UNIVERSITY of HOUSTON
DEPARTMENT OF COMPUTER SCIENCE

Security Analytics

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Outline

Mobile malcode Overview

Viruses

Worms

Mobile Malcode Overview

Malicious programs which spread from machine to machine *without* the consent of the owners/operators/users

Windows Automatic Update is (effectively) consensual

Many strains possible

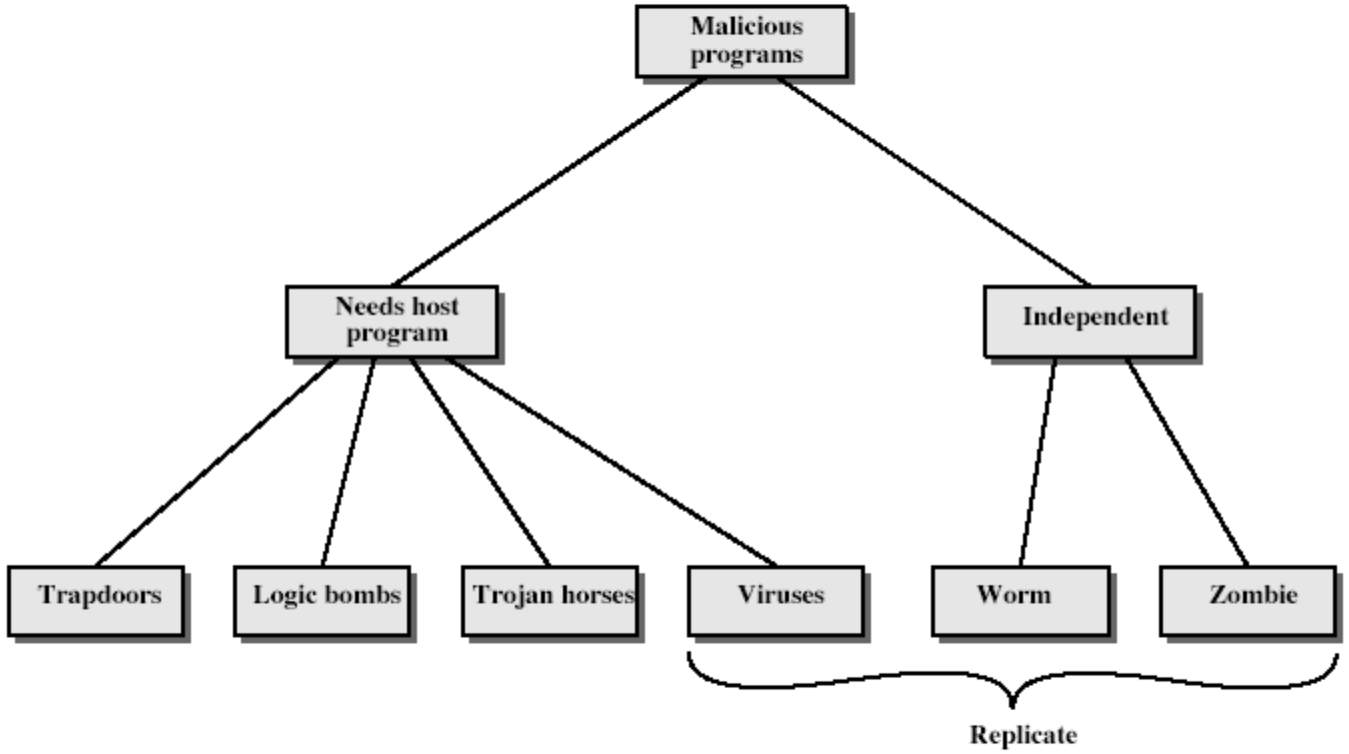
Viruses

Worms

Compromised Auto-updates

No user action required, very dangerous

Malicious Software



Trapdoors (Back doors)

Secret entry point into a program

Allows those who know access bypassing usual security procedures

Have been commonly used by developers

A threat when left in production programs allowing exploited by attackers

Very hard to block in O/S

Requires good s/w development & update

Logic Bomb

one of oldest types of malicious software

code embedded in legitimate program

activated when specified conditions met

eg presence/absence of some file

particular date/time

particular user

particular series of keystrokes

when triggered typically damage system

modify/delete files/disks

Trojan Horse

Programs that appear to have one function but actually perfor

Modern Trojan Horse: resemble a program that the user wishes t superficially attractive

eg game, s/w upgrade etc

When run performs some additional tasks

allows attacker to indirectly gain access they do not have directly

Often used to propagate a virus/worm or install a backdoor

Or simply to destroy data

Zombie

program which secretly takes over another networked computer

then uses it to indirectly launch attacks

often used to launch distributed denial of service (DDoS) attacks

exploits known flaws in network systems

Outline

Mobile malcode Overview

Viruses

Worms

Viruses

Definition from RFC 1135: A *virus* is a piece of code that inserts itself into a host, including operating systems, to propagate. It cannot run independently. It requires that its host program be run to activate it.

On execution

Search for valid target files

Usually executable files

Often only infect uninfected files

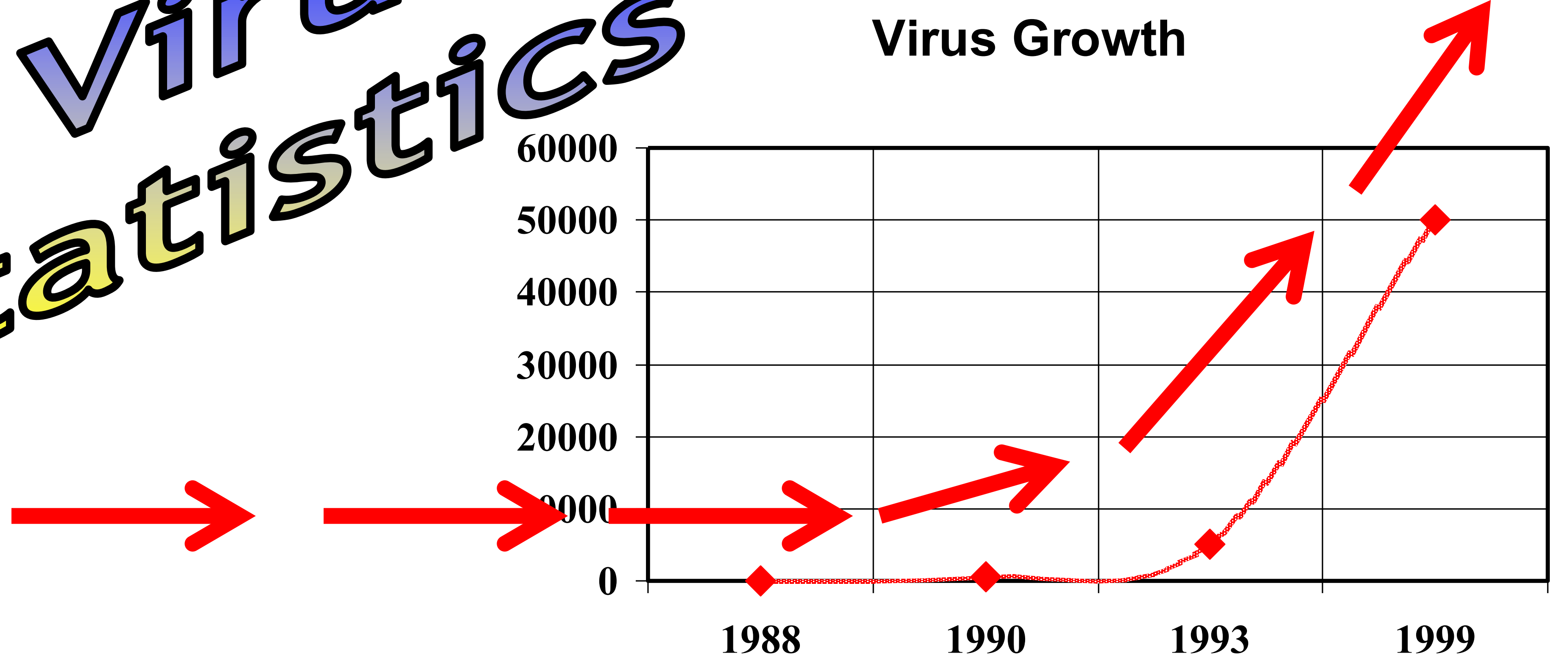
Insert a copy into targeted files

When the target is executed, the virus starts running

Only spread when contaminated files are moved from machine to machine

Mature defenses available

Virus Statistics



1988: Less than 10 known viruses

1990: New virus found every day

1993: 10-30 new viruses per week

1999: 45,000 viruses and variants

Virus Operation

virus phases:

dormant – waiting on trigger event

propagation – replicating to programs/disks

triggering – by event to execute payload

execution – of payload

details usually machine/OS specific

exploiting features/weaknesses

Anatomy of a Virus

Two primary components

Propagation mechanism

Payload

Propagation

Method by which the virus spreads itself.

Old days: single PC, transferred to other hosts by ways of floppy diskettes.

Nowadays: Internet.

Structure of A Virus

```
Virus() {
  infectExecutable();
  if (triggered()) {
     doDamage();
  }
  jump to main of infected program;
}

void infectExecutable() {
  file = choose an uninfected executable file;
  prepend V to file;
}

void doDamage() { ... }
int triggered() { return (some test? 1 : 0); }
```

Virus Infectables

Executable files: .com, .exe, .bat

Macros

With macro languages the line between pure data files and executable files is blurring

An infected file might be attached to an E-mail

E-mail programs may use other programs (e.g., word) with macros to display incoming mail

System sector viruses

Infect control sectors on a disk

DOS boot sectors

Partition (MBR) sectors

System sector viruses spread easily via floppy disk infections

Virus Infectables (cont'd)

Companion viruses

Create a .com files for each .exe files

DOS runs COM files before EXE files

Relatively easy to find and eliminate

Cluster viruses

Change the DOS directory info so that directory entries point to the virus code instead of the real program

Even though every program on the disk may be "infected“, there is only one copy of the virus on the disk

Variable Viruses

Polymorphic viruses

Change with each infection

Executables virus code changing (macros: var name, line spacing, etc.)

Control flow permutations (rearrange code with goto’s)

Attempt to defeat scanners

Virus writing tool kits have been created to "simplify" creation of new viruses

Current tool kits create viruses that can be detected easily with existing scanner technology

But just a matter of time …

Virus Detection/Evasion

Look for changes in size

Check time stamp on file

Look for bad behavior

False alarm prone

Look for patterns (byte streams) in virus code that are unique

Look for changes in file checksum

Compression of virus and target code

Modify time stamp to original

Do bad thing insidiously

Change patterns – polymorphism

Rearrange data in the file

Disable anti-virus programs

Internet checksum

Goal: detect "errors" (e.g., flipped bits) in transmitted segment (note: used at transport layer *only*)

Sender:

treat segment contents as sequence of 16-bit integers

checksum: addition (1's complement sum) of segment contents

sender puts checksum value into UDP checksum field

Receiver:

compute checksum of received segment

check if computed checksum equals checksum field value:

NO - error detected

YES - no error detected. *But maybe errors nonetheless?* More later ….

More on Virus Detection

Scanning

Depend on prior knowledge of a virus

Check programs before execution

Need to be regularly updated

Integrity Checking

Read entire disk and record integrity data that acts as a signature for the files and system sectors

Use cryptographic computation technique instead of simple checksum

More on Virus Detection

Interception

Monitoring for system-level routines that perform destructive acts

Good for detecting logic bomb and Trojan horse

Cannot depend entirely upon behavior monitors as they are easily bypassed.

Combination of all three techniques can detect most viruses

Virus Recovery

Extricate the virus from the infected file to leave the original behind

Remove the redirection to the virus code

Recover the file from backup

Delete the files and move on with life

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History of Viruses

First Wild Viruses Apple I/II/III: 1981

Three viruses for the Apple machines emerged in 1981

Boot sector viruses

Floppies of that time had the disk operating system (DOS) on them by default

Wrote it without malice

First PC Virus: Pakistani Brain Virus (1986)

Written by Pakistani brothers to protect their copyright

Claim: infect only machines that had an unlicensed copy of their software

Boot sector

Printed

“Welcome to the Dungeon (c) 1986 Basit * Amjad (pvt) Ltd. BRAIN COMPUTER SERVICES

730 NIZAB BLOCK ALLAMA IQBAL TOWN

LAHORE-PAKISTAN PHONE :430791,443248,280530.

Beware of this VIRUS.... Contact us for vaccination .... !!"

Destructive Virus: Chernobyl (1998)

Designed to inflict harm

Flash BIOS: would cause permanent hardware damage to vulnerable motherboards

Also overwrote first 2K sectors of each disk

Typically resulted in a loss of data and made it unbootable

Previously believed that being benign was necessary for virus longevity

Chernobyl provided evidence to the contrary

Early Macro Virus: Melissa (1999)

Microsoft Word 97 Macro virus

Target first 50 entries in Outlook's address book

Adjusted subject "Important messages from ______"

Points to attachment as a document requested

Contains a list of porn sites

Macro security was greatly increased with Melissa

Outlines

Mobile malcode Overview

Viruses

Worms

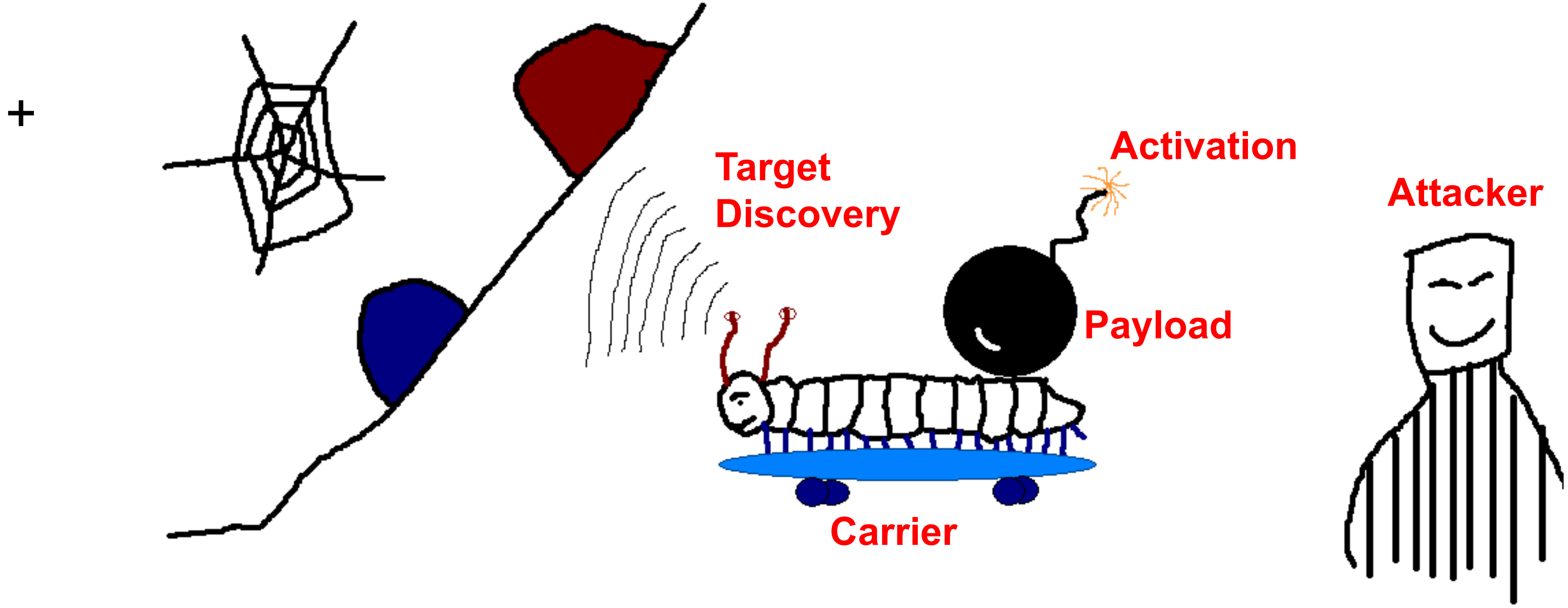
Worms

Autonomous, active code that can replicate to remote hosts without any triggering

