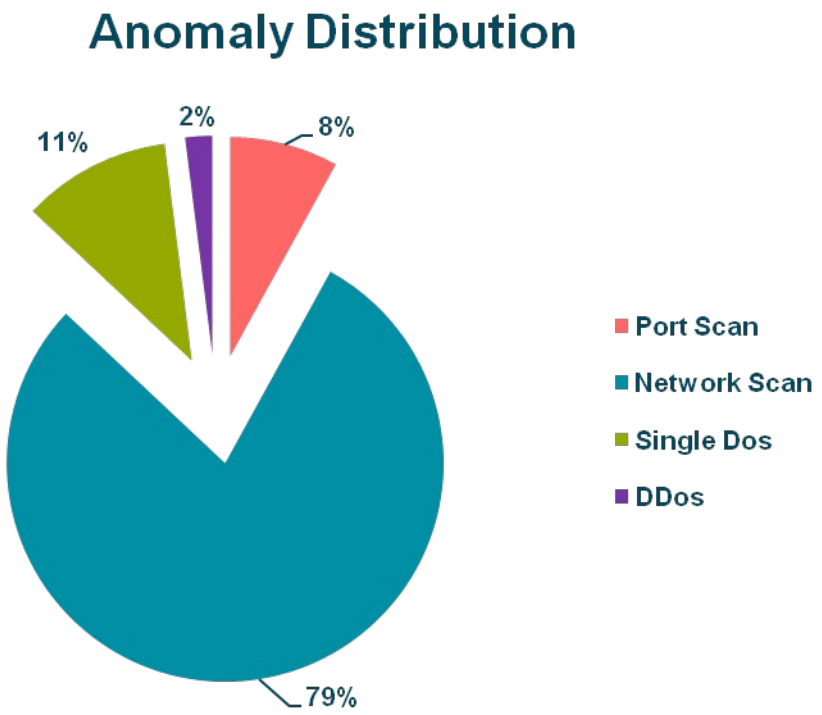
- Chose Netreflex as the Tool for anomaly detection
- More uniform detection of Anomalies across Types
- More uniform detection across Geant Peers
- Higher Cross Section Of Detected Anomalies
- Strengths Cover Scans & (D)Dos
- Origin of Anomalies – Well Balanced NREN vs Non

Deployment and Initial Usage of NetReflex

- NetFlow is now 1/100 sampled (was 1/1,000 during trials)
  - Better detection
  - Lower false positives (below 8%)
- Anomalies can be exported via e-mail
  - Anomaly database created
  - Statistics & Reports Generated for Analysis
- Netreflex v2.5 Deployed in Production Environment
  - Advanced Filtering Capabilities in Anomaly Analysis
  - Updated Reporting

