PCR - A New Flow Metric

Producer Consumer Ratio

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Problem Statement

- Data Exfiltration is a serious problem
  - Cyber Espionage is primary issue in US Cyber warfare
  - APT1 identifies nation state orchestration and exploitation
  - Represents for some, THE worst case scenario
- Detection can be challenging
  - Novel transport strategies can really make it hard
  - Behavioral threshold based systems easily subverted
  - Some involve internal data consolidation, with physical extraction
- For many, the problem is not Data Loss
  - Unknowingly, many infrastructure are used as stepping stones facilitating the transport of data.
  - Implicating them as co-conspirators.
  - Liability and reputation impacts are very damaging

Exfiltration Methods

- Data Exfiltration can be a complex and protracted event
  - "Night Dragon" APT active ~4 years.
  - APT1 identifies nation state orchestration and exploitation
- Majority of the nodes involved are transport nodes, not sources
- Use of overt and covert channels is common
  - IP Multicasting for extra work group exfiltration (overt)
  - Non-IP LAN based data exchange for consolidation and exfiltration
  - Browser based covert channels - DNS prefetching , Java scripting
  - DNS tunneling, HTTP tunneling, XXX tunneling
  - Piggyback transporting - NTPv3, VoIP, ICMP, SIP
- Insider exfiltration generally uses physical media
  - Normally involves data consolidation to a set of extraction nodes, to facilitate physical removal of the data.

Exfiltration Detection

- Data Loss Protection strategies fall short
  - Exfiltration is not exclusively a data loss problem
    - Many impacted by exfiltration exploits are just stepping stones
    - For these sites, content based detection fails, as its not their data.
  - Distributed exploitation frameworks, such as "mesh - in - mesh - out" fabrics, make load based identification very difficult.
- Bell-La Padula type formal methods may provide some help
  - Detect transformation from normal node to an exfiltration node
  - Need new metrics
- Propose that exfiltration is a shift in producer / consumer roles
  - Better methods to describe producer / consumers will really help
  - Early detection involves identifying leading indicators

Producer Consumer Roles

- The purpose of a communications network is to facilitate producer / consumer functions
    - The nature of the produce / consumer role can be formalized, identified, analyzed, tracked and controlled.
- All network nodes are producers and consumers of data
    - All nodes consume network control services
        - ARP and DNS
    - All nodes provide network services, some more than others
        - Switches, routers, file systems, web servers, name servers, whatever
    - Use of the network is a consumer / producer relationship
        - Nodes using applications generally are producers or consumers
        - Nodes supporting applications, generate application exchange
- Exfiltration is a modification of the highly granular and aggregated consumer / producer relationships of an organization of systems.

Producer Consumer Ratio

Novel Flow Metric

- Basic Computer Science Semantics
- Fundamental Flow Dynamic
- Basis for Behavioral Classification
- Simple Arithmetic / Statistical Operations
- Support All Flow Data Operations
    - Aggregation, Inverse, Filtering, Selection, Search, Bining, Metadata Enhancement

Producer Consumer Ratio

Definition

Intuition

A normalized value indicating directionality of application information transfer, independent of data load or rate.

$$PCR = \frac{SrcApplicationBytes - DstApplicationBytes}{SrcApplicationBytes + DstApplicationBytes}$$

$$\text{Application Bytes} = (\text{Total Bytes} - \text{Sum}(L_{[2, 3, 4]} \text{ Headers })) - \text{Retrans Bytes}$$

Producer Consumer Ratio

Properties

Consumer Producer

Range: -1.0 <= PCR <= 1.0

Proportions: Source's Fraction = (1 + PCR) / 2

Destination's Fraction = (1 – PCR) / 2

Analytics: Aggregation, Selection (filtering), Sorting, Cluster Analysis, Frequency Analysis, Classification

Sample Values:

1.0 – pure push - FTP upload, multicast, beaconing

0.4 – 70:30 export - Sending Email

0.0 – Balanced Exchange - NTP, ARP probe

-0.5 – 3:1 import - HTTP Browsing

-1.0 – pure pull - HTTP Download

PCR and Observation Domains

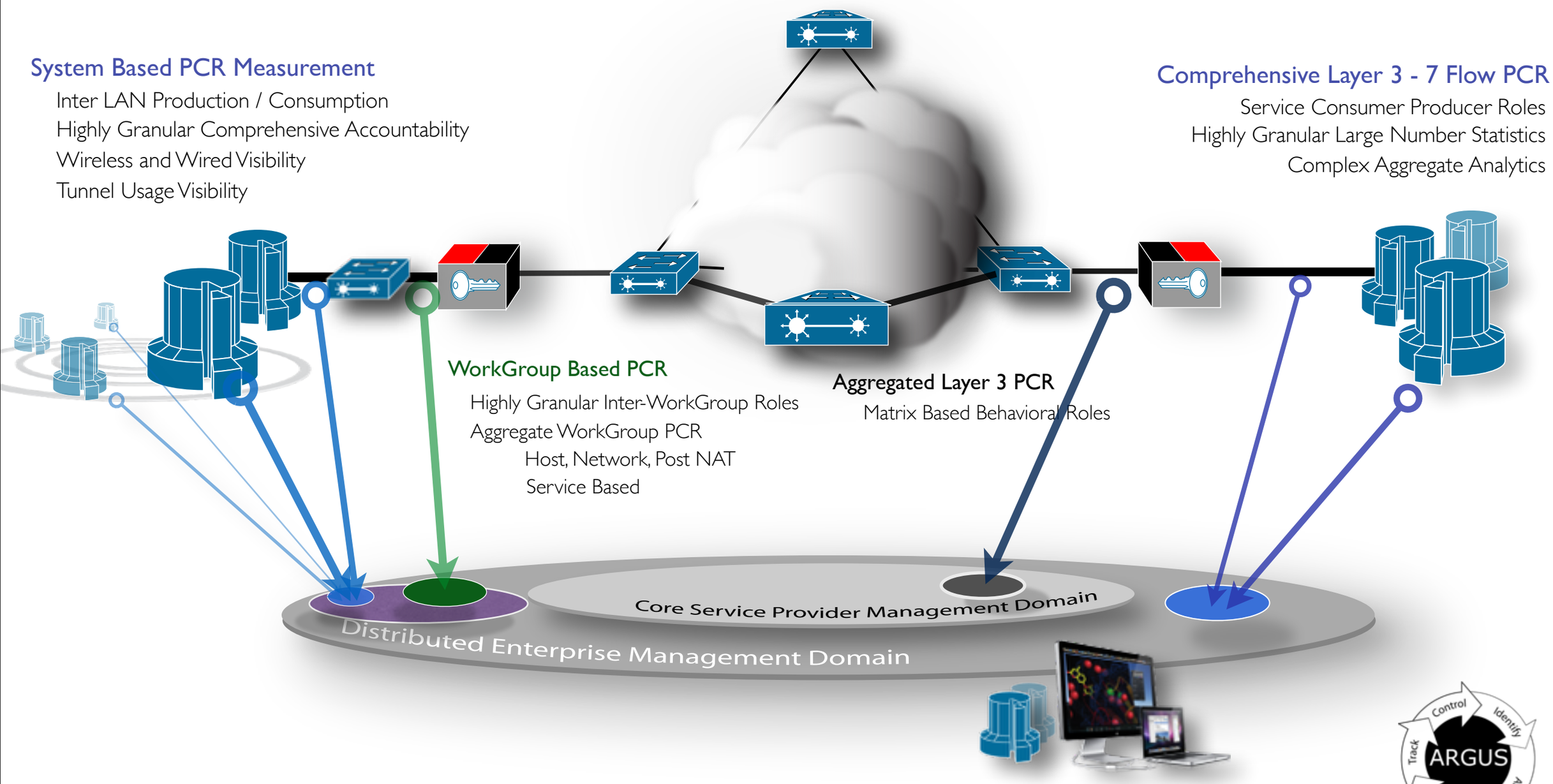
PCR Situational Applicability

System Based PCR Measurement

- Inter LAN Production / Consumption
- Highly Granular Comprehensive Accountability
- Wireless and Wired Visibility
- Tunnel Usage Visibility

Comprehensive Layer 3 - 7 Flow PCR

- Service Consumer Producer Roles
- Highly Granular Large Number Statistics
- Complex Aggregate Analytics