Replicating but not infecting program

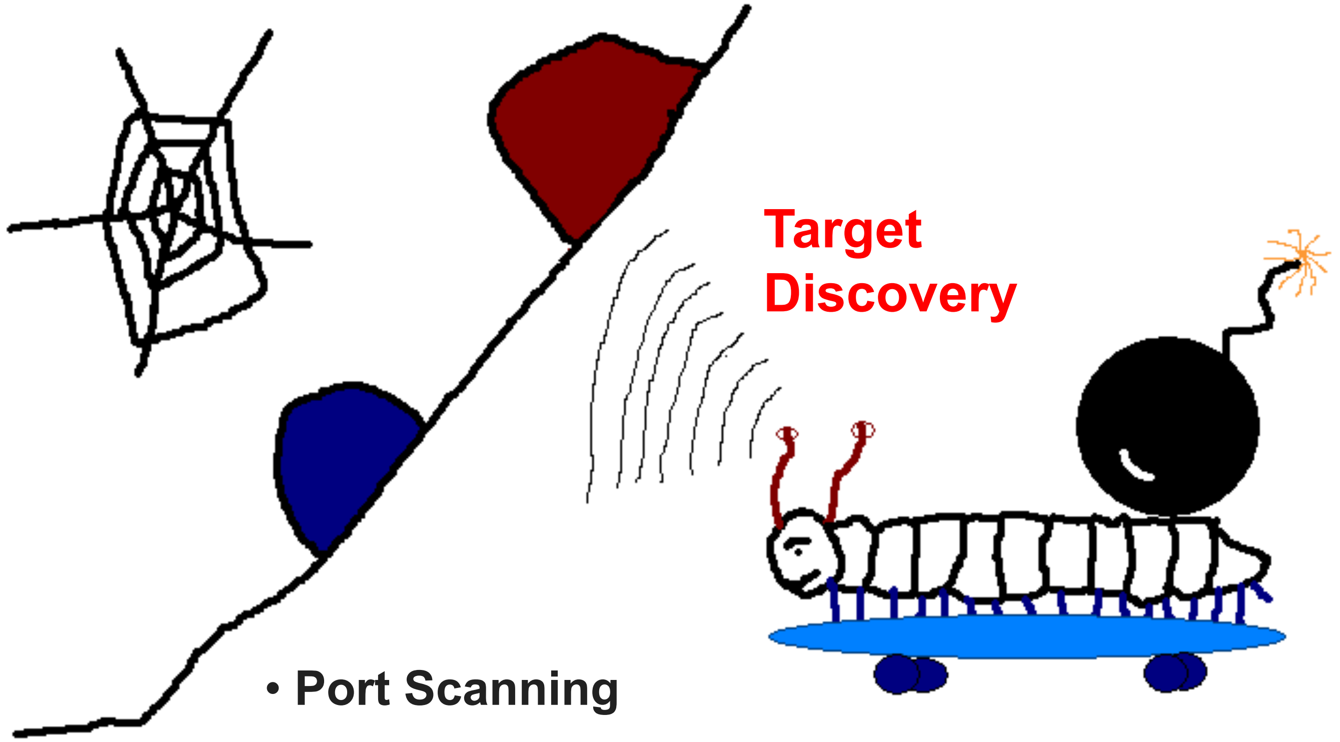
Because they propagate autonomously, they can **spread much more quickly** than viruses!

Speed and general lack of user interaction make them the most significant threats



Worm Overview

Target Discovery



- **Port Scanning**
  - Sequential: working through an address block
  - Random
- **Target Lists**
  - Externally generated through Meta servers
  - Internal target list
  - Passive worms

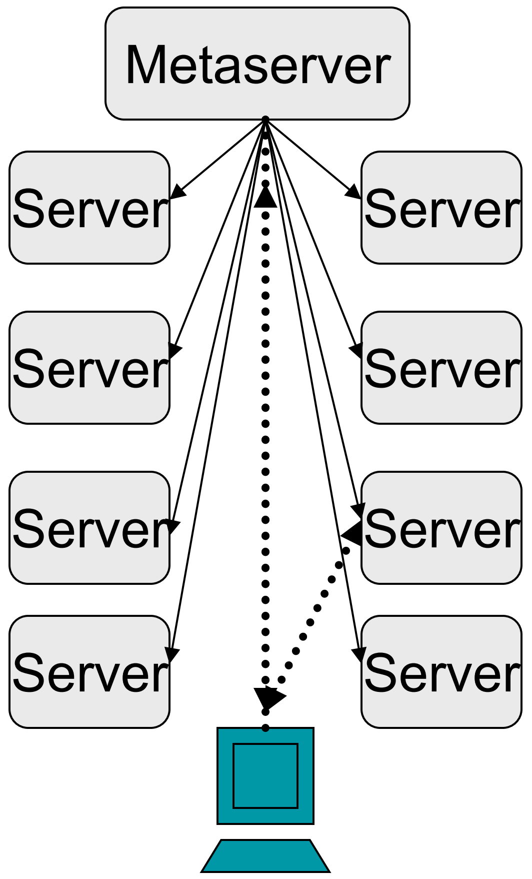
External Target Lists: Metaserver Worms

Many systems use a "metaserver", a server for information about other servers

- Games: Use as a matchmaker for local servers
- Google: Query google to find web servers
- Windows Active Directory: Maintains the "Network Neighborhood"

Worm can leverage these services

- Construct a query to find new targets
- Each new victim also constructs queries
- Creates a divide-and-conquer infection strategy



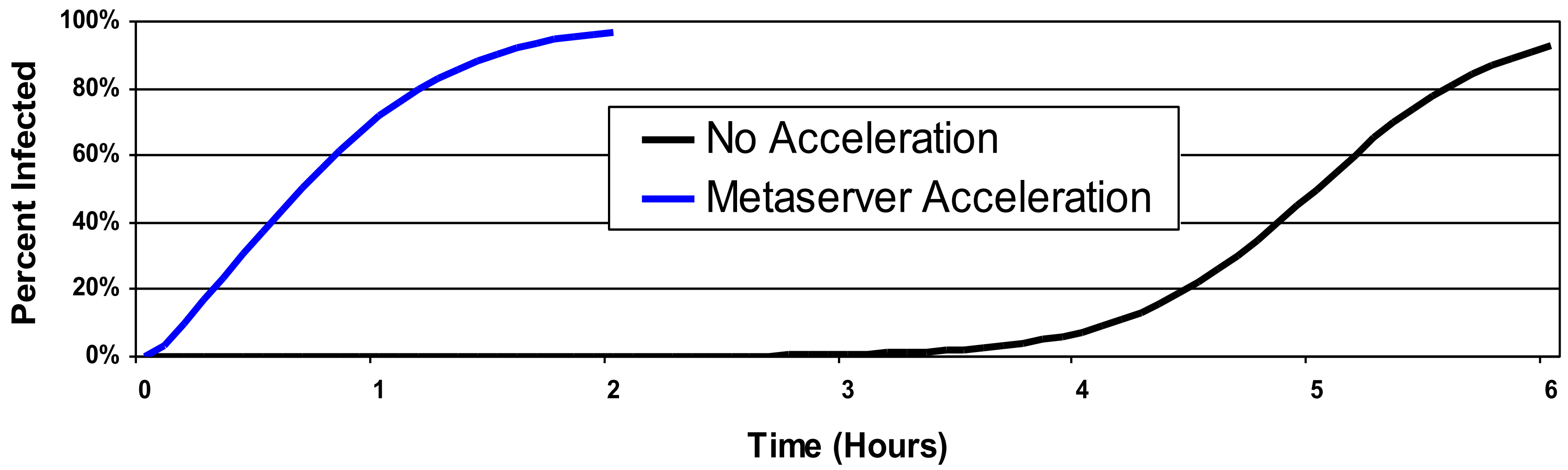
How Fast Are Metaserver Worms?

