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Microsoft Research

Finding the Linchpins of the Dark Web: A Study on Topologically Dedicated Hosts on Malicious Web Infrastructures

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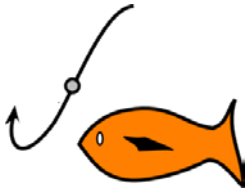
The Dangerous Web

What bothers you?



Phishing

Scam

Theft

Drive-by Download

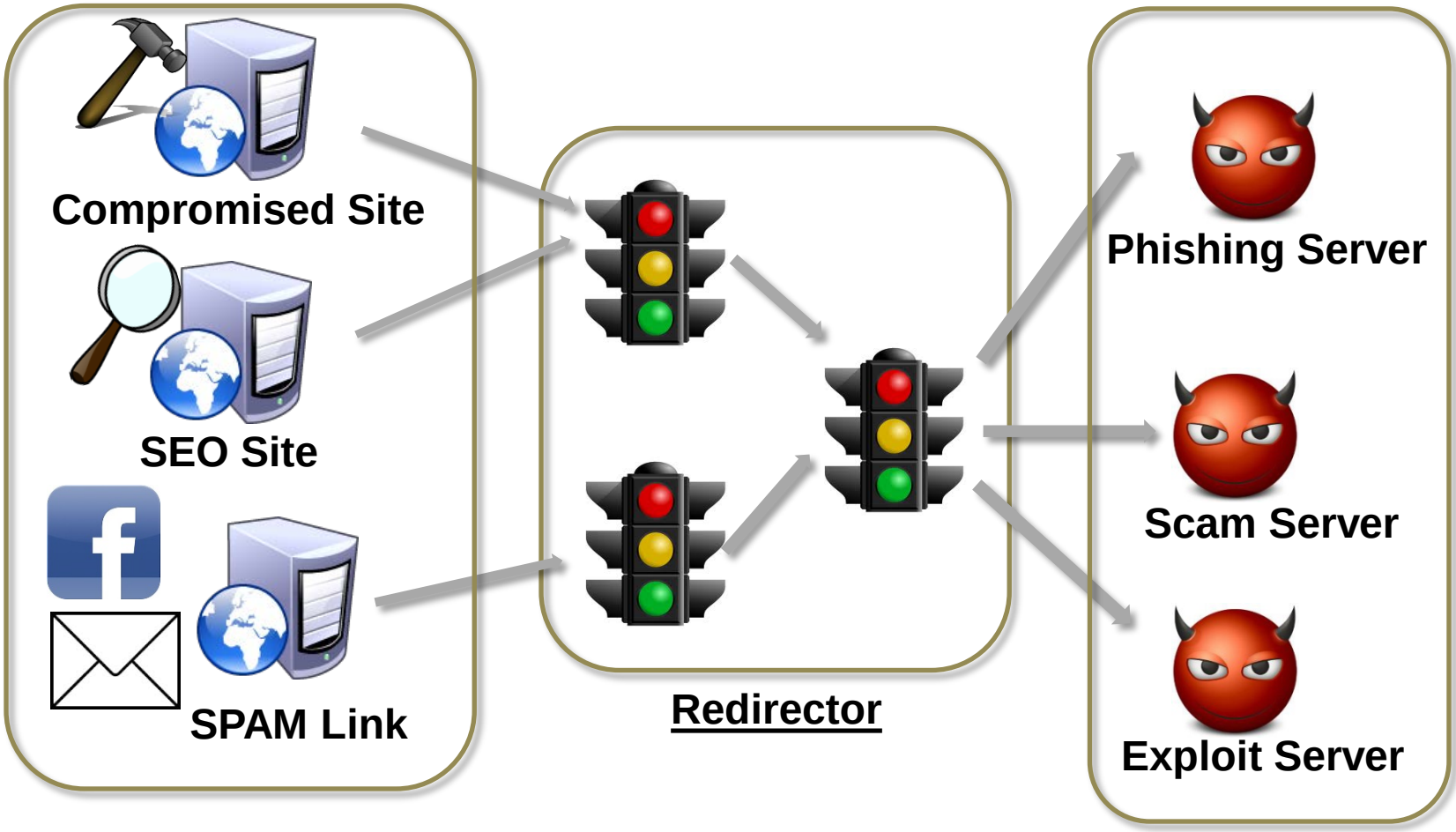
Bot

Who is behind?