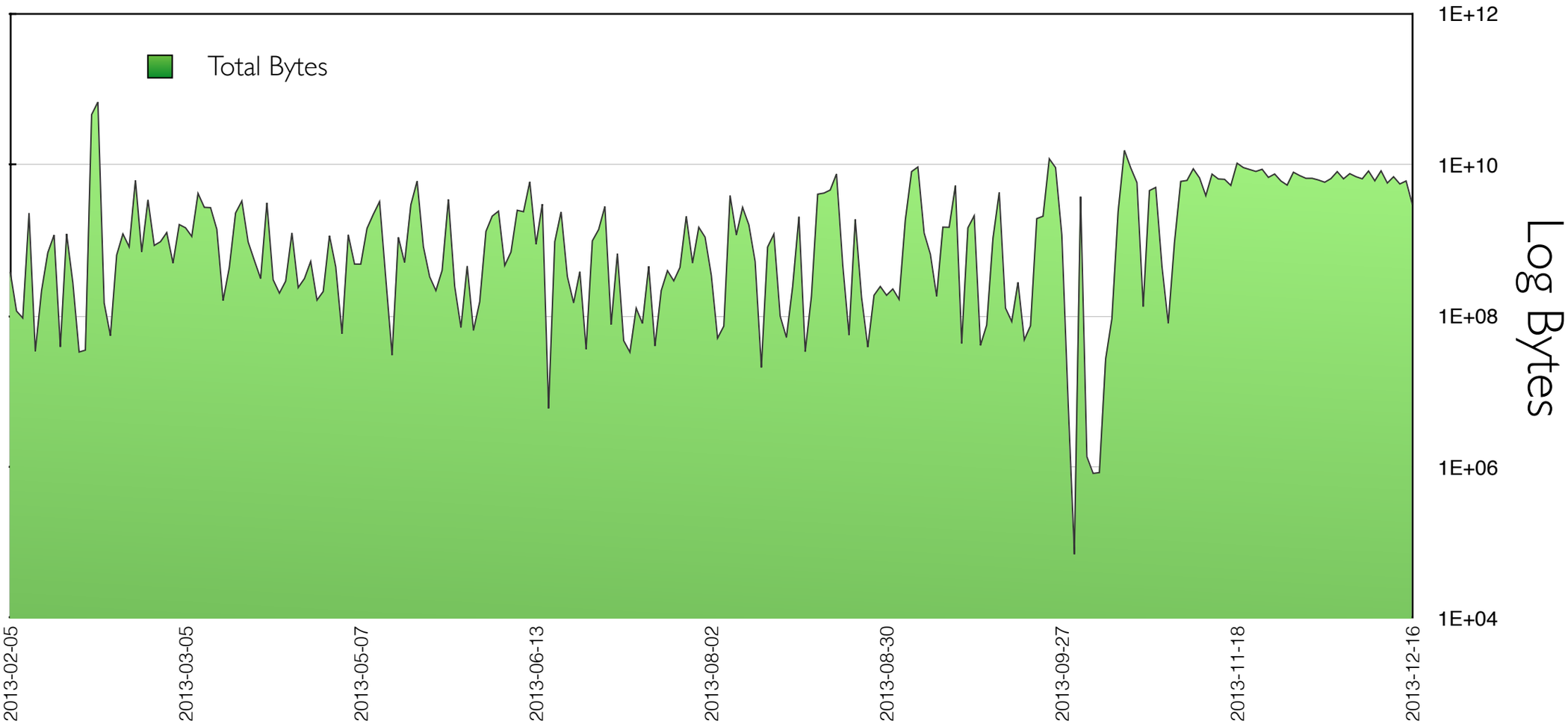


Results

PCR Application Characterization

Enterprise Aggregate PCR

QoSient WHQ Aggregate Daily Producer Consumer Ratio



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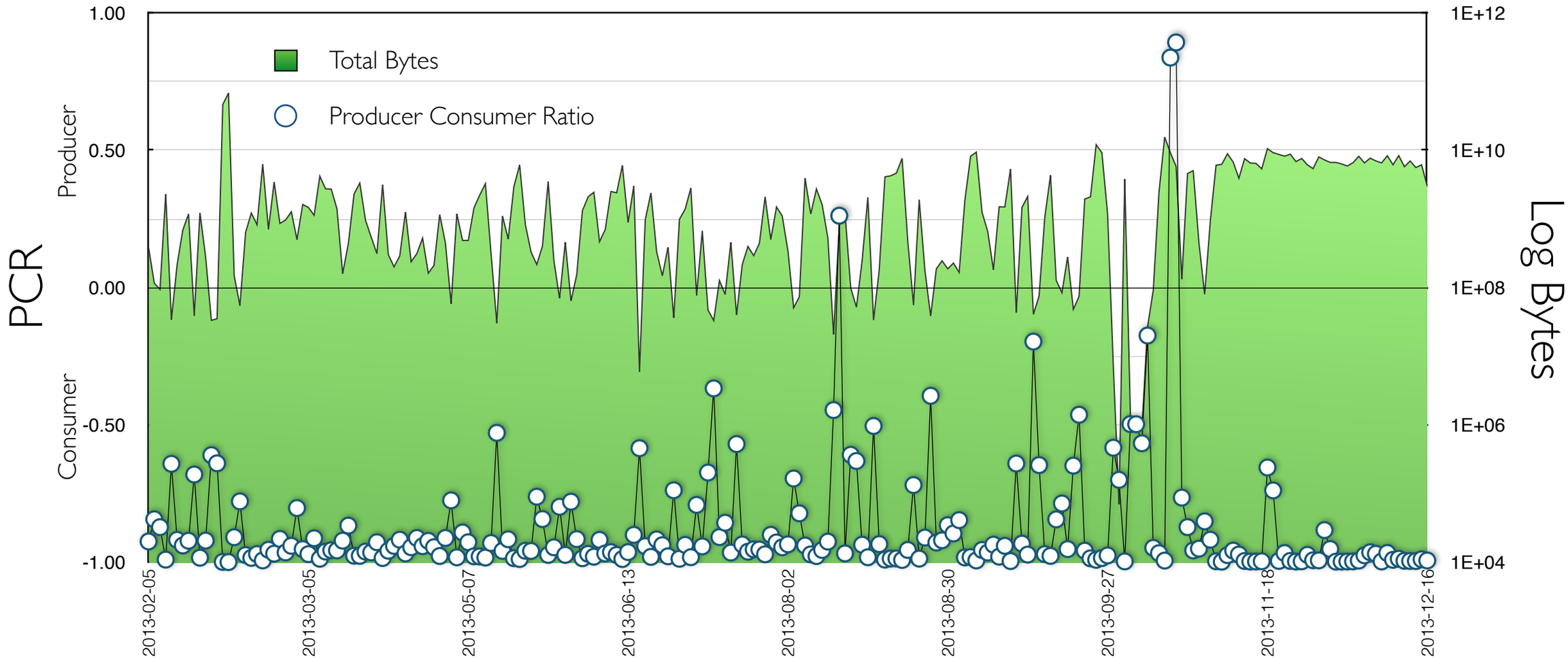

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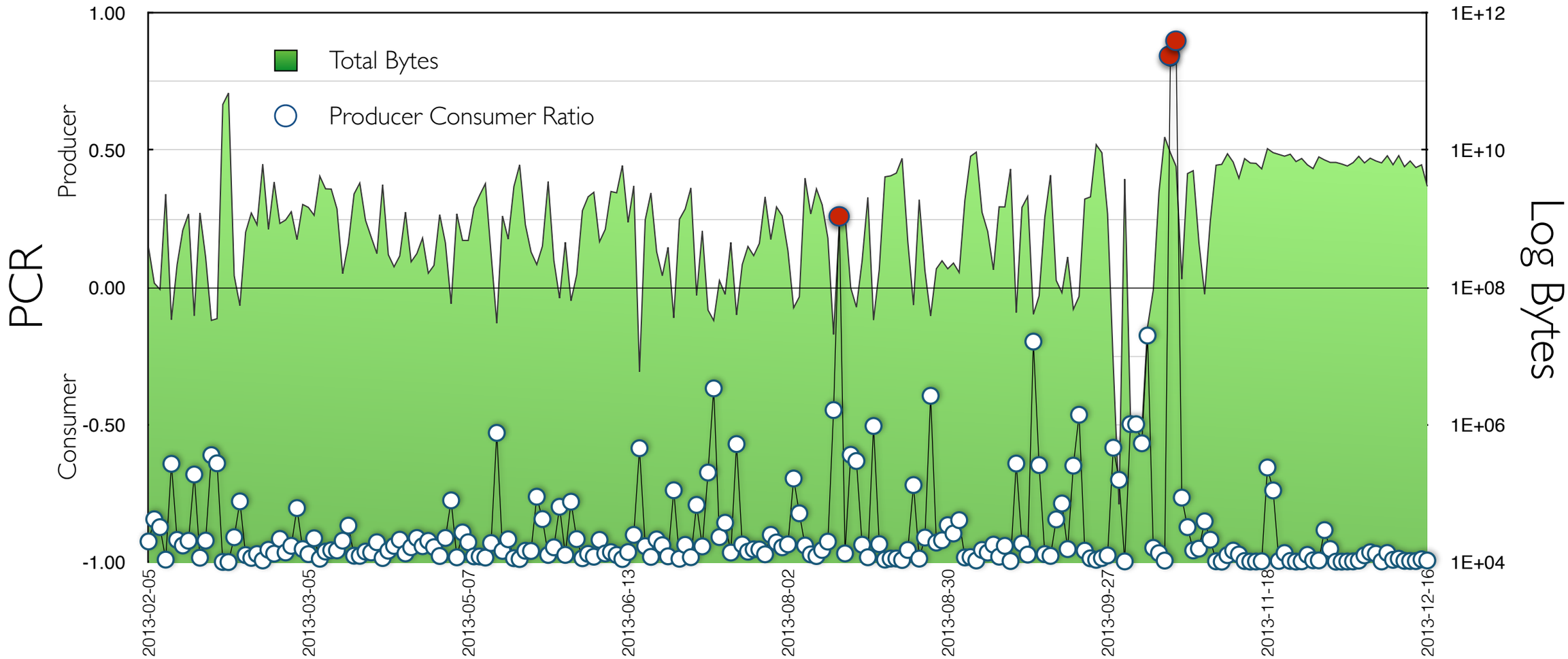

Positive Aggregate PCR caused solely by iCould awacsd - apple wide area connectivity service daemon