Game Metaserver: Use to attack a small population (eg, all Half-Life servers)

~1 minute to infect all targets

Google: Use to enhance a scanning web worm

Each worm conducts initial queries to find URLs



Internal Target Lists: Topological Information

Look for local information to find new targets

URLs on disk and in caches

Mail addresses

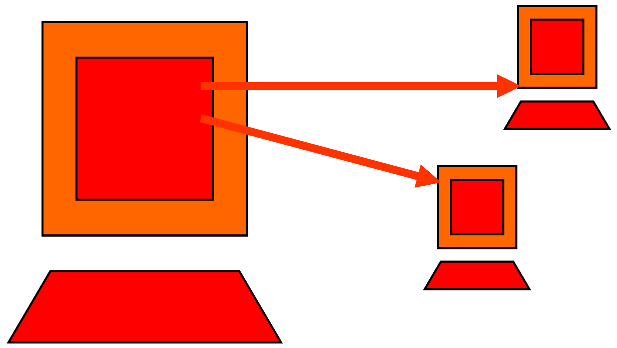
.ssh/known_hosts

Ubiquitous in mail worms

More recent mail worms are more aggressive at finding new addresses

Basis of the Morris worm

Address space was too sparse for scanning to work



How Fast are Topological Worms?

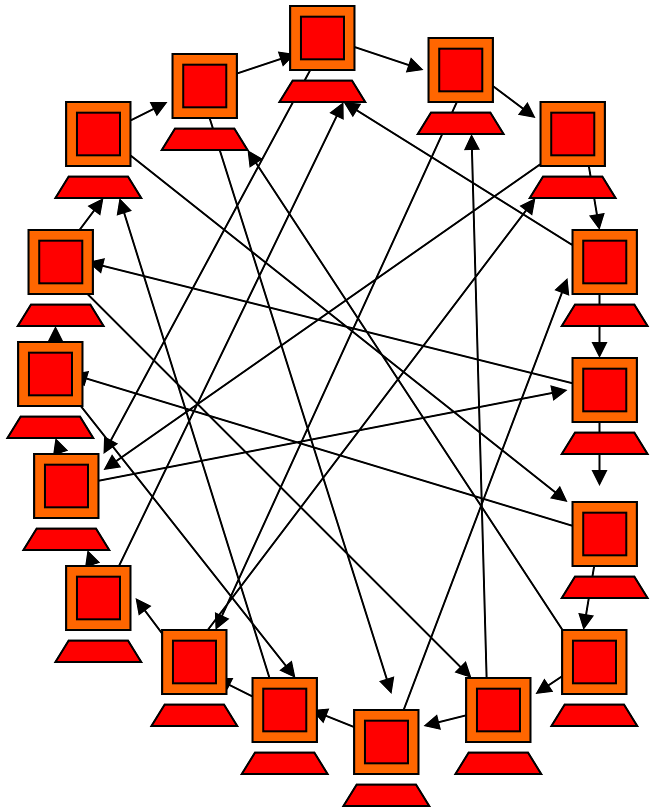
Depends on the topology *G = (V, E)*

Vulnerable machines are vertices,
edges are local information

Time to infect is a function of the shortest paths
from the initial point of infection

Power law or similar graph (KaZaA)

Depends greatly on the parameters,
but generally very, VERY fast



Passive Worms

Wait for information about other targets

CRclean, an anti-CodeRed II worm

Wait for Code Red, respond with counterattack

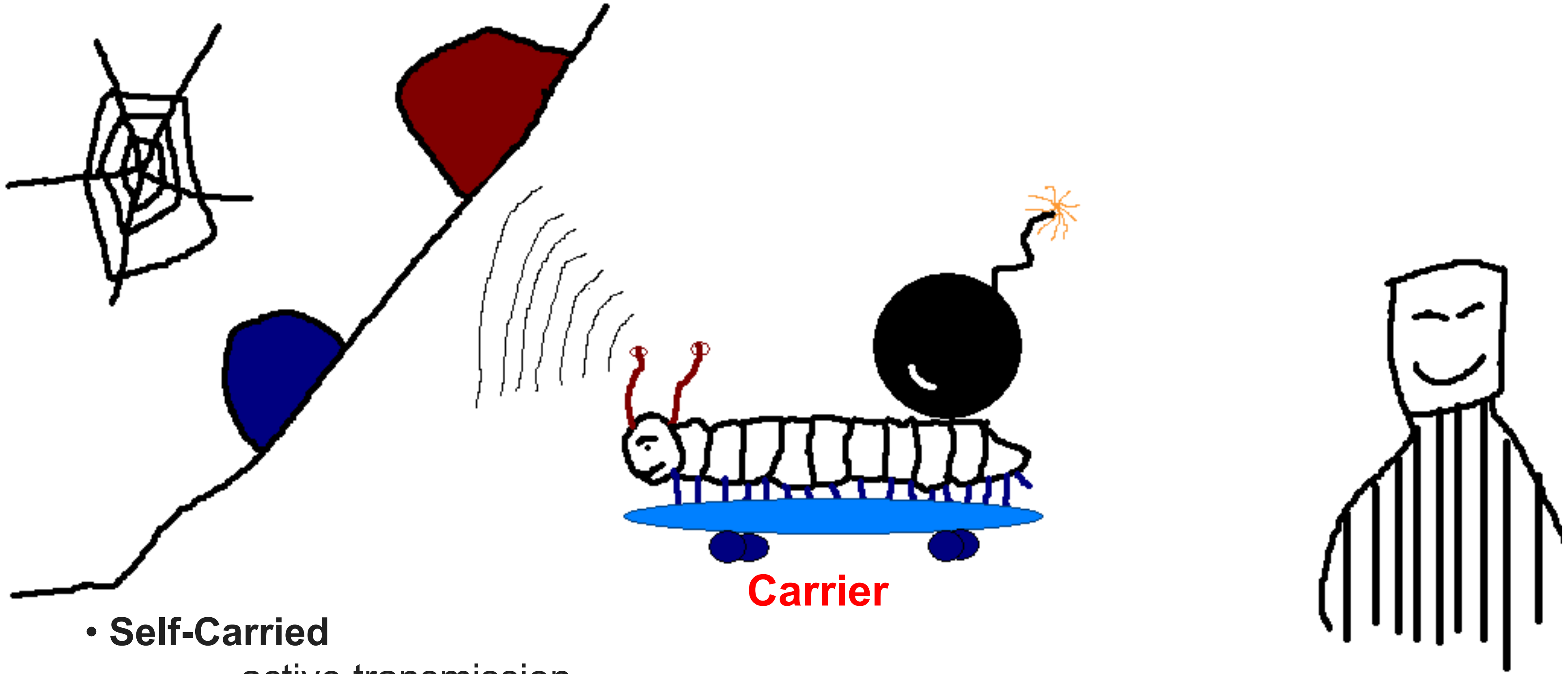
Nimda: Infect vulnerable IE versions with Trojan web-page

