Comprehensive Understanding of Malicious Overlay Networks

Homeland Security
Science and Technology

Cyber Security Division
2012 Principal Investigators' Meeting

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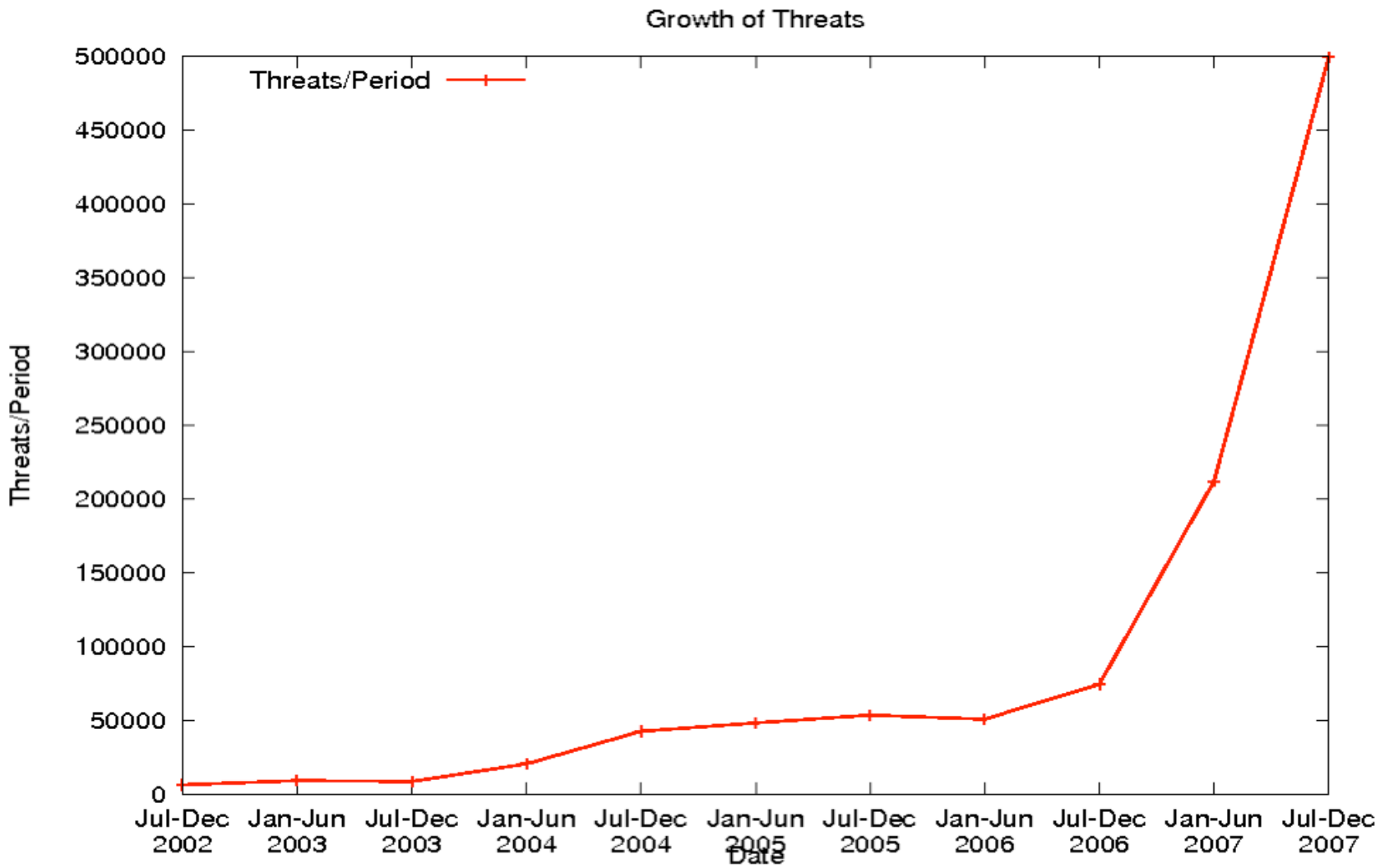
Background

