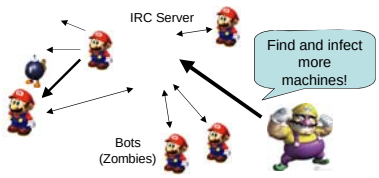
Botnet Analysis & Defense

Dawn Song
dawnsong@cs.berkeley.edu

What is a botnet?

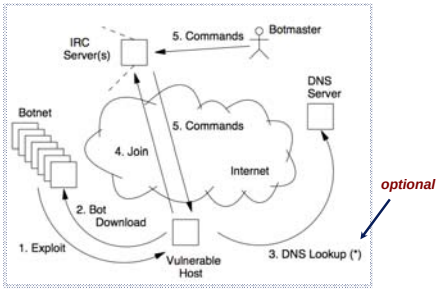
- **An army of compromised hosts ("bots") coordinated via a command and control center (C&C). The perpetrator is usually called a "botmaster".**



"A botnet is comparable to compulsory military service for windows boxes"

-- Bjorn Stromberg

Typical (IRC) infection cycle



Bots usually require some form of authentication from their botmaster

Botnet Analysis & Defense

- **Study of botnet phenomena**
  - **How prevalent are botnets?**
    - » **How many botnets are there?**
    - » **What are their sizes?**
  - **What techniques/tactics do attackers use?**
  - **What are botnets used for?**
  - **What are the trends for botnets?**
- **Detect & defend against live botnets**
  - **What methods can we devise?**

4

What Methods Can you Design to Study/Measure Botnet Phenomena?

- **HoneyX to entice attackers**
  - **Honeynet/honeypots**
  - **Honey email accounts**
  - **HoneyMonkey**
    - » **Craw the web to find drive-by downloads, etc.**
- **Botware analysis**
  - **Gray-box/black-box testing**
  - **Binary analysis**
- **Live tracking**
  - **IRC tracking**
  - **DNS cache probing**

5

You Can Build a HoneyKingdom in Your Garage

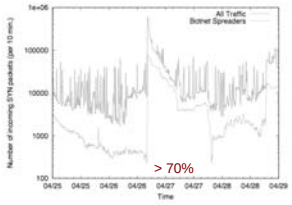
- **A local darknet + 14 PlanetLab nodes**
  - **record ~1 GB of traffic daily**
  - **over 4000 “unique” binaries over months**
- **Even easier to set up Honey email accounts**

6

How much botnet traffic is out there?

- **From a two week snapshot of total incoming SYN packets to darknet, 27% can be attributed to known botnet spreaders**

~20,000 connection attempts every 10 mins



Botware Analysis

- **A *wide* range of technical skills in the botmasters**
- **Bot software is fairly advanced**

Utility Software Thread	Frequency (%)
FTP Server	86
TFTP Server	85
AV/FW Killer	55
System Security Monitor	49
Registry Monitor	41
Identd Server	31
ConnectBack Backdoor	9

IRC-Tracking: What are botnets being used for?

piracy

mining

attacks

hosting

Activities we have seen

Stealing CD Keys:

```
ying!ying@ying.2.tha.yang PRIVMSG #atta :BGR|0981901486 $getcdkeys
BGR|0981901486!nmavmkmyam@212.91.170.57 PRIVMSG #atta :Microsoft Windows
Product ID CD Key: (55274-648-5295662-23992).
BGR|0981901486!nmavmkmyam@212.91.170.57 PRIVMSG #atta :[CDKEYS]: Search
completed.
```

Reading a user's clipboard:

```
B][!Guardian@globalop.xxx.xxx PRIVMSG ##chem## :~getclip
Ch3m|784318!~zbhibvn@xxx-7CCCB7AA.click-network.com PRIVMSG ##chem## :-
[Clipboard Data]- Ch3m|784318!~zbhibvn@xxx-7CCCB7AA.click-network.com PRIVMSG
##chem## :If You think the refs screwed the seahawks over put your name down!!!
```