Individual Hacker

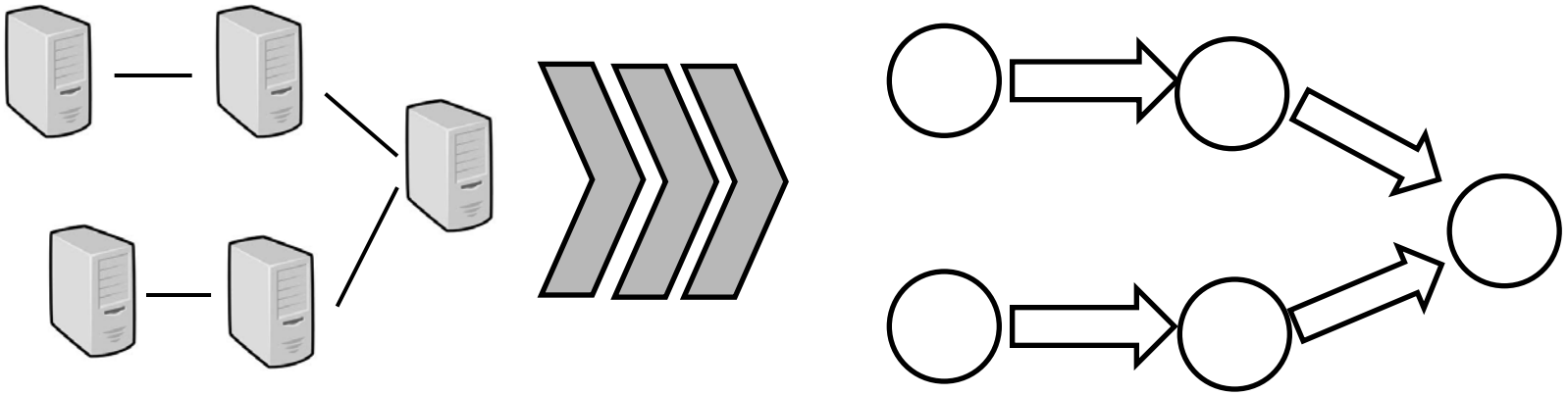
Criminal Organization

Malicious Web Infrastructure



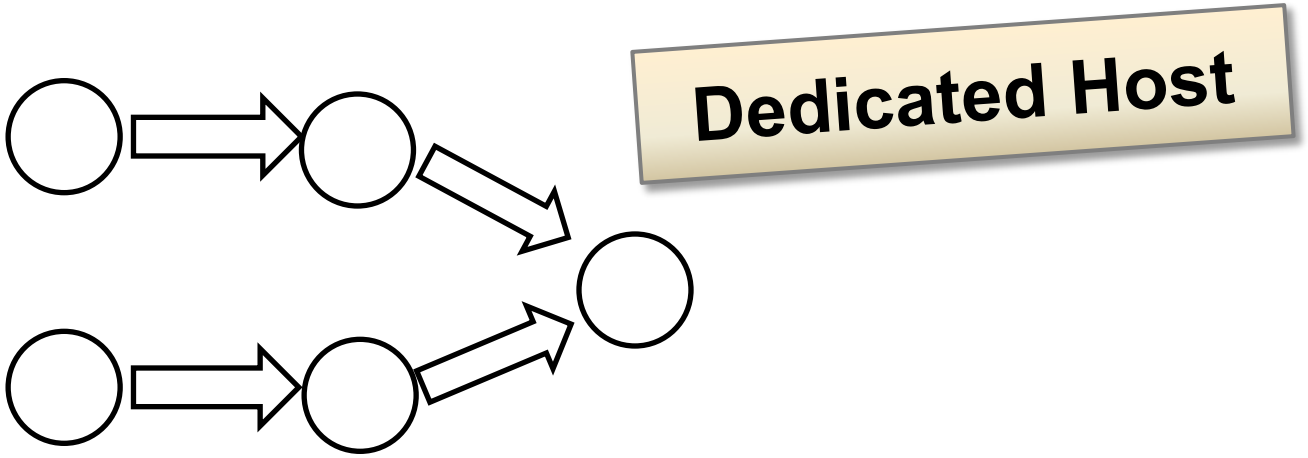
Our Work - I

- What is the topological view of malicious Web infrastructure?
  - ✓ Build redirection graph



Our Work - II

- What are the linchpins?
  - ✓ Topologically Dedicated Malicious Hosts: All redirection paths are malicious
  - ✓ Stay in “dark” side, far from “bright” side



Our Work - III

- How can we find the linchpins?
  - ✓ Topologically detector
  - ✓ Not relying on semantics of attacks
- Study of Traffic Direction System (TDS)
  - ✓ Landscape, Lifetime, Parking

Outline

- ❑ Build graph 
- ❑ Find the linchpins
- ❑ Study Traffic Direction System (TDS)

Data Collection

- Dynamic Crawler
  - ✓ Firefox extension
  - ✓ Redirection: JavaSc… …n, …

Client-side redirection

```
<script>
var a = "<iframe src =...>";
document.write(a);
</script>
```

