Università degli Studi di Milano
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Dipartimento di Informatica e Comunicazione

FluXOR: Detecting and Monitoring Fast-flux Service Networks

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DIMVA 2008

Botnets

What is a botnet?

- a network of infected machines (*bots*) used simultaneously to achieve the same purpose
- different purposes: spam, DDoS, phishing, scam, massive SQL injection, ...

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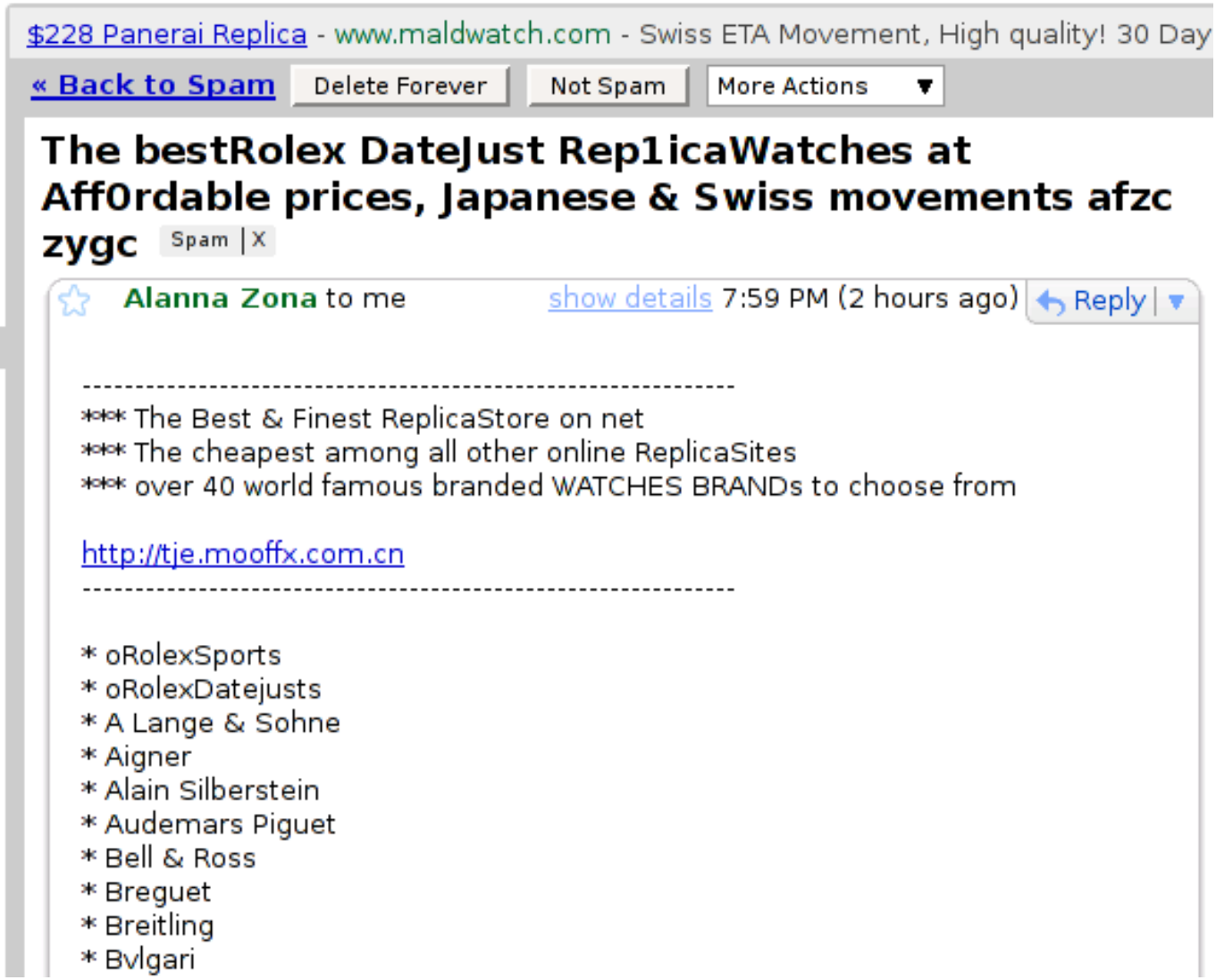
Fast-flux service networks

- a new ($\sim$ 2007) technique to maximize botnets availability
- simple idea: add an additional indirection layer (i.e., proxy) between victims and controlling elements

Fast-flux botnets
Architecture



Fast-flux botnets
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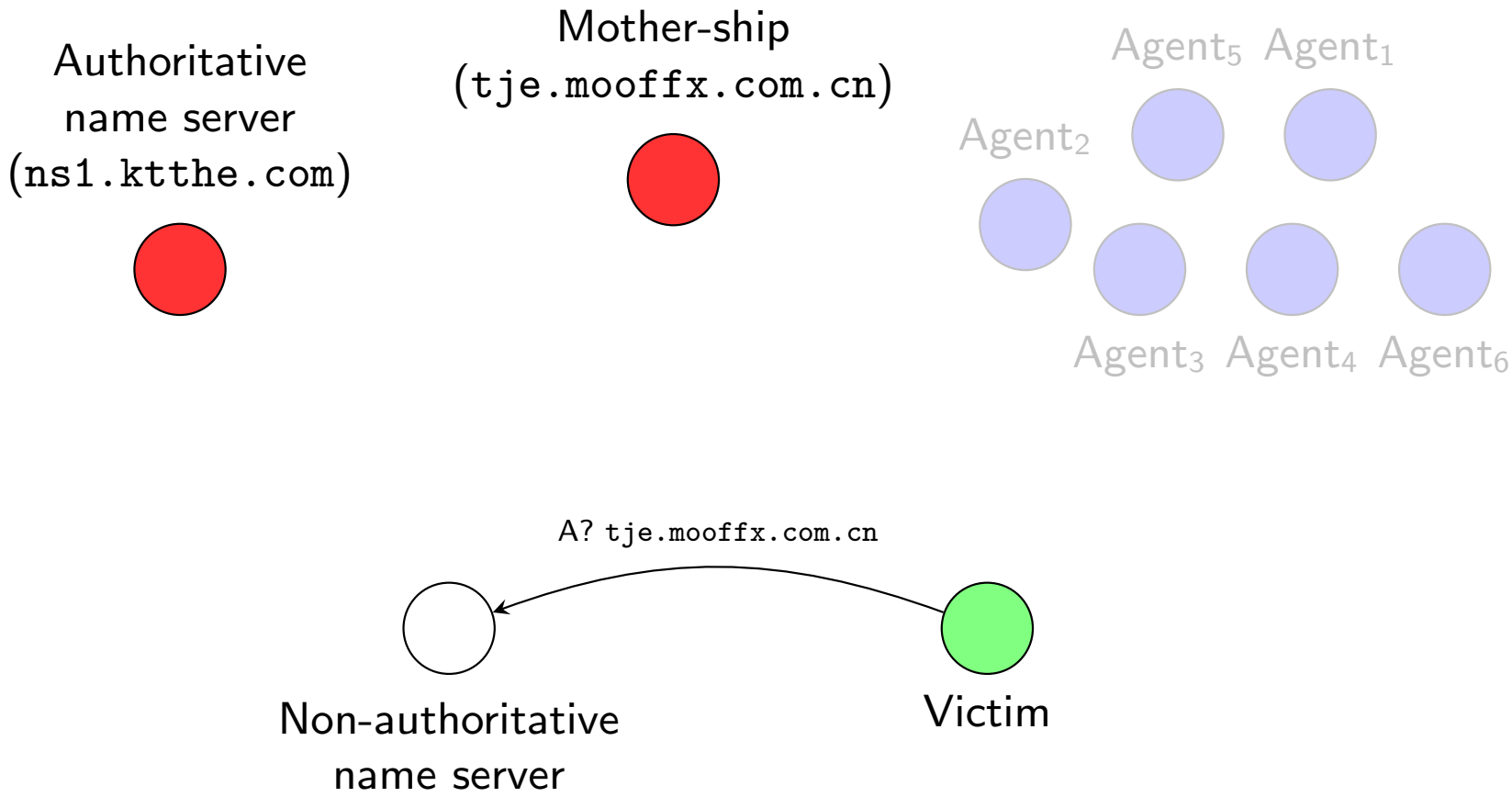

