Exploring Spamming Botnet Signatures and Characteristics

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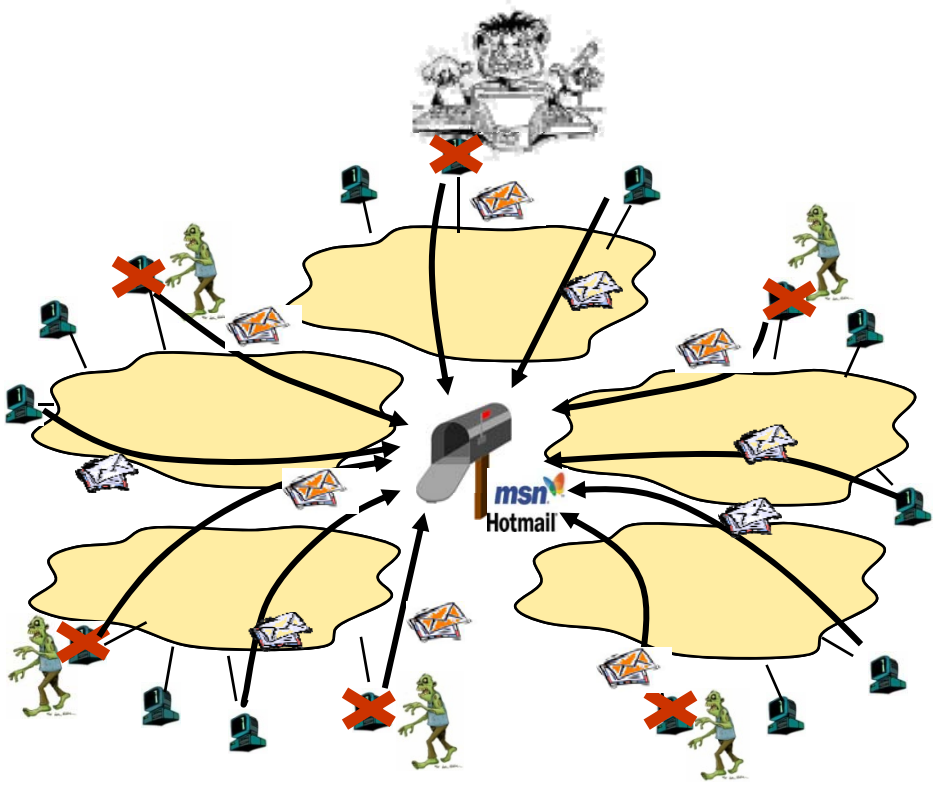
Motivations

- Botnet attacks are prevalent
  - DDoS, spam, click fraud
  - Large-scale, hidden trail
- Can we detect them by signatures?
  - Filter future spam emails
  - Detect botnet membership
  - Understand botnet activities and trends



❖ **Focus on URLs instead of contents**
74% of spam contain at least one URL

Two Observations

- Common or similar URLs from a botnet spam campaign
  - Direct users to one or a few Websites
- Botnet attacks are distributed yet bursty
  - **Distributed:** Involve a large number of hosts
  - **Bursty:** spam sent in a short duration

➧ Identify groups of distributed hosts that sent similar URLs in a burst

Challenge I:

- Mixing spam and legitimate URLs in an email
  - Which URLs characterize a Botnet?
  - White list approach does not work

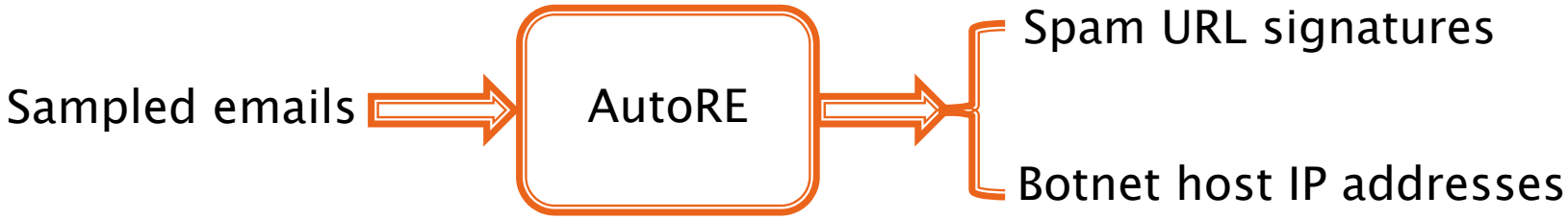
Challenge II:

- Crafting polymorphic URLs across emails
  - Insert random tails
  - Customize based on recipient
  - What are the common URL patterns?