Speed is highly variable

Depends on normal communication traffic

Very high stealth

Have to detect the act of infection, not target selection

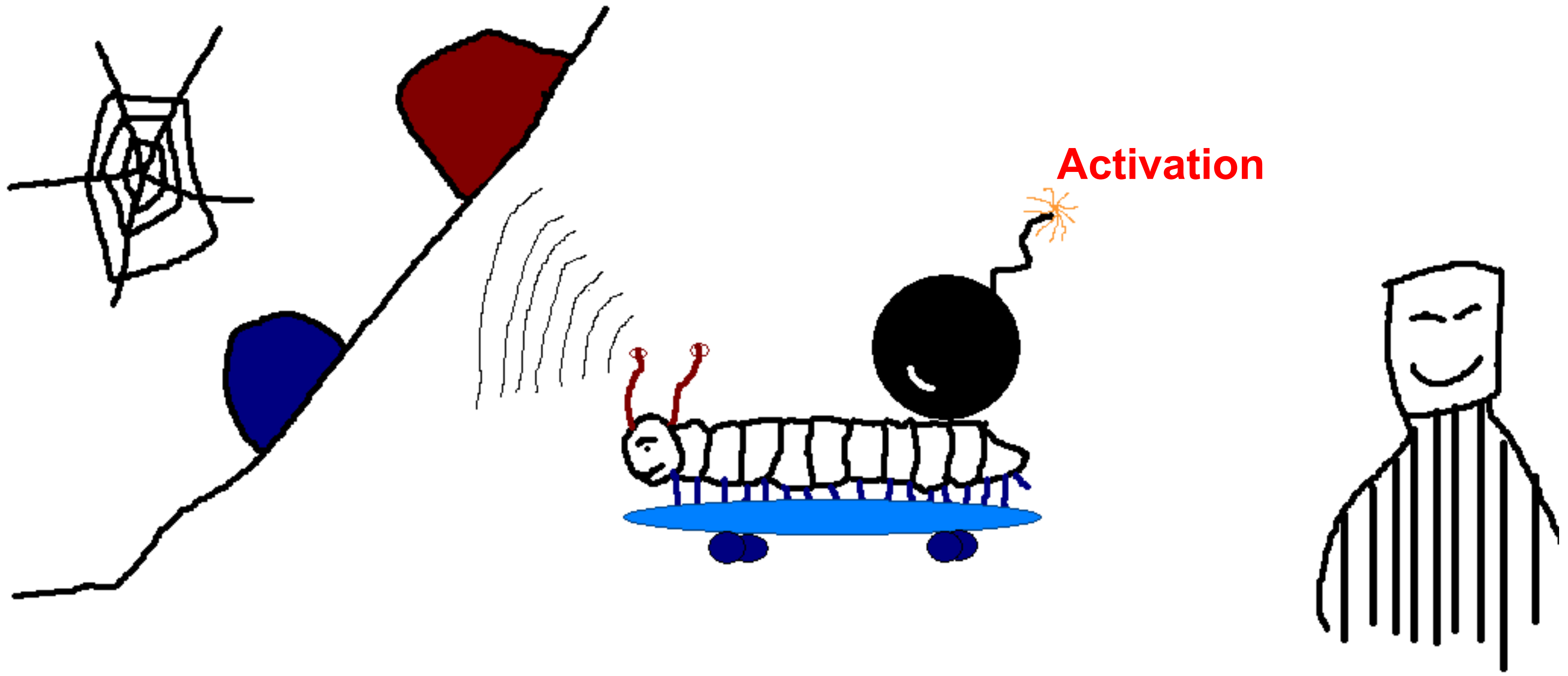


- **Self-Carried**

  active transmission
- **Second Channel**

  e.g. blaster worm use RPC to exploit, but use TFTP to download the whole virus body
- **Embedded**

  e.g. web requests


Activation

Activation

Human Activation

Needs social engineering, especially for email worms

Melissa – “Attached is an important message for you!”

Iloveyou – “Open this message to see who loves you!”

Human activity-based activation

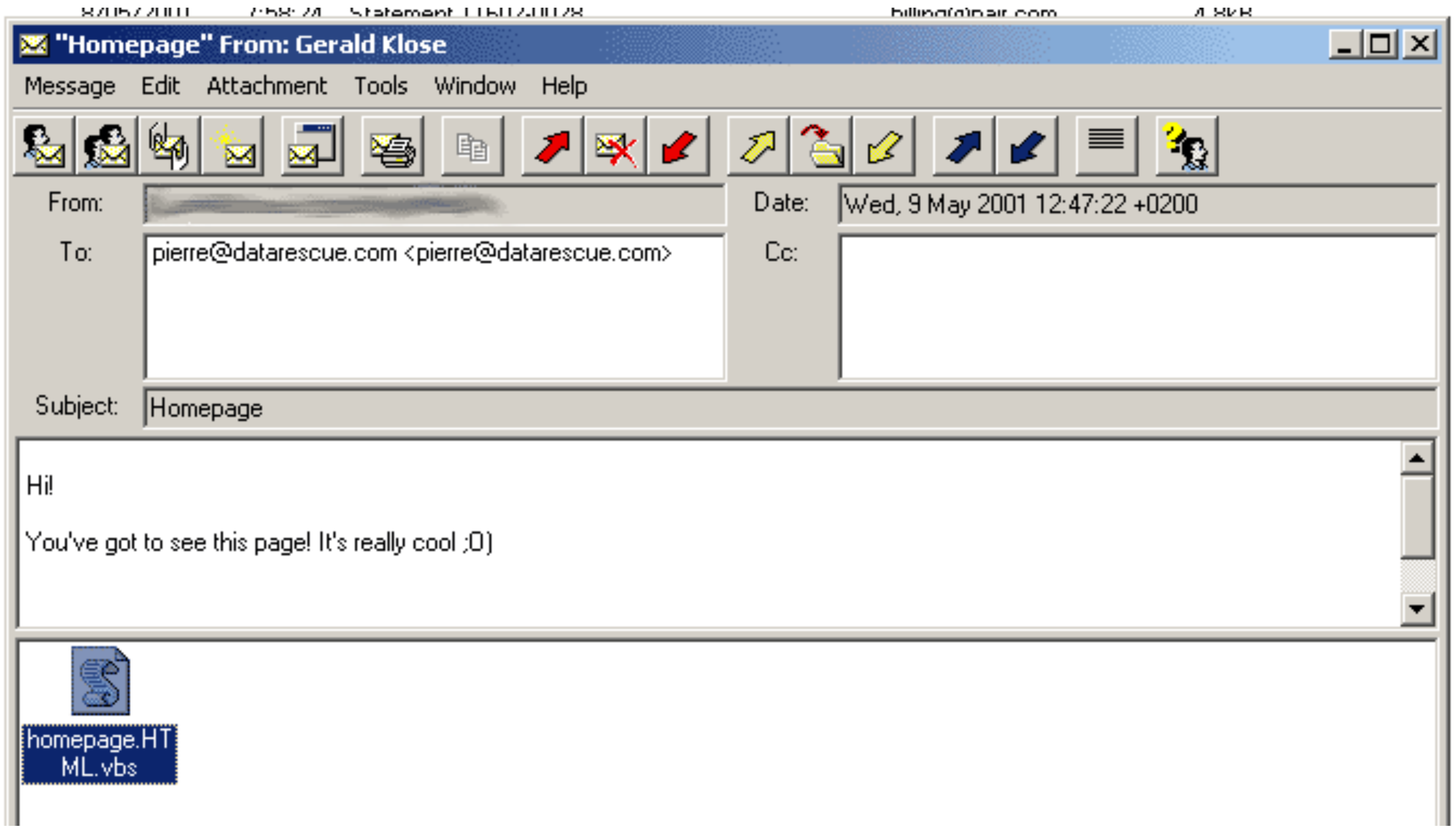
E.g. logging in, rebooting (Nimda’s secondary propagation)

Scheduled process activation

E.g. updates, backup etc.

