Designing a Framework for Active Worm Detection on Global Networks

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Outline

- Worms and Internet Epidemics
  - Internet Reachability
  - Code Red v2
- ICMP Destination Unreachables
- DIB:S
- Simulation Results
- Future work and Concerns

Worms

- What is a "Worm"
  - Email Virus?
  - Code Red, Sapphire?
- Definition:

"An autonomous, self-propagating piece of code that enters networked computer systems uninvited."

- Payload

Internet Epidemics: Population

- Total population: N
- Susceptibles: $s(t)$
- Infectives: $i(t)$
- Recovered/Removed: $r(t)$

$$N = s(t) + i(t) + r(t)$$

Internet Epidemics: Equations

- Classic epidemiology (Kermack&McKendrick, 1927):

$$\frac{\mathrm{d}s}{\mathrm{d}t} = -\beta si$$

$$\frac{\mathrm{d}i}{\mathrm{d}t} = \beta si - \gamma i$$

$$\frac{\mathrm{d}r}{\mathrm{d}t} = \gamma i$$

Internet Epidemics: Parameters

- Beta: Infection parameter

$$\beta = \frac{C}{N} \times \frac{\alpha}{\tau}$$

- Where:
  - C target selection algorithm, 1 for random
  - N size of the address space
  - α number of unique concurrent scans
  - τ average time to determine reachability

Internet Epidemics: Parameters

- Tau: average time to determine reachability

$$\tau = r \times t_{latency} + (1 - r) \times t_{timeout}$$

- Where:
  - r the average reachability
  - *latency* average connection latency
  - *timeout* average time-out, usually depends on OS

Internet Epidemics: Parameters

- Gamma:
  - Removal Parameter
  - Mainly based on Human Response
  - Negligible if worm propagates very fast
  - Not a constant

Internet Reachability

	January 2002		March 2003	
Requests sent	2111469	100%	9288348	100%
No response	1937388	91.7%	6964182	75.0%
Acknowledgements	12038	0.6%	918287	9.9%
Destination Unreachable	145155	6.9%	571857	6.2%
Other, RST, TTL-exceeded	16888	0.8%	827655	8.9%