Time	URLs	Source ASes	URLs
2006-11-02	66	38	http://www.lympos.com/n/?167&carthagebolets http://www.lympos.com/n/?167&brokenacclaim http://www.lympos.com/n/?167&acceptoraudience
2006-11-15	72	39	http://shgeep.info/tota/indexx.html?jxvsgfhjb.cvqxjby,hvx http://shgeep.info/tota/indexx.html?ijkkjija.cvqxjby,hvx http://shgeep.info/tota/indexx.html?ibdivvx_ceh.cvqxjby,hvx

AutoRE Overview

Automatic Botnet spam signature generation



How we address challeng

- Mixing legitimate and spa

Require no labeled data or white list

→ "distributed" and "bursty" spam activity

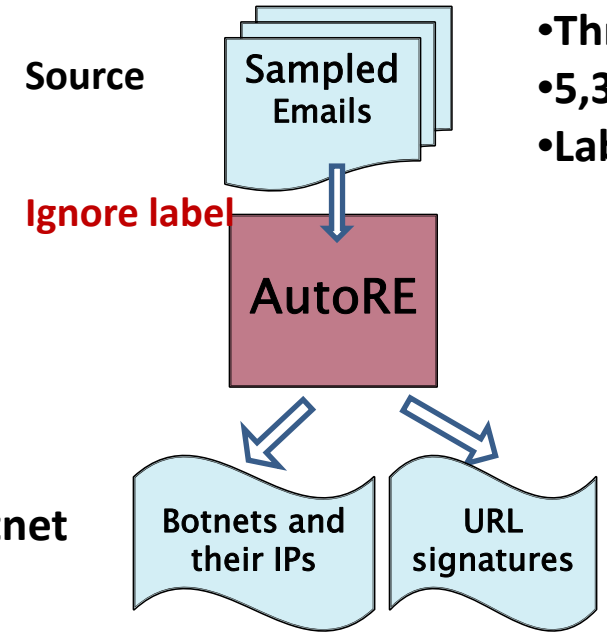
- Porlymorphic URLs

→ Two

FP rate 10x – 30x lower than keywords
FN rate10x lower than complete URLs

• **regular expressions**

Experiment Results



- Three months of sampled emails
- 5,382,460 email messages
- Labeled with spam or non spam

- Identified 7,721 botnet spam campaigns
- Span 5,916 ASes
- 340,050 botnet IP addresses
- 0.5% false positive rate

- 16% -18% of spam not captured by well known blacklists
- 0.2% false positive rate

	Nov-06	Jun-07	Jul-07
Num. of Botnets	1,748	2,426	3,547
Num. of Spam	145,510	234,685	200,271
Num. of IPs	100,293	131,234	113,294

Example Spam URL Signatures

http://deaseda.info/ego/zoom.html?QjQRPxbZf**.cVQXjbY,hVX**
http://deaseda.info/ego/zoom.html?giAfS**.cVQXjbY,hVX**
http://deaseda.info/ego/zoom.html?QNVRcjgVNSbgfSR**.XRW,hVX**
http://deaseda.info/ego/zoom.html?afRZQ**.XRW,hVX**
http://deaseda.info/ego/zoom.html?YcGGA**.XRW,hVX**

http://deaseda.info/ego/zoom.html?*{4,18}.[a-zA-Z]{3,7},hvx

http://arfasel.info/hums/jasmine.html? UbSjWcjHC**.cVQXjbY,hVX**
http://apowefe.info/hums/jasmine.html? PSeYVNfS**.cVQXjbY,hVX**
http://carvalert.info/hums/jasmine.html? SfLWVYgRIBH**.XRW,hVX**

