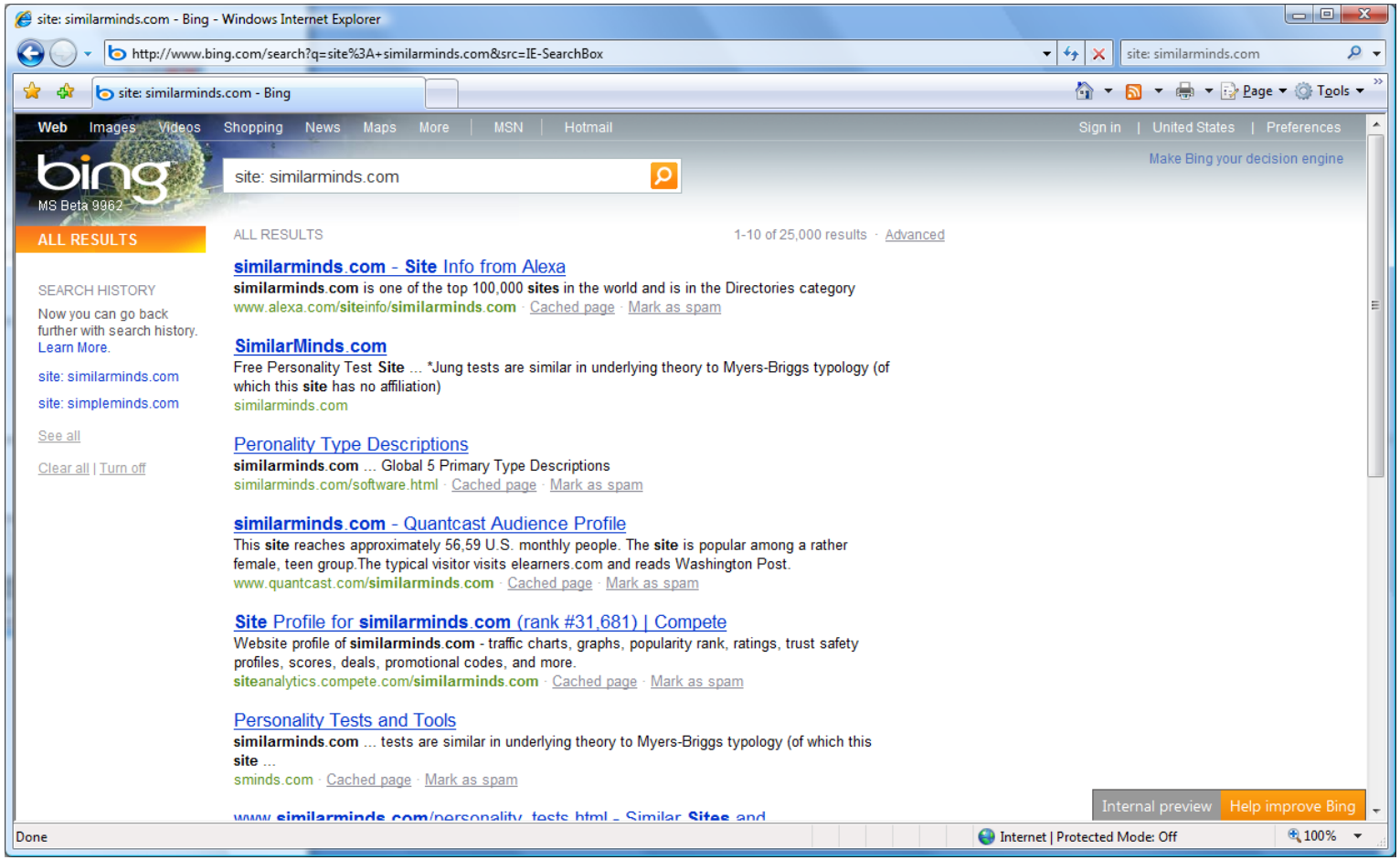
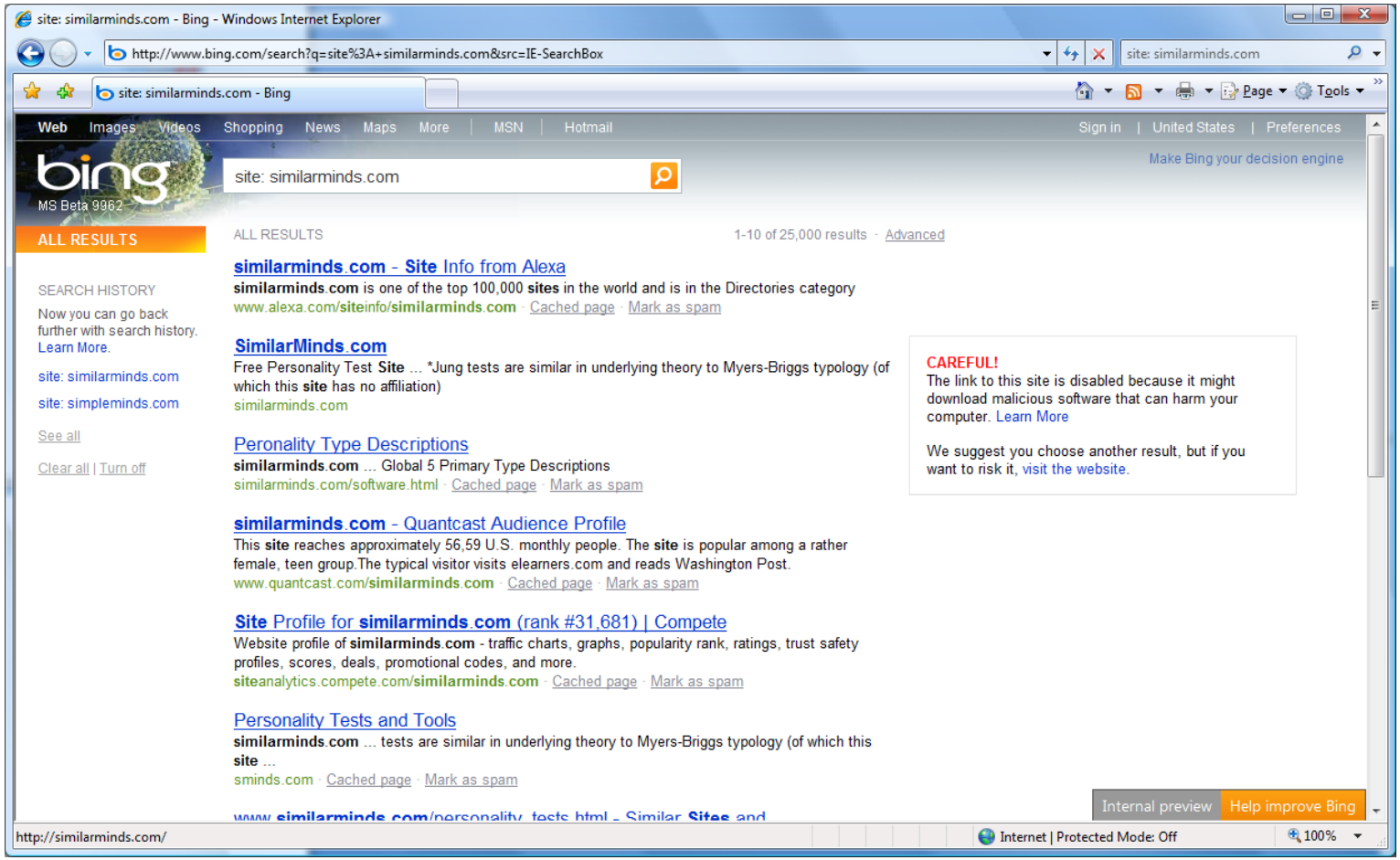
WEBCOP: LOCATING NEIGHBORHOODS OF MALWARE ON THE WEB