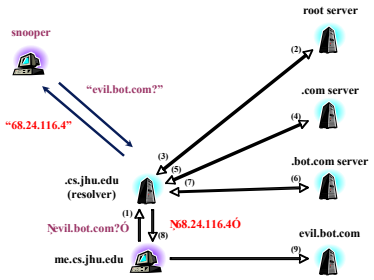
DDoS someone:

```
devil!evil@admin.of.hell.network.us PRIVMSG #t3rr0r0Fc1a :!pflood 82.147.217.39
443 1500 s7n|2K503827!s7s@221.216.120.120 PRIVMSG #t3rr0r0Fc1a :\002Packets\002
\002D\002one \002;\002>\n s7n|2K503827!s7s@221.216.120.120 PRIVMSG #t3rr0r0Fc1a
flooding....\n
```

Set up a web-server (presumably for phishing):

```
[DeXTeR]!alexo@l85-130-136-193.broadband.actcom.net.il PRIVMSG [Del]29466
:.http 7564 c:\\ [Del]38628!zaazbob@born113.athome233.wau.nl PRIVMSG _[DeXTeR]
:[HTTPD]: Server listening on IP: 10.0.2.100:7564, Directory: c:\\.
```

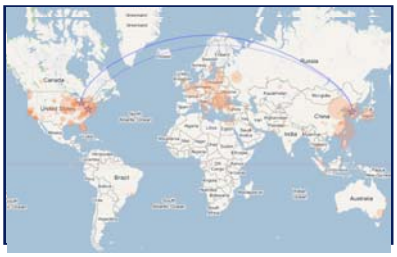
DNS Cache Probing



- What's the limitation with DNS cache probing?

Visualizing botnet footprints via DNS Cache Probing

- Infections in 11% of 800,000 DNS domains



Fun with GoogleMaps and IP2Location

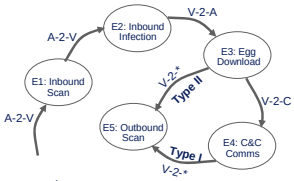
Fabian Monrose

Live Botnet Detection & Defense

- **Vantage Point**
  - **Enterprise perimeter/egress point monitoring**
    - » **BotHunter**
  - **Internet wide-scale monitoring**
    - » **AT&T Wide-scale Botnet Detection & Characterization**

BotHunter: Dialog-based Correlation

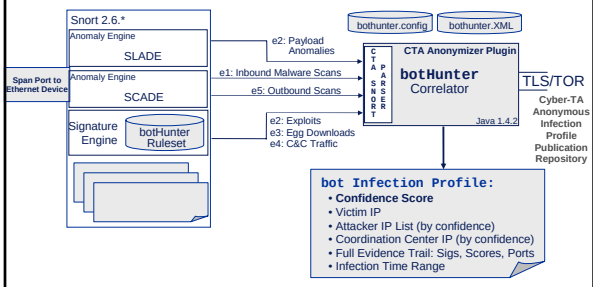
BotHunter employs an ***Infection Lifecycle Model*** to detect host infection behavior



- Egress point (internal – external)
- Search for duplex communication sequences that map to I.L. model
- Stimulus does not require strict ordering, but does require temporal locality

Guofei Gu

BotHunter: Architecture Overview



Guofei Gu

Limitations of BotHunter

- **Alert generation**
  - **SLADE: statistical payload anomaly detection engine**
    - » **Evasion?**
  - **Signature engine**
    - » **E2 rulesets: exploit injection**
    - » **E3 rulesets: download events**
    - » **E4 rulesets: protocol, behavior & payload content signature for IRC & HTTP bot C&C**
    - » **E1 & E5: scan detection**
    - » **Evasion?**
- **Alert correlation**
  - **Can't cover slow attacks**
  - **Scalability?**

Internet Wide-scale Monitoring & Detection (AT&T)

- **Identifying suspicious bot machines**
  - **Spam**
  - **Scanning**
  - **DDoS**
- **Identify candidate controller conversations**
  - **Identify hubs communicating with many bot machines**
  - **Identify IRC-like traffic with bot machines**
- **Analyze candidate controllers**
- **Limitations?**

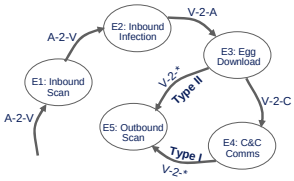
Comparison of Two Approaches

- **Can you apply the AT&T method to enterprise networks?**
- **Can you apply BotHunter to large ISP networks?**

Break Time

- **This time we are really going to take a break :-)**

A Generic Bot Cycle



How do you generalize the cycle?