http://[^\/]*/hums/jasmine.html?*{4,18}.[a-zA-Z]{3,7},hvx

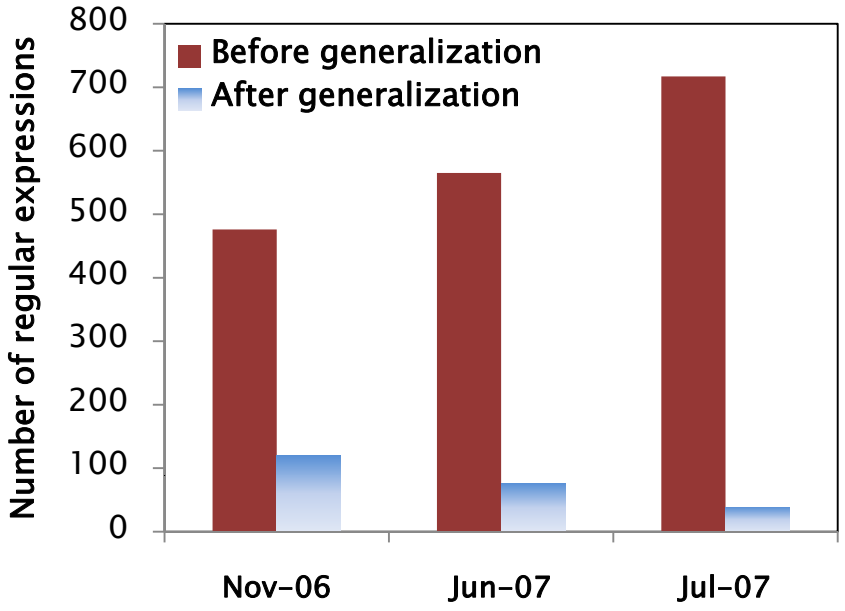
http://www.mezir.com/n/?167& acetyleneassign
http://www.aferol.com/n/?167& commonwealcirce
http://www.bedremf.com/n/?167& deprivationalign
http://www.mokver.www/n/?167& bleachbeneficial

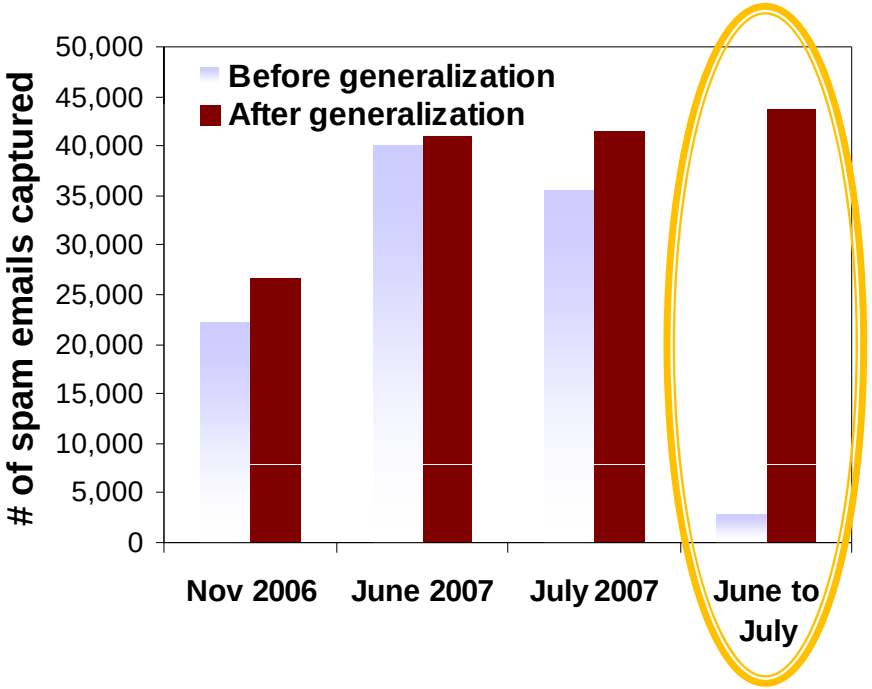
http://[^\/]*/n/?167&[a-zA-Z]{9,27}

Signature Domain Generalization

http://www.bedremf.com/n/?167&[a-zA-Z]{10,19}
http://www.mokver.www/n/?167&[a-zA-Z]{11,23}

→ http://[^\/]*/n/?167&[a-zA-Z]{9,27}





Source of Botnets

- Botnet IP addresses are less than 0.5% of all IPs
- Their spam emails:
  - 4%–6% of all detected spam

AS description	AS number	Number of bot IPs
Korea Telecom	4766	15757
Verizon Internet Service	19262	11426
France Telecom	3215	11303
China 169-backbone	4837	9960
Chinanet-backbone	4134	8113