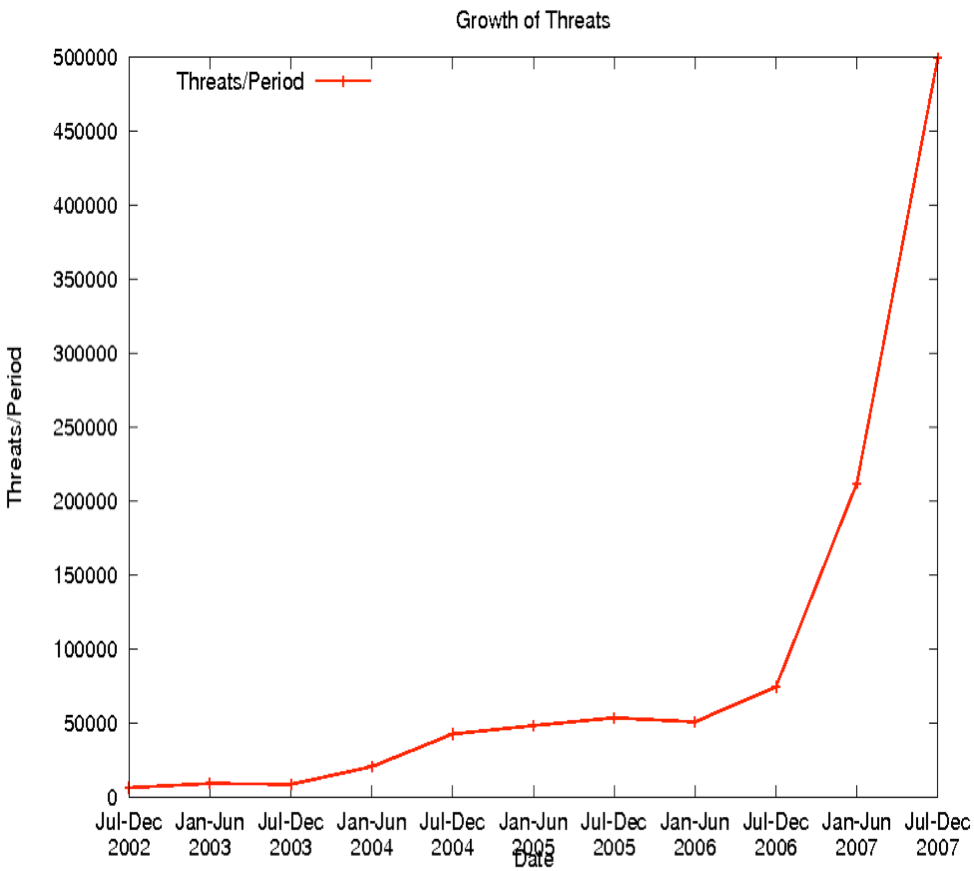
- Malware churn
  - Very short shelf life
  - Techniques: evasive packing; polymorphic malware; generative programming
  - Noted example: Storm botnet, June 2006 (new sample pushed on hourly-basis)

- A botnet is not merely a single binary. It is the overlay network of malicious infrastructure and supporting malware samples.

Malware Sample Growth

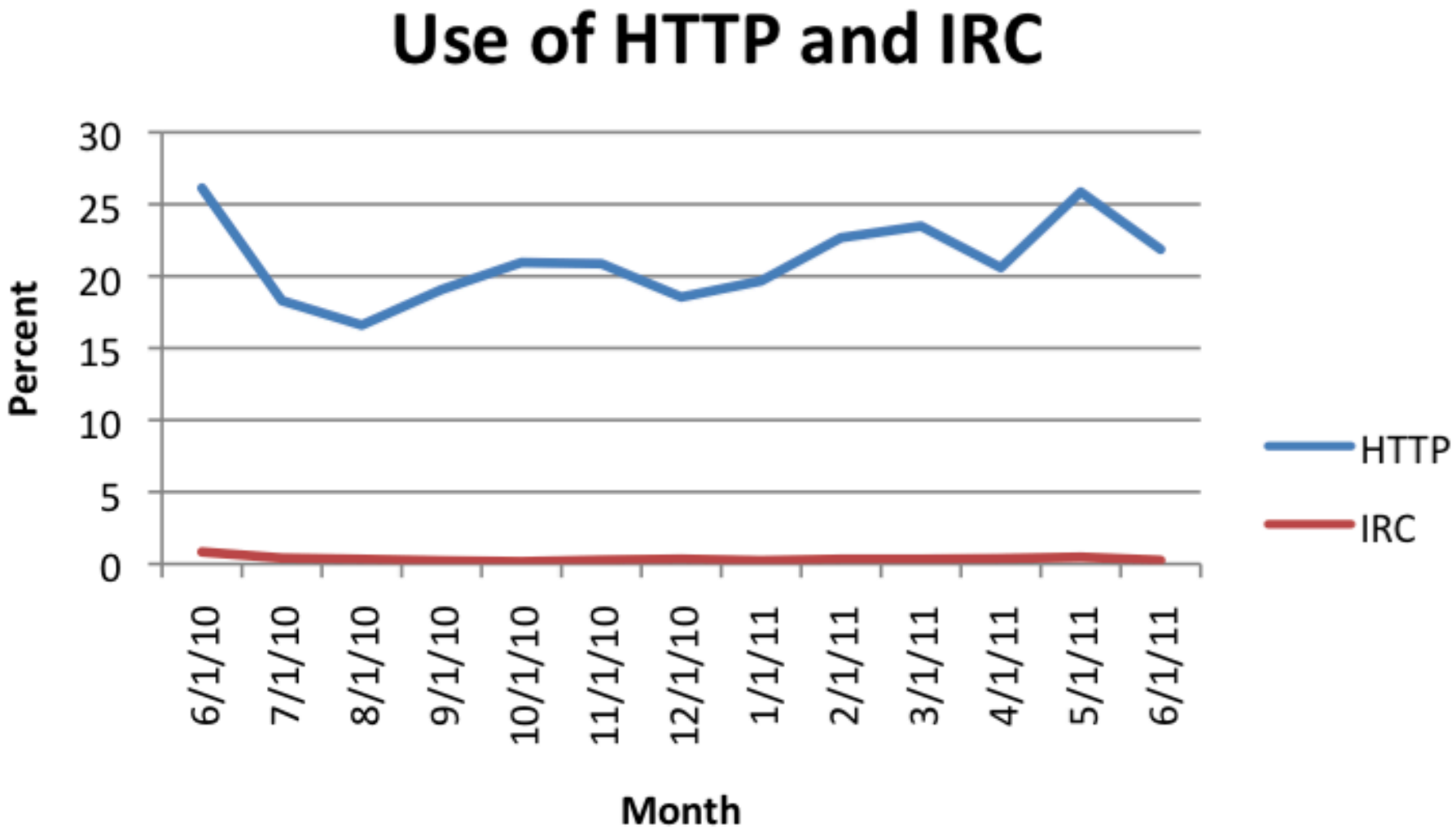


Malware Sample Growth



- Salient points:
  - Exponential growth
  - Within our team, about 50 million samples
  - The challenge is to analyze the clusters and collections of samples, not merely discrete samples.