- Jay Stokes
  Microsoft Research
- Reid Andersen
- Christian Seifert
- Kumar Chellapilla
  Microsoft Search

Detecting Malicious Web Pages

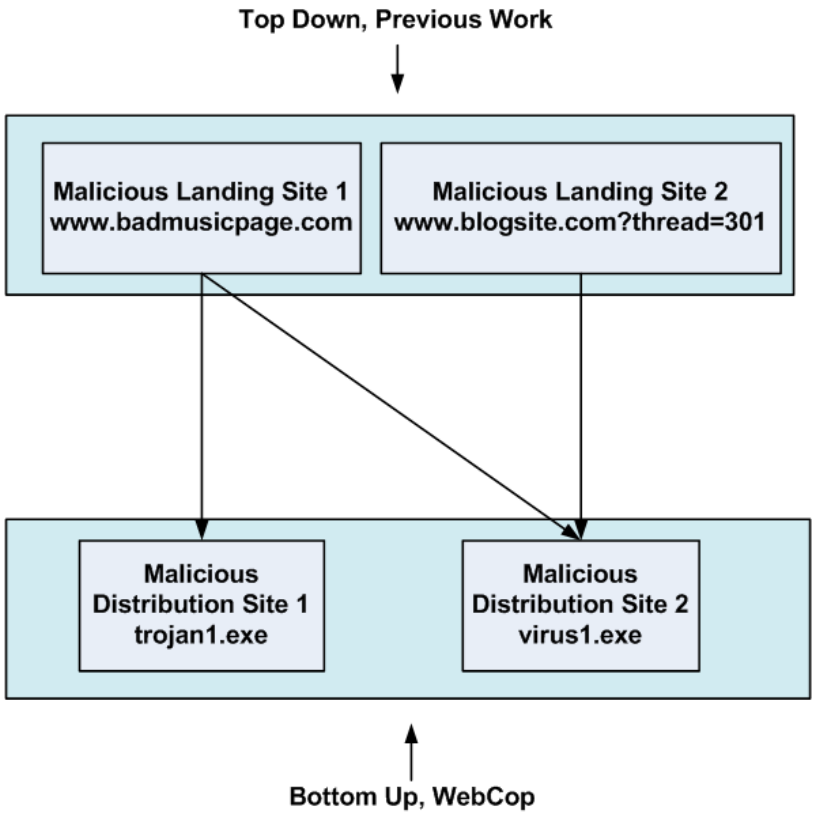


Detecting Malicious Web Pages



Production System

- Drive-By Download
  - Malware is automatically downloaded
  - No user interaction
  - Strider HoneyMonkey (Wang 2006)
- Top-Down Approach
- Obfuscated JavaScript redirections
- Other notable work (Moshchuk 2006, Provos 2007, 2008)