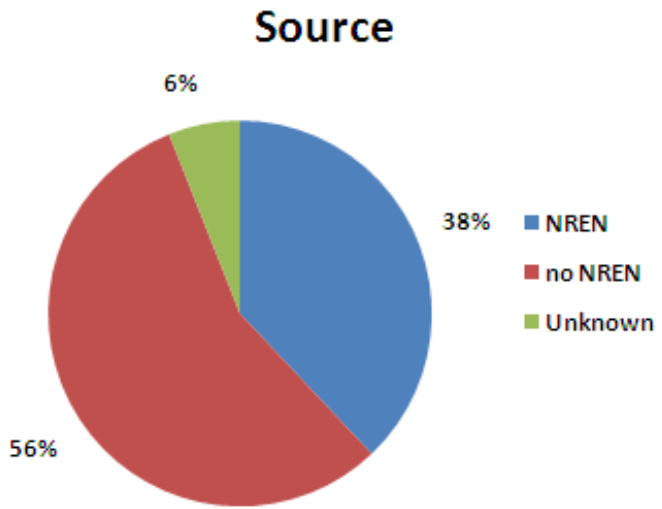
Early Results – Anomaly Distribution

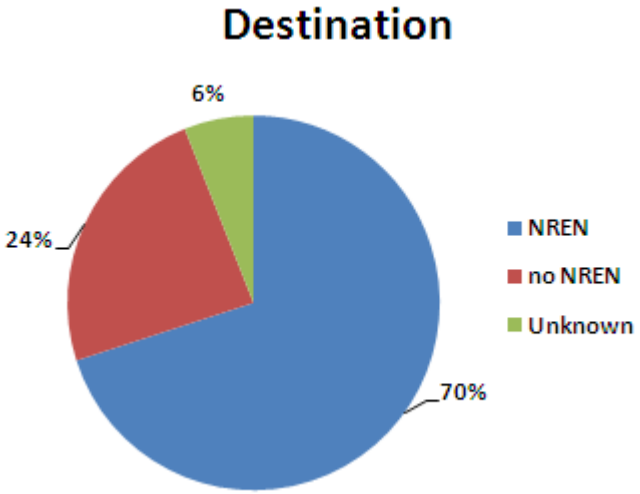
- Network Scans 79%
- DDos only 2%
- Network Scans a Precursor
- 40% of Network Scans from Global Connectivity Providers
- Network Scan SRC IP's traced to Port Scans & Dos Events



Early Results – Source & Destination Grouping

- NRENs target of attacks at 70%
- 56% of Events originating outside of GN
- 38% of Events originating from NRENs
  - NREN to no NREN accounts for 21%
  - NREN to NREN 17%
- 25% of Countries & Regions account for 77% of Attacks





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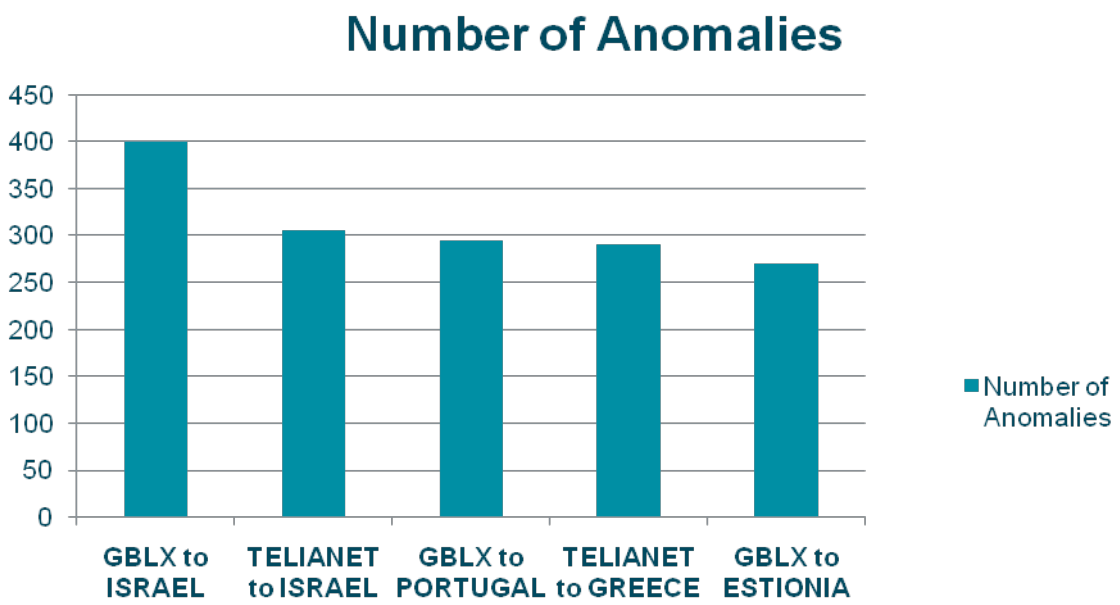
Early Results, AS Pairs for Anomaly Distribution

- Global Connectivity Providers
- Greece & Portugal?
- Israel & Estonia
- Small networks appear high in the list of targets: why?