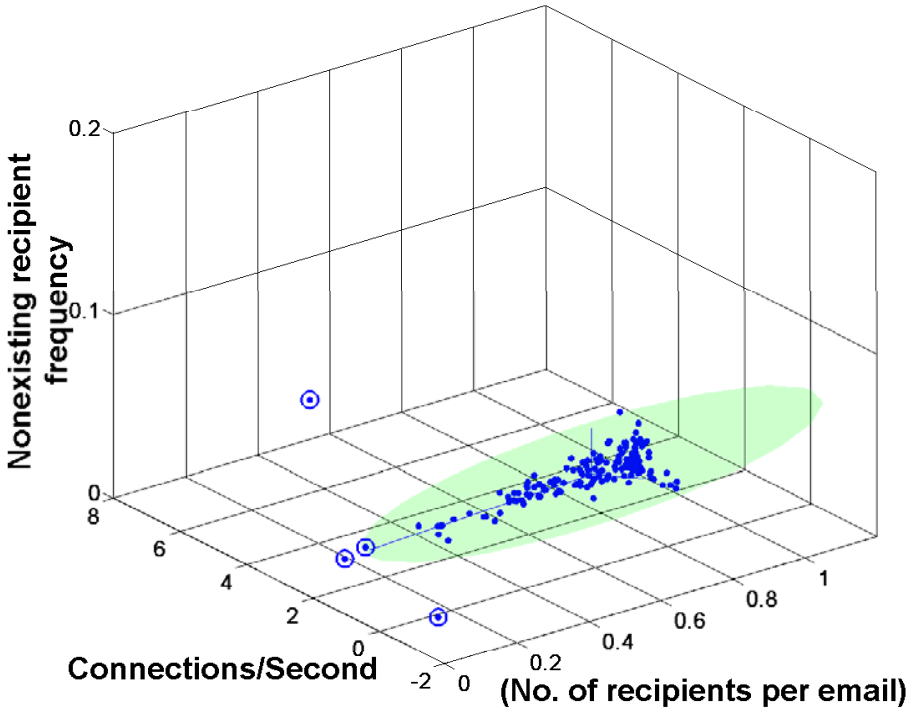
Email Sending Characteristics

- Email content similarity
  - Destination Web pages
    - Over 90% at least 75% similar
  - Features: # of URLs, # of domains, email length
    - Over 95% with negligible std
  - Email text
    - Over 60% less than 50% similar
- Sending behavior similarity
  - Over 90% with sending time std <20 hours
  - Over 50% with sending time std < 1.8 hour
  - Clustering botnet sending patterns

