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NTT Information Sharing Platform Laboratories

Extending Black Domain Name List by Using Co-occurrence Relation between DNS Queries

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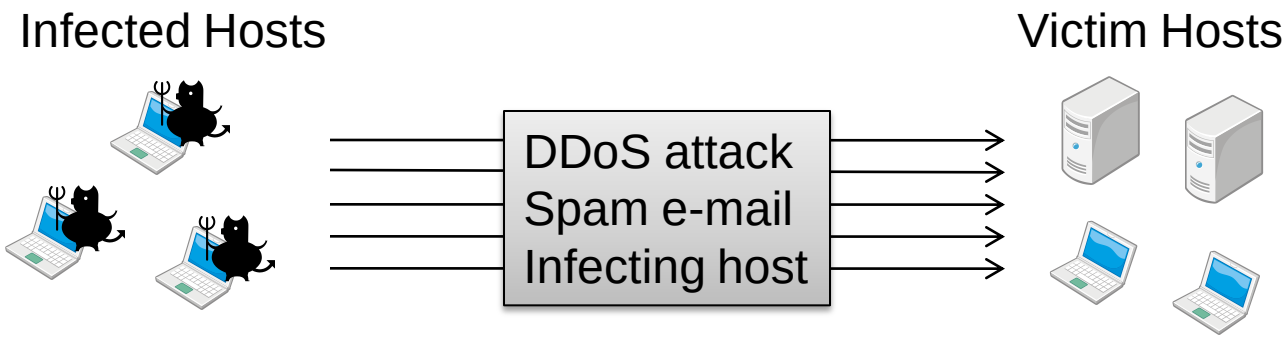
Outline

- Motivation
  - Method for detecting botnets by using blacklist
  - Coverage of blacklist
- Proposed Method
  - Extend blacklist by using co-occurrence relation
  - Problems of naively using co-occurrence relation
  - Eliminating popular domain names and heavy user effect
- Experimental Results
- Conclusion