Self Activation

E.g. Code Red exploit the IIS web servers


"Homepage" From: Gerald Klose

Message Edit Attachment Tools Window Help

From: [redacted]

Date: Wed, 9 May 2001 12:47:22 +0200

To: pierre@datarescue.com <pierre@datarescue.com>

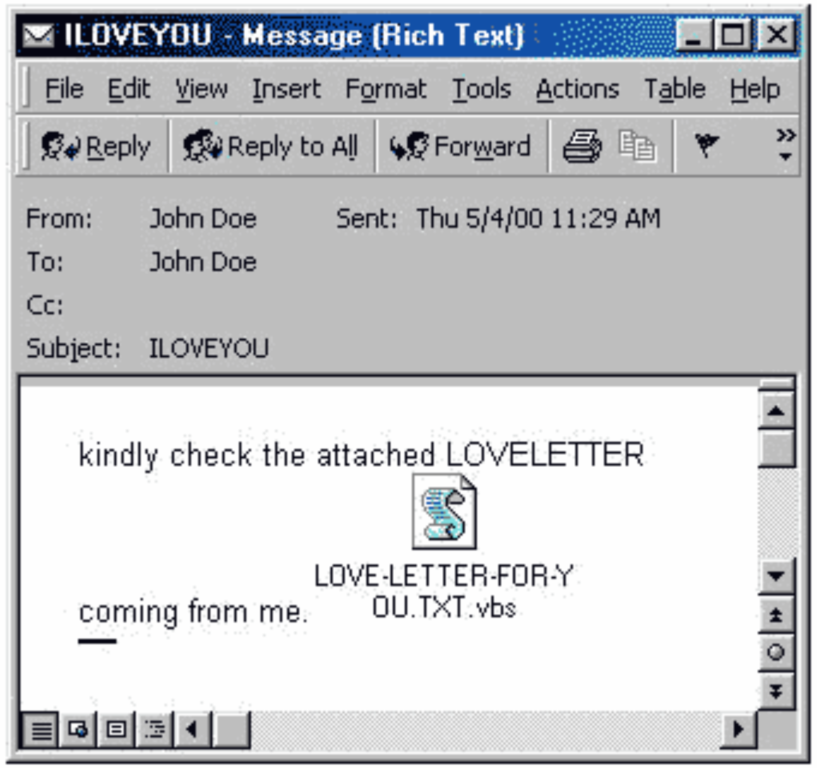
Cc:

Subject: Homepage

Hi!

You've got to see this page! It's really cool ;O)

homepage.HTML.vbs

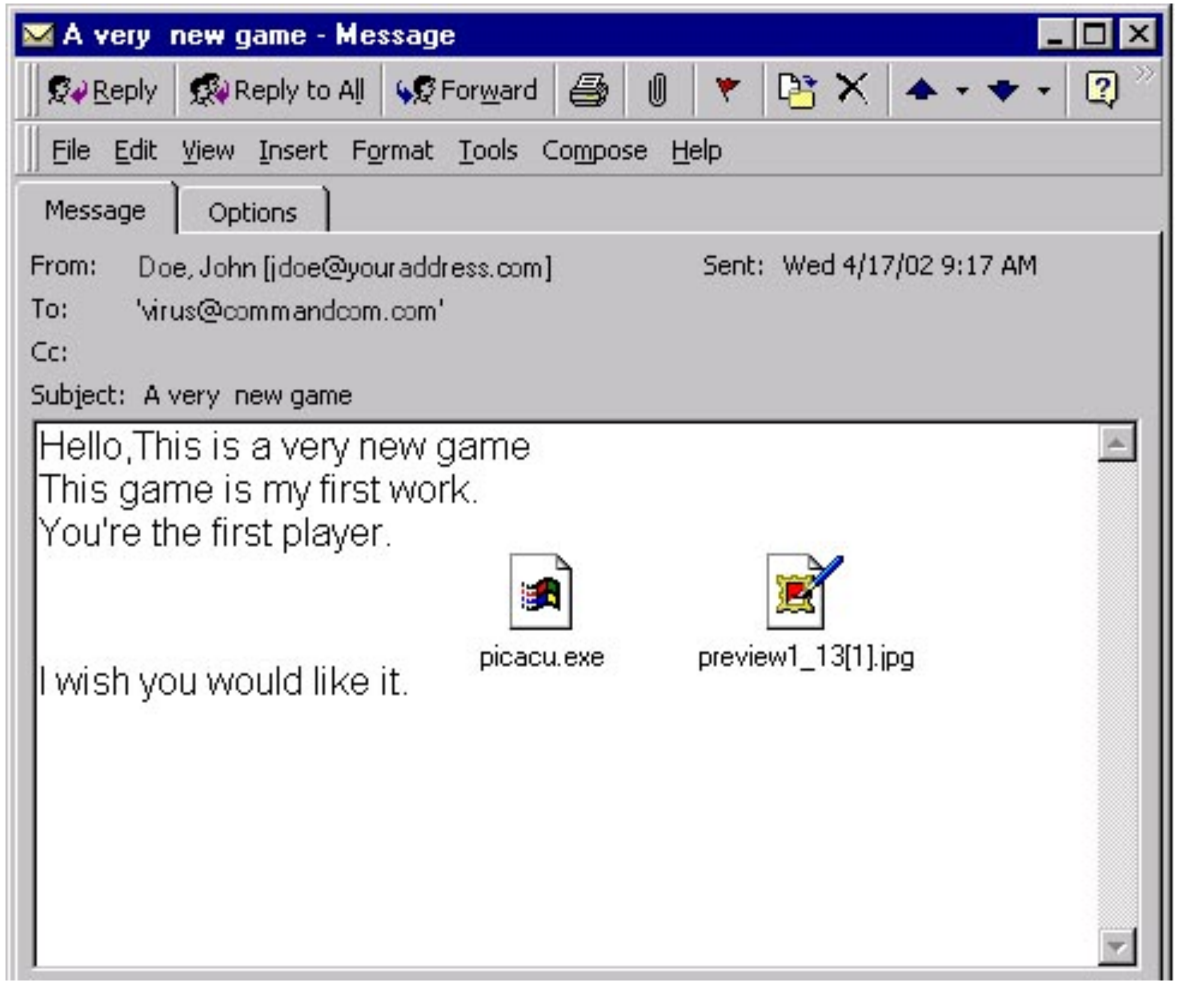

ILOVEYOU - Message (Rich Text)
File Edit View Insert Format Tools Actions Table Help
Reply
Reply to All
Forward

From: John Doe Sent: Thu 5/4/00 11:29 AM
To: John Doe
Cc:
Subject: ILOVEYOU

kindly check the attached LOVELETTER coming from me.