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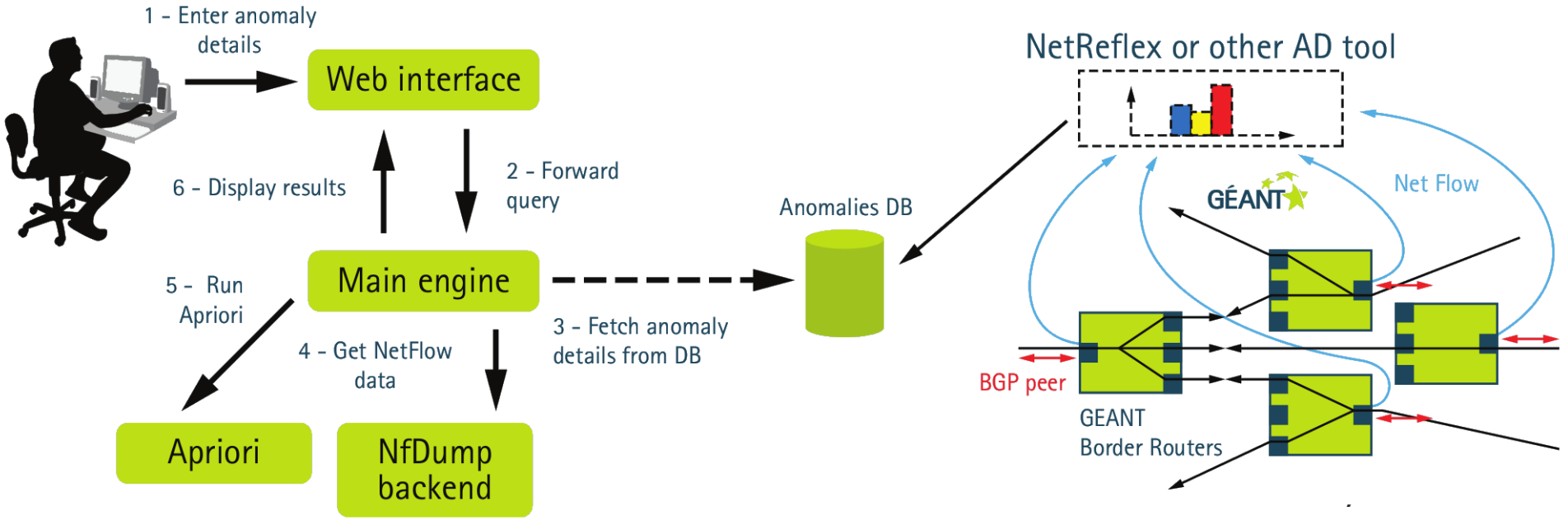
A (research) enhancement: apriori

- The *manual* validation of 1000+ anomalies via NetFlow record inspection stimulated us to explore *automatic* approaches
- "Apriori": algorithm adapted from marked basked analysis to find association rules **(*)**
  - "If customer buys item X, what is he likely to buy as well?"
- Analogy: if a flow is involved in an anomaly, what other "similar" flows may be involved?
- We refined the original algorithm and implemented a GUI

(*) D. Brauckhoff, et al. - Anomaly extraction in backbone networks using association rules - IMC'09 - November 2009.

Apriori for mining anomalies: GUI



Anomaly Investigation

Anomaly detection

Apriori for mining anomalies: one example

The Anomaly detection tool detected this port scan

	Source IP	Destination IP	Source Port	Destination Port
Portscans	.191.64.165	.13.137.129	55548	*
	.191.26.33	.13.137.129	39573	*
DDoS	*	.13.137.129	3072	80
	*	.13.137.129	1024	80