- Data Source

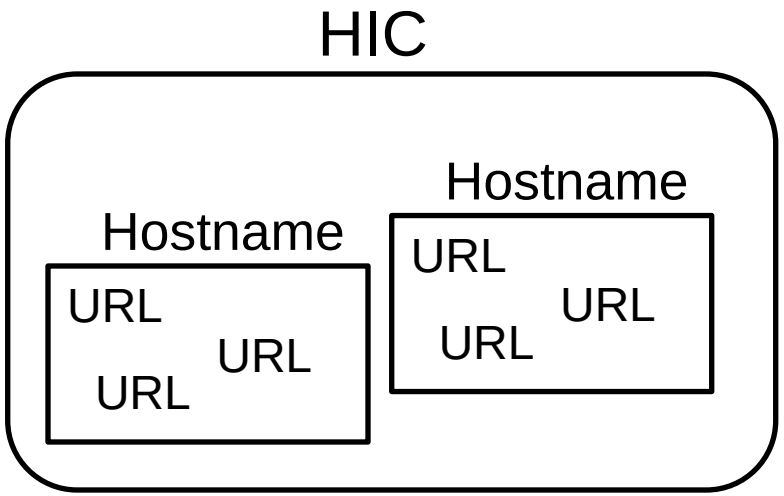
Feed	Type	Start	End	# Doorway URLs
Microsoft	Malicious	3/2012	8/2012	1,558,690
WarningBird[1]	Malicious	3/2012	5/2012	358,232
Twitter Search	Mostly good	3/2012	8/2012	1,613,924
Alexa	Mostly good	2/2012	8/2012	2,040,720

[1] WarningBird: Detecting Suspicious URLs in Twitter Stream, Lee et.al, NDSS'12

Building Redirection Graph

- Data Labeling
  - ✓ Malicious (Forefront)
  - ✓ Legitimate (Whitelist)
  - ✓ Unknown

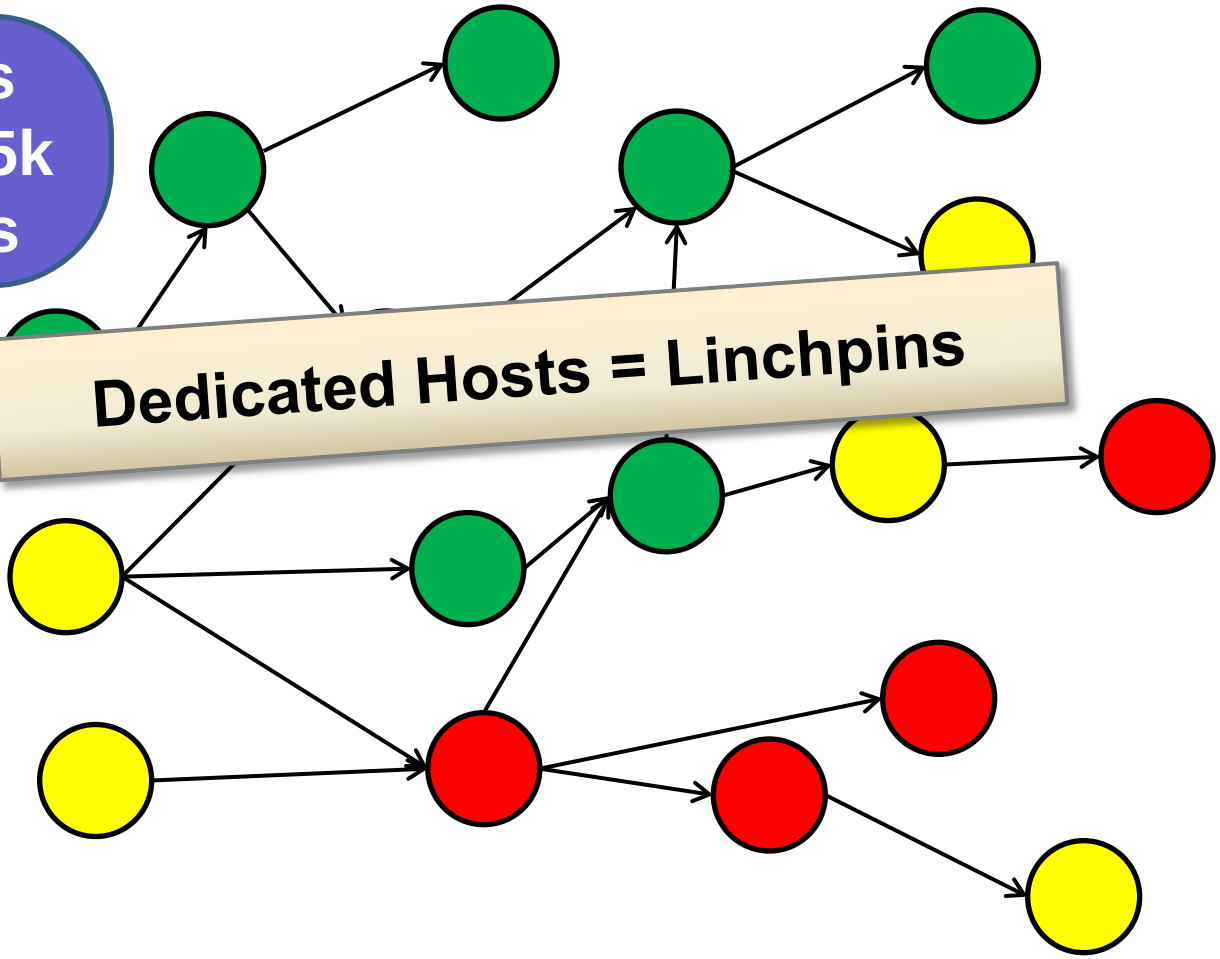
2M Nodes, 9M Edges



- Node Constructing
  - ✓ Node: Hostname-IP Cluster (HIC)
- Edge Constructing
  - ✓ Link 2 nodes if there is an URL redirection

Building Redirection Graph (Cond.)