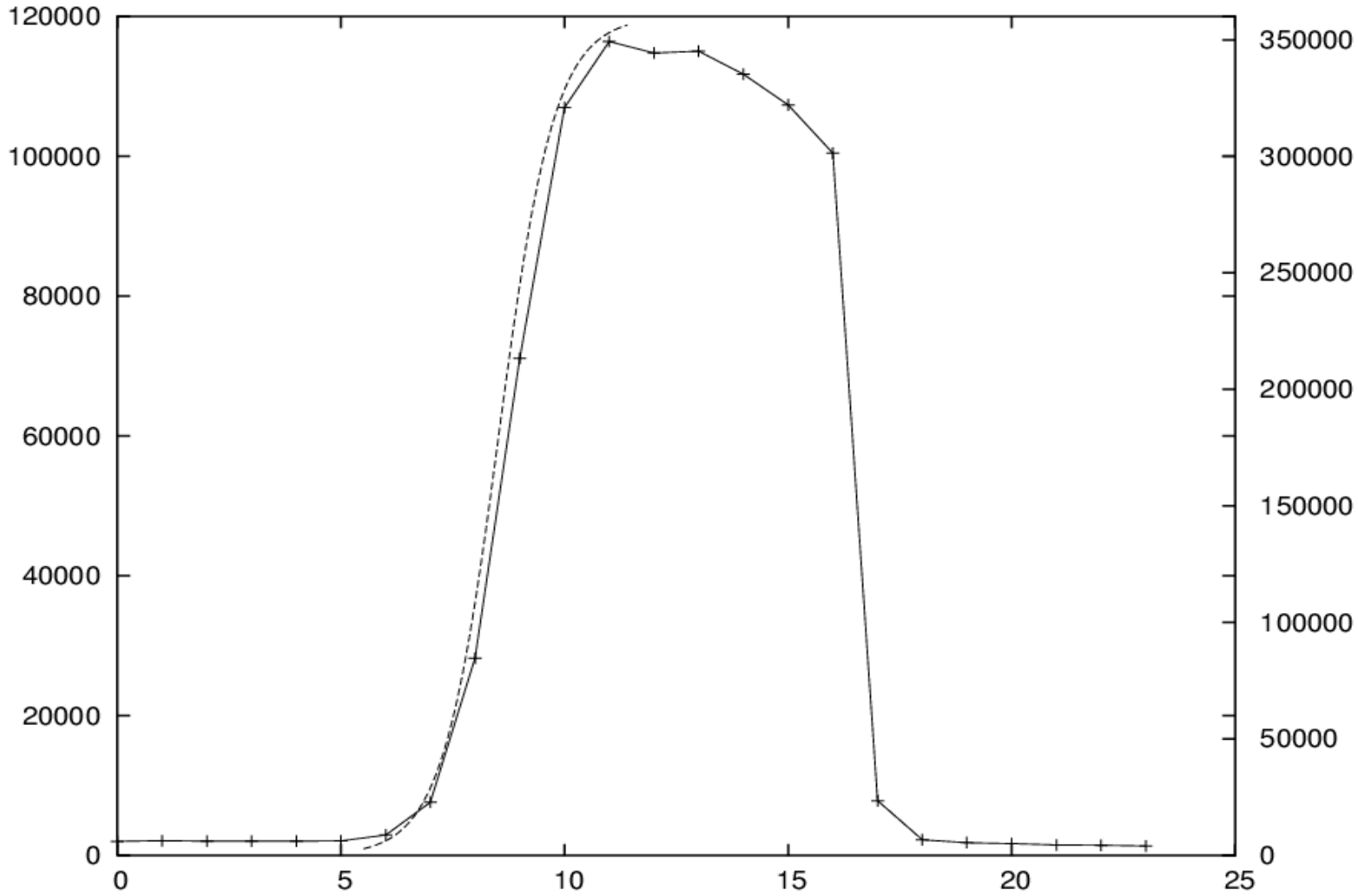
Code Red v2

- Spread on July 19th 2001
- Infected nearly 360.000 hosts
- in 14 hours