Fast-flux botnets
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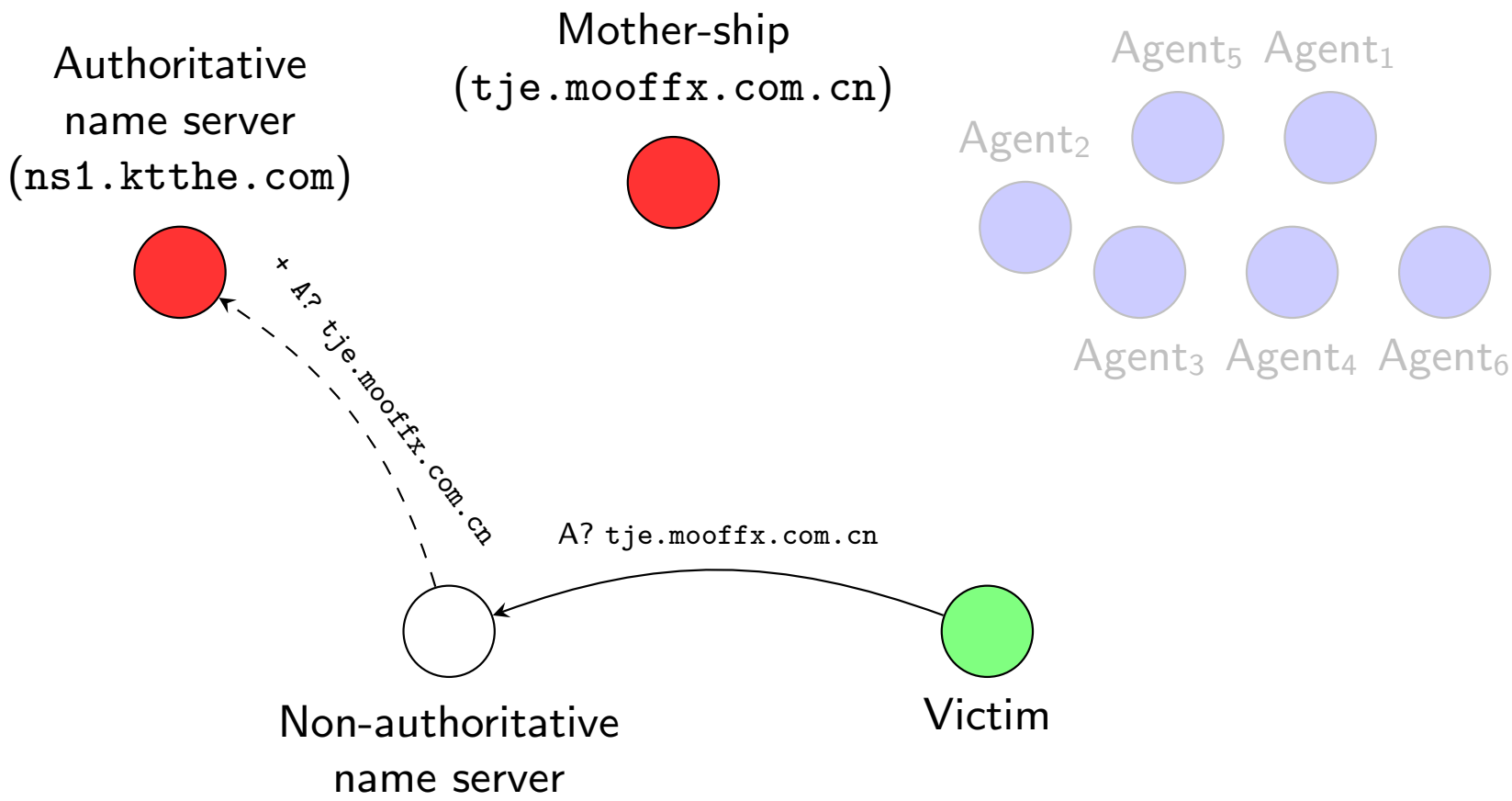

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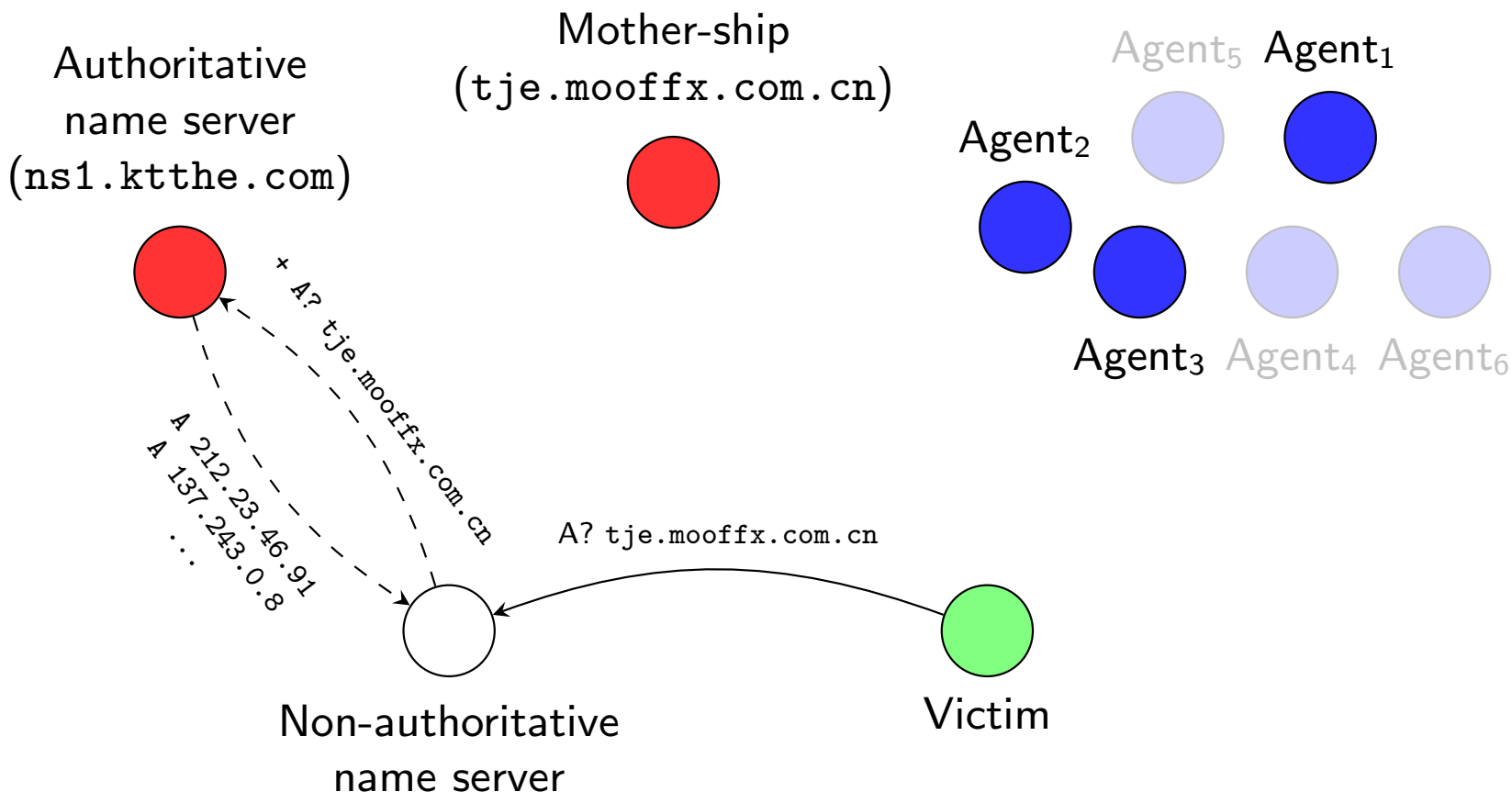