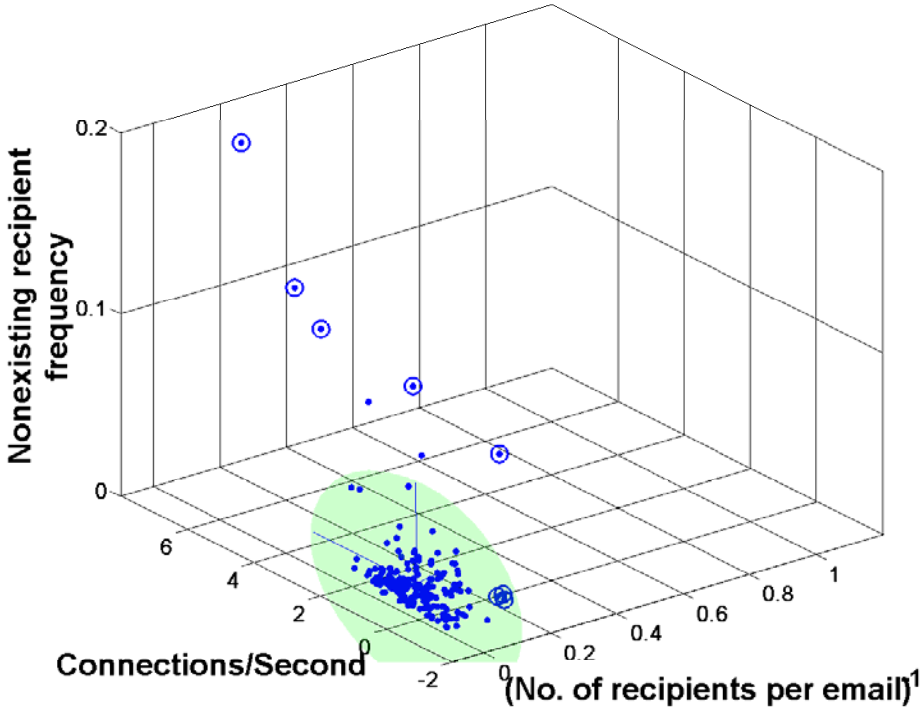
Example Per-Botnet Clusters

- 85% of spam campaigns are well clustered

162 hosts with 4 outliers

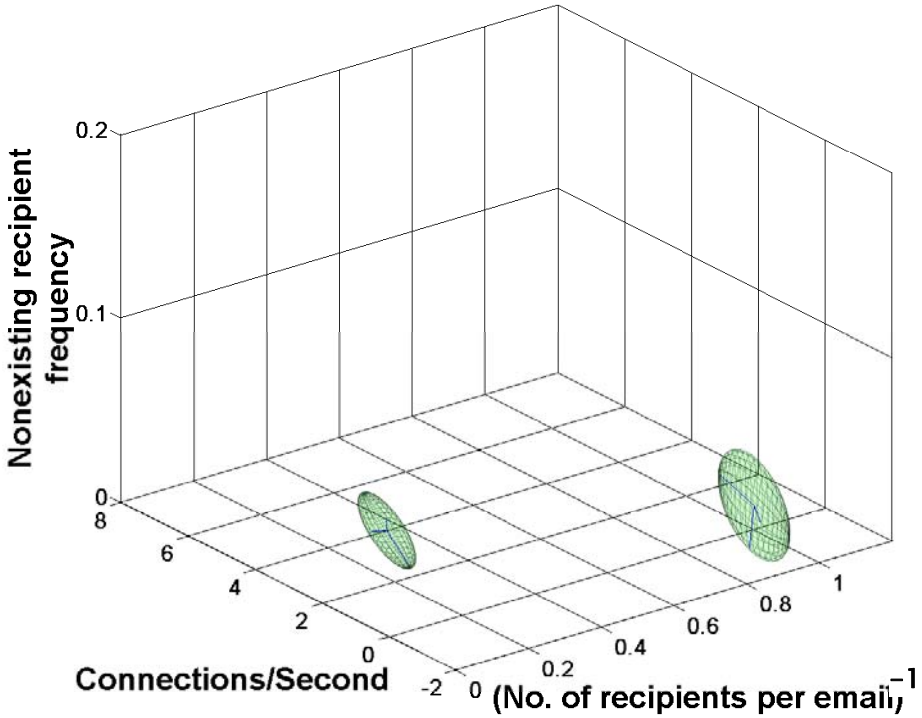