$$\tau = \frac{1}{10} \times 1 + (1 - \frac{1}{10}) \times 21 = 19$$

$$\beta = \frac{1}{2^{32}} \times \frac{100}{19} = 1.23 \times 10^{-9}$$

Code Red v2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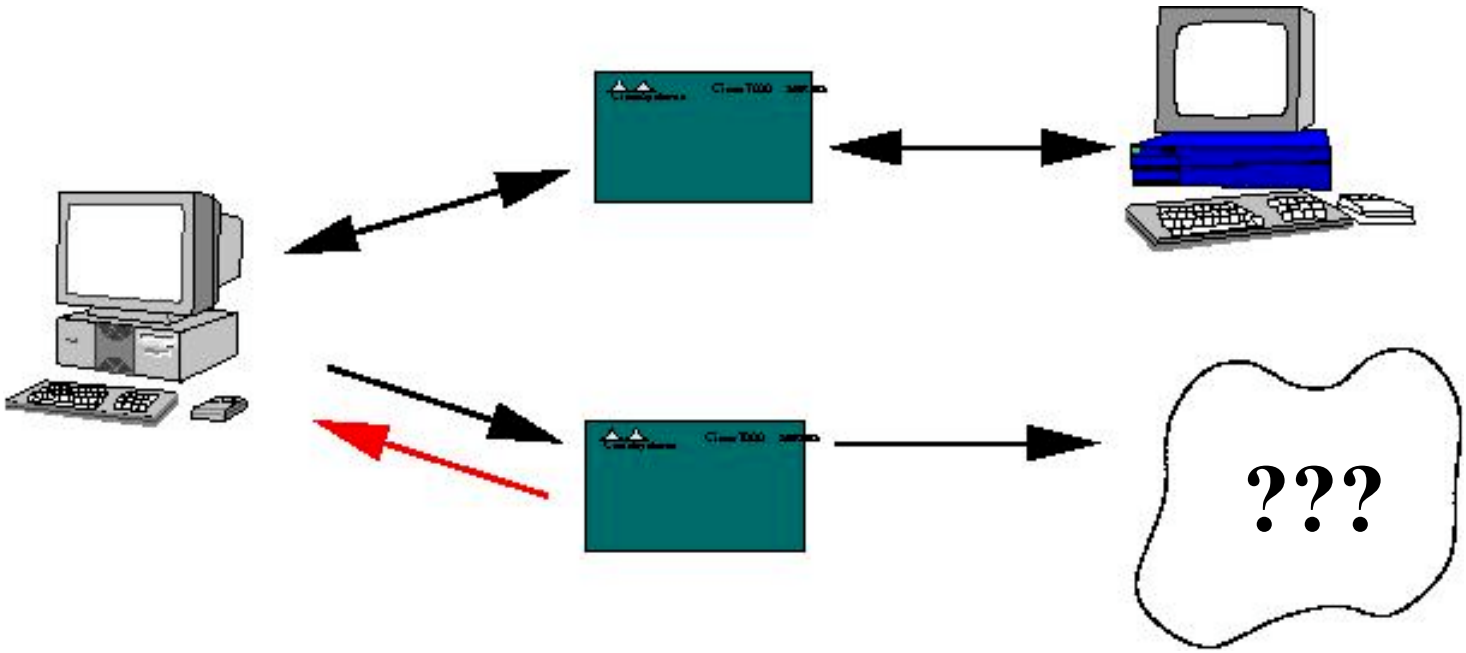
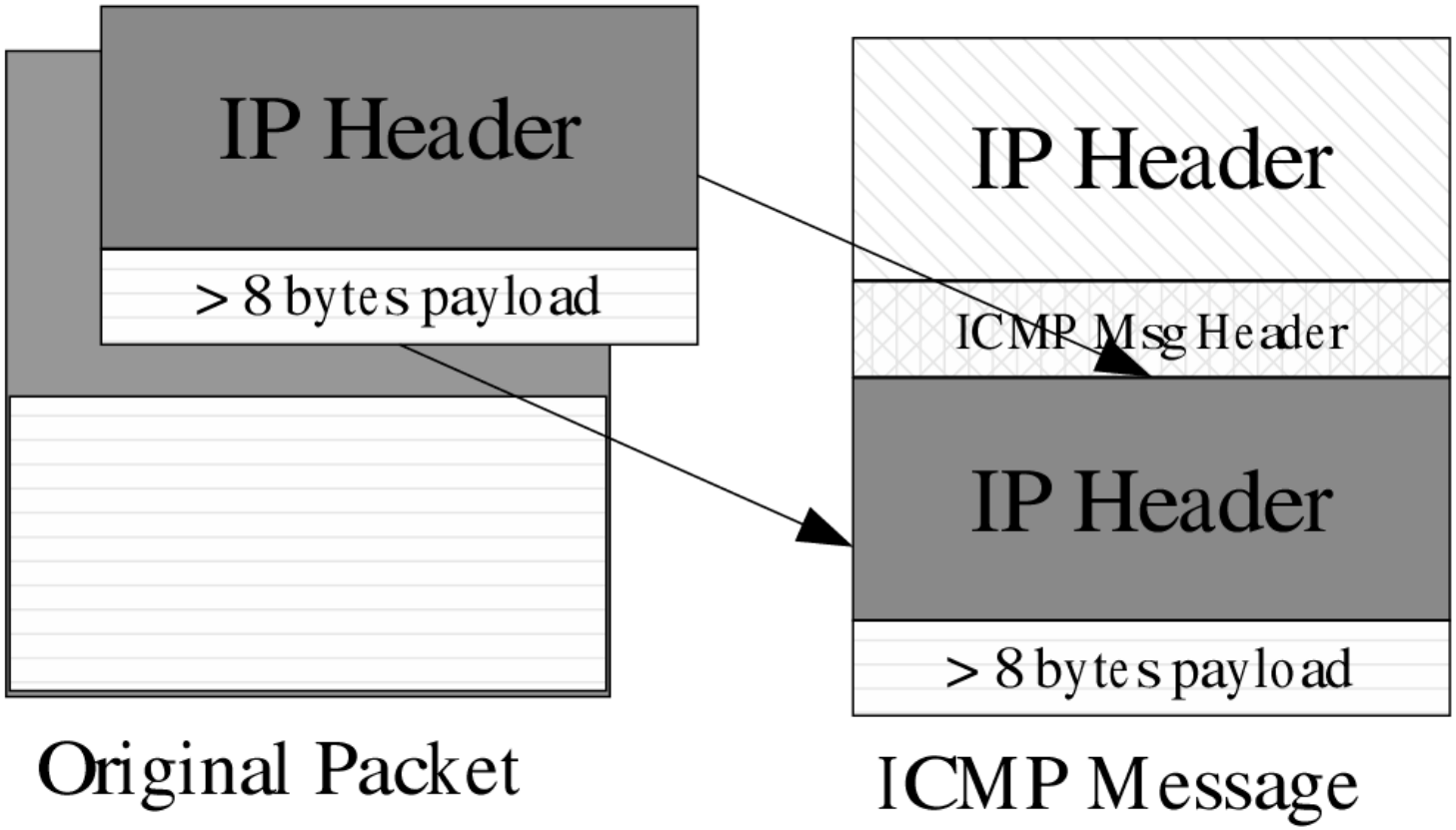
ICMP Destination Unreachable