>70% malicious paths through 15k dedicated hosts



Legitimate
(Totally good)

Dedicated
Malicious
(Totally bad)

Non-dedicated
Malicious
(Mixed)

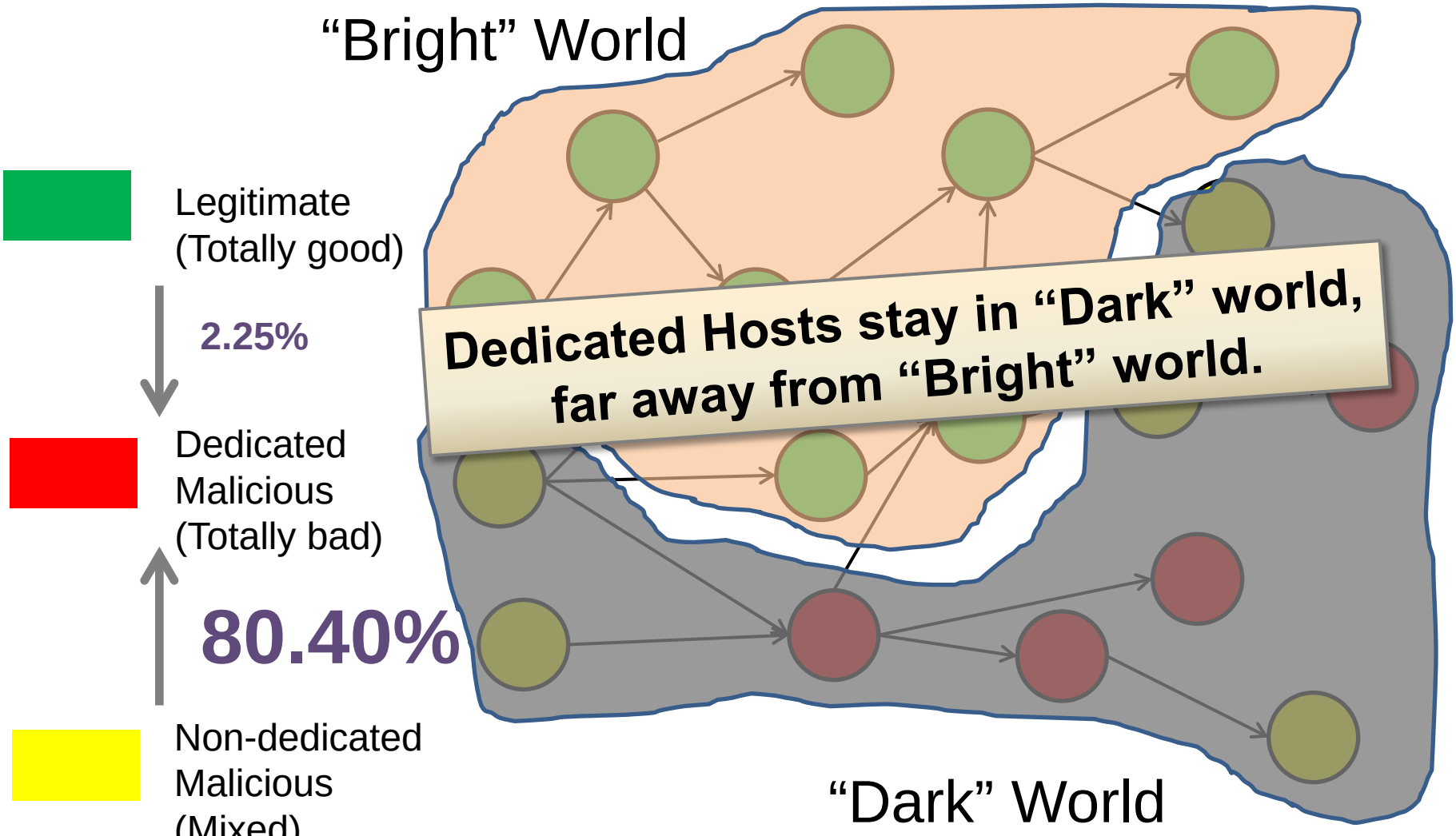
Outline

- ❑ Build graph
- ❑ Find the linchpins 
- ❑ Study Traffic Direction System (TDS)

Finding the Linchpins is Challenging

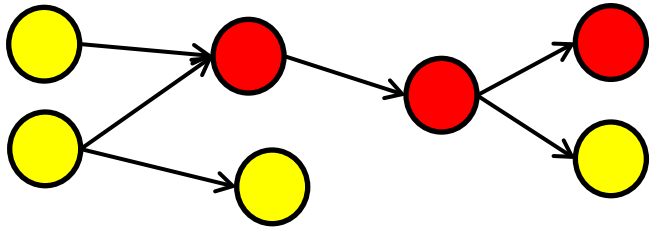
- Serve for different attacks and different sources
- Hide by cloaking
- Mixed with legitimate nodes