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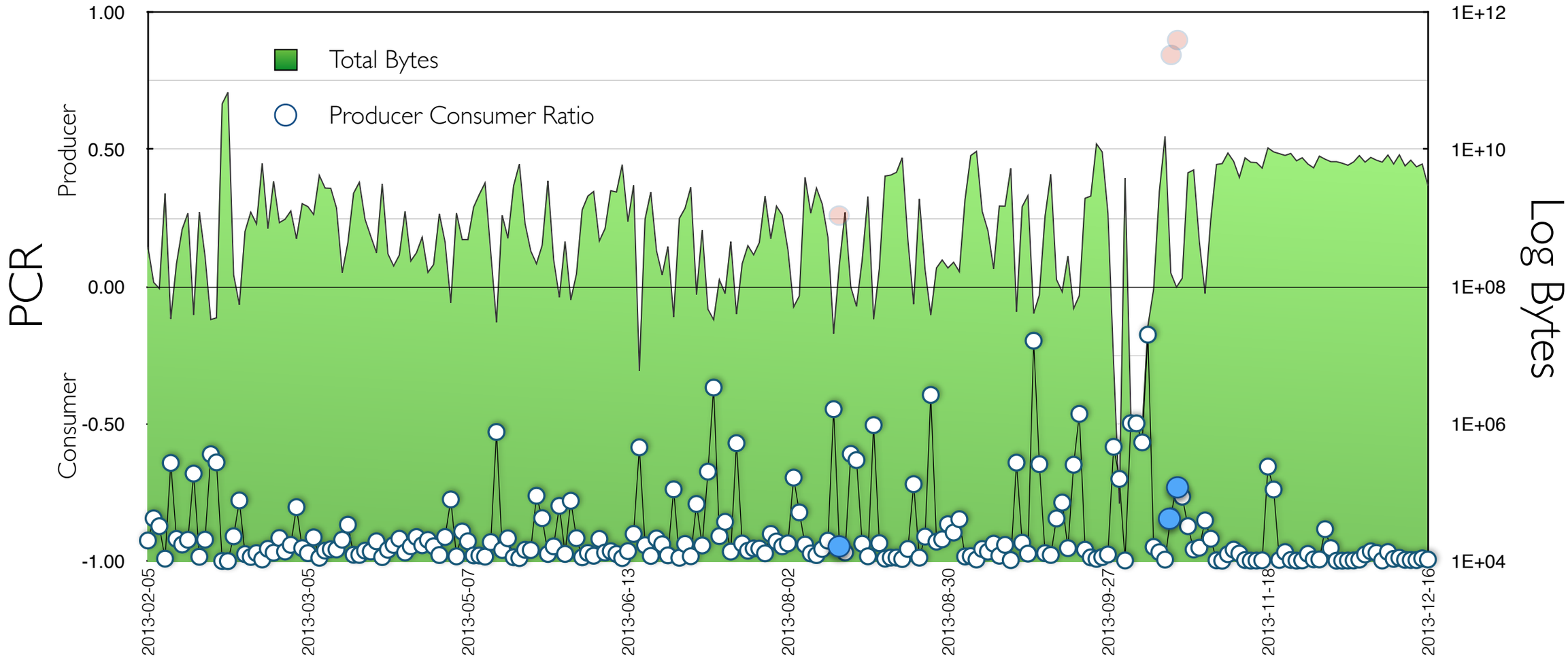

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