LOVE-LETTER-FOR-YOU.TXT.vbs

Screenshot courtesy of F-Secure.com

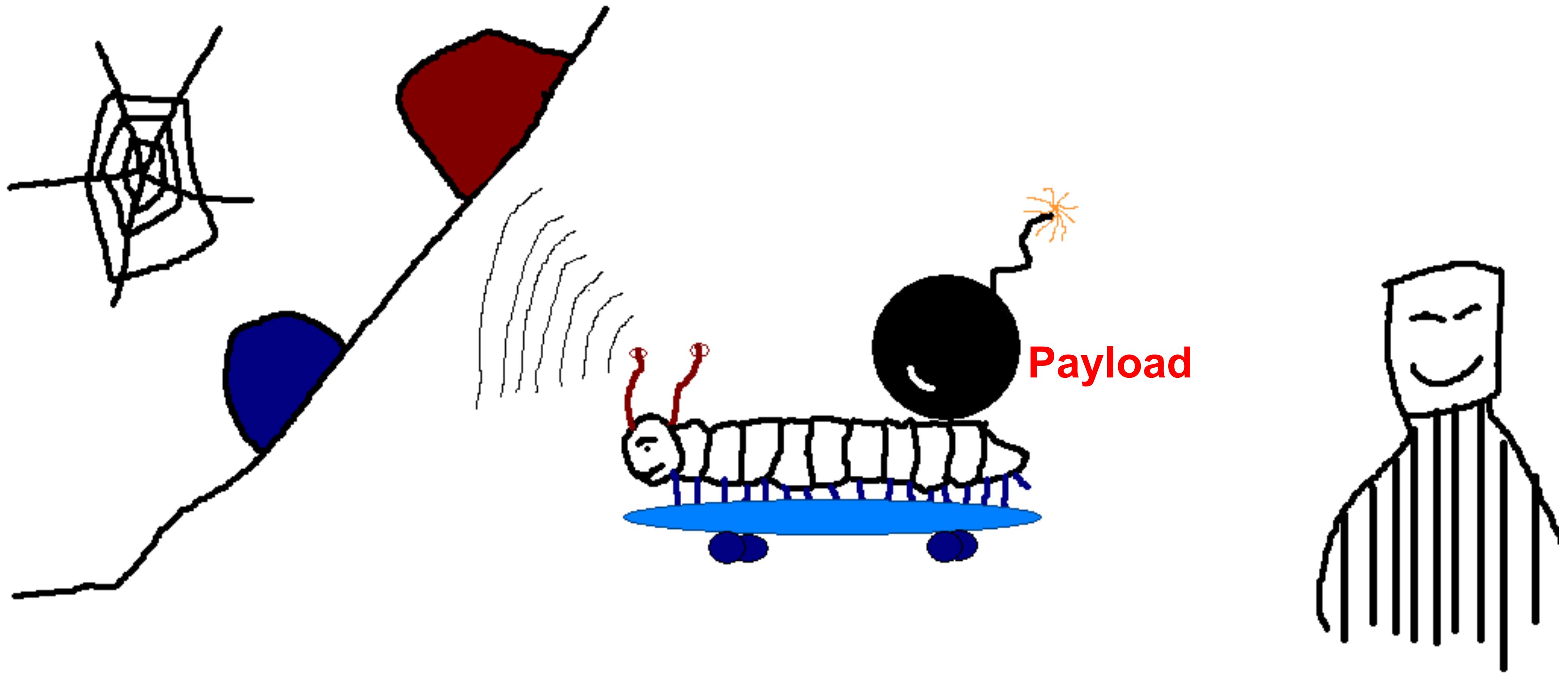


From: Doe, John [jdoe@youraddress.com]
Sent: Wed 4/17/02 9:17 AM
To: 'virus@commandcom.com'
Cc:
Subject: A very new game

Hello,This is a very new game
This game is my first work.
You're the first player.

I wish you would like it.

picacu.exe
preview1_13[1].jpg


Payload

Payloads

None/nonfunctional

Most common

Still can have significant effects through traffic and machine load (e.g., Morris worm)

Internet Remote Control

Code Red II open backdoor on victim machines: anyone with a web browser can execute arbitrary code

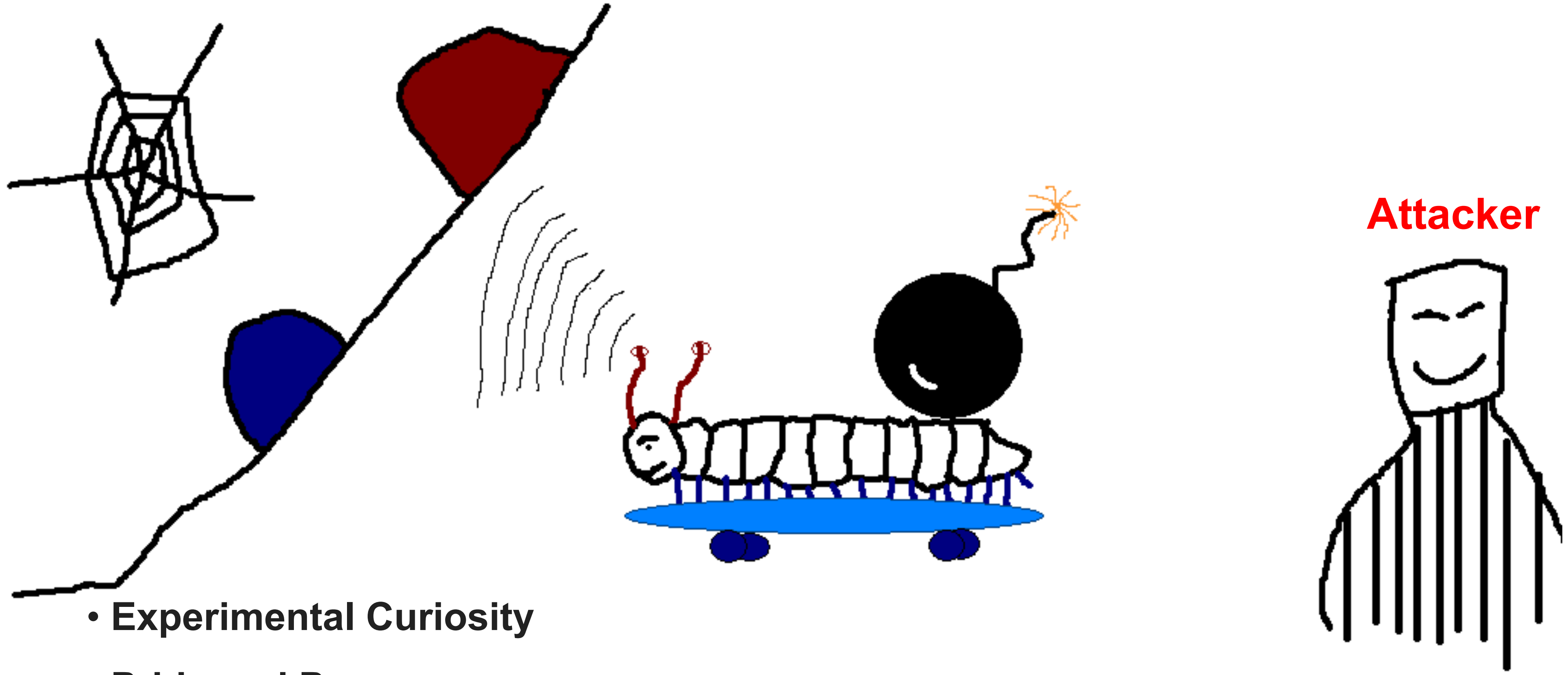
Internet Denial of Service (DOS)