Fast-flux botnets
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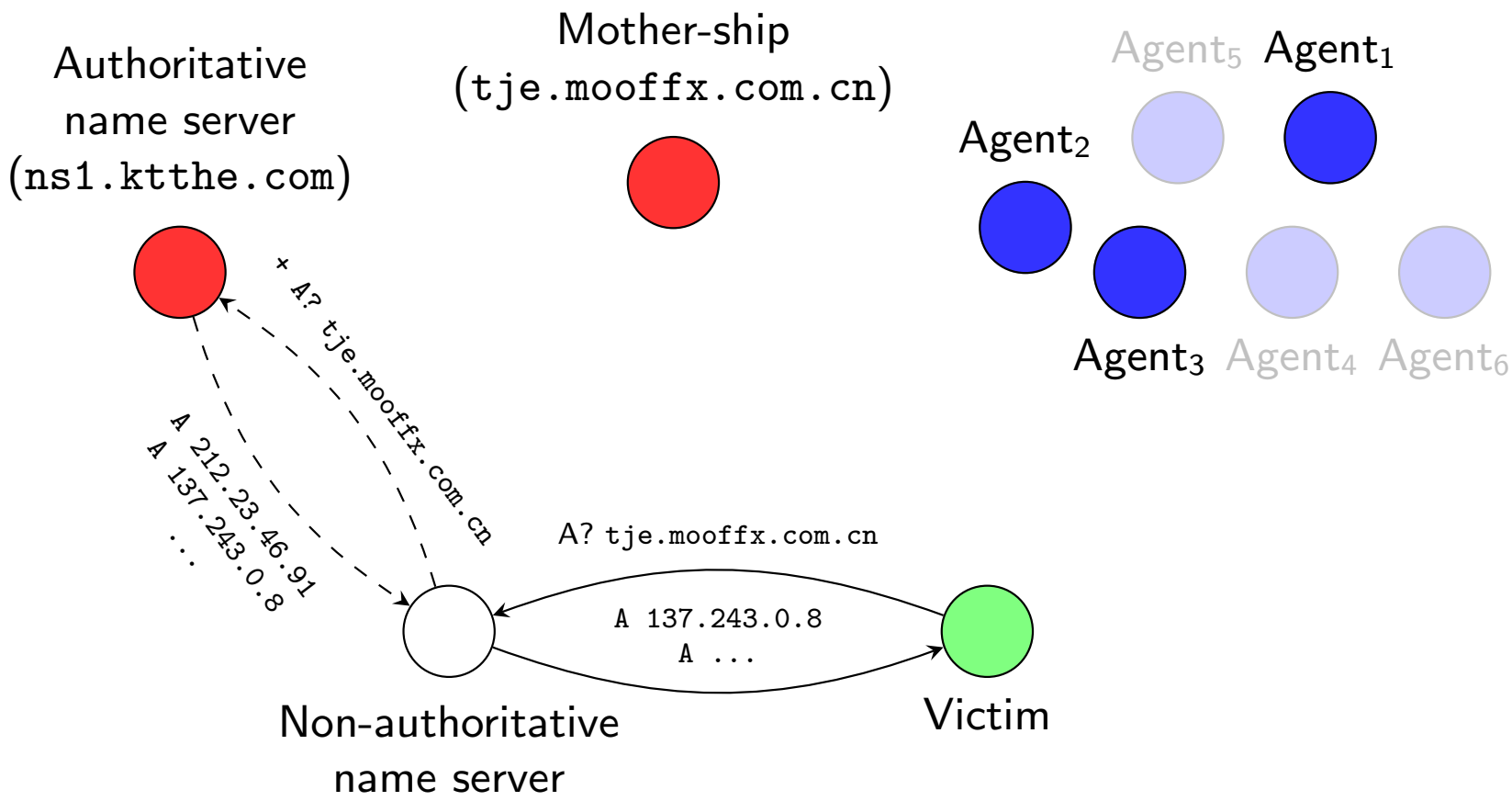

Fast-flux botnets
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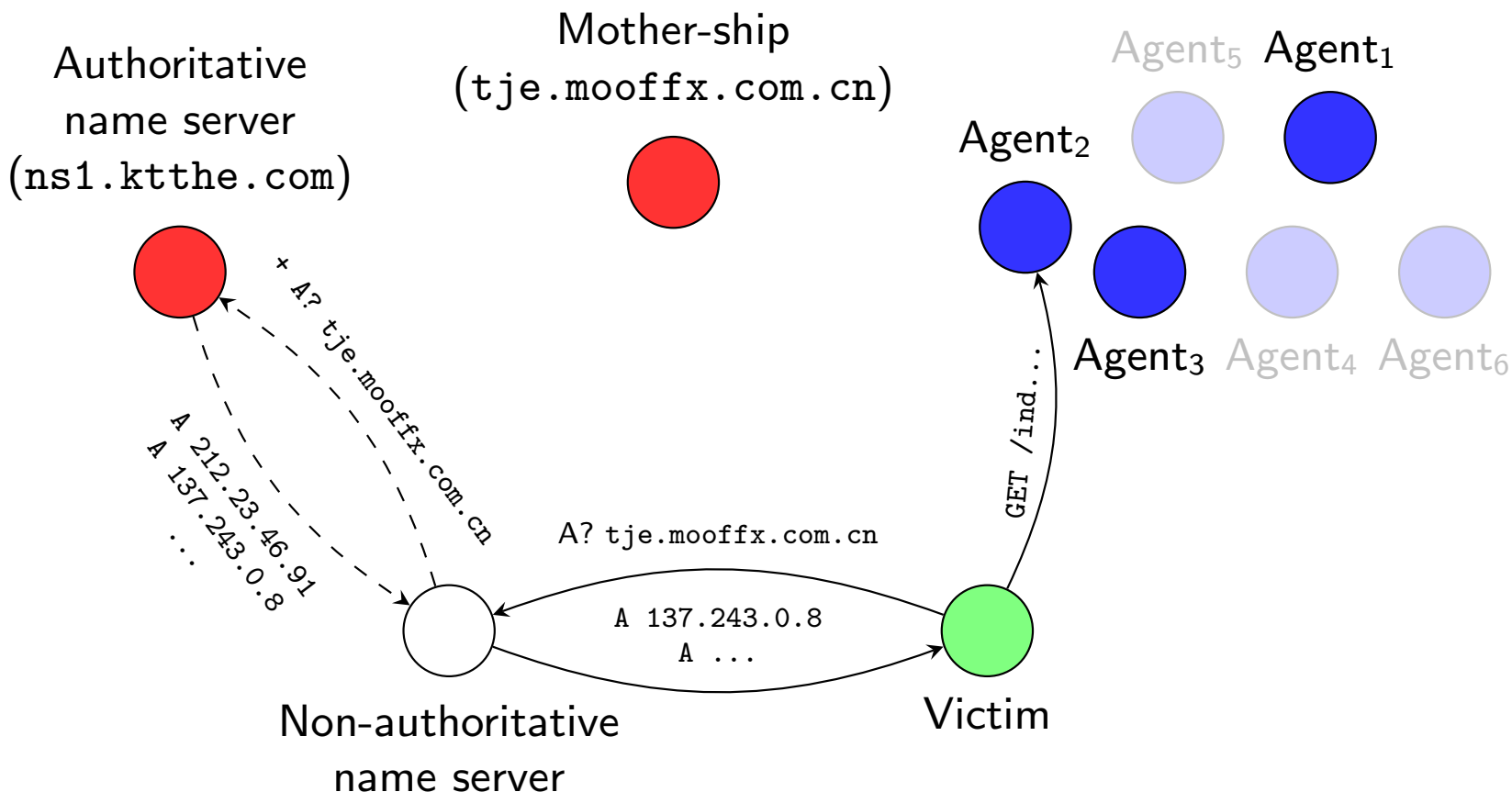