ICMP Destination Unreachable

- Can get generated when a host or network is not reachable. (About 6%-7%)
- An ICMP Destination Unreachable includes:
  - The IP header of the original packet
  - At least 8 bytes of its original payload
- This holds:
  - Source and Destination IP and protocol
  - For TCP and UDP: Source and Destination port

ICMP Destination Unreachable



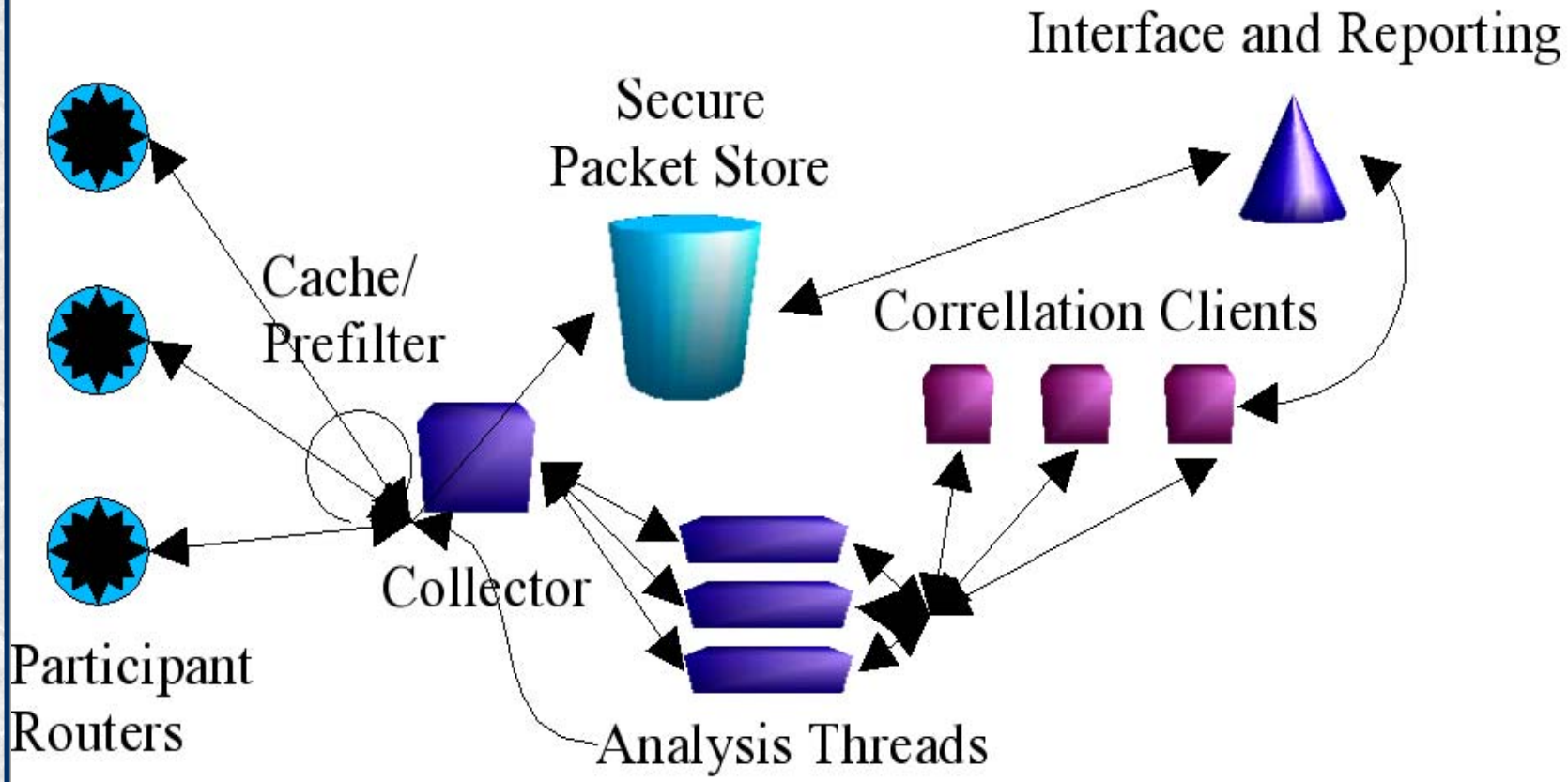
Worms & ICMP Unreachables

- Worm Paradigm:
  - Select Target
  - Probe for Vulnerability and (if possible) Infect
  - Repeat
- (Random) Target Selection Scanning will:
  - hit many unused IP addresses
  - in many different networks
- ICMP-T3s will come from many routers

DIB:S Collecting ICMP-T3

- Participating routers forward the ICMP Destination Unreachable messages that *they themselves* generate to an analysis point:
  - No privacy concerns regarding "sniffing"
  - Only "error messages" are analyzed
  - A Blind Carbon Copy is sent, optionally the original can still be dropped.
- Scanning shows as a "fan" or "bloom" of ICMP-T3s provoked by 1 IP address

DIB:S Framework



DIB:S Incoming Messages

- Incoming ICMP-T3 messages are:
  - Stripped of their IP/ICMP headers
  - Only Embedded data is used
  - Messages sorted on Embedded IP source and destination address
  - Analyzers are assigned an IP address range
  - Each Internet host will always be analyzed by the same Analyzer