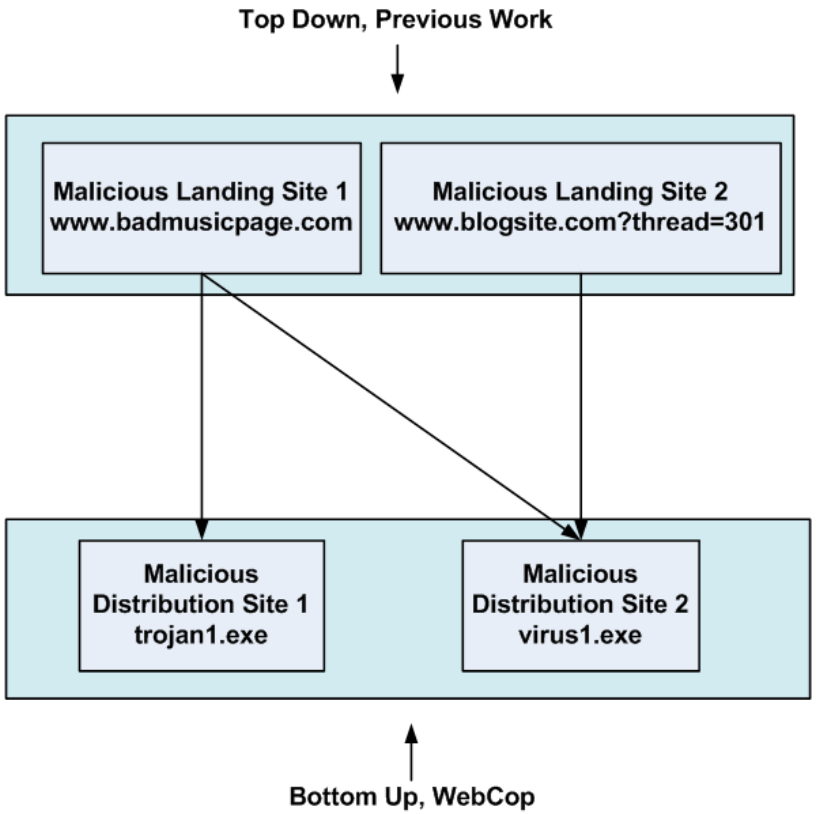


Drive-by Detection Limitations

- Difficult to identify suspicious pages to scan
- Production system looks for changes after running malware in a virtual machine
  - Attackers adapt and learn to avoid detection
  - Malware will often detect it is running in a VM
  - Halt execution
- Centrally Located Service

Top-Down with Crawler

- Moshchuk 2006, Stamminger 2009
- Crawl the web
- Direct Links
- Download and test executables
- AM Scan