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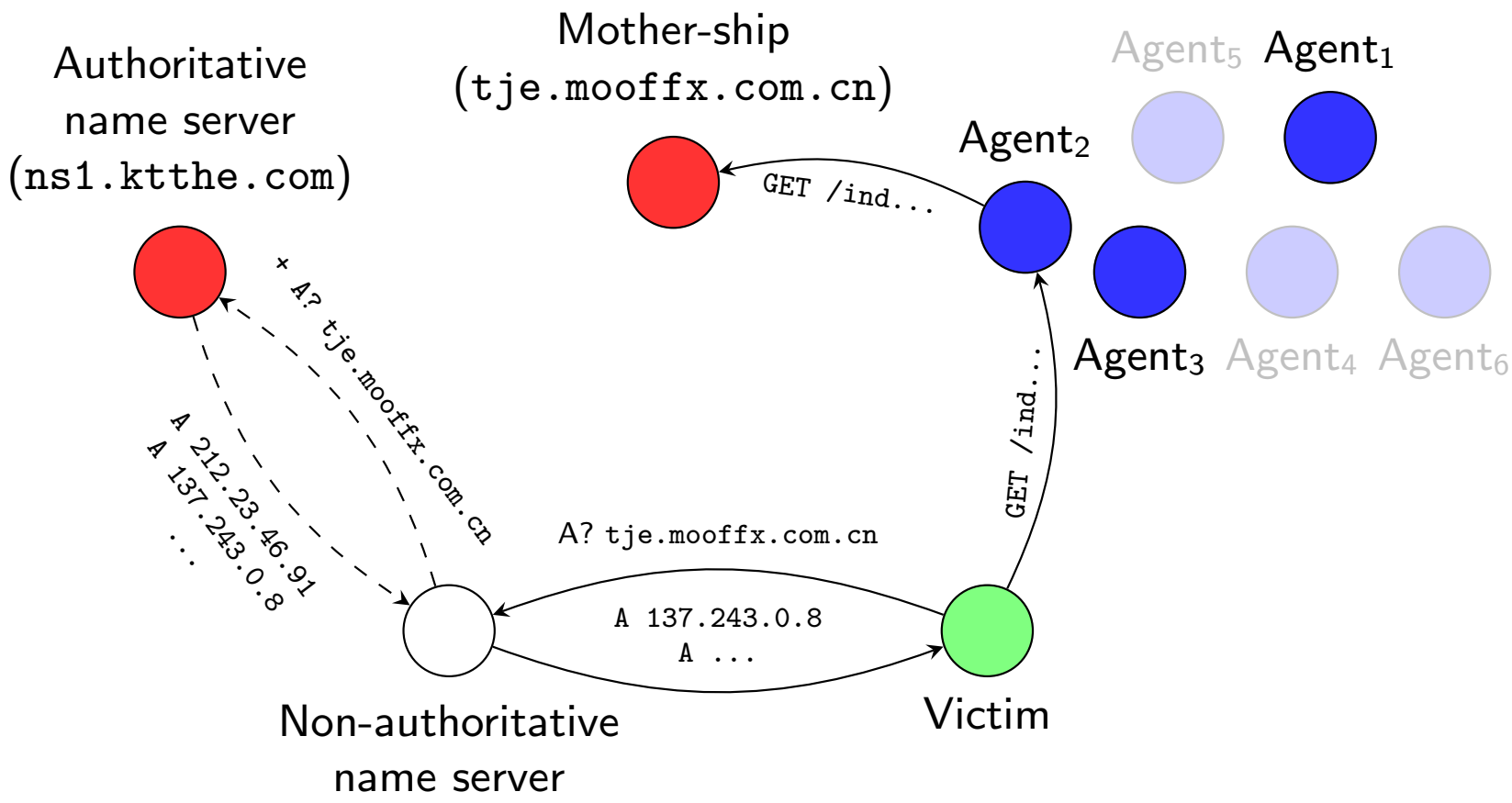
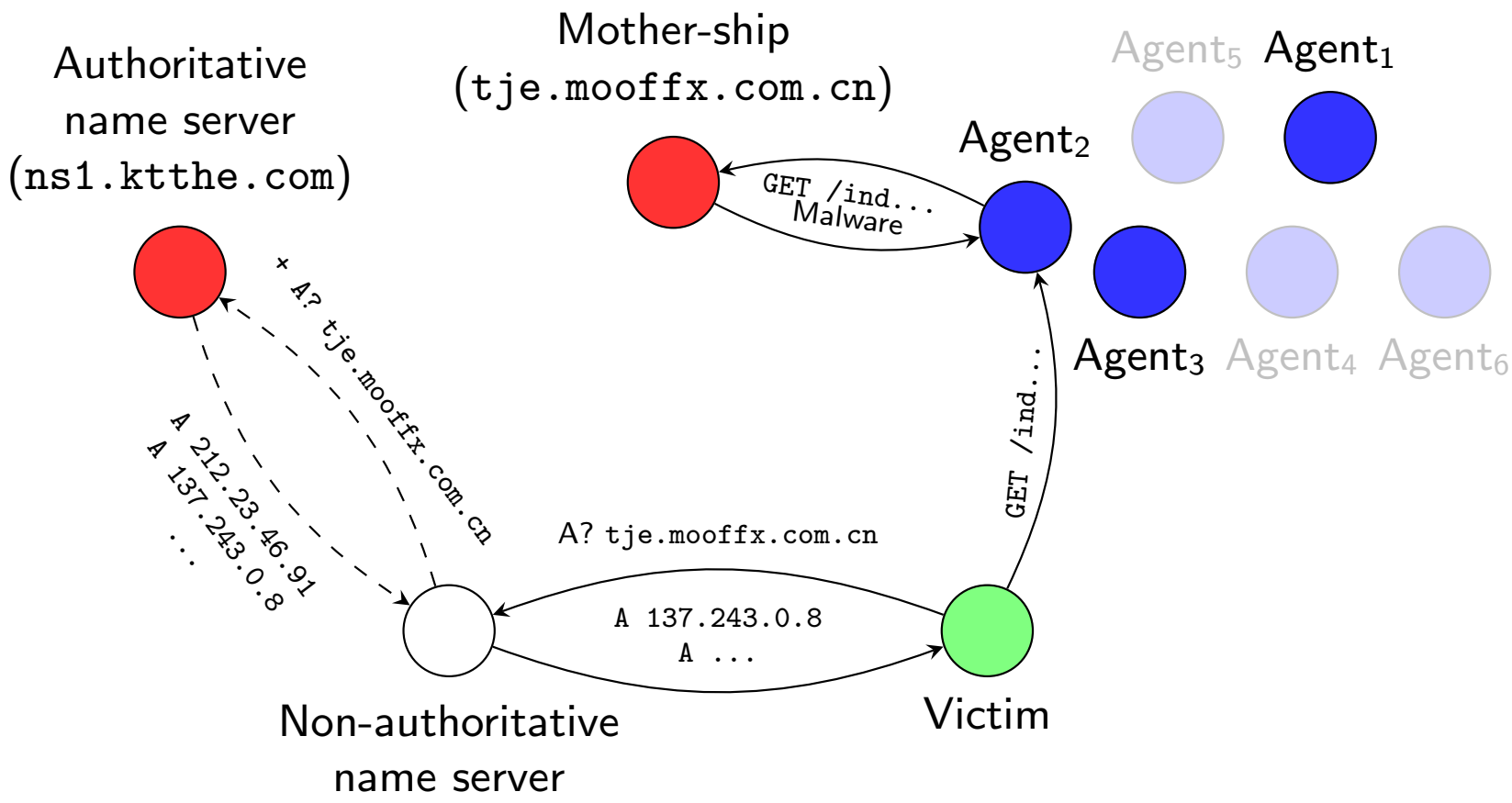