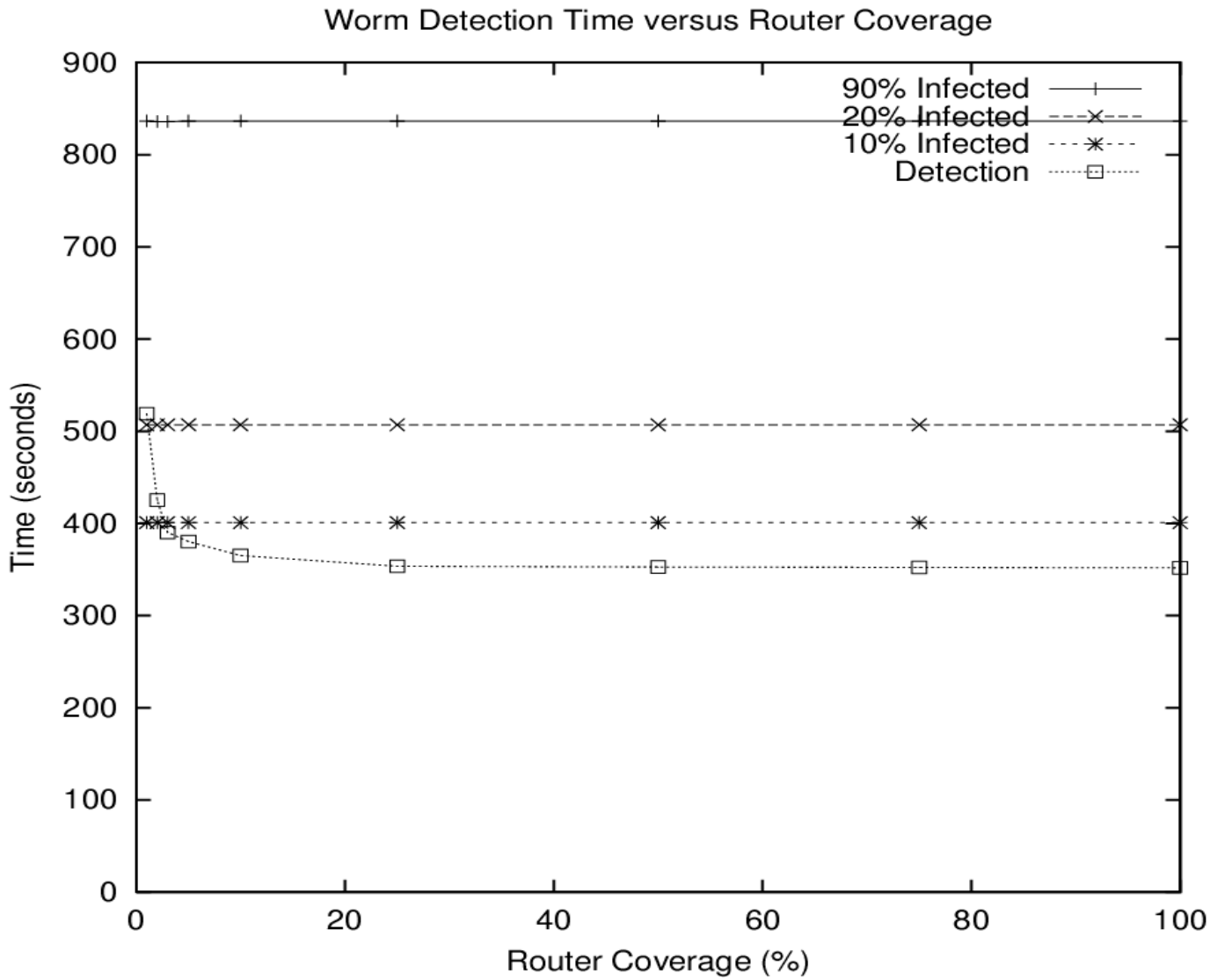
DIB:S Reporting

- Parameters to the system:
  - *N* Threshold
  - *t* Timeout for received packets
- If one IP address contacts N other IP addresses on the same port with t seconds an Alert is issued.
- Other Alerts also possible
- A “track” of Alerts might indicate a Worm