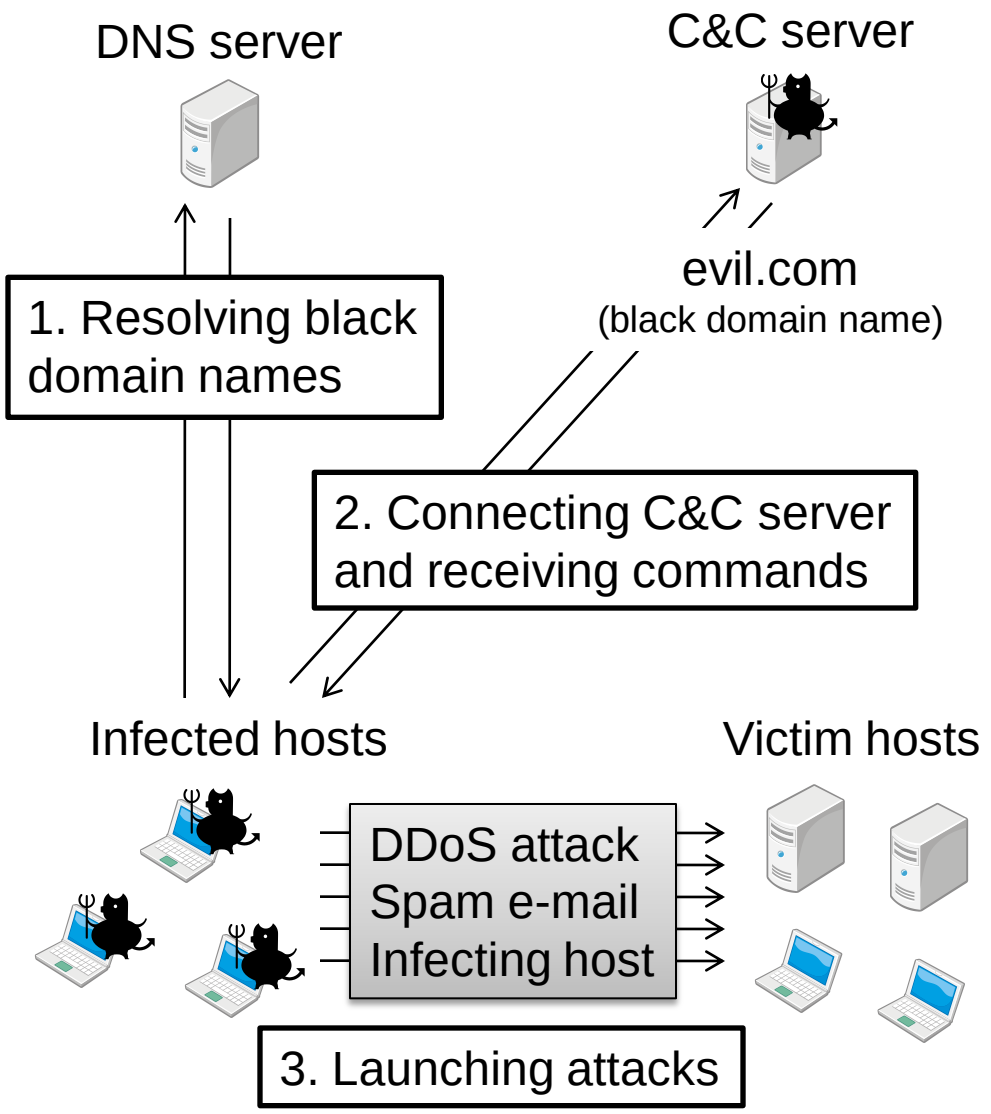
Motivation

- Botnet threats increasing
  - Launching DDoS attacks
  - Sending spam e-mail
  - Stealing personal information
  - Infecting other hosts
- Finding infected hosts and stopping malicious activities is necessary



Black Domain Name List

- Match black domain names with DNS queries to detect infected hosts
  - Bot sends DNS query to resolve domain name of C&C server
  - Black domain name list created by capturing and analyzing bots
- Block connections from infected hosts to C&C servers to stop malicious activities



Problem of Black Domain Name List

- Blacklist does not cover all black domain names
  - Numerous new bots are observed every day, thus we cannot capture all bots
  - Some bots resolves many different black domain name , thus it is hard to maintain blacklist (e.g., Conficker worm)

Objective of Study

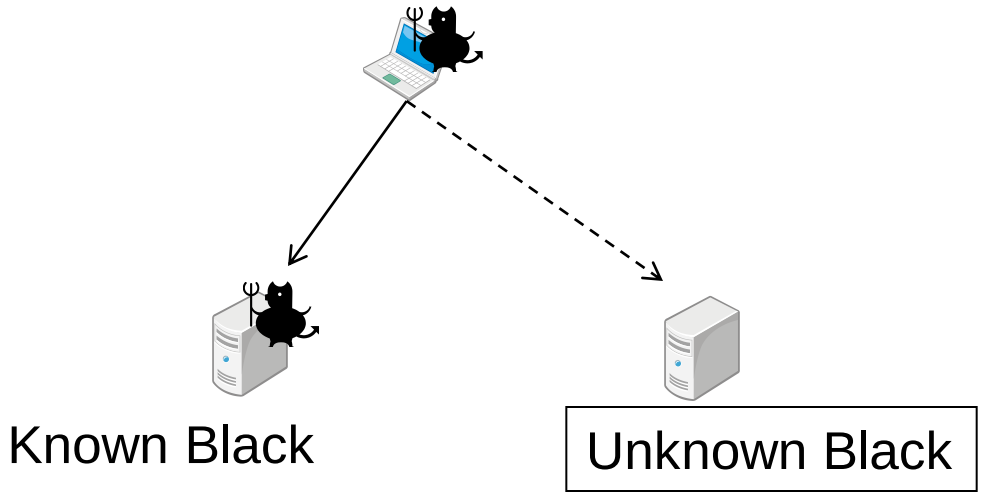
- Extending blacklist
  - Find unknown black domain names
    - Stop malicious activities by blocking connections from infected hosts to C&C servers
  - Using extended blacklist, find unknown infected hosts
    - Alert infected hosts to removing bot