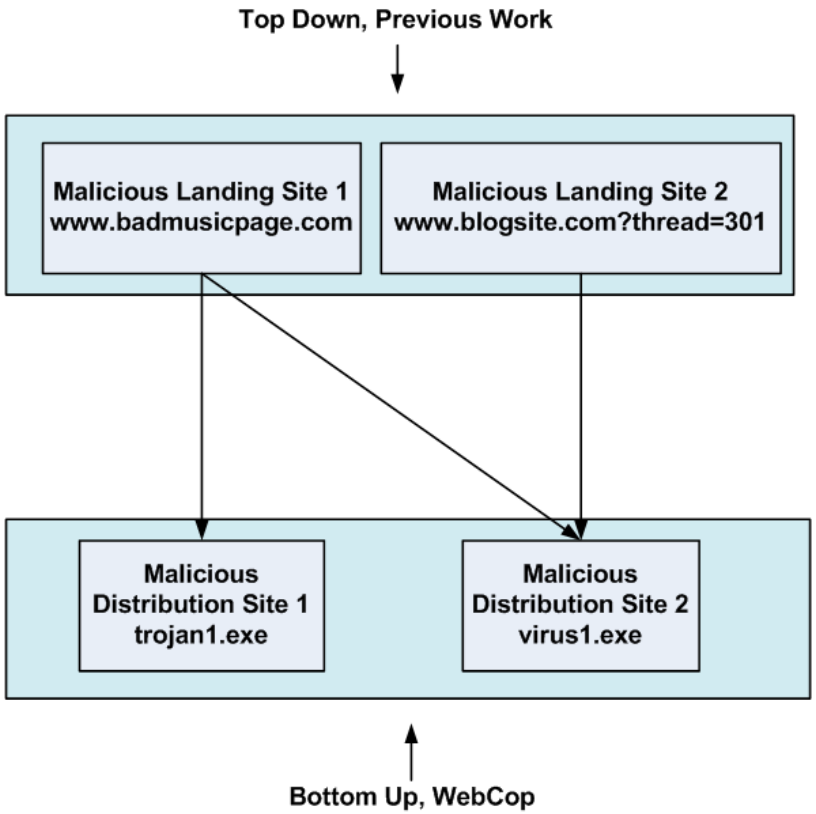


Top-Down Crawling Limitations

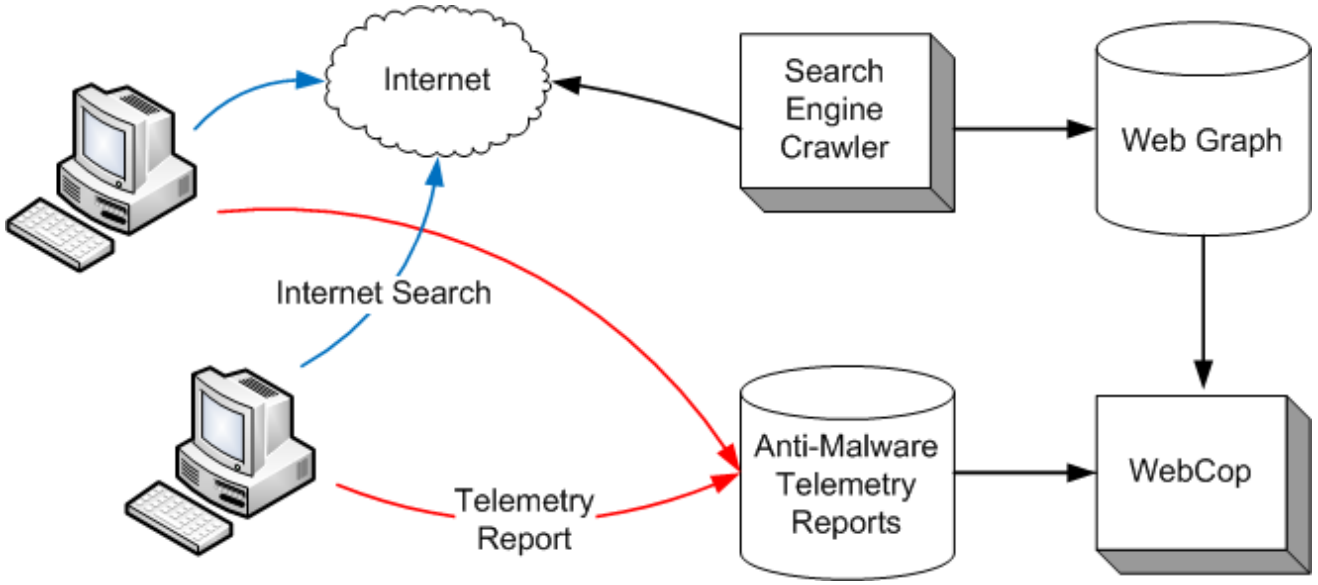
- Downloading all executables from the internet is problematic
- Need to simulate user input
  - Installation, web surfing
- Scanning with an AM engine
  - May require full system scan (Stamminger 2009)
- To avoid reimaging, test in a VM
  - Again, malware can detect VM and hide
- Centrally located service

WebCop Solution

- Bottom-Up Approach
- Anti-Malware reports indicate malware distribution pages
- Crawler discovers all web pages linking to the malware
- Direct Links
- Additional Goal:
  - Identify neighborhoods of malware on the web