1. **Recruiting and taking control of bot machine**
2. **Communicating & obtaining commands through C&C**
3. **Conducting malicious tasks**

Design Your Favorite Bot

- **Desired properties**
  - **Strong survival ability**
    - » **Stealthy**
    - » **Die-hard/Recover/resurrect**
  - **Slavery**
    - » **Robust communication to master**
    - » **Receive orders ONLY from real-master**

How to Achieve Desired Properties in Bot Cycle

- **Bot Cycle:**

1. **Recruiting and taking control of bot machine**
2. **Communicating & obtaining commands through C&C**
3. **Conducting malicious tasks**

- **Desired properties**
  - **Strong survival ability**
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Recruiting and taking control of bot machine (I)

- **Stealthy**
  - **Gain control**
    - » **Low rate scanning, polymorphic attacks, etc.**
  - **Hold control**
    - » **Rootkits, VM-based rootkits**
    - » **Memory-resident only (issues?)**
    - » **Hide in other processes**
    - » **Don't bother users**
- **Die-hard/Recover/resurrect**
  - **Patch all the security holes**
  - **Watch attempts to kill bot & restart**

Recruiting and taking control of bot machine (II)

- **Other tricks**
  - **Making it hard to analyze bots**
    - » **DoS attacks on analyzers**
  - **Making it hard to obtain bot footprint**
    - » **Kill harddrive as soon as detecting any attempt to compromise nodes**
  - **Targeting low profiles**
    - » **Avoid .mil, .gov, etc.**

Communicating & Obtaining Commands through C&C--- How to Be Stealthy?

- **Decentralized: e.g., p2p**
- **Asynchronous C&C**
- **Mimic legitimate communication profile**
- **Add randomness in communication (no periodicity)**
- **Encryption**
- **Stegnography**
- **Hiding commander**
  - **Change topology often**
  - **Anonymous communication**
    - » **Onion routing**
    - » **Dining cryptographer network**
- **Covert communication**
  - **ICMP, one-way communication**
- **Ensure minimum loss of information about botnet structure given the loss of a node**

Communicating & Obtaining Commands through C&C--- How to Be Robust?

- **Very few students discussed this point**
- **Built-in redundancy**
- **Self-repairing in routing**
- **Secure routing**
  - **Even if some nodes are "compromised"**

25

Conducting Malicious Tasks

- **Stealthy**
  - **Low rate attacks**
  - **Different parts of botnet carry out different tasks**
- **Robust**
  - **Specific to different attacks**

26

How to Defend against Joe's Favorite Bot?

- **Bot Cycle:**

1. **Recruiting and taking control of bot machine**
2. **Communicating & obtaining commands through C&C**
3. **Conducting malicious tasks**

- **Desired properties**
  - **Strong survival ability**
    - **Stealthy**
    - **Die-hard/Recover/resurrect**
  - **Slavery**
    - **Robust communication to master**
    - **Receive orders ONLY from real-master**

27

Preventing Recruiting and taking control of bot machine

- **Does absolute host security solve the problem?**
- **Educating users?**
- **Any silver bullet?**
  - **Hopeless?**
  - **Bot programs don't require root**
  - **With Web 2.0, running third-party code is more prevalent**

Detecting & Destroying C&C

- **What does it take?**
  - **Network monitoring for communications with suspicious nodes**
    - » **Bots could deliberately communicate with legitimate nodes to make analysis even more difficult**
  - **Insider view**
    - » **Doesn't work for small botnets**
- **IP addr is not a trust-worthy/long term identifier**
  - **Will authenticated traffic help?**
- **How about ISP cutting off offending nodes?**
  - **Why should ISP do it?**

Preventing Bots from Conducting Malicious Tasks

- **Ideas?**
  - **Depending on different tasks**
- **Different angle**
  - **Reduce economic incentives**

Summary

- **Botnets is real, serious, & here to stay**
- **How to defend against it?**
  - **No single silver bullet**
  - **Need many pieces of the puzzle**
- **Next class**
  - **Privacy-breaching malware**