Fast-flux botnets
Architecture



Fast-flux botnets
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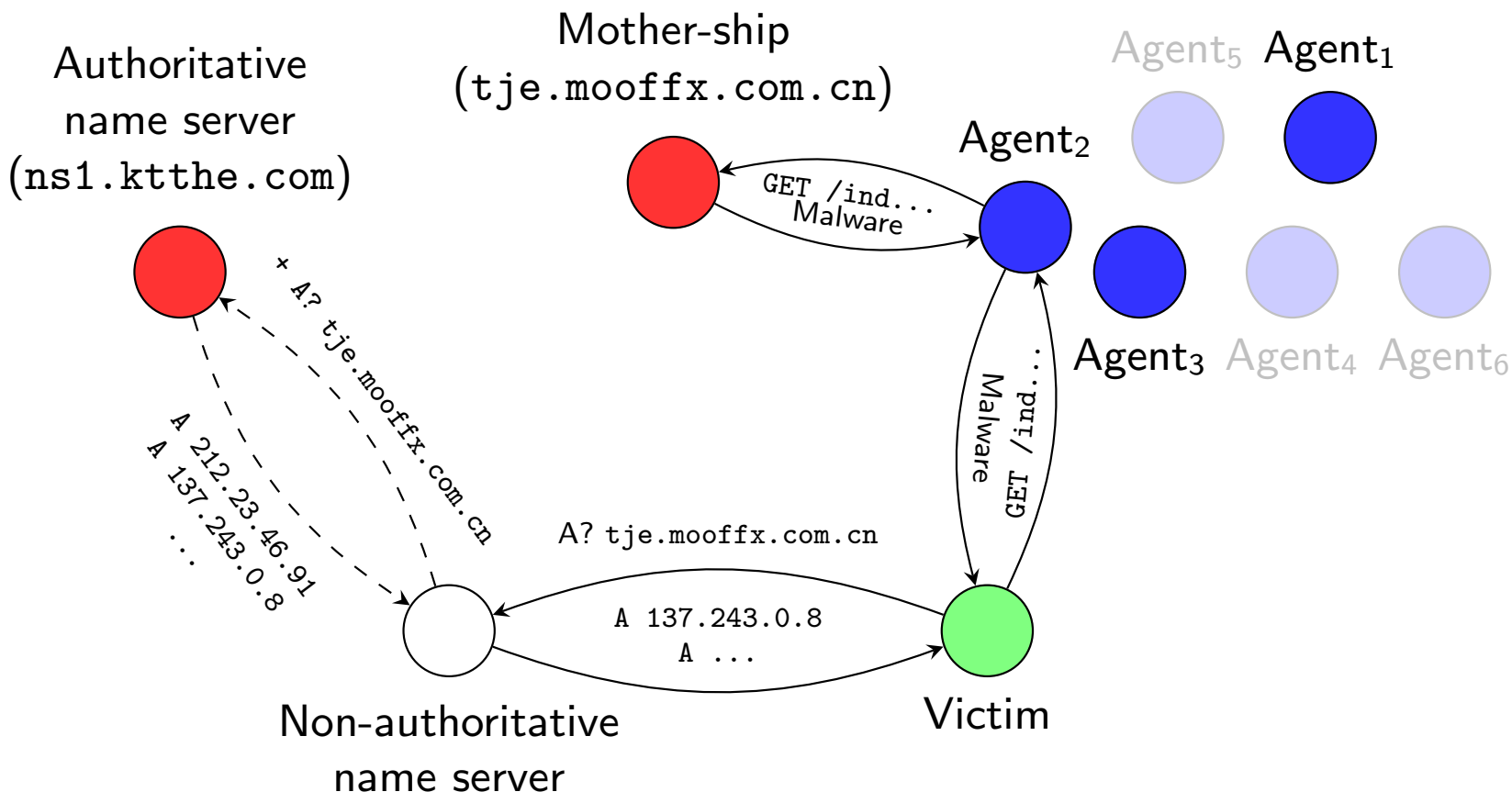
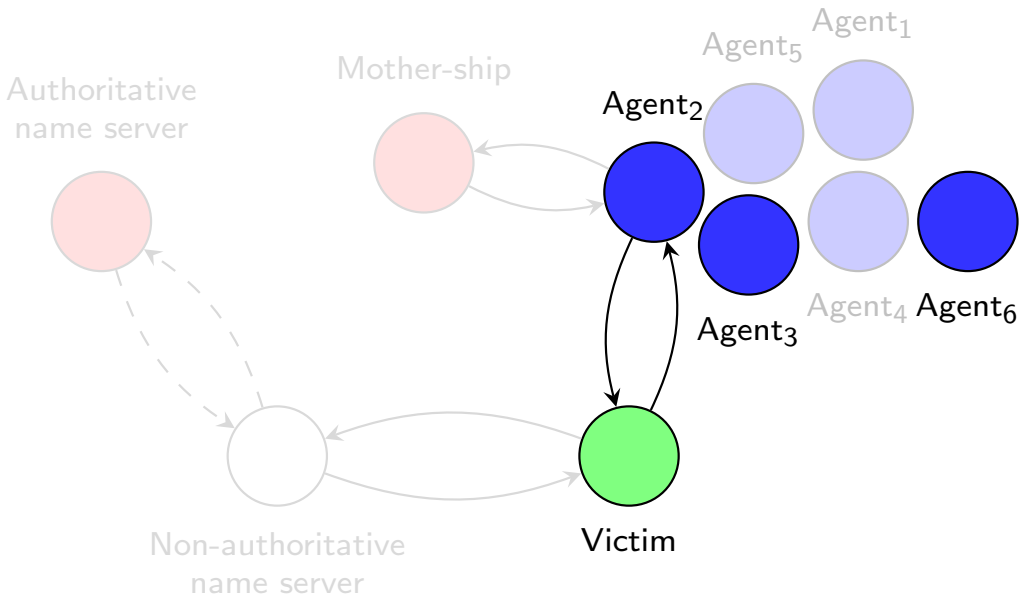
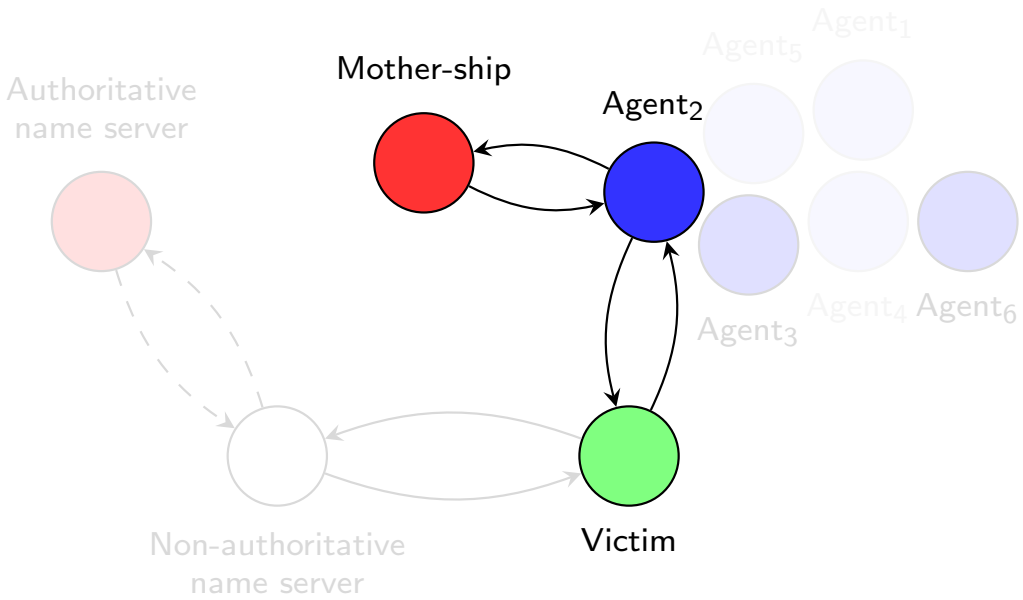


Fast-flux botnets
Characteristics



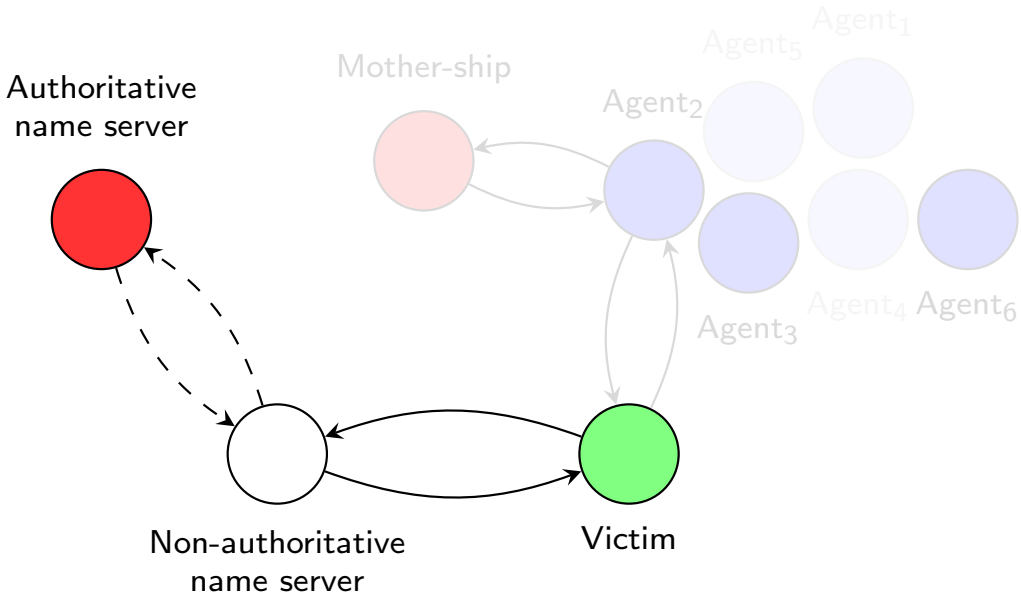
- off-line, disinfected, and faulty bots (or agents) are immediately replaced by others
- Warezov/Storm networks have *millions* of agents!
- Storm: $\sim$ 1 billion spam messages during a six-weeks attack