Properties of Dedicated Hosts



Topological Detector

- Can we leverage this topological feature? **YES!**
  - ✓ Use known bad and good as seed
  - ✓ Detect dedicated hosts
  - ✓ Expand the result using topology
- Work on different attacks and different sources

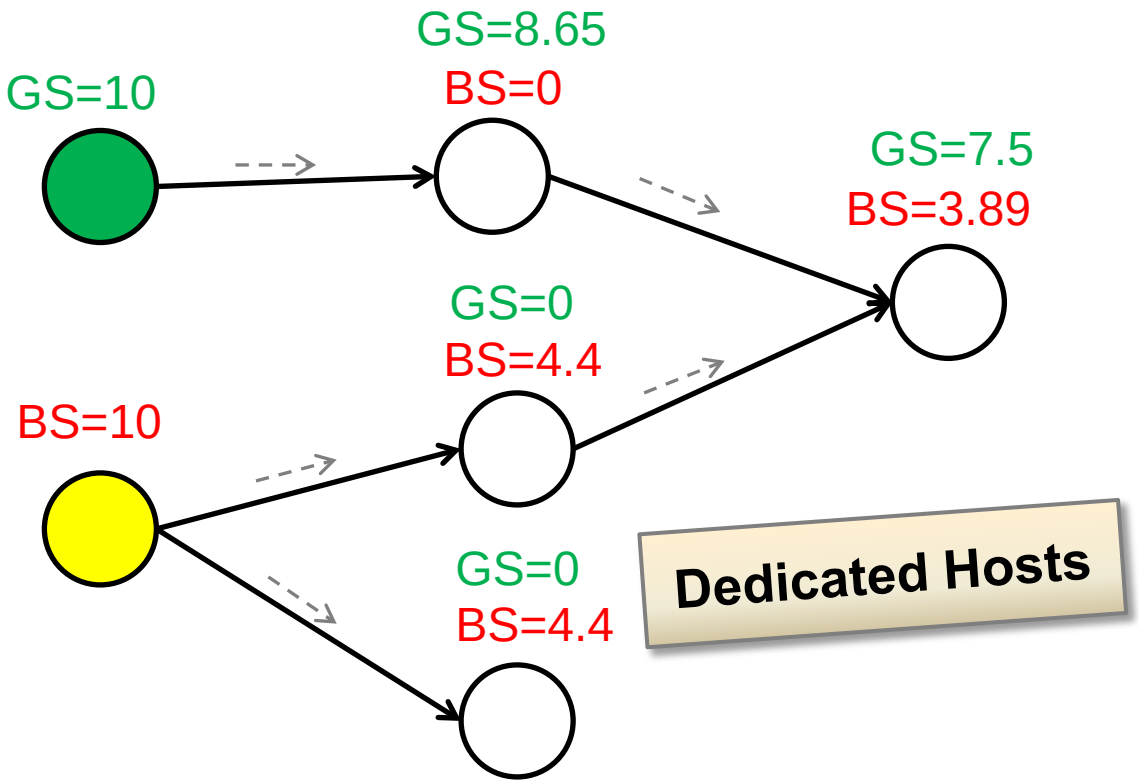


Topology!

Hunting Dedicated Hosts

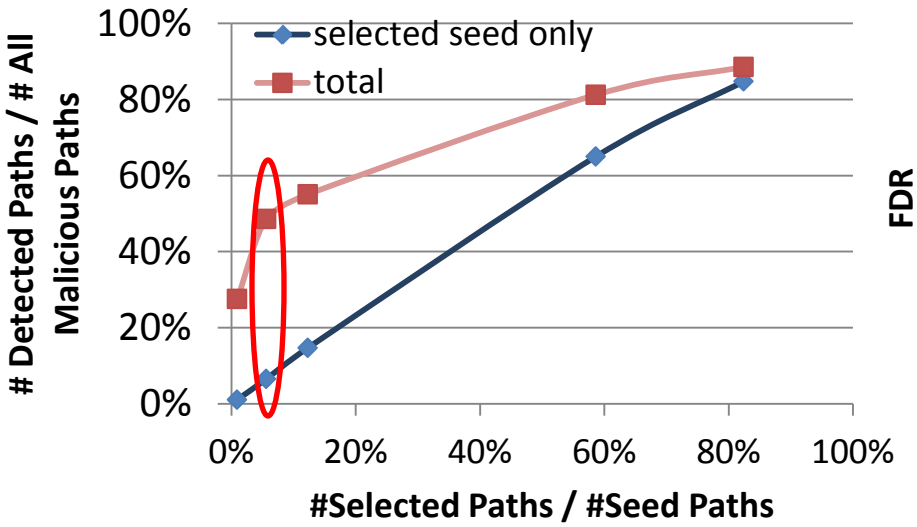
❑ Score Propagation using PageRank { Good / Bad