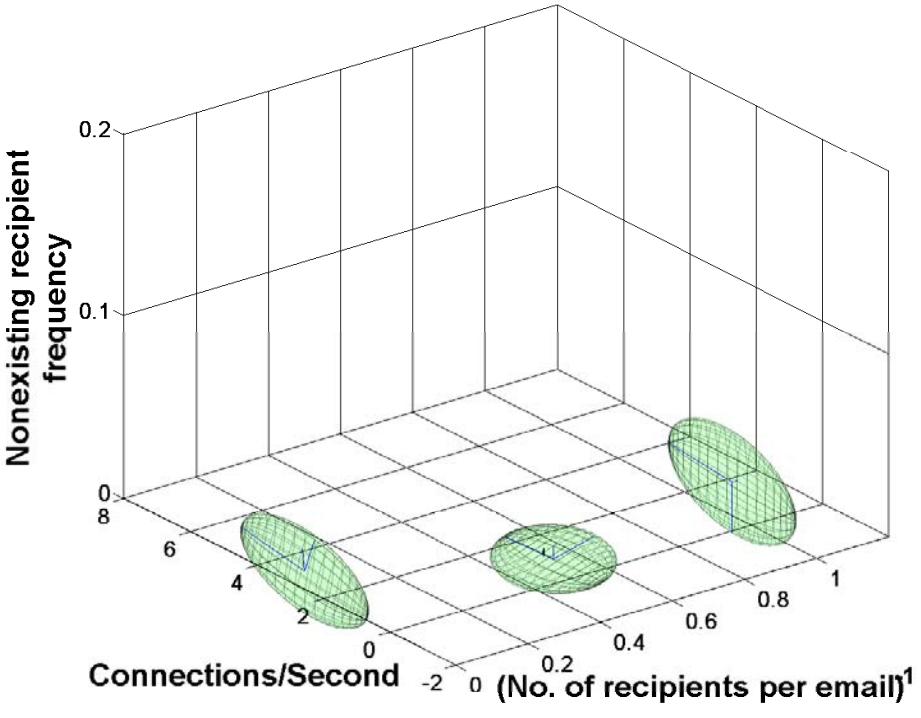
191 hosts with 9 outliers



All-Botnet Clusters

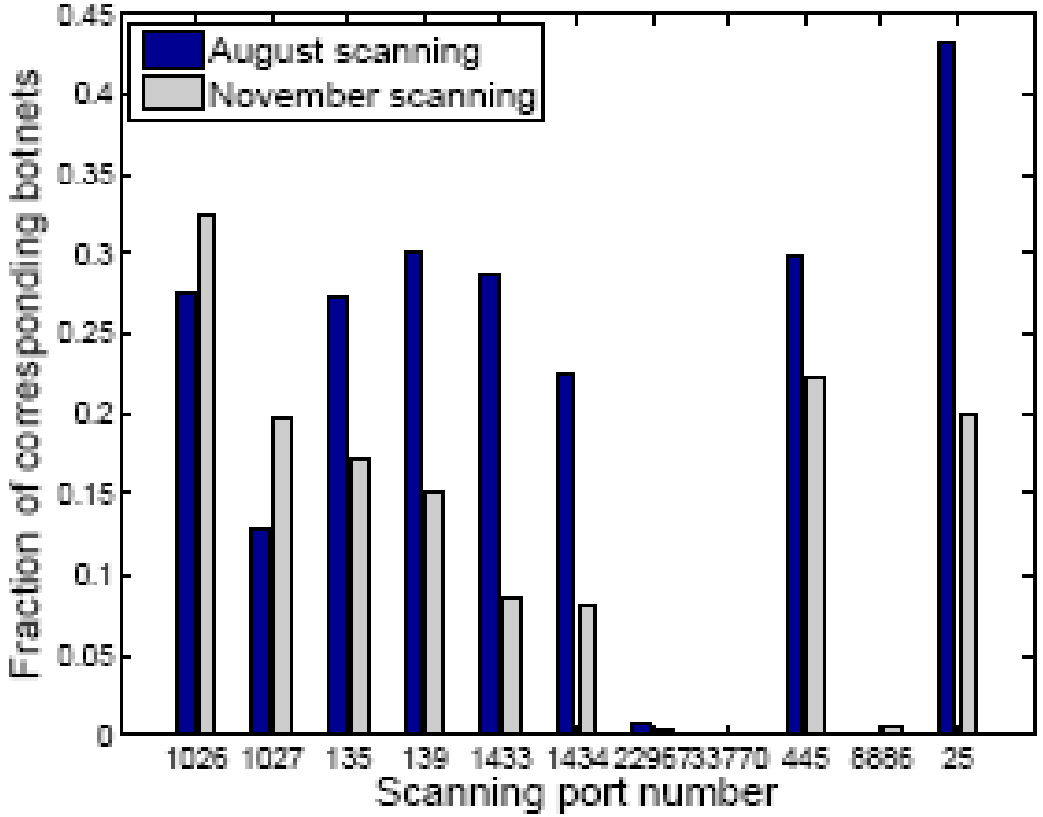
- Botnet sending activities are clusterable