Fast-flux botnets
Characteristics



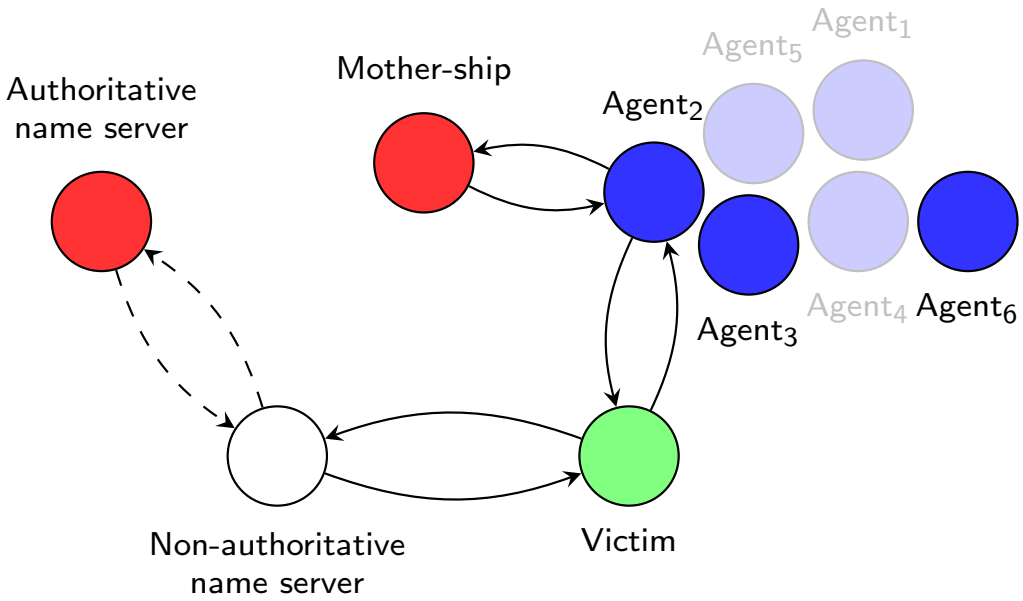
identity of the core components of the architecture (e.g., mothership) is hidden to the victims

Fast-flux botnets
Characteristics



- multiple FQDNs can be associated with the same fast-flux service network
- it is not enough to close malicious FQDN!

Fast-flux botnets
Characteristics



Real impact

- The average lifetime of the scam site becomes months instead of days!
- The only way shut down scam site is to clean all agents

Our contribution

Observation

- a fast-flux service network has multiple distinguishing features
- taken singularly are not enough to distinguish between benign and malicious hostnames

Idea: FluXOR

- monitor the suspicious hostname for a small period of time to collect distinguishing features, behaving like a recidivious victim
- combine features to distinguish between benign and malicious domains
- monitor malicious domains to enumerate all infected agents

Features of fast-flux service networks

Domain

- Domain age
- Domain registrar

Availability of the network

- # of DNS records of type "A"
- TTL of DNS resource records

Heterogeneity of the agents

- # of networks
- # of autonomous systems
- # of resolved QDNs
- # of assigned network names
- # of organisations

Benign

avast.com	539
adriaticobishkek.com	65
google.com	542
mean	**493.27**
std. dev.	**289.27**

Malicious

eveningher.com	18
factvillage.com	2
doacasino.com	2
mean	**4.85**
std. dev.	**4.9**

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Benign

`avast.com`	NetworkSolutions
`adriaticobishkek.com`	Melbourne IT
`google.com`	MarkMonitor
mean	**N/A**
std. dev.	**N/A**

Malicious

`eveningher.com`	PayCenter
`factvillage.com`	PayCenter
`doacasino.com`	NameCheap
mean	**N/A**
std. dev.	**N/A**

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Benign	
avast.com	12
adriaticobishkek.com	21
google.com	3
mean	**2.86**
std. dev.	**3.89**

Malicious	
eveningher.com	127
factvillage.com	117
doacasino.com	33
mean	**98.13**
std. dev.	**37.27**

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Benign

avast.com	3600
adriaticobishkek.com	1200
google.com	300
mean	**4592.53**
std. dev.	**7668.74**

Malicious

eveningher.com	300
factvillage.com	300
doacasino.com	180
mean	**261.49**
std. dev.	**59.64**

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Benign

avast.com	5
adriaticobishkek.com	1
google.com	2
mean	**1.27**
std. dev.	**0.65**

Malicious

eveningher.com	83
factvillage.com	81
doacasino.com	19
mean	**63.75**
std. dev.	**23.91**

Features of fast-flux service networks

Domain

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Availability of the network

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Heterogeneity of the agents

- # of networks
- # of autonomous systems
- # of resolved QDNs
- # of assigned network names
- # of organisations

Benign	
avast.com	3
adriaticobishkek.com	1
google.com	1
mean	**1.11**
std. dev.	**0.36**

Malicious	
eveningher.com	49
factvillage.com	46
doacasino.com	14
mean	**38.36**
std. dev.	**12.34**

Features of fast-flux service networks

Domain

- Domain age
- Domain registrar

Availability of the network

- # of DNS records of type “A”
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Heterogeneity of the agents

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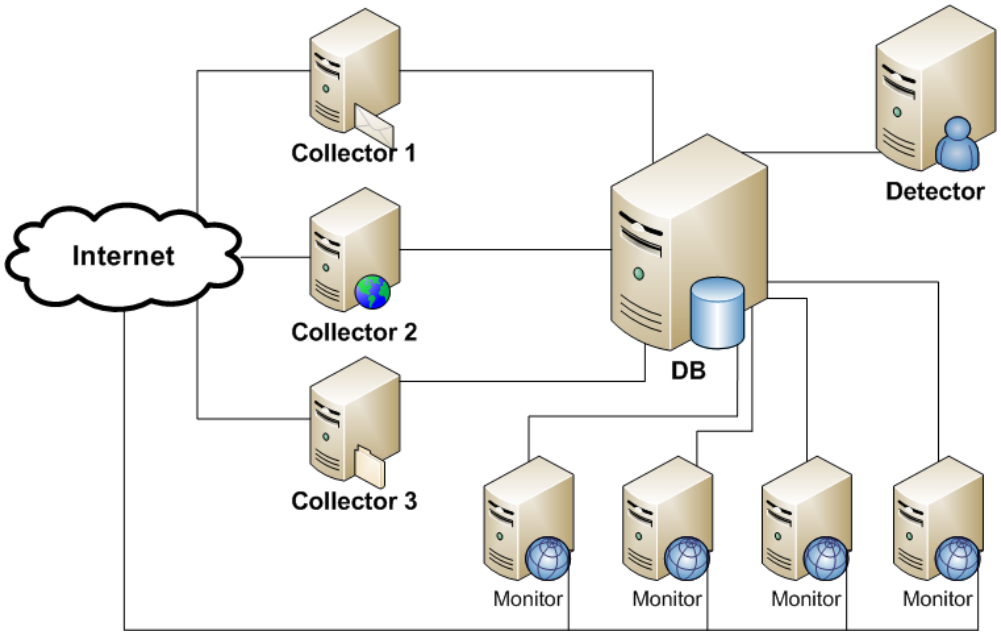
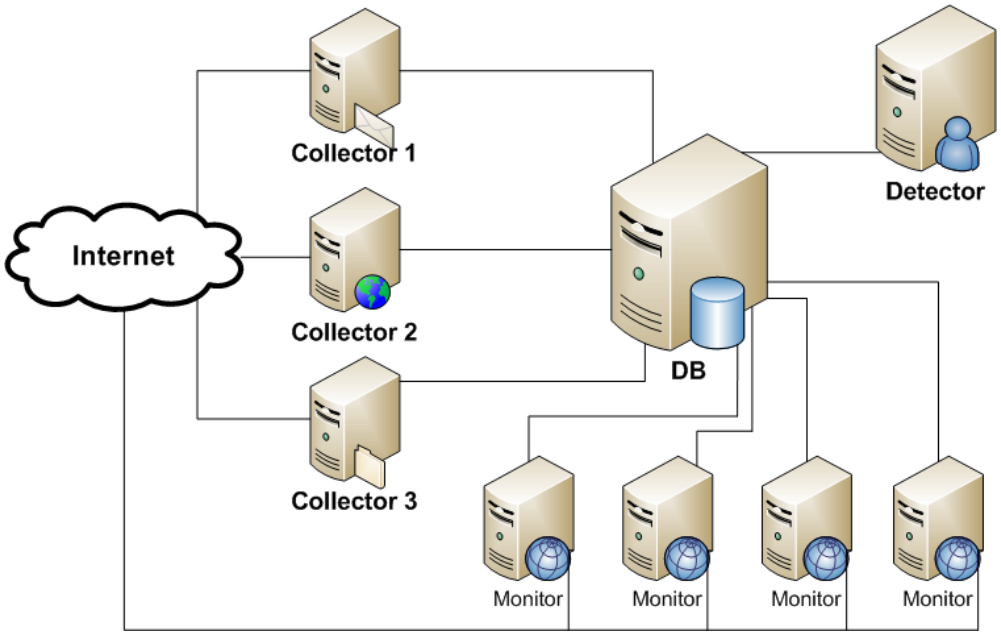
Overall architecture