Assumption

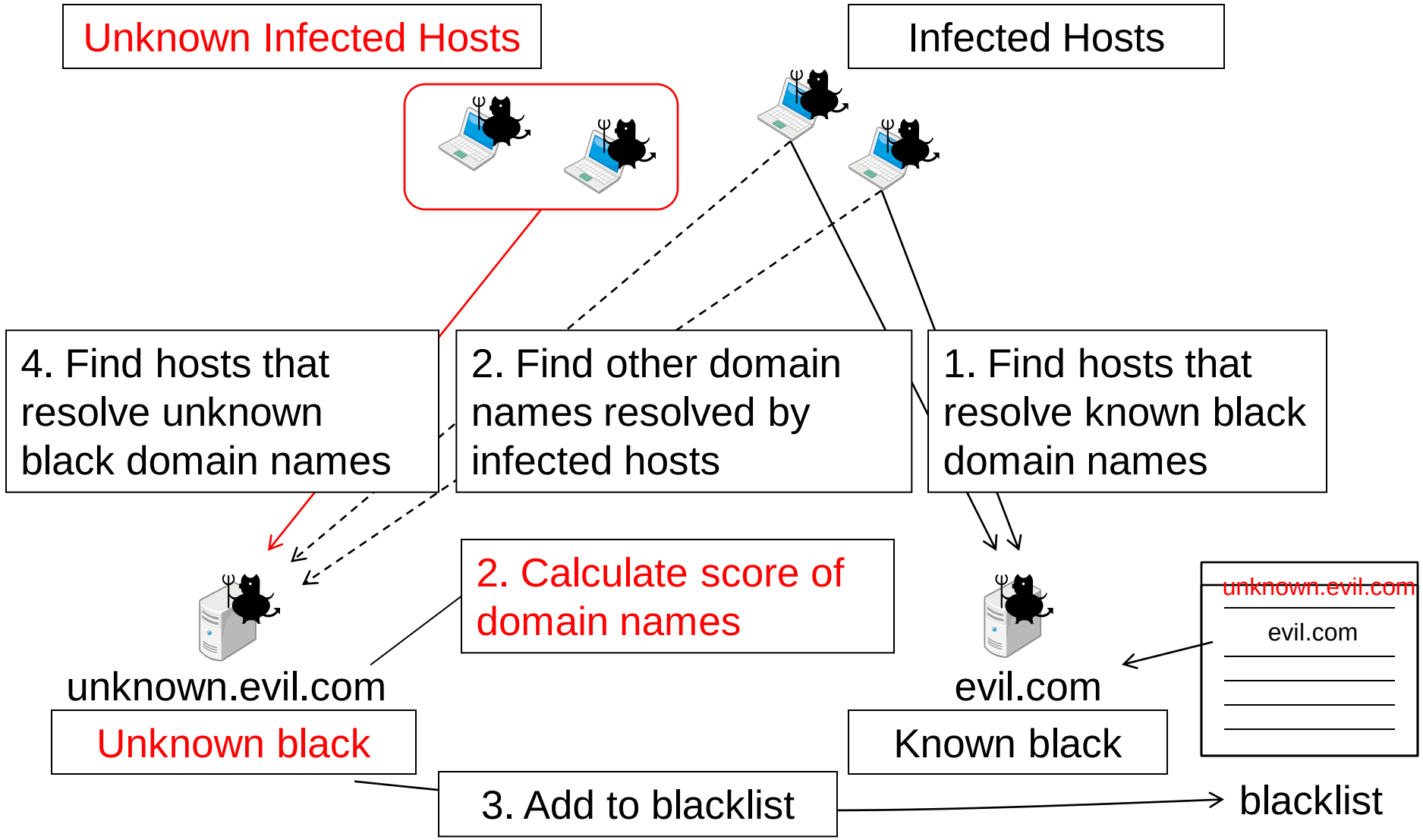
- One bot resolves several black domain names
  - For redundancy of C&C servers

Assumption

If two domain names are resolved by the same host frequently and one is black, the other is also black.



Approach Overview



Naive Scoring Method

- Our assumption
  - If two domain names are resolved by the same host frequently and one is black, the other is also black.

Focus on Co-occurrence relation

- Scoring method by using co-occurrence relation

$$C(d_1, d_2) = \frac{\#\ \text{hosts that resolve } d_1 \text{ and } d_2}{\#\ \text{hosts that resolve } d_1 \text{ or } d_2}$$

