HIVE: an Open Infrastructure for Malware Collection and Analysis

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1st Workshop on Open Source Software
for Computer and Network Forensics
2008

Goals

- a forensics approach to Internet malware and botnets
- self-spreading malware study and classification
- monitoring of attack trends and targets
- botnets behavior, structure and evolution

To achieve these goals we built an **automated** infrastructure for malware collection and analysis.

Outline

1. Introduction
   - Malware
   - Honeypot
2. HIVE
   - Architectural design
   - Experimental setup
   - Preliminary results
3. Conclusions

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Malware

Malware = **mal**icious soft**ware**

- unwanted software with an agenda
    - virus
    - worm
    - trojan horse
    - spyware
    - ..
- malware spreads
    - automatically, relying on software bugs to self-replicate itself on new computer systems
    - manually, employing social engineering techniques against the users
- malware types
    - strictly destructive
    - for profit
        - SPAM and phishing
        - ransom requests
        - botnet construction

Botnet

- distributed network of autonomous programs (**bot**)
- created spreading *ad hoc* malware
    - infected computers turn into **zombie** systems
    - stealth behavior
- the attacker (**botherder**) remotely controls its botnet
    - using IRC or HTTP (centralized botnet)
    - using peer-to-peer protocols (distributed botnet)
- ...and rents its services to the best offer
    - criminal organizations
    - SPAM and advertisement
    - phishing
    - Distributed DoS attacks
    - "data mining"
- self-sustaining and reliable source of income

Honeypot

- decoy computer system designed to attract external attacks
  - human: study attacker behavior
  - automated: collect the malware binary code
- no valuable data (fake data sometimes used as bait)
- used to study attacks dynamics and attacker's tools
- sits on an otherwise unused IP space (**darknet**)
- **honeynet** = a network of honeypots

Honeypot: types

Low interaction honeypot

- software simulation of a computer system
- efficient: a single machine can simulate a large network
- not so effective: attack can fail due to simulation mishaps
- quick and easy to deploy, low TCO

High interaction honeypot

- a *real* vulnerable computer system
- very effective: the attacker compromises an actual system
- expensive to deploy and maintain, higher TCO
- legal liability issues

State of the art

We currently have:

- several low-interaction honeypot implementations
  - but there is no standardized framework for high-interaction honeypots
  - most works on the subject tend to reinvent the wheel
- a number of analysis services for malware samples

What we lack is an integrated framework encompassing the collection of samples, the analysis of malware and the monitoring of detected threats.

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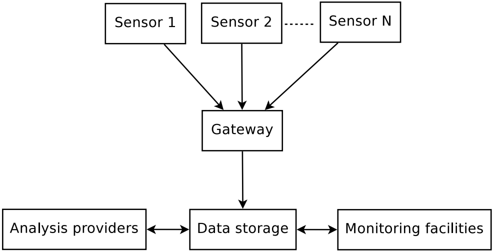
HIVE

HIVE = Honeypot Infrastructure in Virtualized Environment

- integrated infrastructure for malware collection and analysis
- fully automated
- open architecture
  - easy to interact with
  - easy to extend with new tools
- based on proven Open Source software

HIVE: architecture

- three-layered architecture
  - sensors (honeypot)
  - gateway
  - data storage and analysis
- layers are fully decoupled
- extensible and scalable

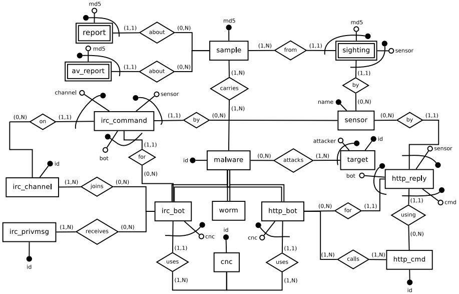


HIVE: honeynet

- a combination of low and high interaction systems
- extensive use of virtualization techniques (VirtualBox)
- automated self-maintenance
    - malware samples collection
    - honeypot systems rebuild

HIVE: database

- use of a relational DBMS (**PostgreSQL**)
  - malware samples storage
  - central repository for all acquired data
  - database views allow aggregate high-level data reporting



- automated samples analysis
  - static analysis: antivirus
  - behavioral analysis
    - CWSandbox
    - Anubis

HIVE: monitoring facilities

Malware analysis provides information on botnets

- C&C address location
- botnet login information

Computer programs disguised as zombies can then infiltrate the botnets

- zombie activity monitoring
- attacks issued
- botnet size and expansion
- attacker behavior and targets