Collector

- harvests domain names from various sources (e.g., spam emails, DNS queries, . . .)
- each collected domain name is flagged as *suspicious*

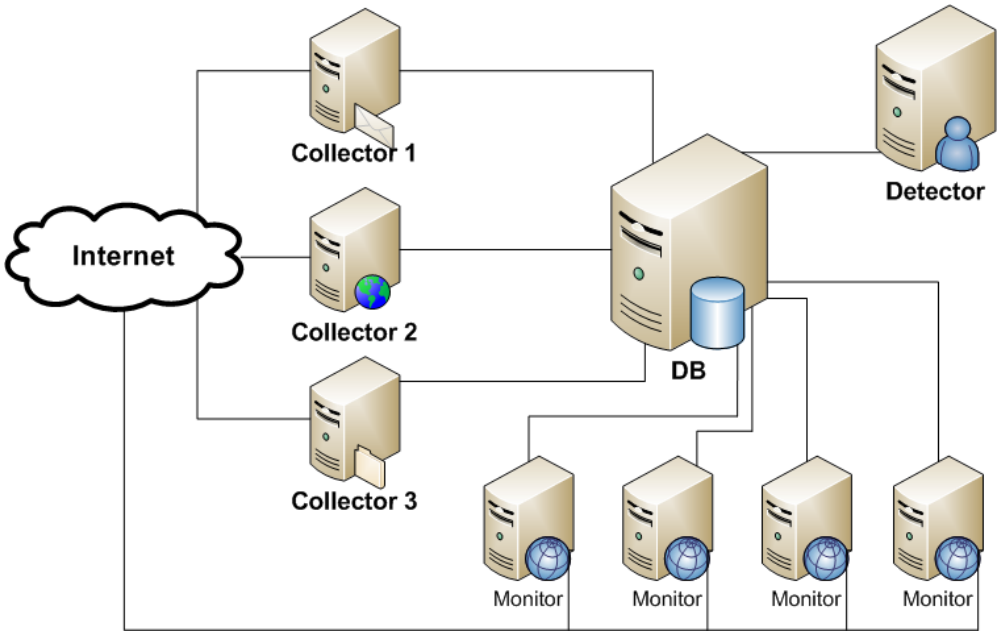
Overall architecture



Monitor

- for each suspicious domain name, it collects characterizing features
- for each malicious domain name, it enumerates the IP addresses of the agents serving the network

Overall architecture



Detector

- automatic classification of domain names as malicious or benign
- combine collected features using naïve Bayesian classifier
- training sets: 50 benign + 58 malicious domains (manually classified) — automatic cross-validation

Implementation and deployment of the system

Implementation & deployment

- $\sim$ 2150 lines of Python code + web interface
- MySQL DB (3 tables, the biggest one has $\sim$75 millions tuples)
- distributed on 5 hosts (1 DB + 1 collector + 2 monitor + 1 detector)

Experimental results

Detection accuracy

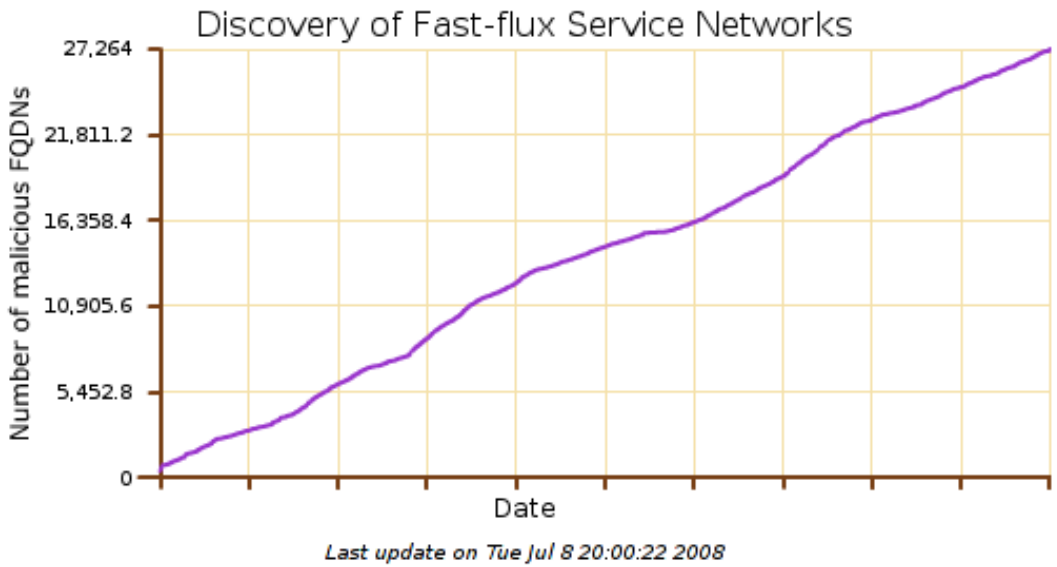
Testing strategy:

- manual analysis of a random subset of the active domains
- just 1 hour to tell if a FQDN is malicious or not

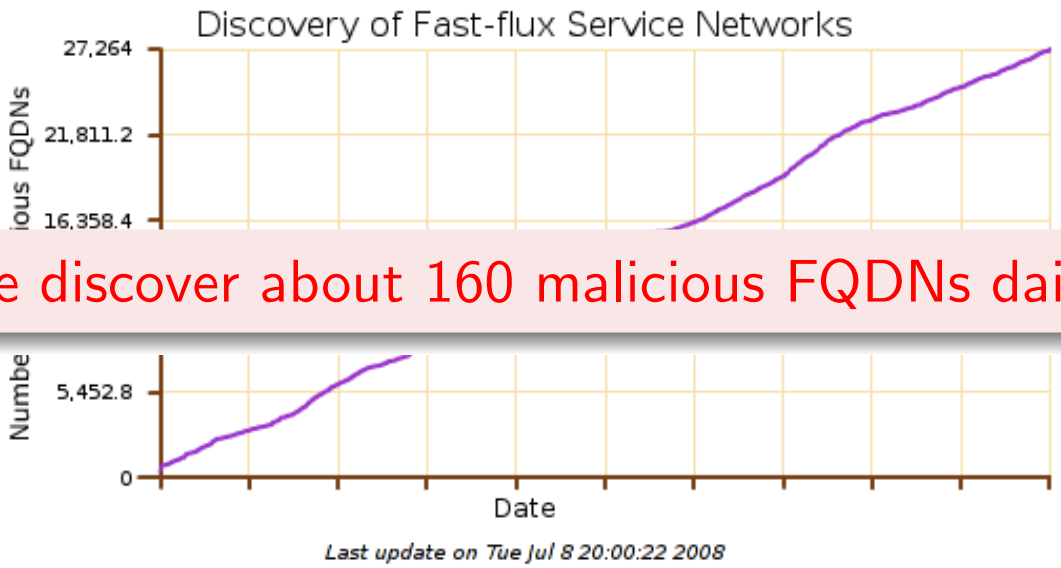
spam e-mails	989530
FQDNs	100508
benign FQDNs	56920
inactive FQDNs	35902
malicious FQDNs	**27264**
agents	**479546**

Table: Summary of the results obtained using FluXOR since January 2008.