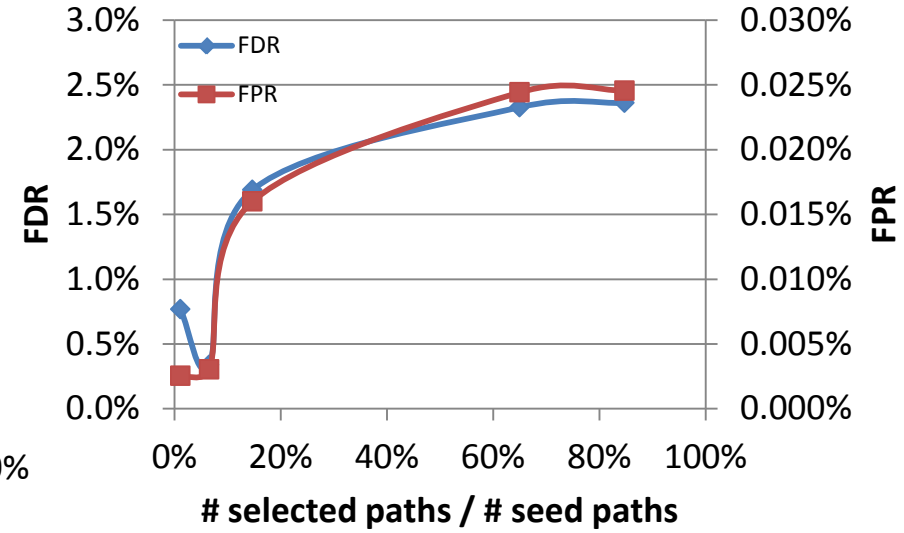
- ✓ Assign score to good seed
- ✓ Assign score to bad seed
- ✓ Score Propagation
- ✓ Choose nodes with high bad score and low good score



Evaluation

- Using x% of known malicious hosts as bad seed
- How many more malicious paths can be identified?





5% bad hosts, 7x expansion rate

0.025% FPR, 0.34% FDR

Evaluation (Cond.)

- Detect new hosts
  - ✓ 6k new malicious hostnames identified
- Detection result can serve as new seed
  - ✓ 12x expansion rate if rolling back the detected result
- Path sharing across different sources
  - ✓ 56% malicious paths from WarningBird feed overlapped with Microsoft feed