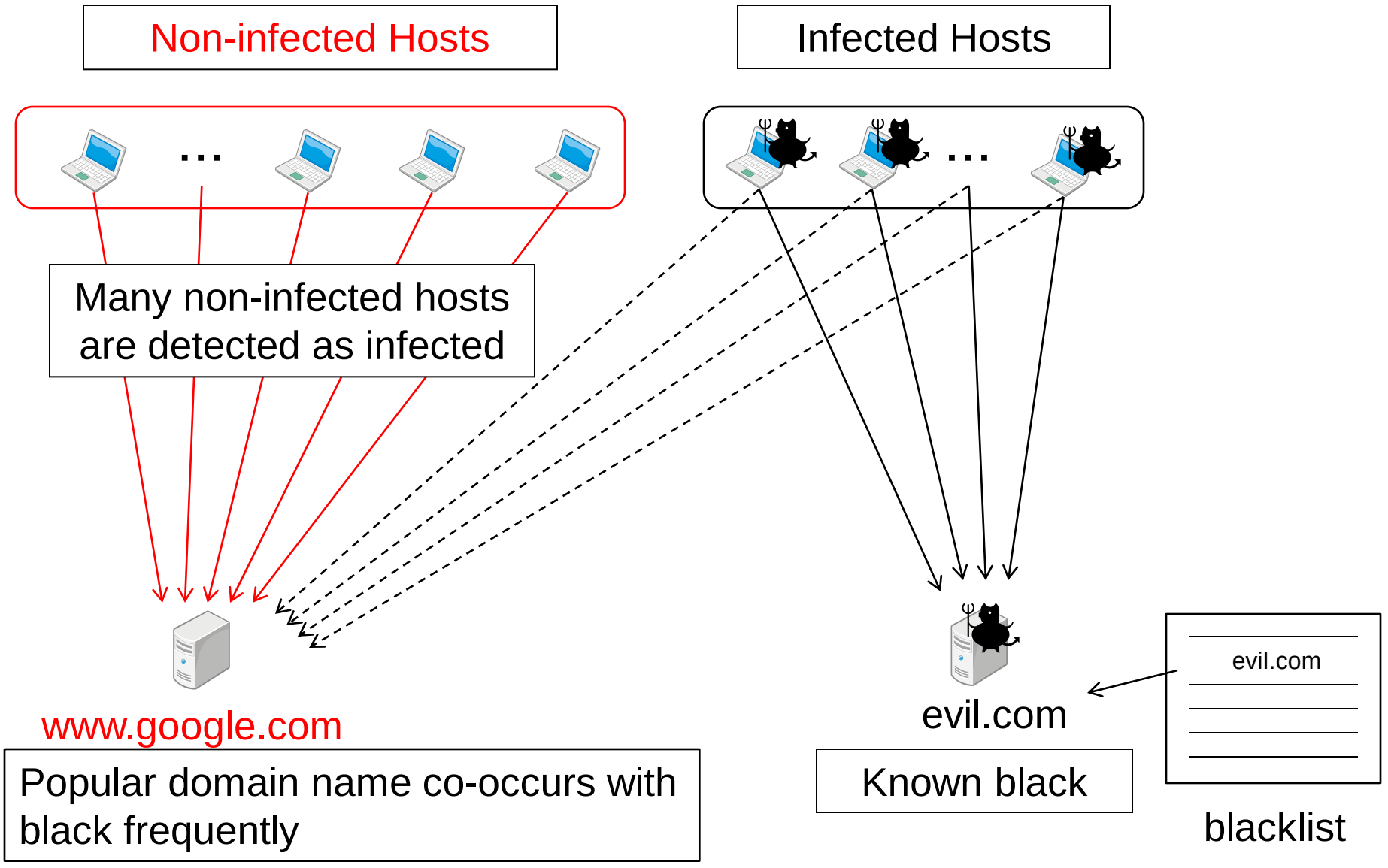
Co-occurrence rate

$$S(d) = \sum_{d_m \in blacklist} C(d_m, d)$$

Total co-occurrence rate with black domain names

If score is high, assume *d* is black

Problem of Popular Domain Name



Weight of Number of Non-infected Hosts

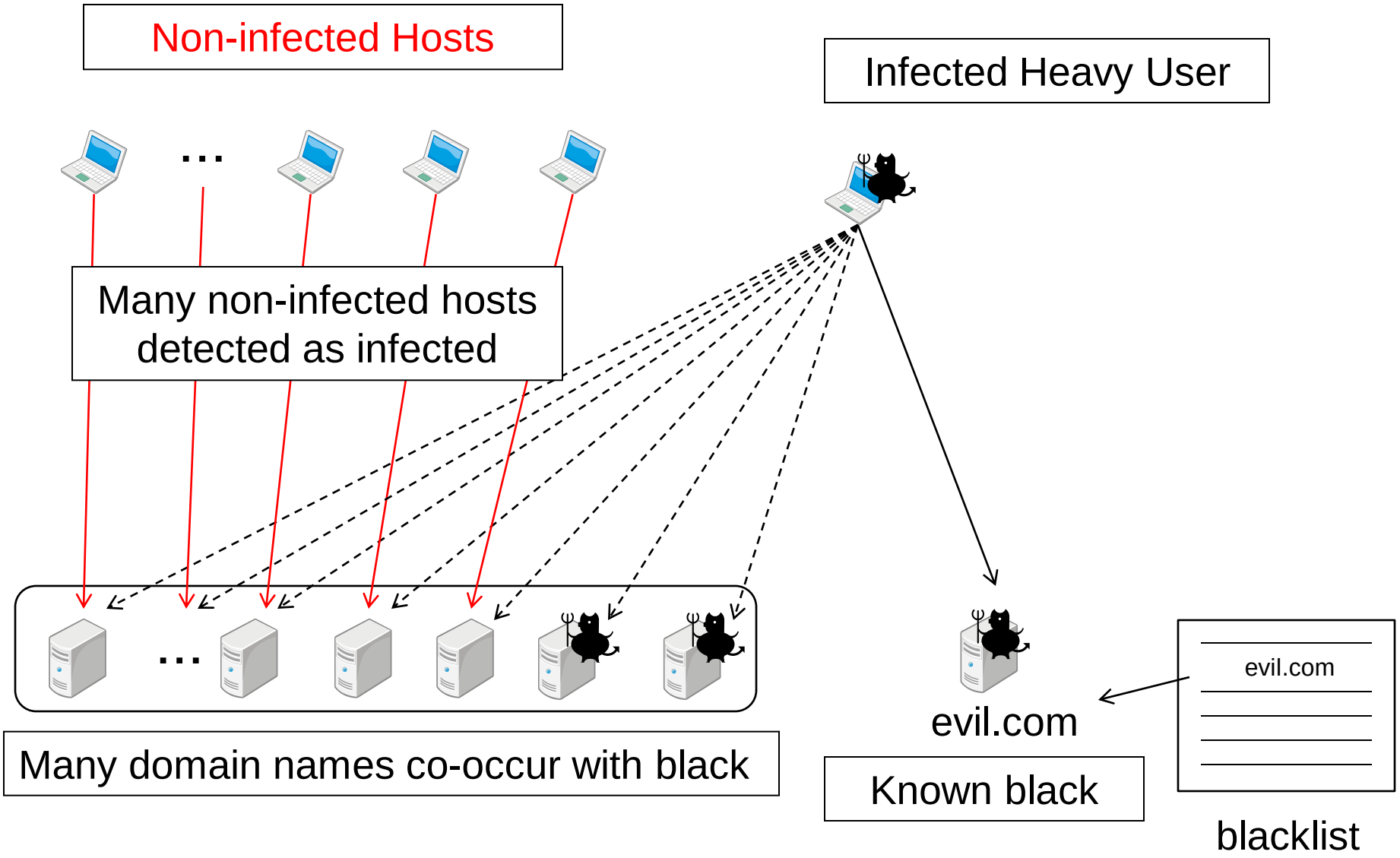
- Focus on number of non-infected hosts that resolve a domain name
  - Popular domain names are resolved by both infected and non-infected hosts
  - Black domain names are resolved by only infected hosts
- Define weight of number of non-infected hosts

$$W(d) = \frac{\#\text{ infected that resolve } d}{\#\text{ infected that resolve } d + \#\text{ non-infected that resolve } d}$$

If d is popular, $W(d)$ is relatively small

If d is popular, value is relatively large

Problem of Infected Heavy User



Weight of Number of Queries

- Focus on number of domain names resolved by infected hosts
  - Add weight of number of queries to naive co-occurrence rate
- Weighted co-occurrence rate

$$C'(d_1, d_2) = \frac{\sum_{h \in \text{hosts that resolve } d_1 \text{ and } d_2} 1/\#\text{ domain names resolved by } h}{\#\text{ hosts that resolve } d_1 \text{ or } d_2}$$