Experimental results

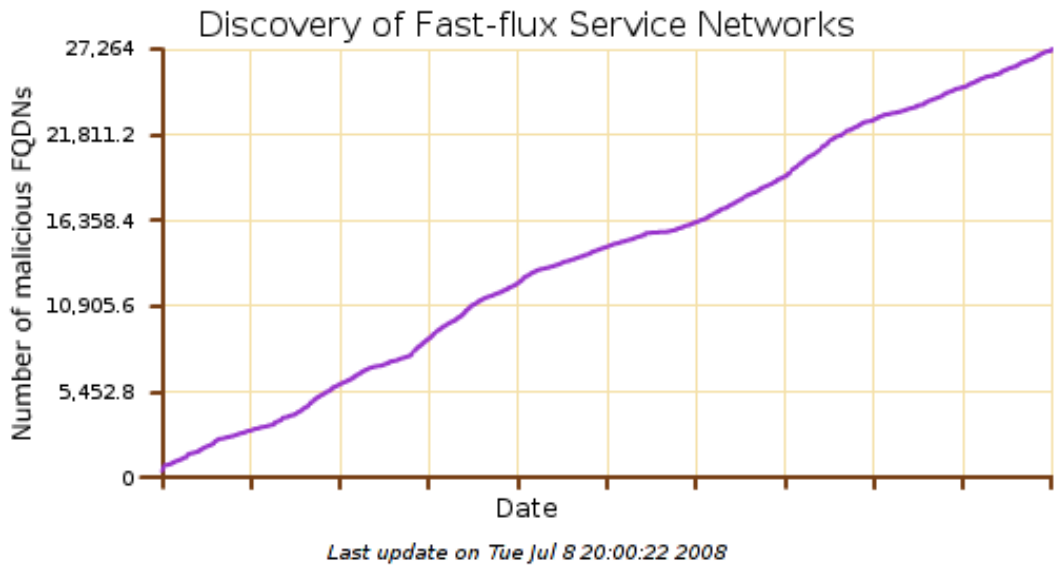


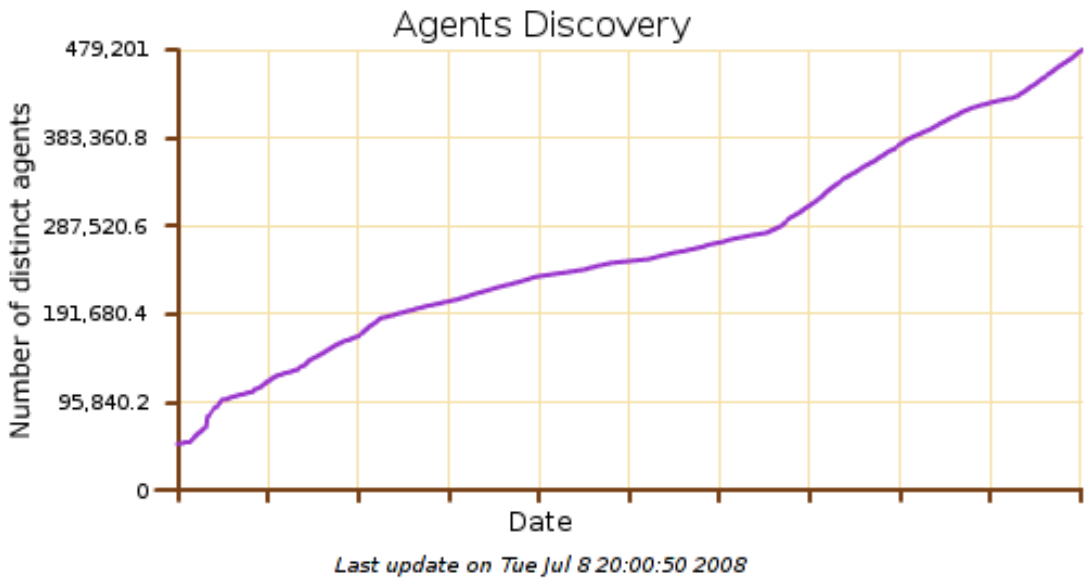
Experimental results



We discover about 160 malicious FQDNs daily!

Experimental results





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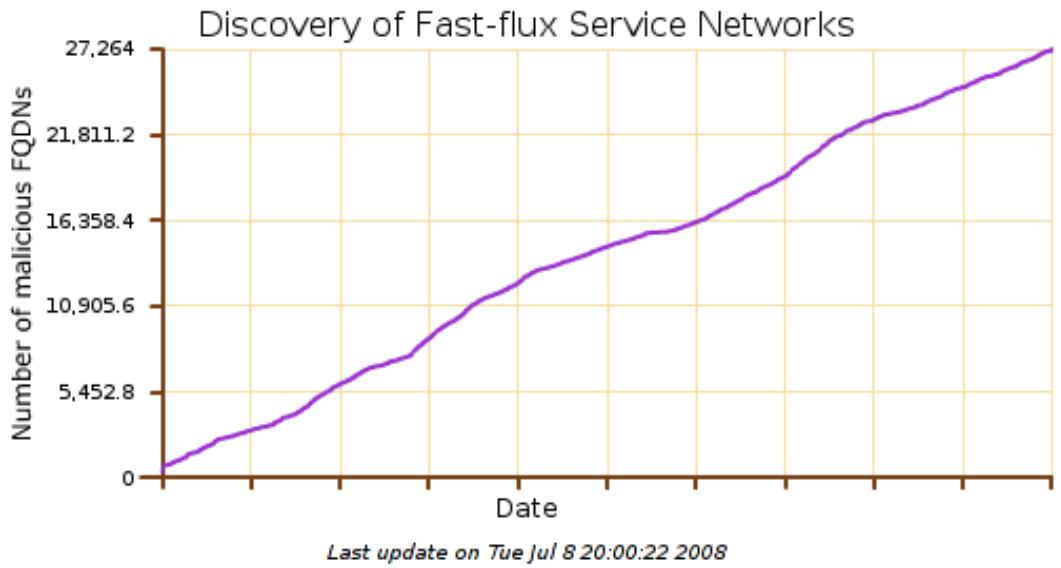

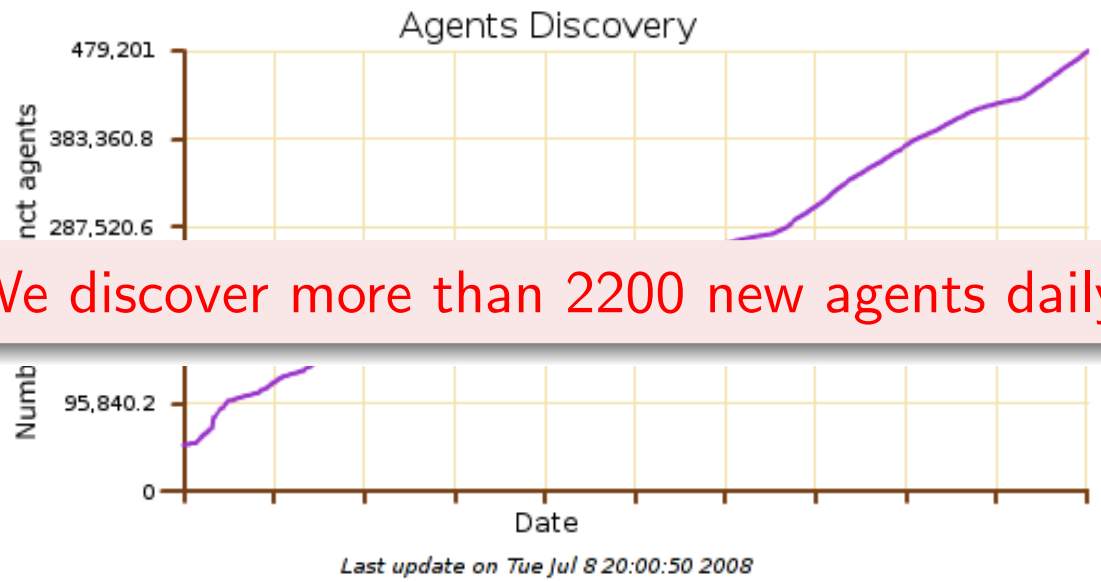

We discover more than 2200 new agents daily!

Conclusions

Contributions

- identification of the features that characterize fast-flux botnets
- experimental system to monitor fast-flux service networks
- empirical analysis of the fast-flux phenomenon

FluXOR: on-line web interface

Real-time results are publicly available on-line at:

`http://fluxor.laser.dico.unimi.it/`

Please wait until this afternoon: we have a (planned) blackout right now at our department in Milan ;-)

Thanks for the attention!

Questions?

`http://fluxor.laser.dico.unimi.it/`

The average system load is 9.78, we need a sponsor!!