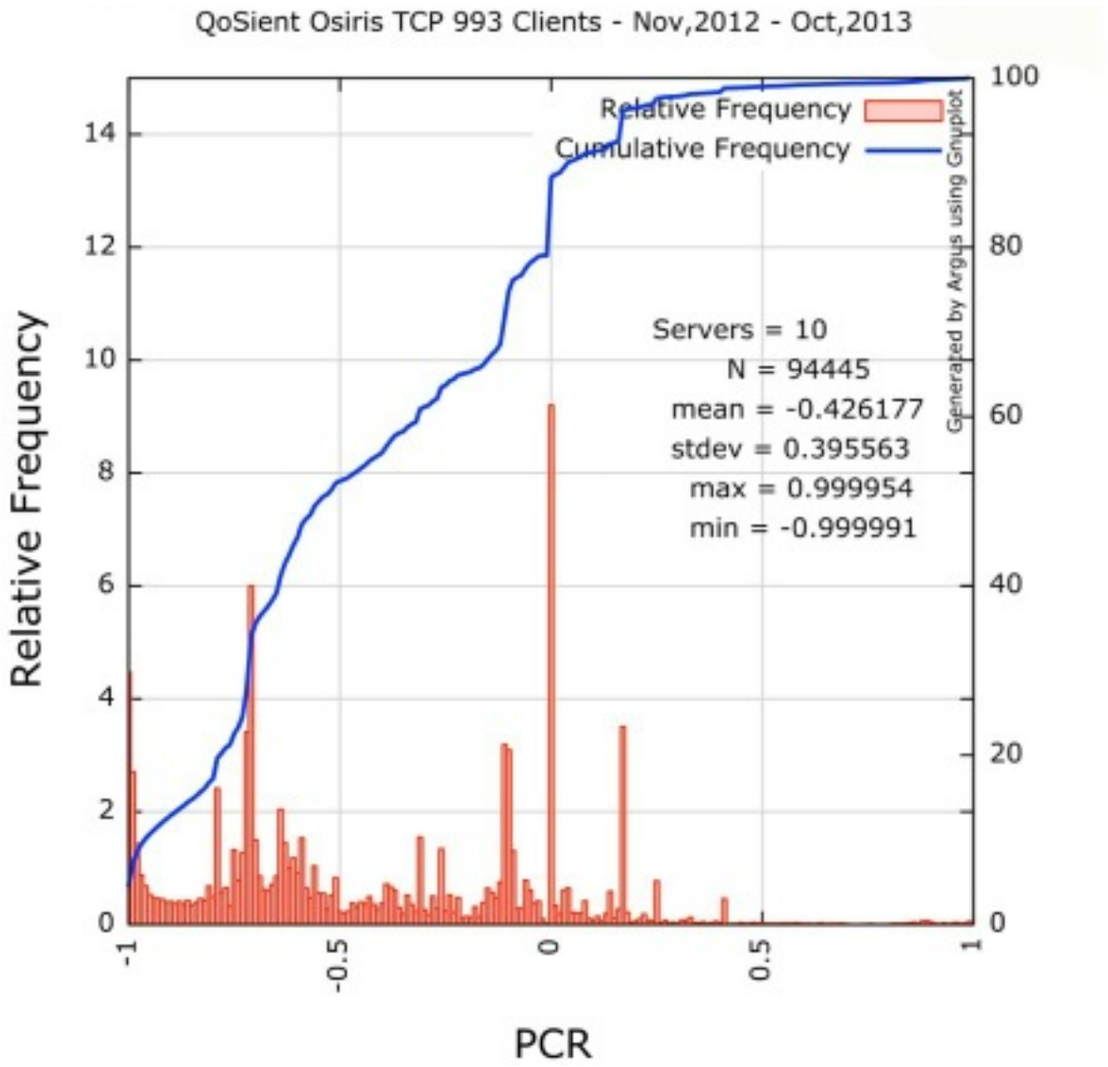
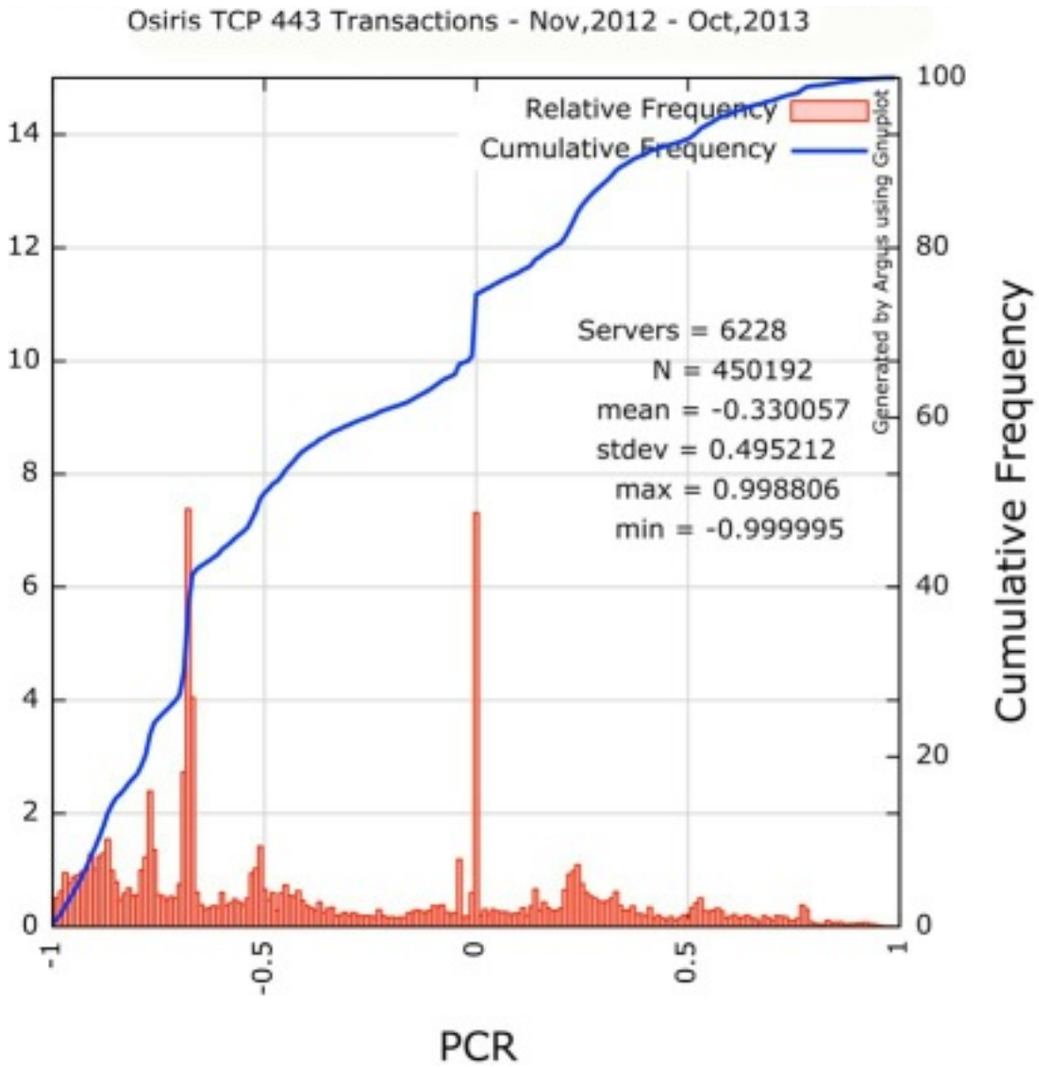
Baseline Enterprise PCR - Aggregate PCR value after removing awacsd flow metrics