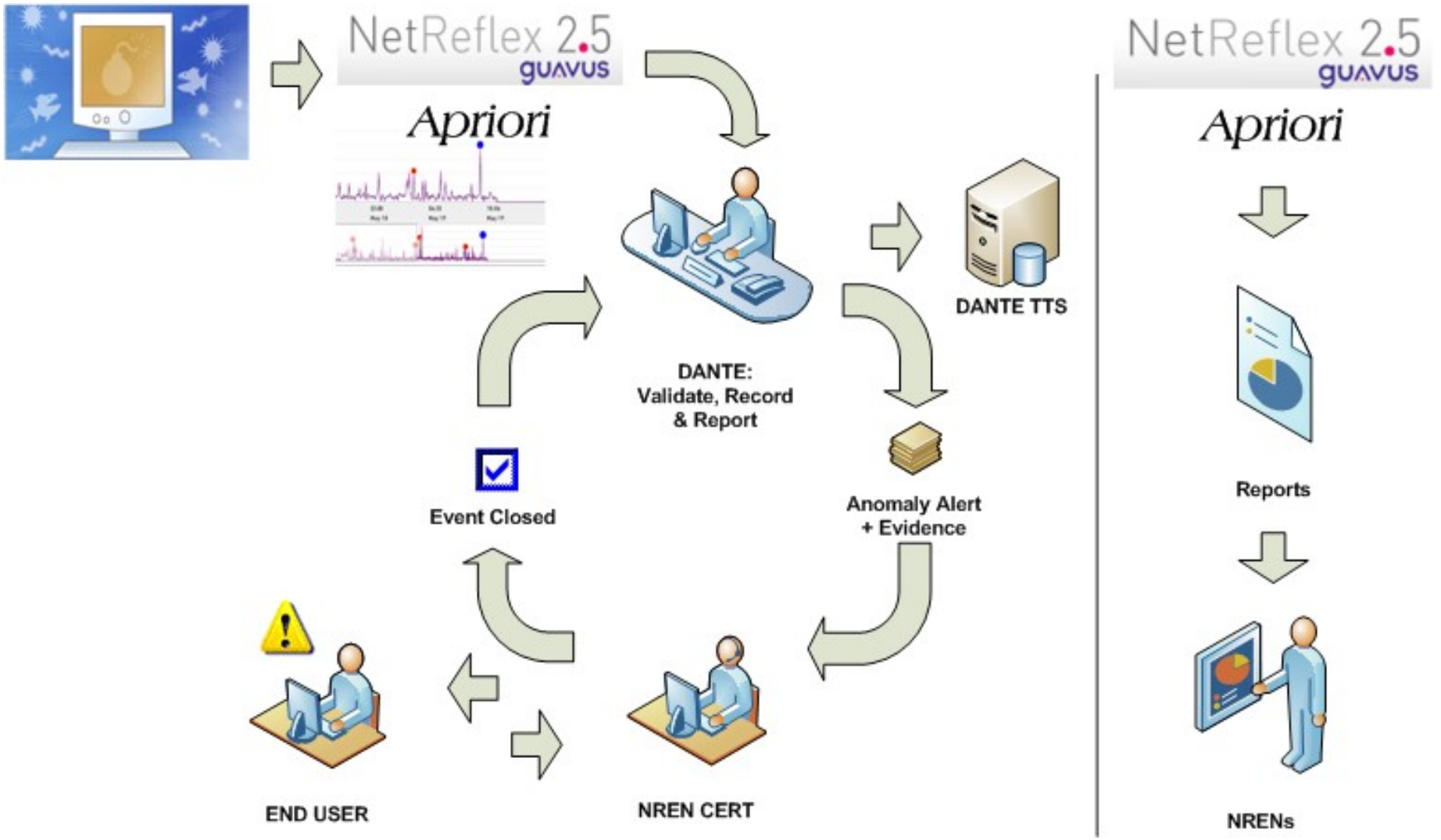
Apiori revealed another port scan can on the same target, and a DDoS as well

Network Security Service – The Objectives

The NSS is a service that will enhance backbone security and will extend the NRENs ability to protect their infrastructure.

- … thereby assisting in reducing the network impact of security events on their networks
- … provide additional security incident response to NRENs to extend to their customers
- … and prevent attacks against the GN infrastructure thereby providing a safer GN network

Network Security Service – Event Workflow



Network Security Service – The Service Details

- **Protect GEANT Infrastructure**
  - Identify Threats
  - Identify Targets & Sources
  - Identify Affected Peering's
- **Protect NREN Access to the Backbone**
  - Collaborate with NRENs to mitigate threats affecting them
  - Provide NREN's with additional network visibility
  - Assist less advanced NREN's with security event notifications
  - Provide reports on security events affecting NREN

Network Security Service – Current Status

- **Phase 1 – Anomaly Detection Toolset Deployment,**
  - Selection & Tool Tuning
  - Further Analysis & Reduction of FP rate
  - Findings widely reported to community; TF-CSIRT; FIRST;
- **Phase 2 - NREN Security Event reporting**
  - Reporting Security Events to NRENs
  - Provide event evidence with notifications
  - Collaborate with NREN's on events.
  - Increase level of security monitoring for NREN's

Conclusion

- Proven detectability of Security Events in the Backbone Network
- Extensive Tool Comparison Trial
- Reduction in FP Ratio of Anomalies in Netreflex
- Automatic Anomaly Validation
- Network Security Service
  - Provide NREN's with Additional Visibility
  - Provide Security Event Notification and Reporting
- Phase Two of Deployment
  - Targeted NREN Alerts
  - Closer Security Interaction & Collaboration

Acknowledgements

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Conclusion

Thank-You

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