Protocols Used in Malware



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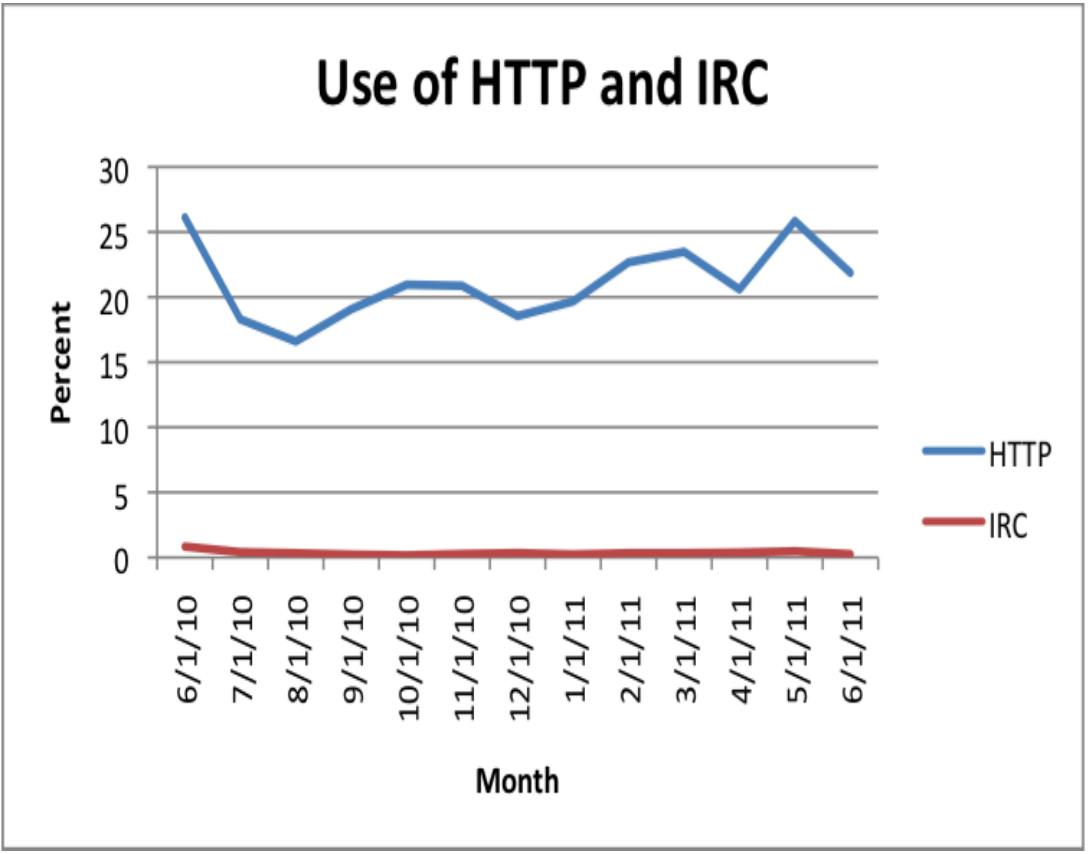
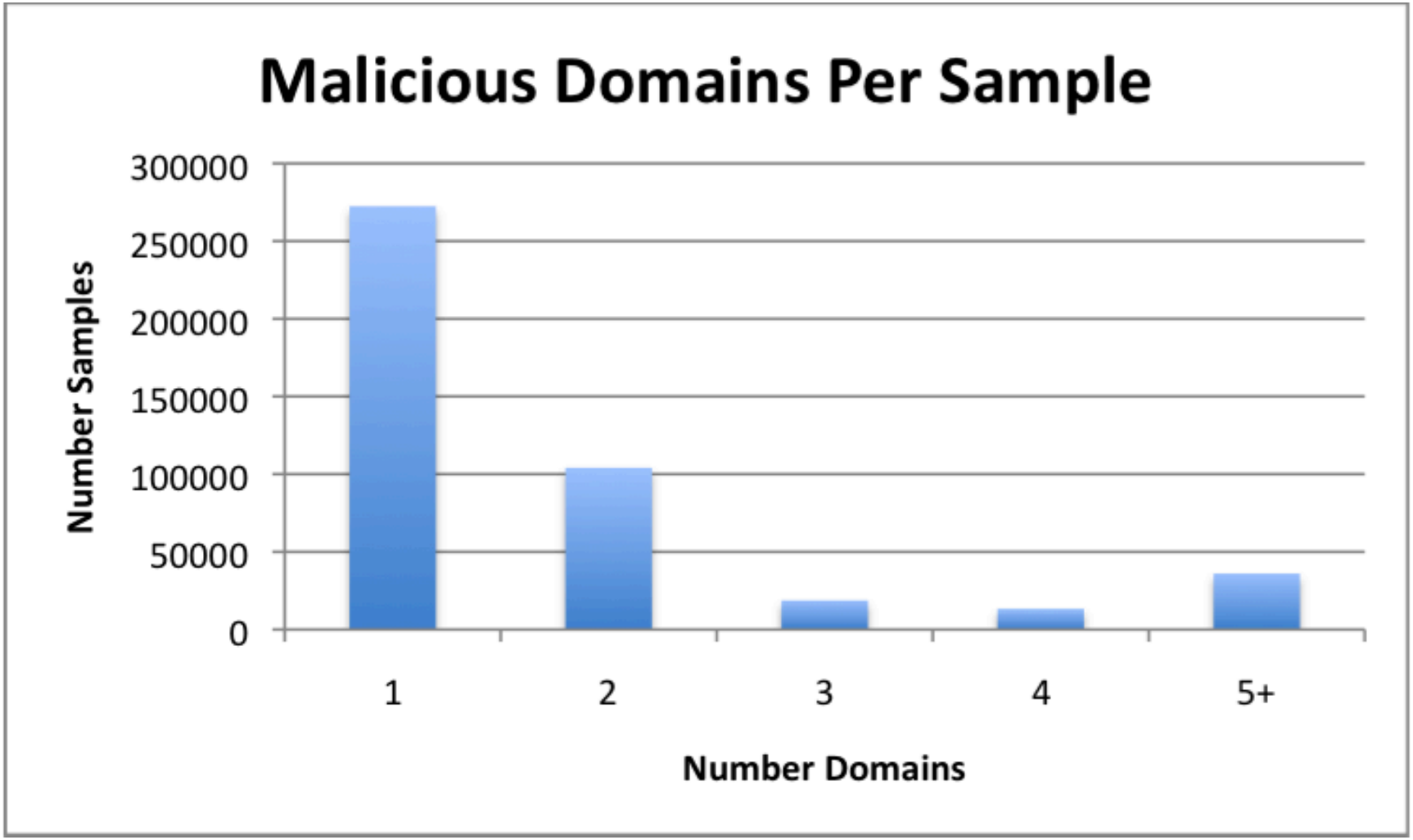