PCR Application Characterization

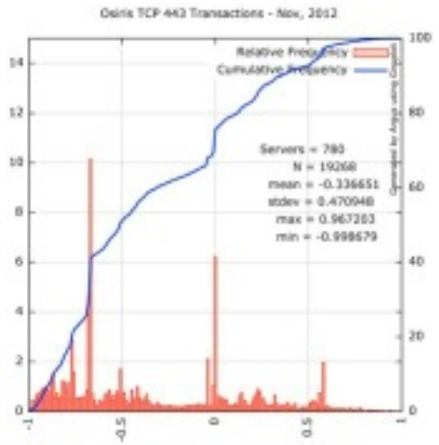
IMAPS, HTTPS

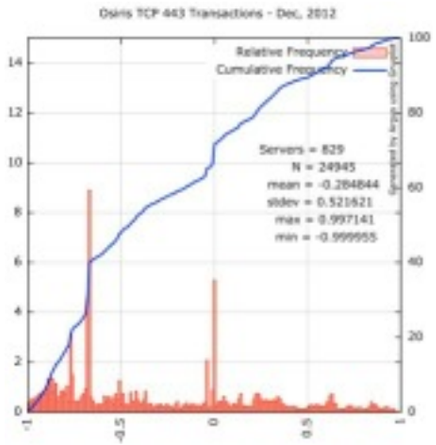


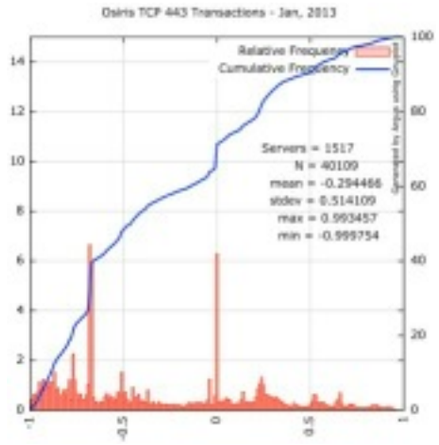


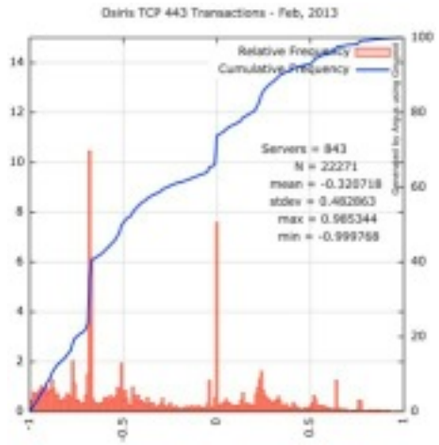
PCR Application Stability

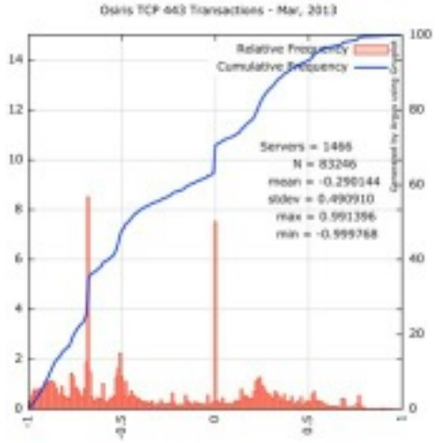
HTTPS - One Year Period

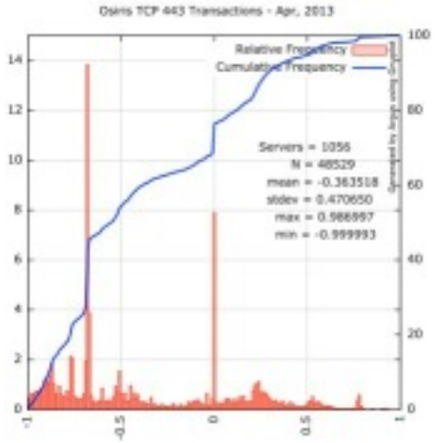


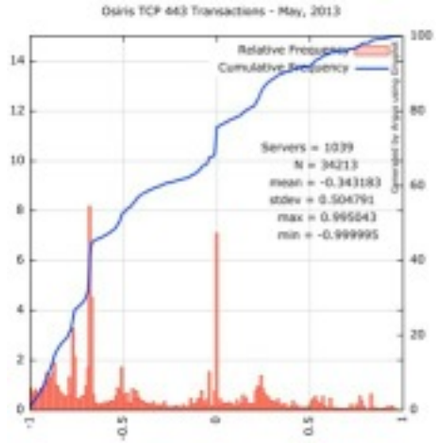


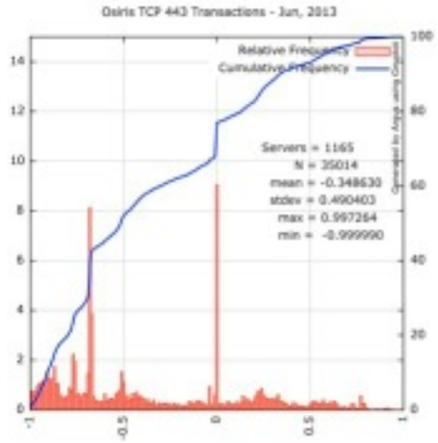