WebCop System



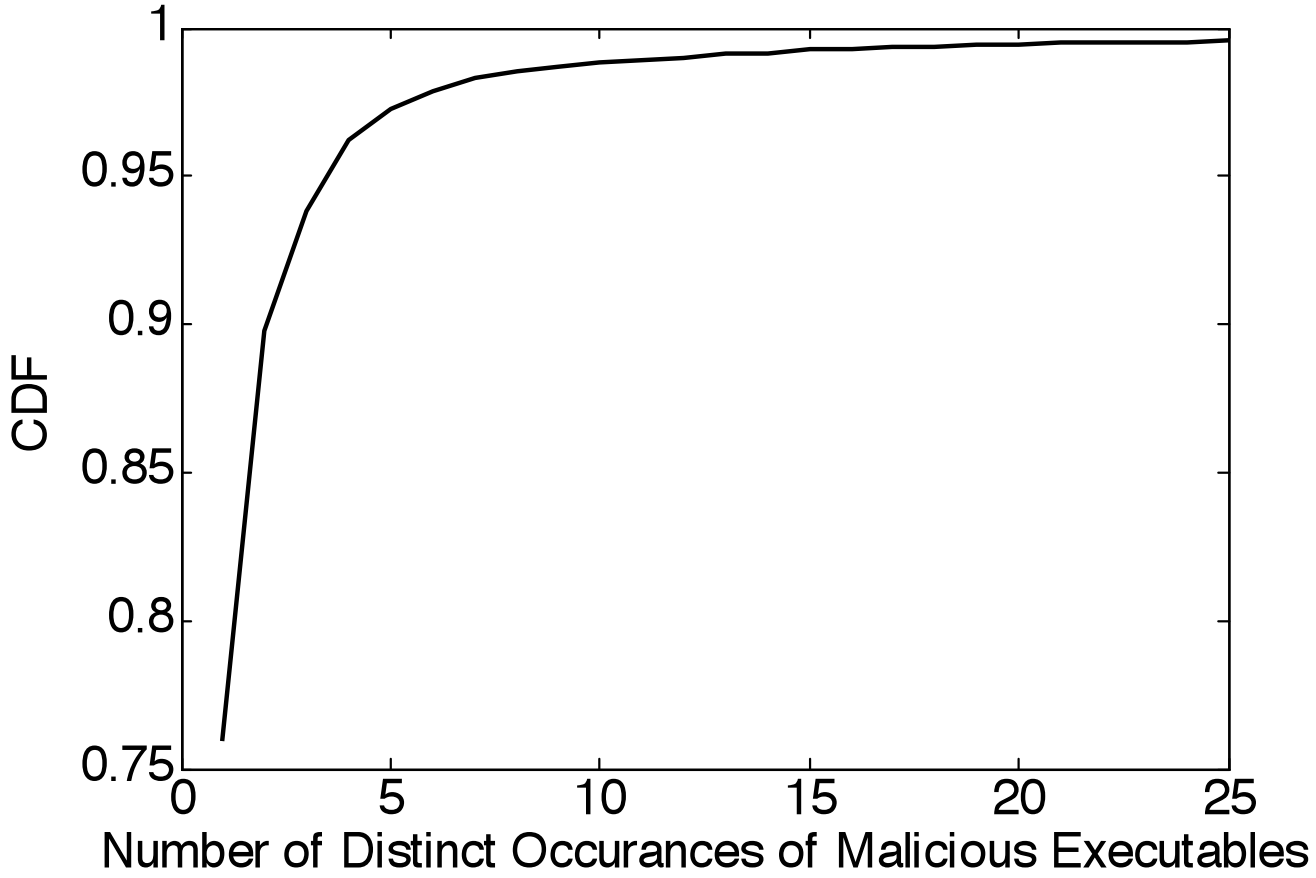
WebCop Advantages

- WebCop only deals with hard classifications
- Distributed worldwide sensor network
  - Millions of clients
- Targeted detection
- AM service detects malware running on native OS
  - Not in a VM
  - Malware will not try to hide
- Users input all UI interactions

Telemetry Reports

- Automatically submitted to backend
  - File is downloaded from internet
  - Malware detection
  - Unknown file was not signed by a trusted entity
- Reports include
  - Distribution page URL
  - File Hash
- Most recent 1 million distinct labeled URLs through end of May 2009
  - 837,882 Malware URLs
  - 162,118 Benign URLs
- Telemetry reports from a URL are usually only seen during a one month period
  - Only 8.7% overlap of malicious distribution URLs between April and May, 2009

Occurrences of Executables

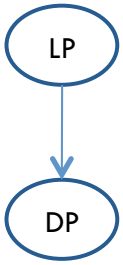


Link Analysis

- Web graph from June 1, 2009
- Intersecting distribution pages
  - Occurs in both AM reports and web graph