- Salient points:
  - Trend towards http, use of proxies, and overlay networks
    - Port 80 provides a large haystack in which to hide, frustrating DPI.

DNS Agility in Malware



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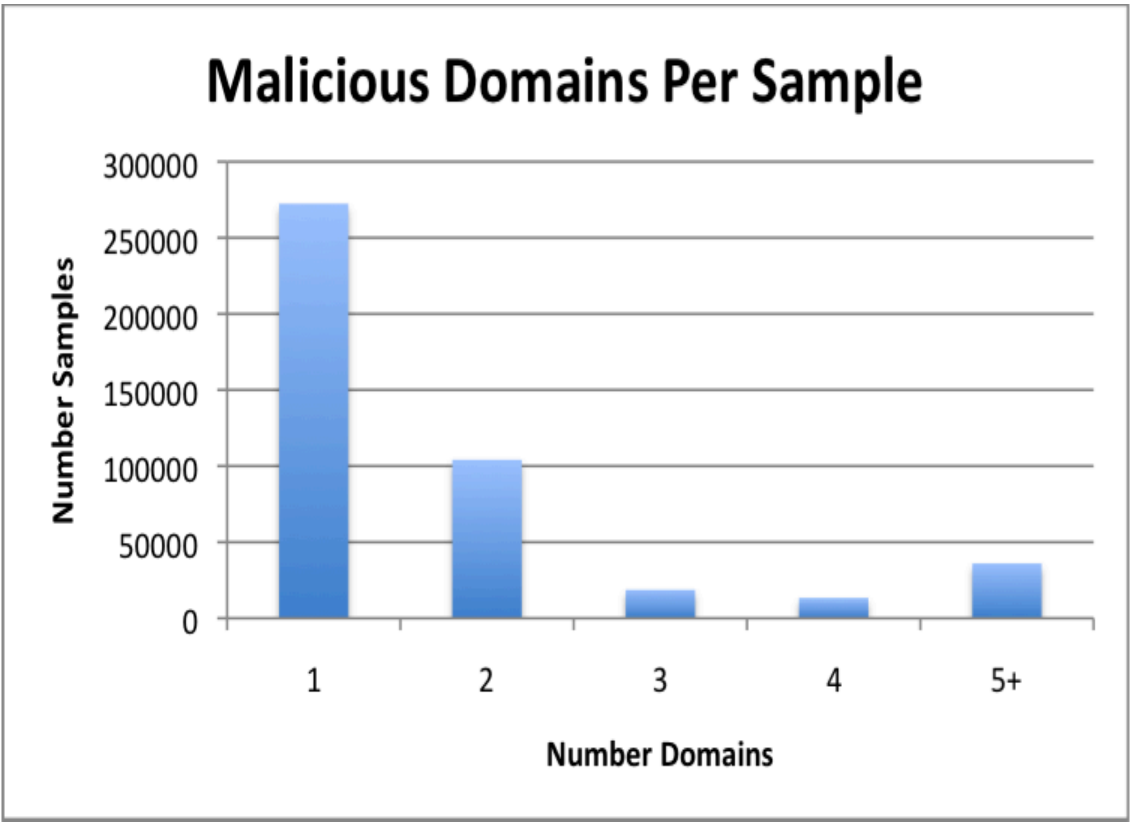