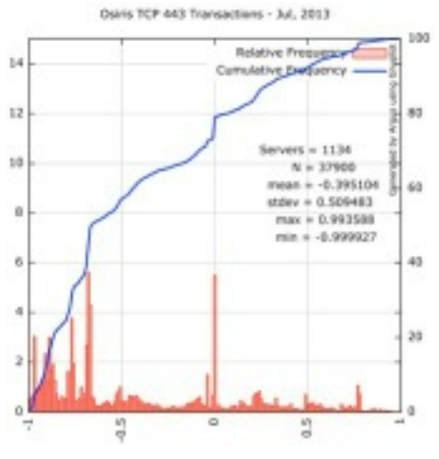


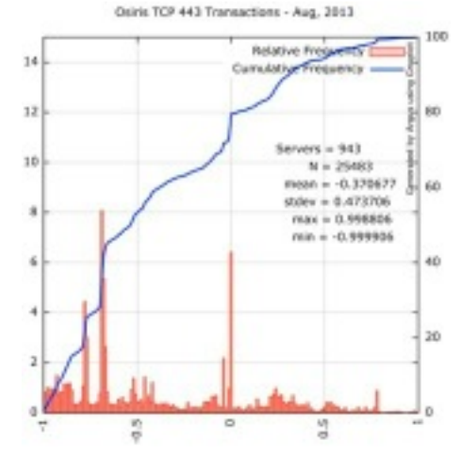


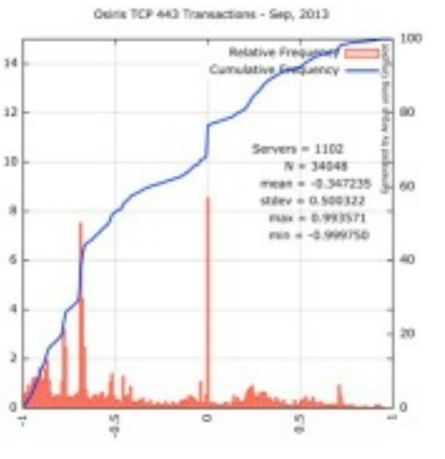


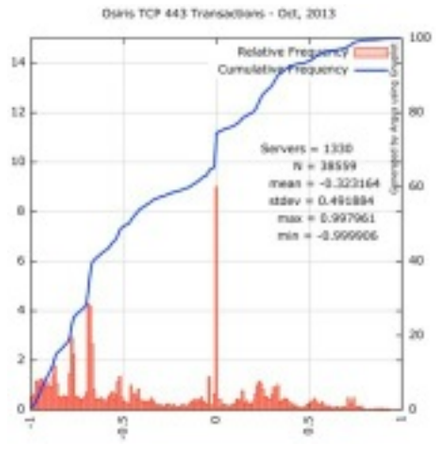






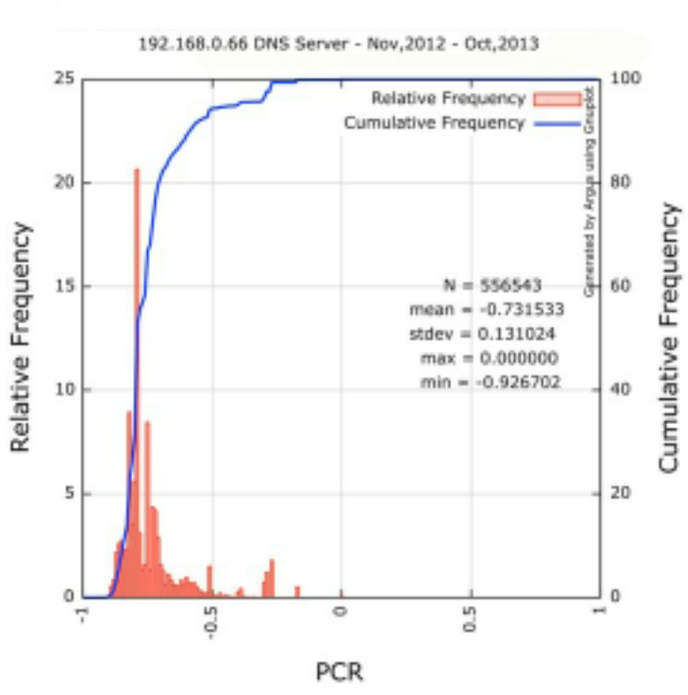


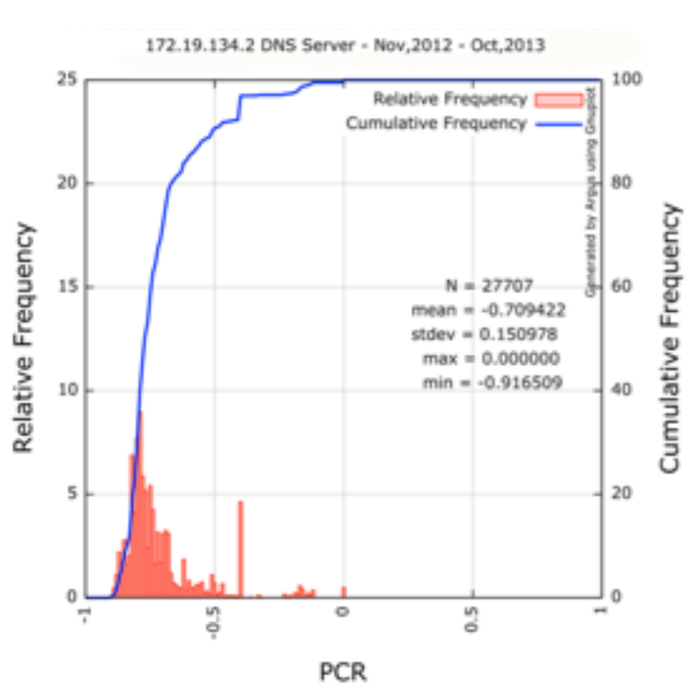


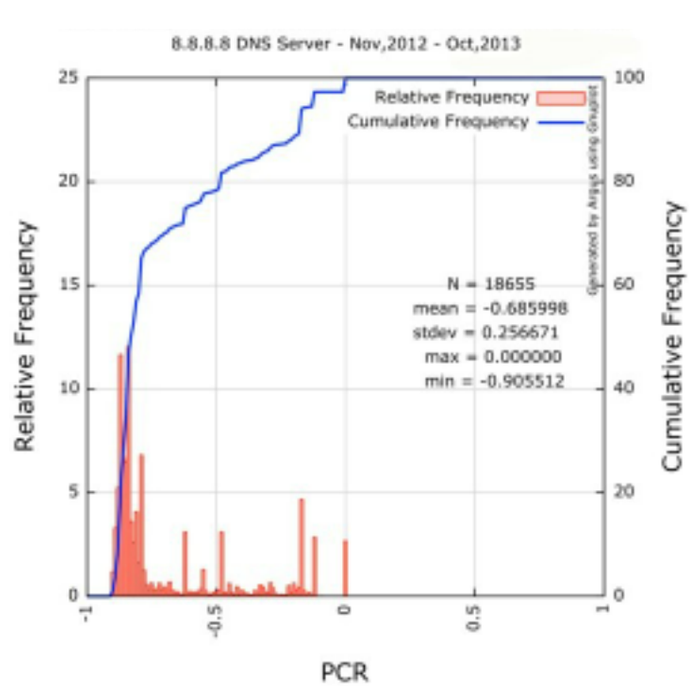


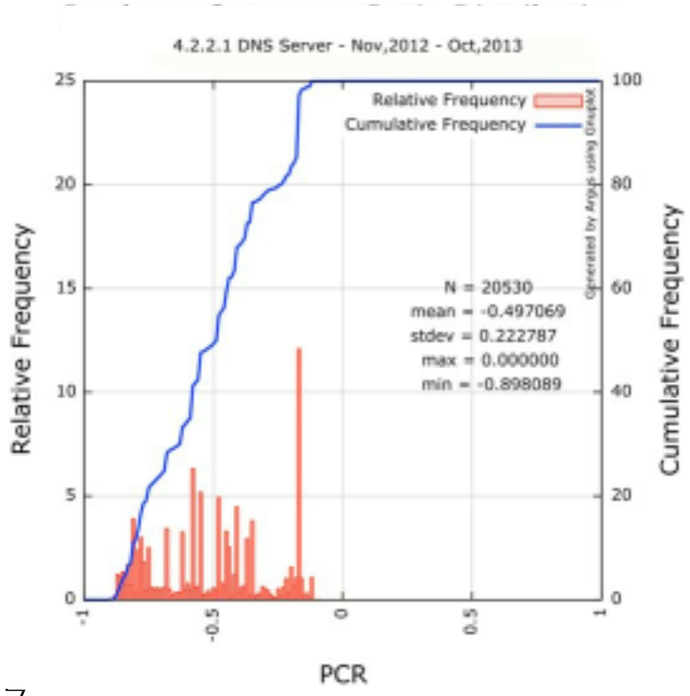
PCR Application Characterization

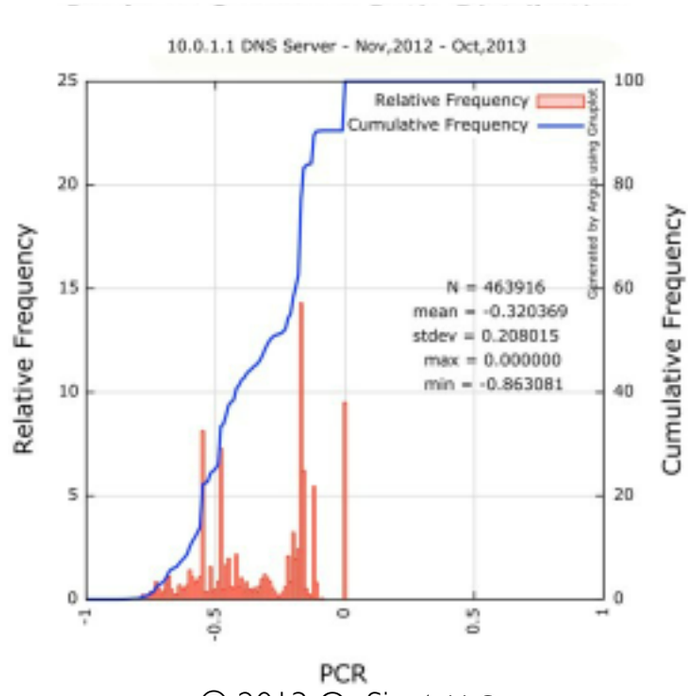