Measure	Count
Number of intersecting malware distribution pages	10,853
Number of malware landing pages	391,893

Median Malware Topologies



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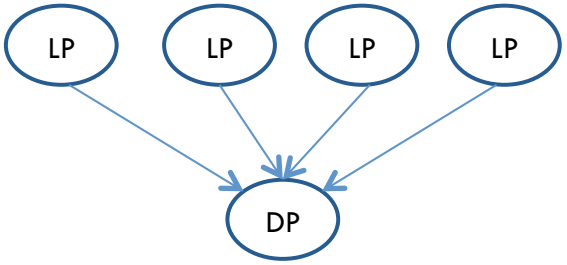
Single Edge



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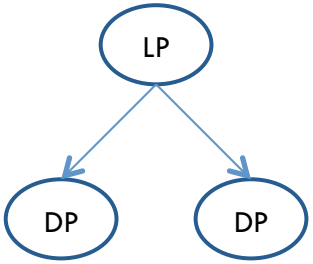
Fan-In



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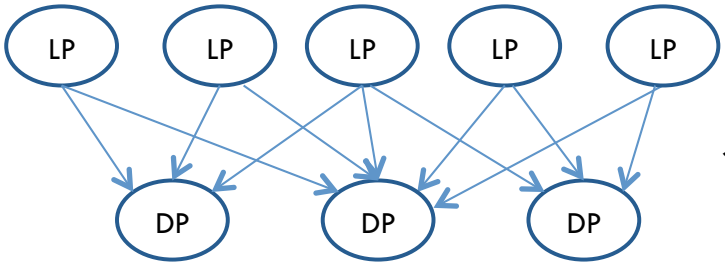
Fan-Out



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Complex

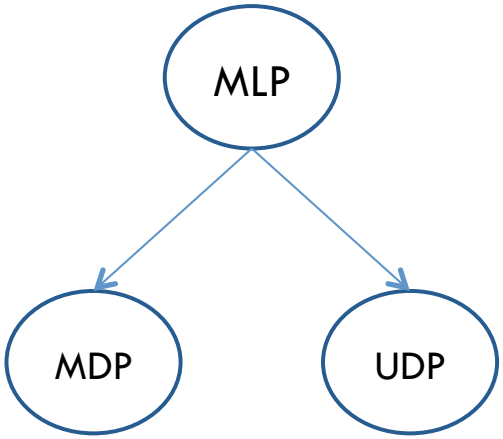
Malware Subgraph Statistics

Measure	Topology	Median	Average
Number Landing Pages	Fan-In	4	31.3
	Complex	5	33.7
Number Distribution Pages	Fan-Out	2	3.5
	Complex	3	4.9
Number Edges	Fan-In	4	31.3
	Fan-Out	2	2.9
	Complex	11	72.2

Comparison with Production System

- Drive-by detections from April 6 – June 1, 2009
- Little overlap
  - 2 matching distribution pages
  - 0 matching landing pages
- Complementary to current production system
- Lists can be combined