If host is heavy user, value is small and C' increases little

Proposed Scoring Method

Eliminate influence of infected heavy user

Even if *d* is resolved by infected heavy user, *C'* increases little

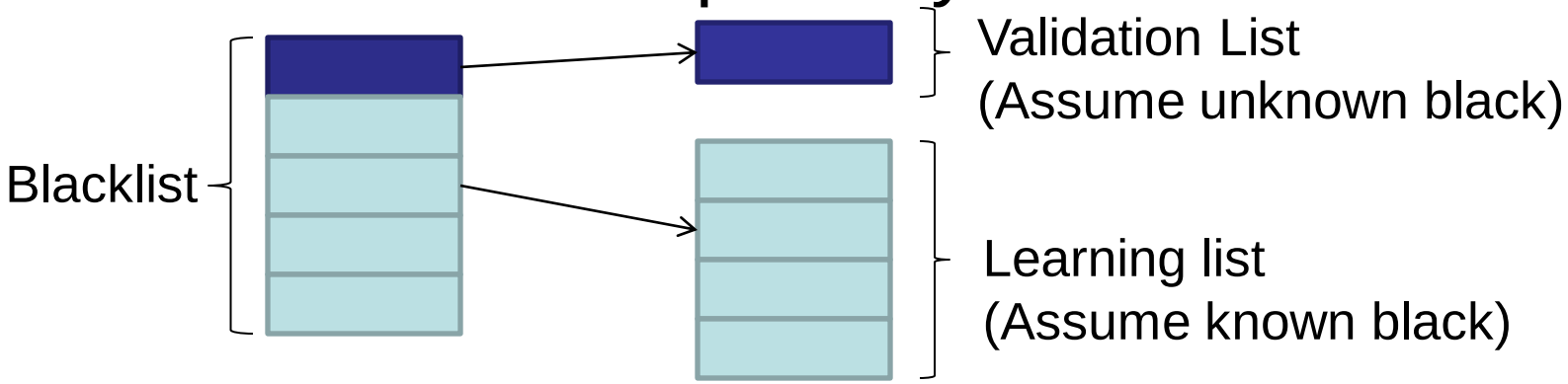
$$S'_W(d) = \left(\sum_{d_m \in blacklist} C'(d_m, d) \right) \times W(d)$$