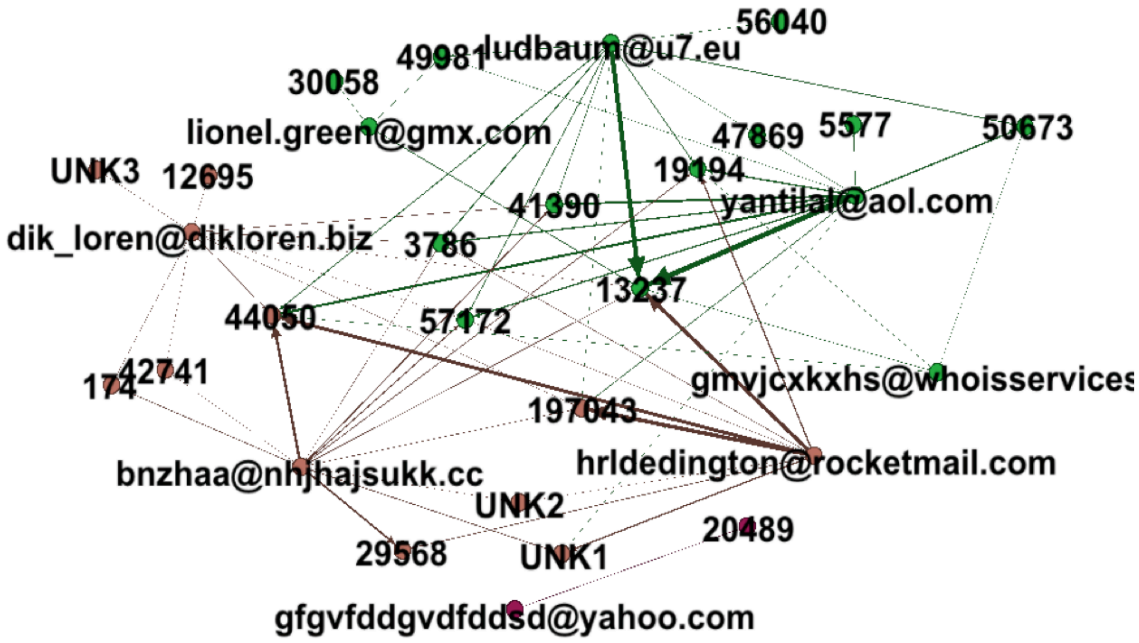
Salient points:

- Many associate with one domain
  - But this is an artifact of malware churn – a botnet may use hundreds of malware samples
  - Our challenge is to identify collections and cluster related samples.

Example: TDSS

- Example Botnet: TDSS
  - Millions of victims
  - Components: rootkit; p2p; DGA; secondary drops reside in RAM-only
  - Created by affiliate program ($20 to $200 for every 1,000 installations)
  - Called “indestructible” by AV researchers

Example: TDSS



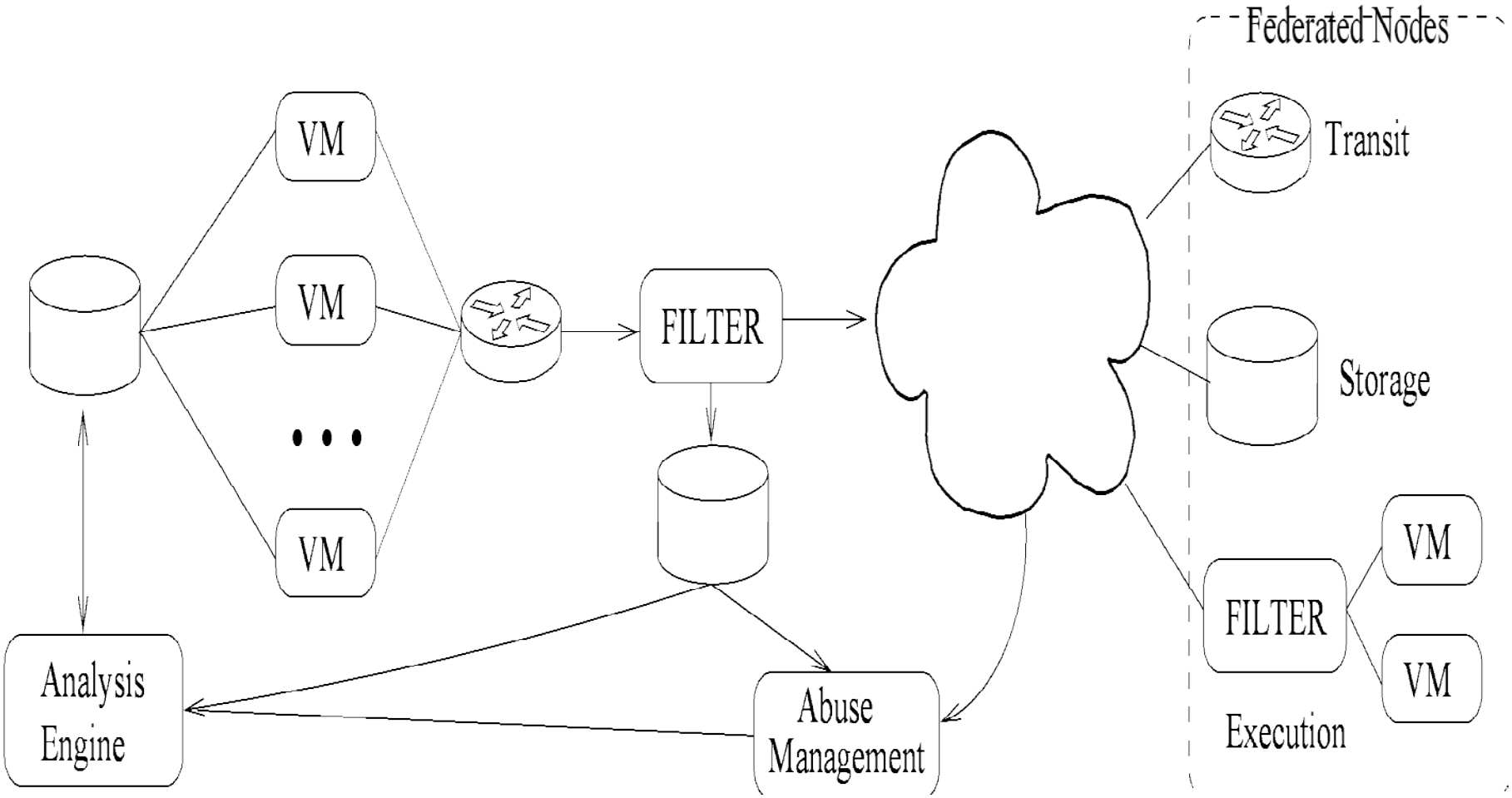
Salient points:

- A cloud of DNS services and related malware
  - Hundreds of colos; thousands of domains
- Incorporate other “botnets”, e.g., fake AV and clickfraud malware campaigns
  - We must describe the network platform of related binaries and network resources, not just a slice of the botnet

Federated Malware Analysis System

- Will use GT's MNIF (Malware Network Intelligence Gathering and Analysis Framework)
  - DURIP funded 2011
  - Designed to share intelligence with DETER
- Participants bring one or more of:
  - Localized storage: I can't run malware, but I can store analysis
  - VM Execution: I can execute/analyze malware, but lack storage/IPs
  - Transit/Filter/Egress: I only have IP addresses to offer; assuming there are sane policy controls on exit traffic

FMAS Overview



FMAS Design Criteria

- Process 100K+ samples/day, via distributed analysis system
- Three classes of messaging between federated hosts
  - Management Messages: start/stop VMs, forcing firewall rule updates, add/remove nodes, etc
  - Partial-Evidence Messages: Informational broadcasts representing partial learning from remote nodes. E.g., feature and vector observations, to be used in machine learning. Likely, only analysis nodes subscribe
  - Conclusive Findings Messages: Announcing facts about samples (availability, AV scans, DNS analysis, clustering output, etc.)

FMAS Policy Layer

- Most industrial malware analysis runs samples in honeypots
- Existential risks
  - Possible harm to 3rd parties
  - Provides robust messaging/support for botnet (e.g. 3322.org takeover omitted 60-misc malicious domains, which then resolved via MS-operated DNS servers.)
  - Taints data/analysis (e.g., if PII is obtained from analysis and shared in network)
- Global Cyber Risk (GCR) will perform extensive policy analysis

GCR Analysis

- Legal, policy and ethical analysis of proposed framework, noting data sources, handling, and FMAS interactions with other individuals and networks.
- Operator Agreements
  - Draft MOUs for participants in FMAS
  - Tailored to role (storage, execution, transit)
  - Legal policies for malware analysis
  - Policy analysis of passive DNS collection

DNS Analysis

- Construction of Passive DNS mirror
  - Existing DNSDB mirror proving too critical to security companies, LEO, and analysts; research-oriented mirror required
  - Includes vetting of operator agreements, data collection, identification of policy issues in above-the-recursive data collection, etc.