Locating Potential New Malware



Unknown Executable Two-Hops Away from Malware

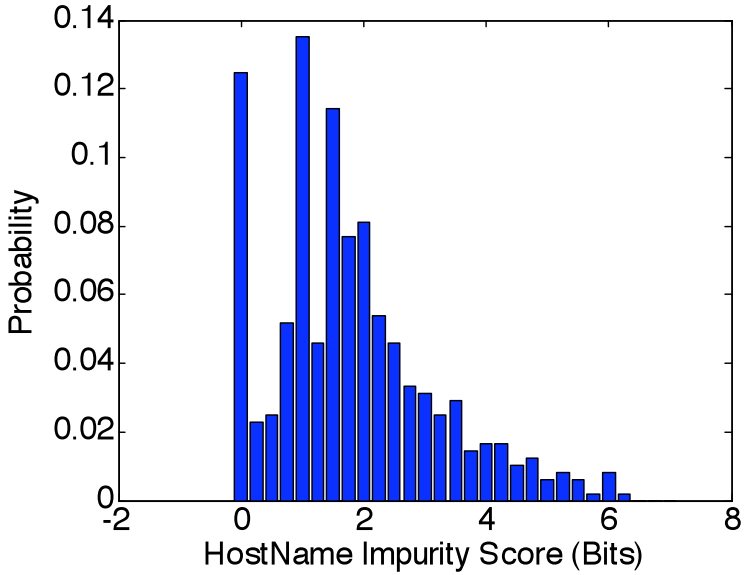
- Neighborhood graph
  - Unknown distribution pages (UDP)
- Identified 346,084 unknown distribution pages
- 32 suspicious pages for each labeled malware pages
- Suspicious Executables
  - Download and scan
  - More sophisticated automated analysis
  - Rank for analysts

HostName Impurity

- How often do landing and distribution pages share same hostname?
- HostName impurity score

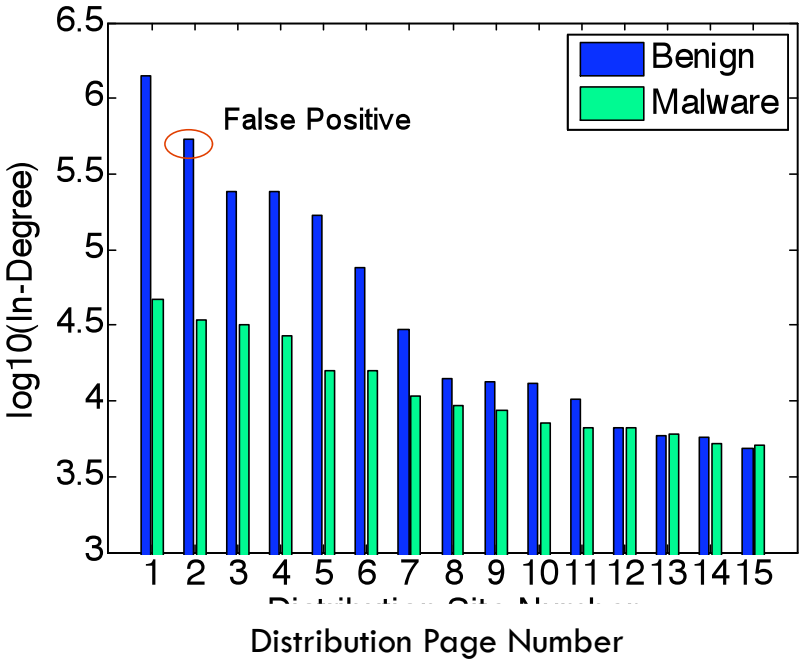
$$hi(n) = -\sum_{j} P(\omega_j) \log_2 P(\omega_j)$$

- w_i - fraction of nodes sharing same hostname
- Low score, most nodes in neighborhood share same hostname



Discover AM False Positives

- Use graph topology
- In-Degree
  - Total number of edges where node is the head
- Malware distribution page with 540K links



Will WebCop Work in Production?

Telemetry Reports	Malicious Intersecting Distribution Pages	Malicious Landing Pages
May 2009 Only	2,763	158,333
March – May, 2009	4,633	212,688
Most Recent One Million Reports	10,853	391,893

- Queues of distribution pages (e.g. 2 or 3 months)
- Telemetry reports only seen for a short time
- Find large number of new landing pages each month

Conclusions

- WebCop provides
  - Targeted, bottom-up approach for detecting malware landing pages on the internet
  - Large scale evaluation of malicious internet neighborhoods composed of direct links
  - New way to detect false positives in an AM service using the internet web graph
  - New method to discover potential malware

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Microsoft Security Essentials

- Privacy Statement
  - "…, by accepting this privacy statement, you agree to send reports to Microsoft"
  - "… reports include information about … cryptographic hash, …"
  - "… might collect full URLs …"