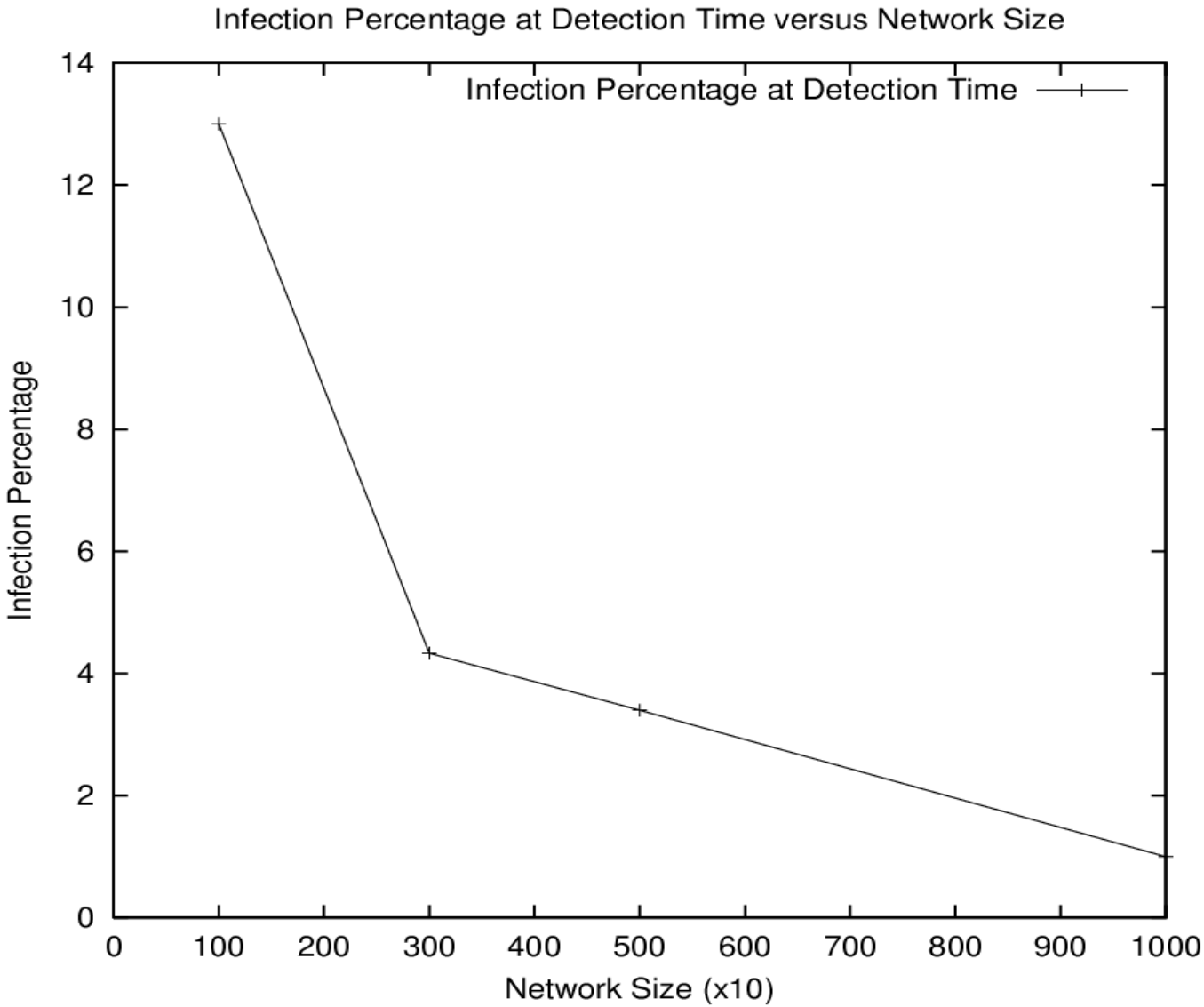
Simulation Results

- Simulation done on a network with:
  - 100.000 hosts
  - 25 percent is reachable
  - 0.1 percent is vulnerable
- DIB:S configuration:
  - $N = 10$
  - $t = 600$ seconds

Simulation Results



Simulation Results



Simulation Results

- Random Noise:
  - Increases load on the system
  - Does not yield significant false-positives
  - BUT: don't set *N* too low *(N > 5)*
  - Detection based on initial exponential curve of worms
- Large scale Internet Simulation needed
  - Real Internet is less uniform

Future Work

- Deployment
  - LINUX based BCC routers
  - CISCO-IOS
  - For 1.5% coverage: 3.5 Class A networks needed
- Small network scale systems
  - Being a good Internet neighbour
- Use of other types of data
- Active Response

DIB:S

Dartmouth ICMP BCC: System

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