Scan History

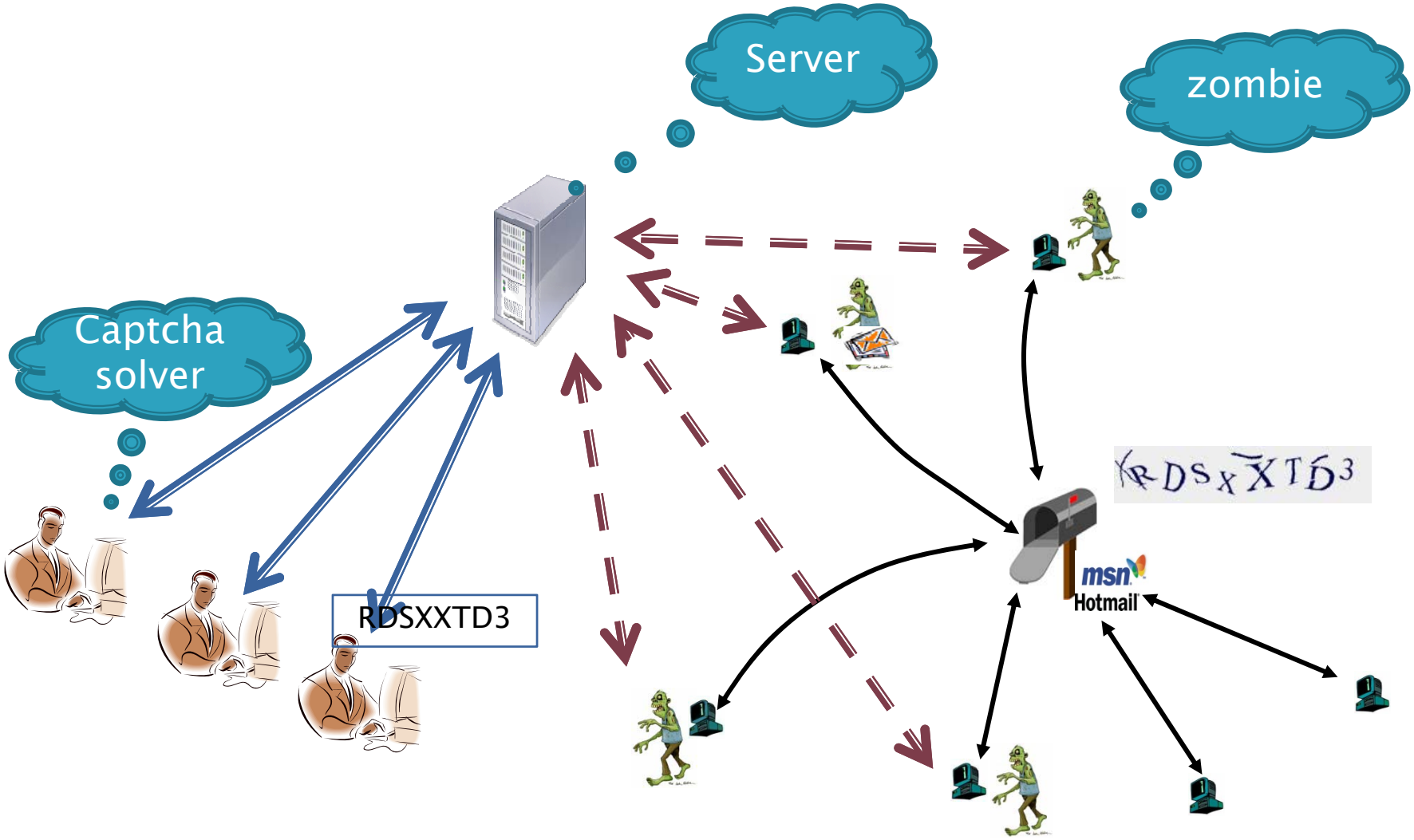
- Higher correlation in Aug than in Nov



Summary of Botnet Activities

- Botnets are more popular for sending spam
  - Number of spam campaigns doubled
  - Number of botnet IPs increased by 10%
- Spam campaigns are more stealthy
  - Adoption of polymorphic URLs increased by 50%
- Email sending patterns are clusterable when viewed in aggregate
- Botnet activities show correlation with the network telescope data