Domain Name Servers





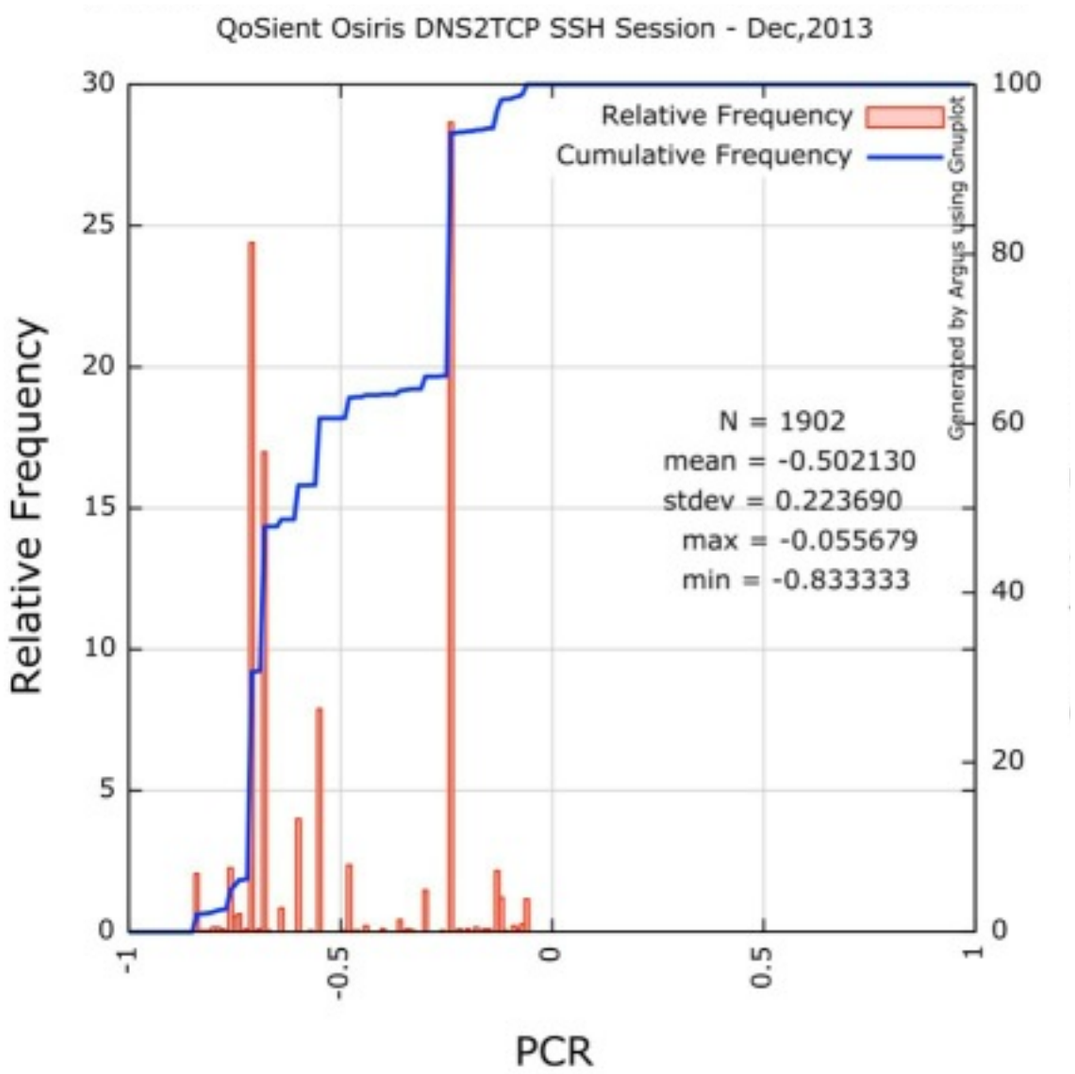


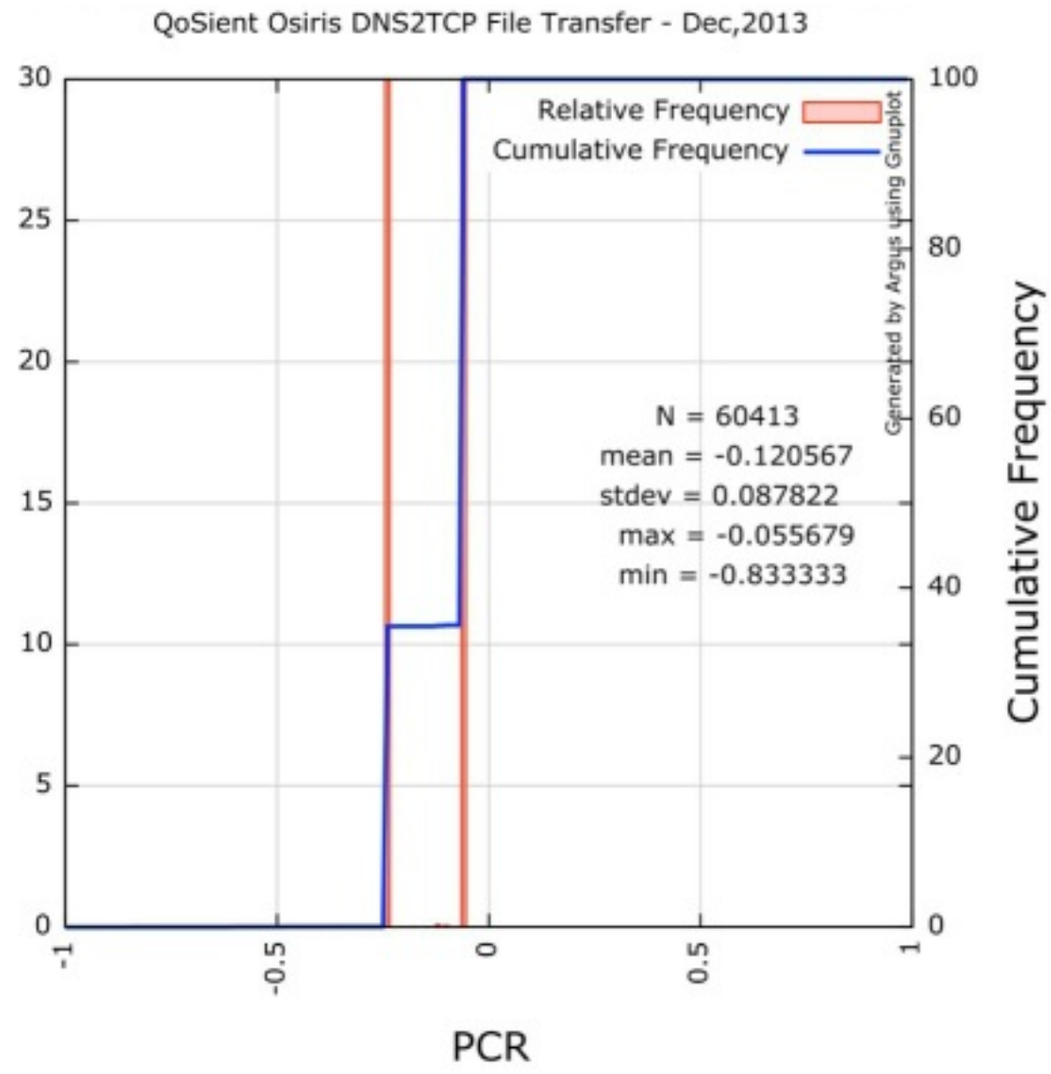




PCR Covert Channel Analysis

Domain Name Service - dns2tcp





Farnham, G. and Atlasis, A. *Detecting DNS Tunneling,* SANS Institute InfoSec Reading Room, Feb, 2013.
https://www.sans.org/reading-room/whitepapers/dns/detecting-dns-tunneling-34152

Supporting Slides

PCR Stability Characterization

PCR vs Total Application Bytes