“Reputation” Analysis

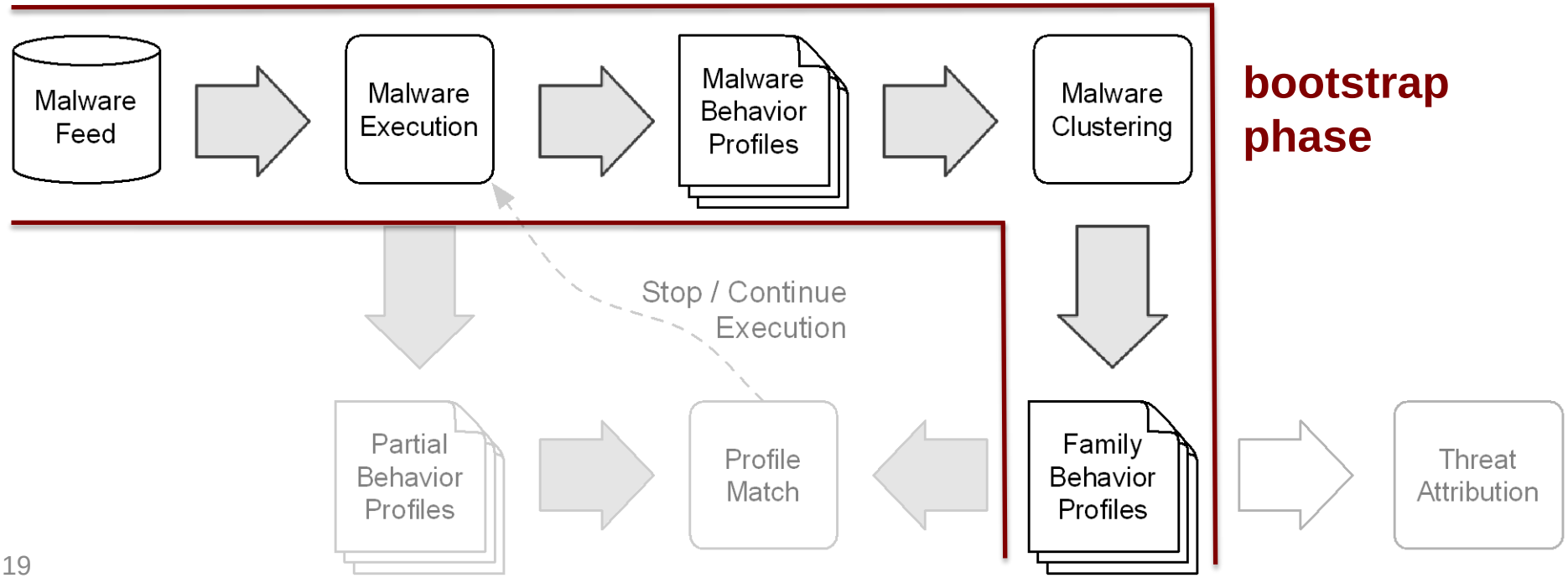
- Identify key properties of NS-reputation
  - Goals
    - Leverage large-scale domain intelligence (prefix whois, bulk whois for gTLDs and ccTLDs)
    - Create indexed datasets for high-speed and mobile access

Clustering Analysis

- Identify semantic equivalence between malware samples using system- and network-level analysis.
- Goals
  - Identify optimal flexible execution schedule, to speculatively halt analysis of similar/redundant samples
  - Selectively group samples using static/low-cost attributes to execute only a few group representatives, without loss of C&C information
  - Identification of key domain, static, and URL-based features
  - To be exported as a “malware channel” of broadcast information

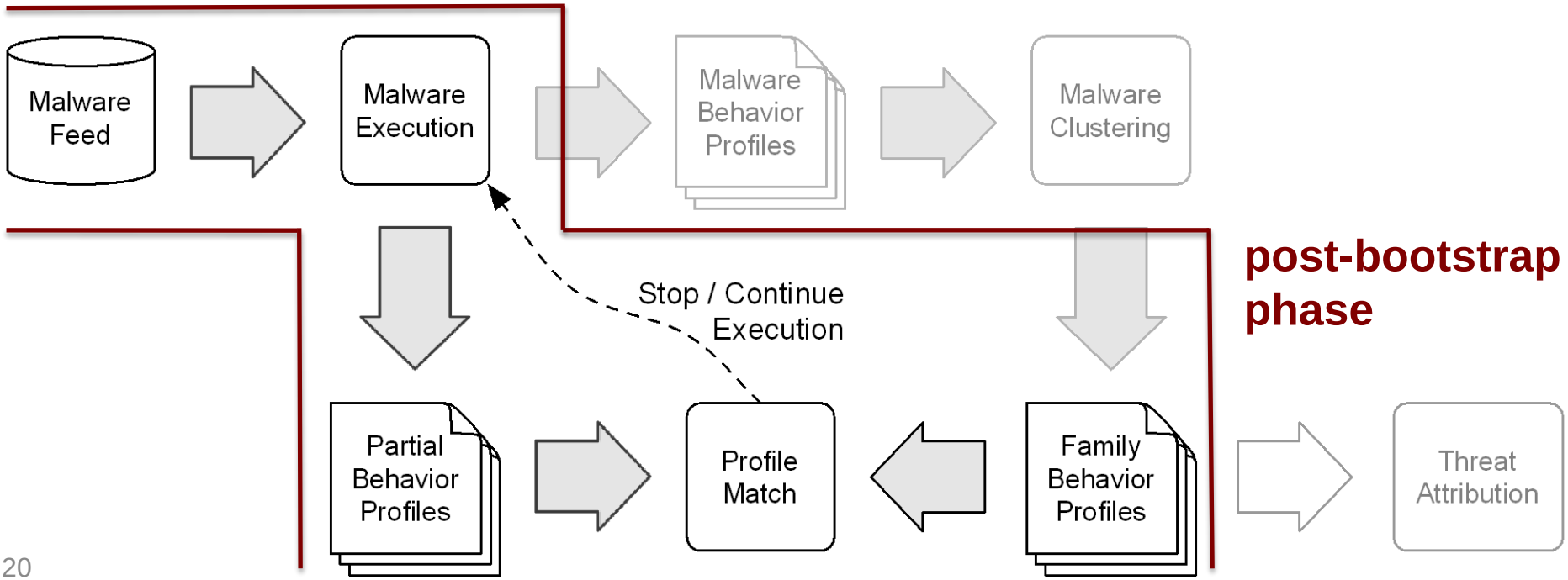
Scaling Malware Execution

- Analyze “bootstrap” malware dataset
  - Run each sample for a relatively long time (e.g., few hours)
  - Group samples that behave similarly into *malware families* (clustering)
  - Extract *family behavior profiles* for each malware family



When Should We Stop?