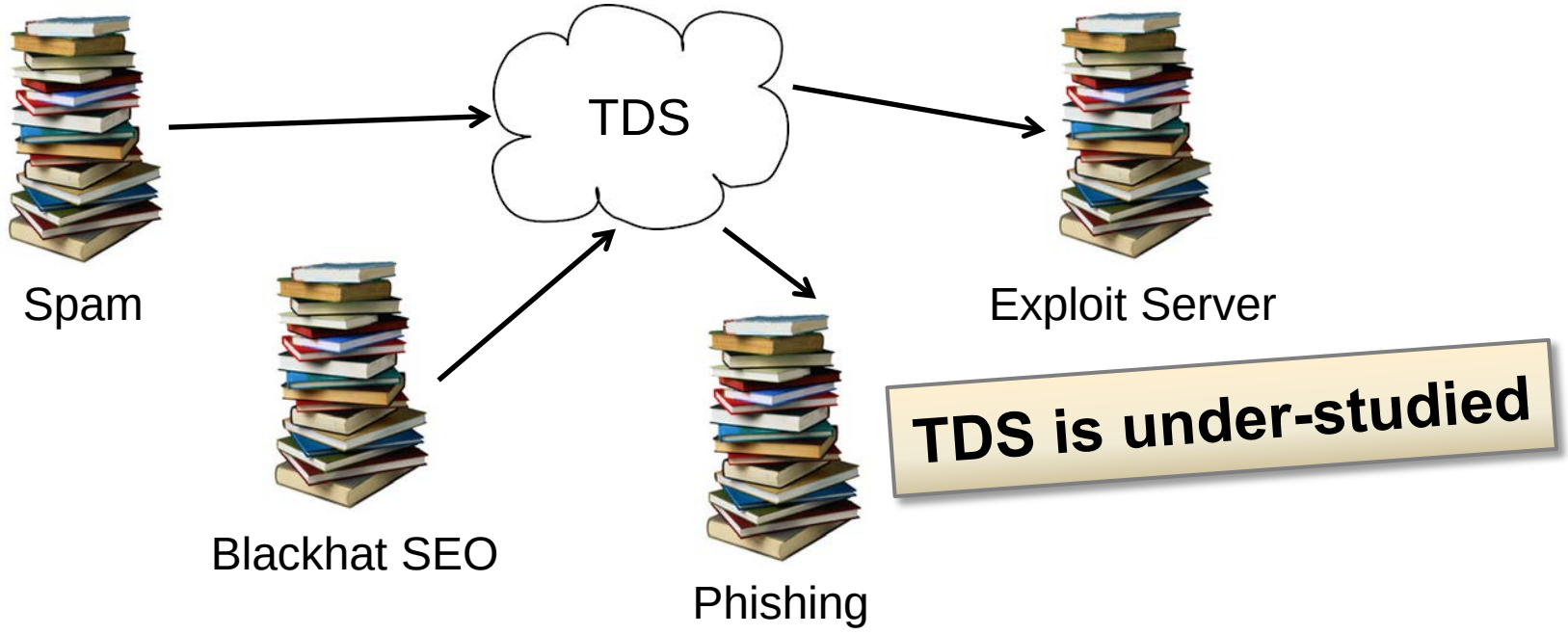
Outline

- ❑ Build graph
- ❑ Find the linchpins
- ❑ Study Traffic Direction System (TDS)

Traffic Direction System (TDS)

- Underground traffic brokers who buy traffic from generators (e.g., malicious doorways) and sell to consumers (e.g., exploit servers)

- >50% of the malicious paths go through TDS.



TDS Landscape

- 71% TDS use Sutra TDS kit.
- 26% Dynamic DNS, 14% Free Domain Providers.
- Inbound traffic: 97% from doorway, 6% from non-doorway redirectors.
- Outbound traffic of Active TDS: 49% to exploit servers, 3% to scam sites.

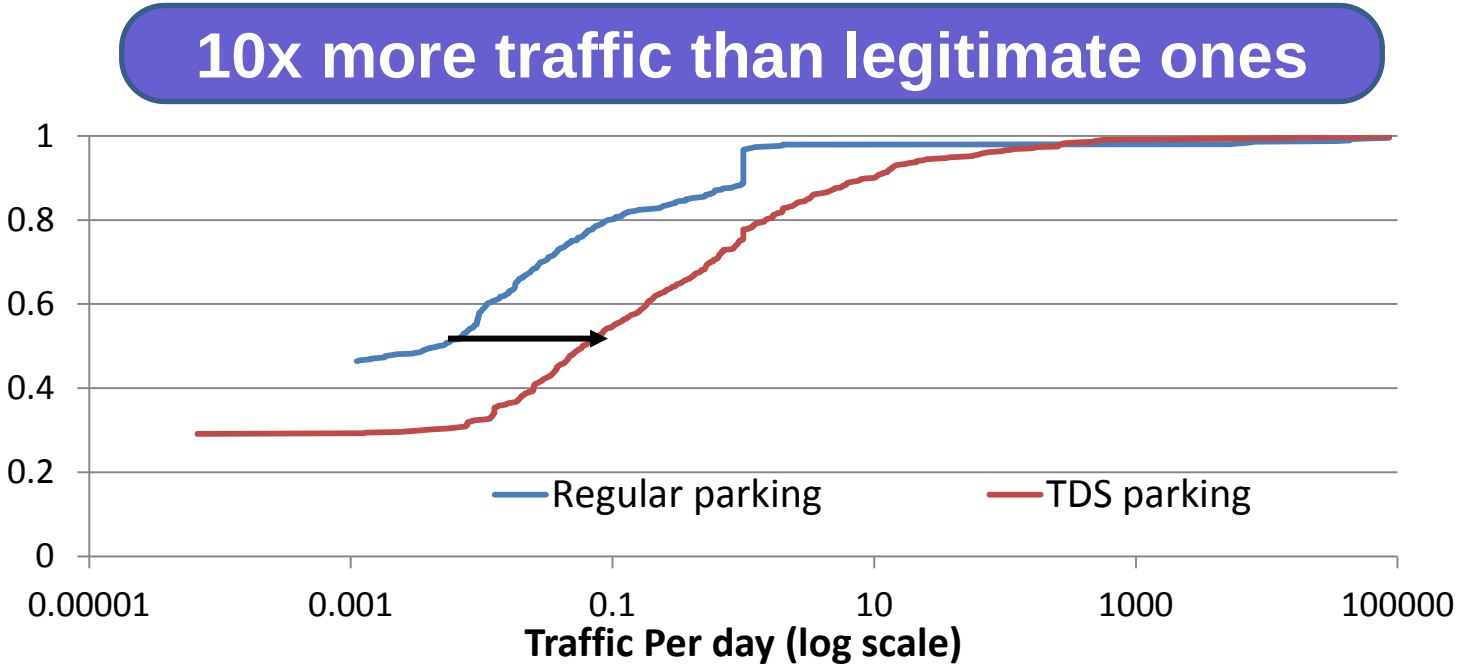
TDS Lifetime

- Query Passive DNS Database from SIE
- Lifetime: interval of host when A record bounding to bad IP
- Result
  - ✓ 65 days (exclude DDNS/ Free Domain Providers)
  - ✓ Much longer than exploit servers, 2.5 hours[1].

[1] Manufacturing Compromise: The Emergence of Exploit-as-a-Service, Chris et. al., CCS'12

TDS Parking

- Even suspended TDSes monetized by attackers
  - ✓ 20% TDS hosts parked.
  - ✓ Continue to receive high volume of traffic after parking.
  - ✓ 62% traffic to ad-networks.