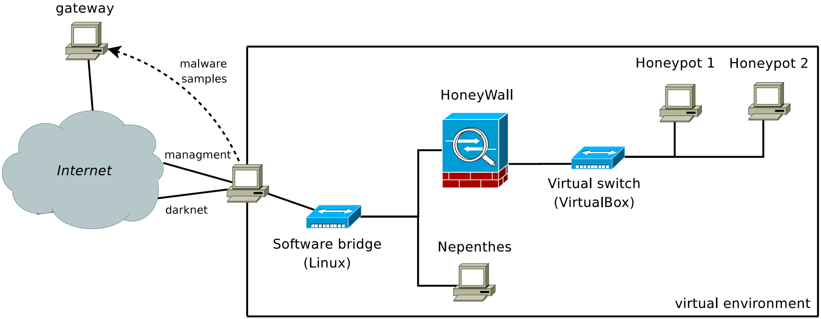
Tools developed

- **infiltrator** (originally by Göbel) for IRC botnets
- **httpmole** for HTTP botnets

Experimental setup

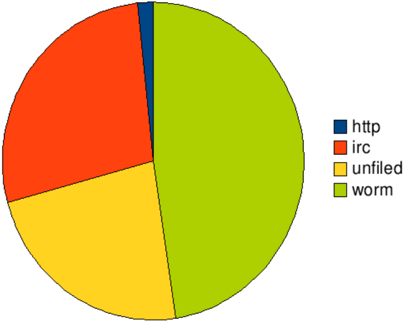
- three-systems virtual honeynet
  - Windows XP
  - Windows 2000 Server
  - Nepenthes (low interaction)
  - deployed on a single physical machine
- darknet: three contiguous IPs on an unprotected commercial network
  - perimetral defense systems can dramatically lower the honeynet efficency

HIVE: honeynet



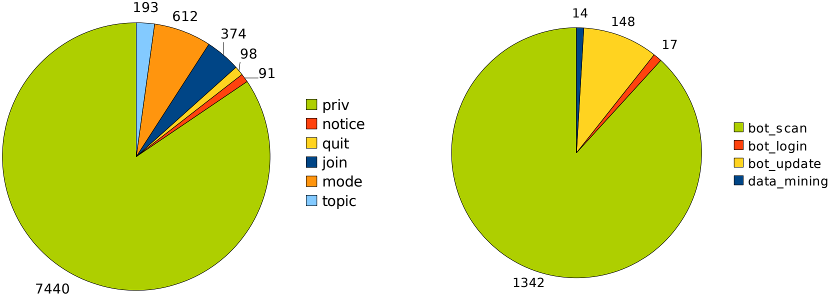
Results: collected malware

- during a month of operation
  - we collected more than 14k malware samples...
  - with 13k unique samples
  - over 50 centralized botnets were monitored



Results: botnets monitoring

Commands detected on the IRC botnets control channels



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Conclusions and future works

To summarize

- botnets are an actual and widespread menace
- HIVE has proved to be an efficient tool for malware collection and analysis

In the future

- reporting engine
- HoneyWall integration
- peer-to-peer botnet study

Availability

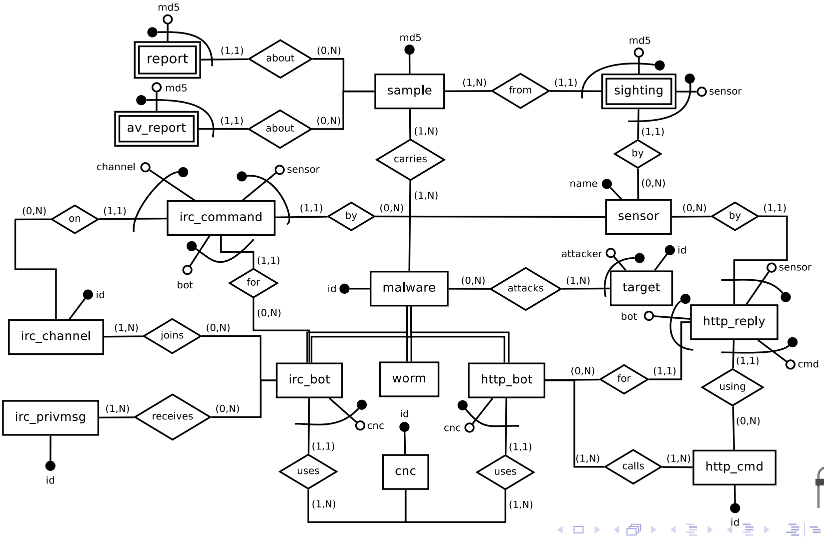
The HIVE software and this presentation can be downloaded from