Eliminate influence of popular domain name

If *d* is popular, *W(d)* is small

Evaluation

- Validated our assumption by cross validation

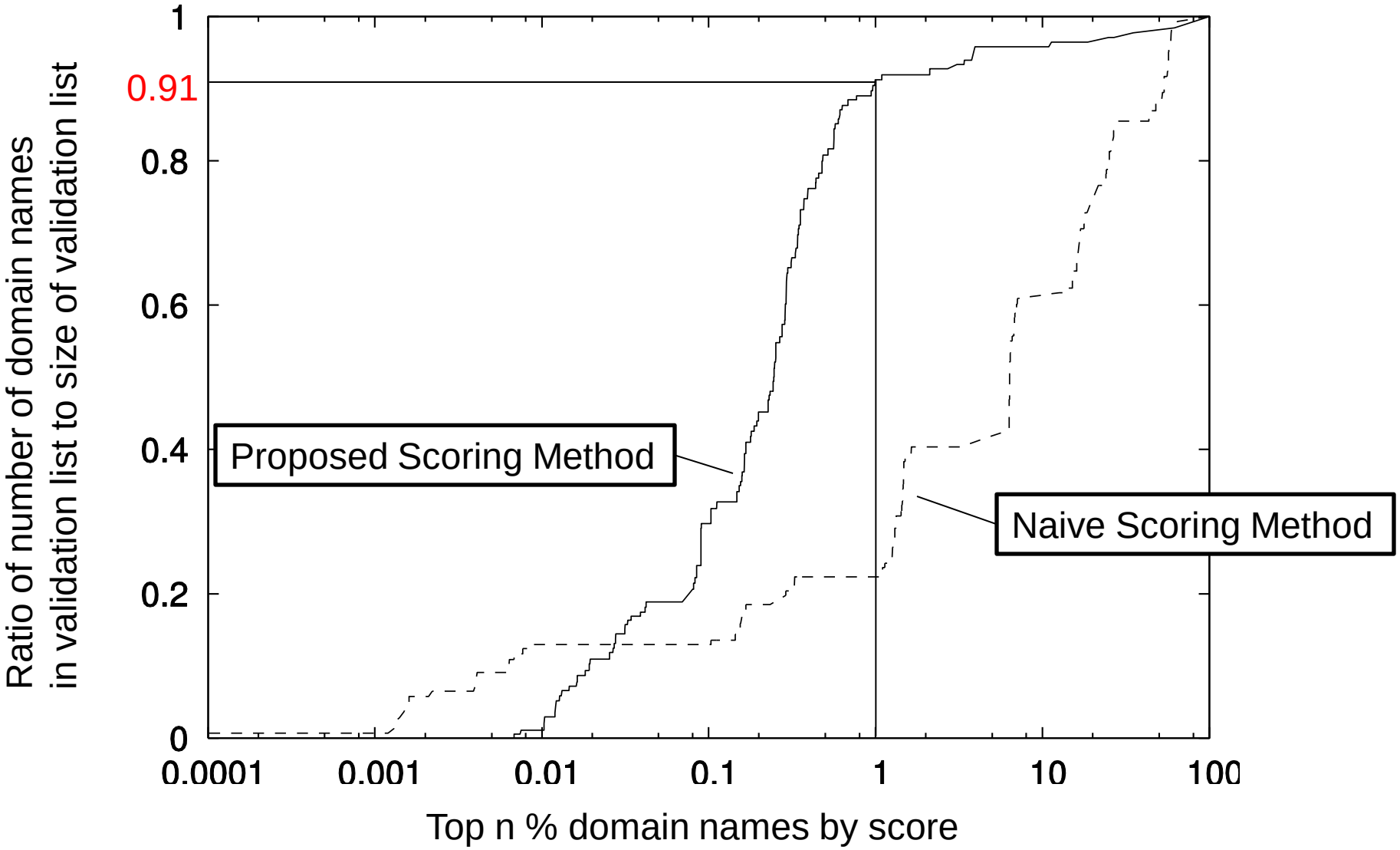


- Validated high-scored domain names
  - Applied proposed method to all domain names in known blacklist and classified 100 high-scored domain names as black, legitimate, or unclear
- Validated effectiveness of extended blacklist
  - Found hosts that resolved domain names in extended blacklist

Dataset

- DNS traffic data
  - Captured during one hour in Feb. 2009
- Blacklist
  - Created by using honeypot during same period
  - Blacklist has about 270 domain names

Cross Validation Results



Classification Results

- Domain names for top 100 scores consisted of
  - 39% black, 4% legitimate, and 56% unclear
- Domain names for top 20 scores
  - 70% black
  - No legitimate domain names included

Score	Domain Name	Result
0.571	spy.nerashti.com	**Black**
0.571	bla.bihsecurity.com	**Black**
0.571	aaaaaaaaaaaaa.locop.net	**Black**
0.500	icq-msg.com	**Black**
0.319	mail.tiktikz.com	**Black**
0.300	x.zwned.com	**Black**
0.300	evolutiontmz.sytes.net	Unclear
0.300	dcom.anxau.com	**Black**
0.292	usa.lookin.at	Unclear
0.292	rewt.buyacaddi.com	**Black**

Score	Domain Name	Result
0.250	unkn0wn	Unclear
0.250	google-analitucs.com/loader/	**Black**
0.222	netspace.err0r.info	Unclear
0.203	win32.kernelupdate.info	**Black**
0.203	free.systemupdates.biz	Unclear
0.200	zjjdtc.3322.org	**Black**
0.200	ykln.3322.org	Unclear
0.200	dr27.mcboo.com	**Black**
0.189	china.alwaysproxy.info	**Black**
0.167	home.najd.us	**Black**

Details of Unclear Domain Names

- Some unclear domain names are suspicious
  - –Domain name whose subdomain differs from known black domain name
    - ykln.3322.org (zjjdtc.3322.org is known black)
  - –Domain name with format "<black>.<legitimate>"
    - www.h7smcnrwlsdn34fgv.info.<legitimate>
  - –Domain name for DNSBL lookups
    - <IP address>.zen.spamhaus.org

Finding Unknown Infected Hosts

- Rate of increase of number of unknown infected hosts is only 3%
  - Insufficient rate
  - Need to improve proposed method

Conclusion

- Proposed scoring method for finding unknown black domain names
- Found unknown black domain names and extended blacklist
  - –Stop malicious activities by using extended blacklist more effectively
- Cannot find unknown infected hosts sufficiently
  - –Improve method for finding unknown infected hosts as future work

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Thank You