- Running new samples (post-bootstrap phase)
  - Frequently vet network/system behavior against family behavior profiles
  - If a profile matches a known family:
    - do malware in the family exhibit new behaviors if run for longer?
  - Stop/continue execution accordingly



Feature Extraction and Similarity Metrics

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- Extract features from network behavior profiles
  - Domain-related features
    - Set of domain names queried
    - Name, location and reputation of authoritative name servers
  - IP-related features
    - Set of contacted IPs
    - Location and reputation of BGP prefixes and AS
  - Features for HTTP-base malware
    - URL structure
      - path similarity, variable names, etc.
    - Other HTTP request header characteristics
      - E.g., anomalies in header compositions, compared to normal browser-generated headers

FMAS Status

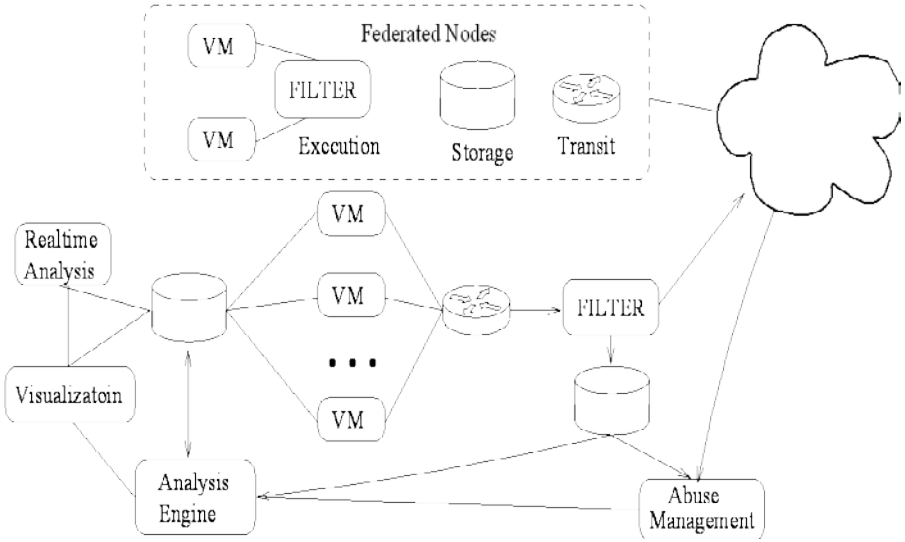
- Identified sources for malware at about 100,000 samples/day
  - No financial arrangement for samples
- Started work on NS reputation (esp. mobile analysis framework)
  - Android: Search for “Early2Rise” https://play.google.com/store/apps/details\?id=com.dissectcyber.early2rise
  - Apple iOS: Pending Apple review; request early access via https://testflightapp.com/register/

Technology Transition

- Several team members are directly involved in network operations and policy work
  - Malware samples, spam, DNS, and other real-world data
  - Directly adopt technologies developed and publish/broadcast data (e.g., SIE at ISC) and guidelines

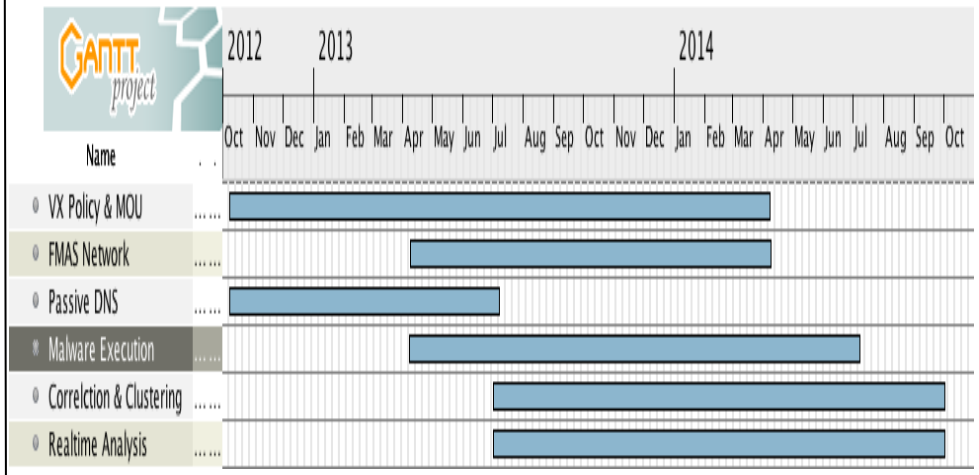
- Damballa a Georgia Tech spin-off, on-going collaboration, established tech transfer relationship
- When appropriate: malware samples to PREDICT, and malware analysis system part of DETER

Quad Chart



- Legal and policy framework for malware exchange
- Large-scale federated malware exchange and execution system
- Policy and technical framework for passive DNS collection
- Next-gen malware and domain correlation algorithms
- Real-time threat data

- **Federated Malware Analysis System:** Large-scale malware execution; scalability and quantitative transparency assessment; innovative egress filtering; next-gen baremetal framework
- **Malware Repository:** Vetted mirroring of binary and metadata with transparent, in-depth policies
- **Malware Clustering:** Based on host- and network- based properties
- **Real-time Data Analysis:** Visualization and query of synthesis of data



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Thank You!