New Types of Botnet Spamming Attacks



Our Experiences

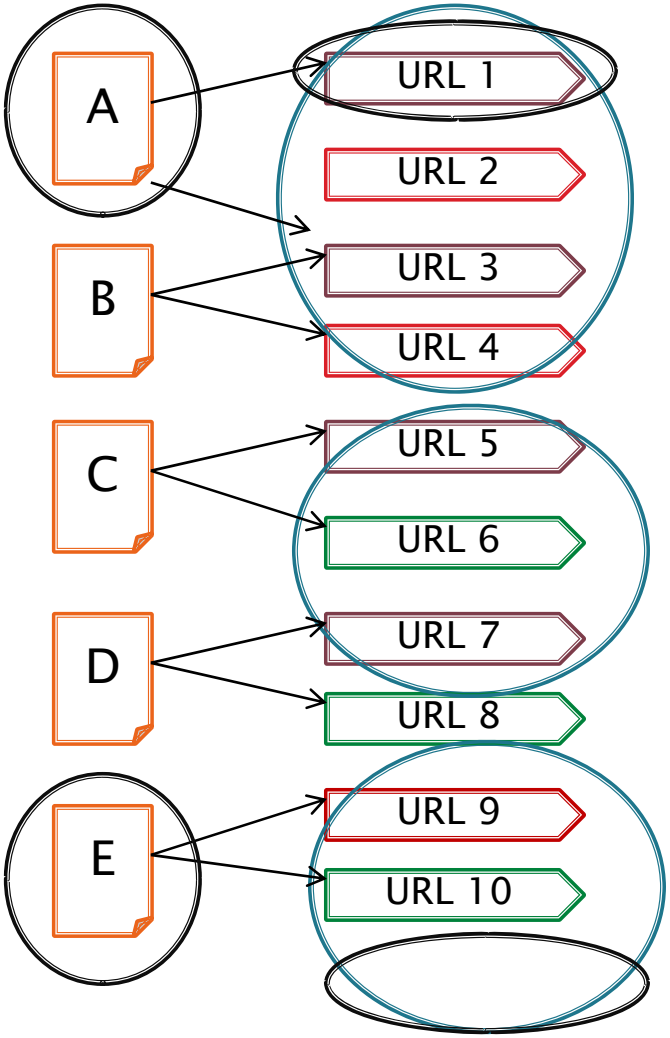
- Large volume of input data
  - Efficient algorithm
  - Distributed computing infrastructure
- Attackers are stealthy and evolving
  - Individual detection difficult
  - An aggregated view for detection
  - Robust features or attack invariant
- Rigorous evaluation challenging
  - Usually no ground truth data
  - Collaborative monitoring

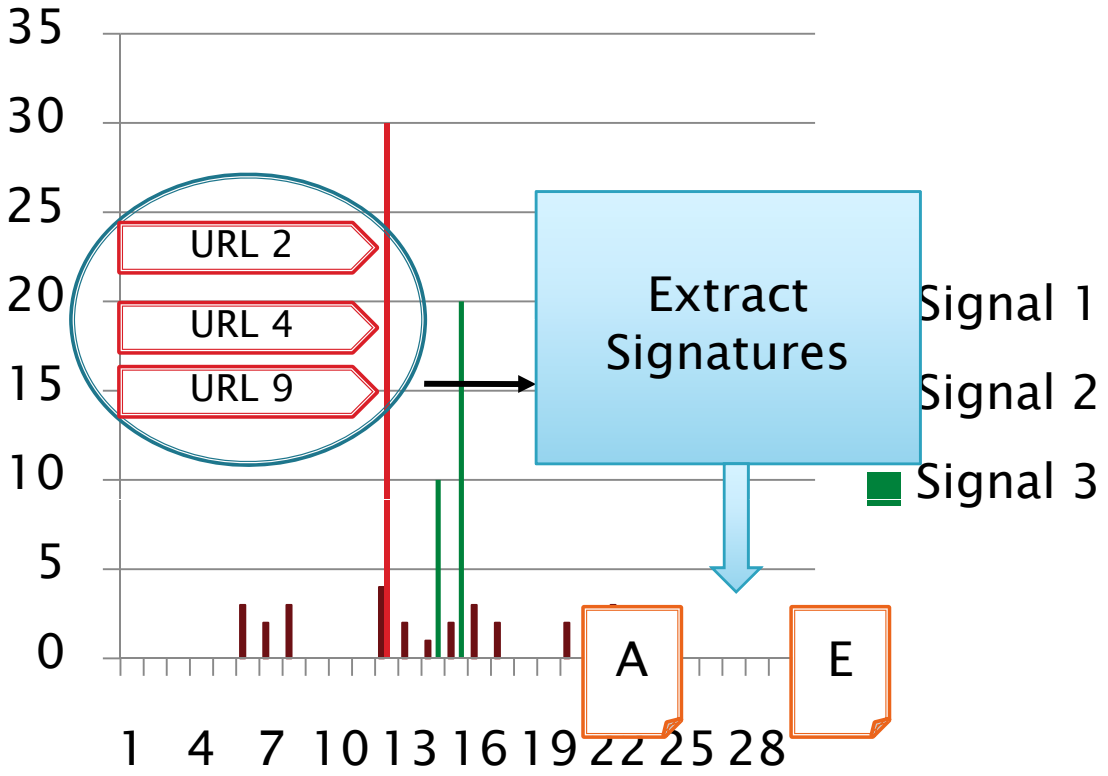
Open Questions

- Economic underpinnings of botnet attacks
- Information sharing for collaborative research
- Attack forensics and deterrence

Thanks!

Candidate URL Selection





Regular Expression Generation

- Why regular expressions?
  - Need specific signatures