Conclusion

- Dedicated Hosts are critical in Malicious Web Infrastructure
  - ✓ Serve >70% malicious paths.
- Detect Dedicated Hosts only using Topological information.
  - ✓ No need to know semantics of specific attacks.
  - ✓ 7x expansion rate, <1% FPR & FDR
- TDS Hosts deserve in-depth study
  - ✓ Key role in malicious Web infrastructure
  - ✓ Long lifetime (65 days)
  - ✓ Traffic monetized even after suspended

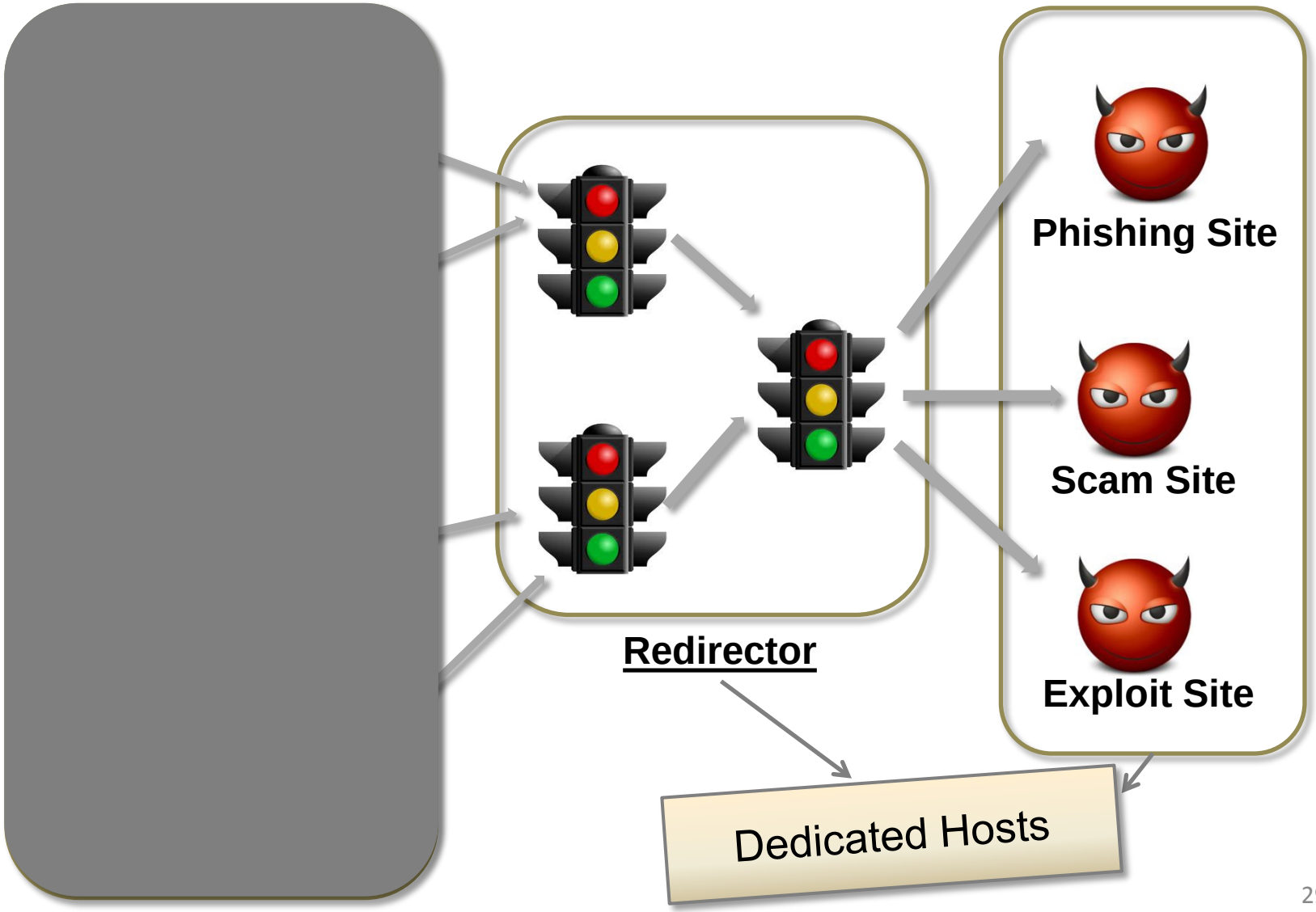
Thank You!

Q & A

Validation

- Forefront reporting
- Content and URL clustering
- Safebrowsing reporting

Dedicated Malicious Hosts



Limits of Prior Works

- Code Analysis [Cova'10, Curtsinger'10]
  Obfuscate Code
- Code Execution [Provos'08, Wang'06]
  Detect Emulator
- URL Pattern [Zhang'11, John'11]
  Regenerate URL Pattern
- Redirection Chain [Li'12, Lee'12, Lu'11]
  Depend on Semantics of Attacks