`http://netlab-mn.unipv.it/hive`

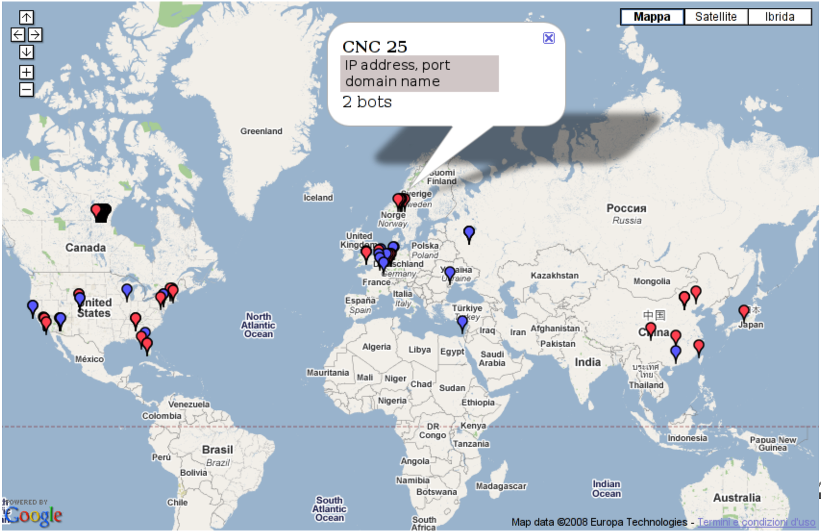
Future updates will be published at the same location.

Questions?

Simplified Entity-Relationship diagram



Botnets C&C map



CNC 25

IP address, port
domain name

2 bots

Chart: sightings

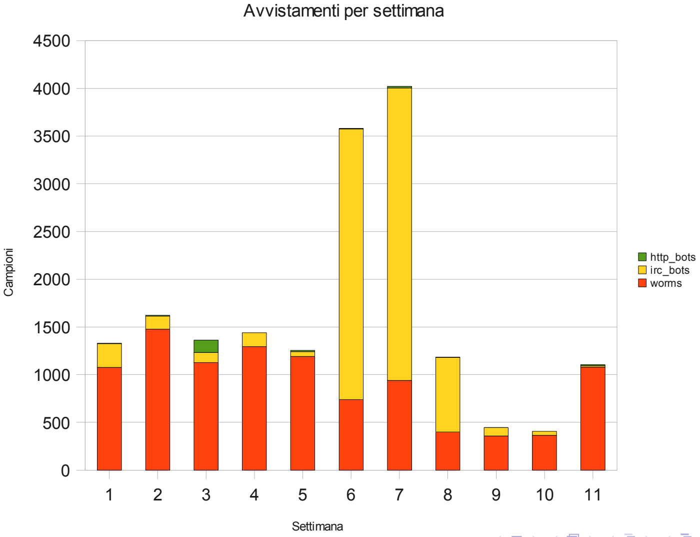
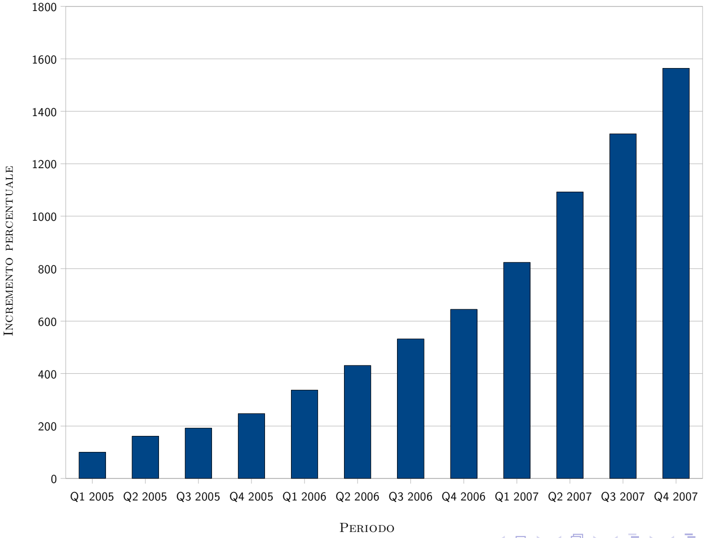


Chart: malware advance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