E.g., Code Red, Yaha

Data Collection

Data Damage: Chernobyl , Klez

Worm maintenance

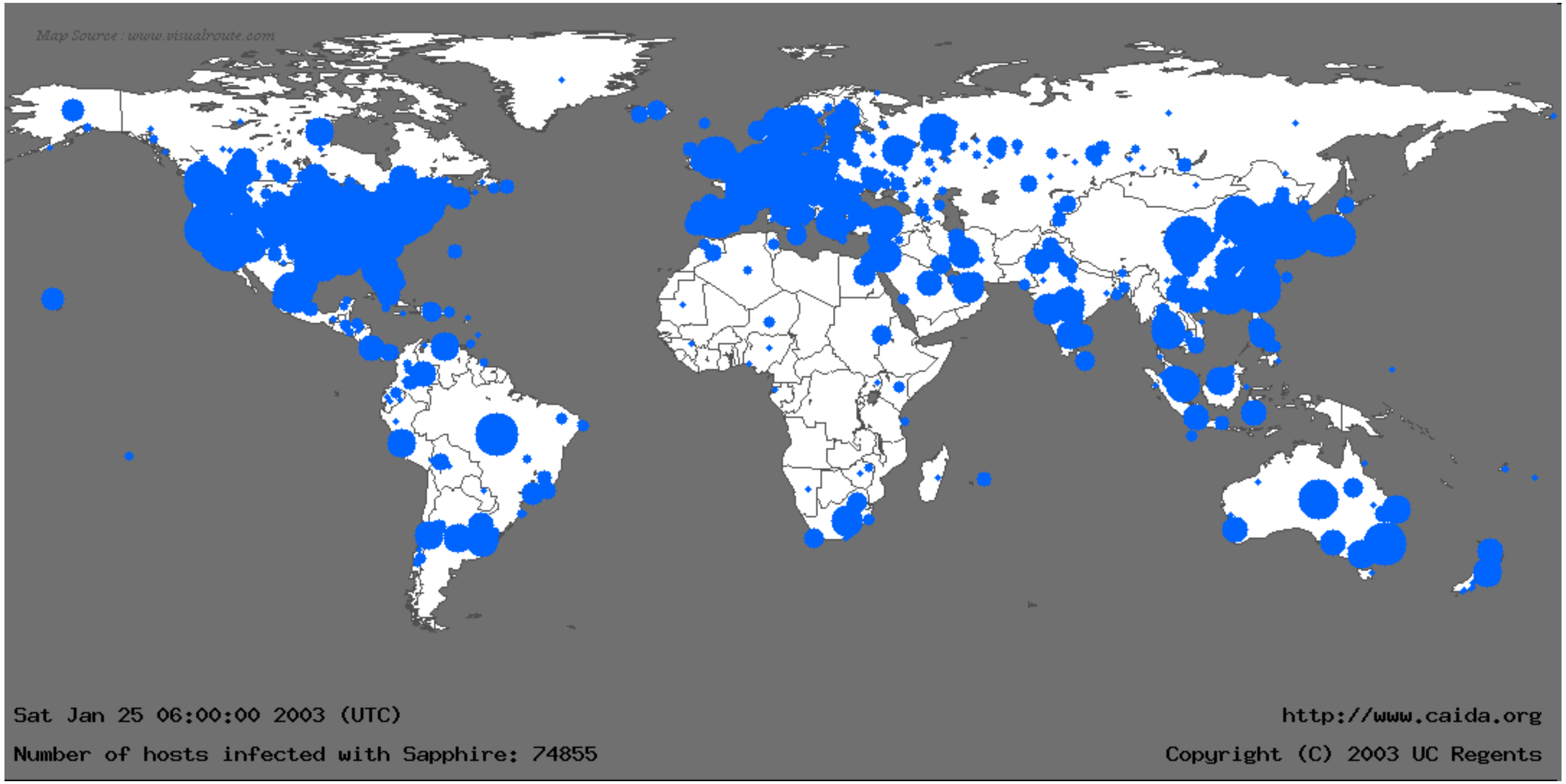


- Experimental Curiosity
- Pride and Power
- Commercial Advantage
- Extortion and criminal gain
- Terrorism
- Cyber Warfare

Some Major Worms

Worm	Year	Strategy	Victims	Other Notes
Morris	1988	Topological	6000	First major autonomous worm. Attacked multiple vulnerabilities.
Code Red	2001	Scanning	~300,000	First recent "fast" worm, 2nd wave infected 360,000 servers in 14 hours
CRClean	2001	Passive	none	Unreleased Anti-Code-Red worm.
Nimda	2001	Scanning IIS, Code Red 2 backdoor, etc	~200,000	Local subnet scanning. Effective mix of techniques
Scalper	2002	Scanning	<10,000	Released 10 days after vulnerability revealed
Slammer	2003	Scanning	>75,000	Spread worldwide in 10 minutes

The Spread of the Sapphire/Slammer SQL Worm


Map Source : www.visualroute.com
Sat Jan 25 06:00:00 2003 (UTC)
Number of hosts infected with Sapphire: 74855
http://www.caida.org
Copyright (C) 2003 UC Regents

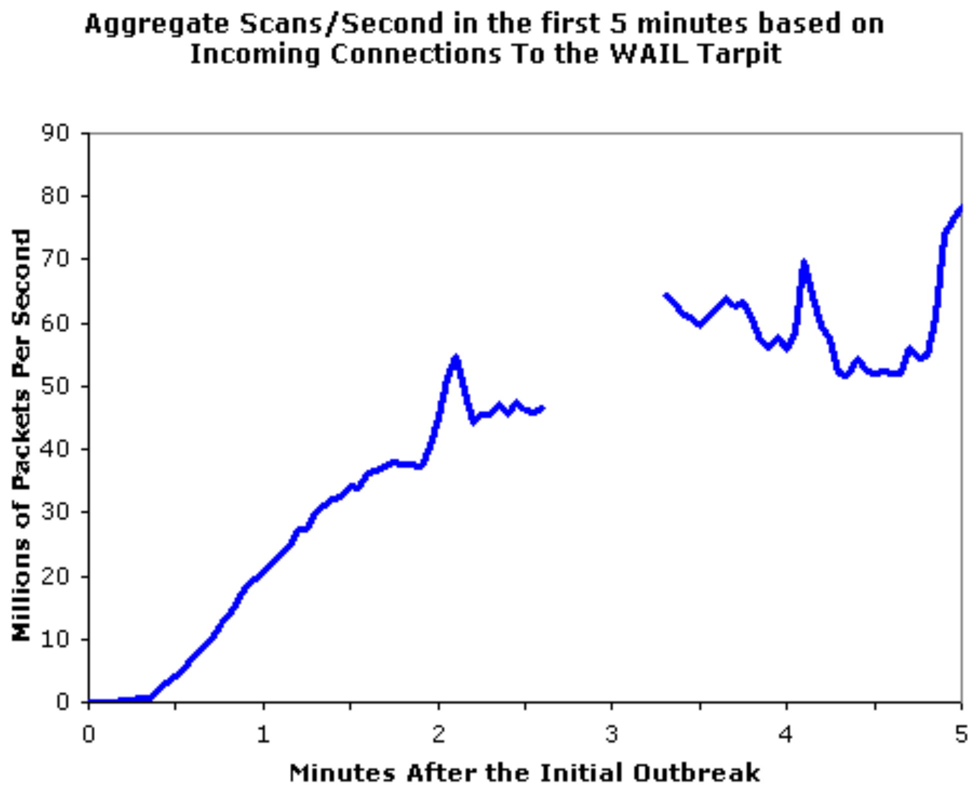
How Fast was Slammer?

Infected ~75,000 machines in 10 minutes

Full scanning rate in ~3 minutes

>55 Million IPs/s

Initial doubling rate was about every 8.5 seconds



Why Was Sapphire Fast: A Bandwidth-Limited Scanner

Code Red's scanner is latency-limited

In many threads: send SYN to random address,
wait for response or timeout

Code Red → ~6 scans/second,

population doubles about every 40 minutes

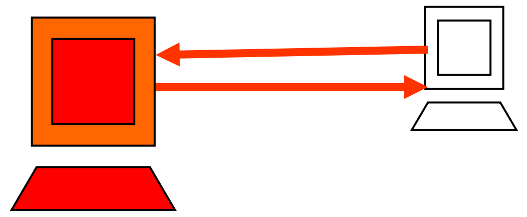
Every Sapphire copy sent infectious packets at maximum rate

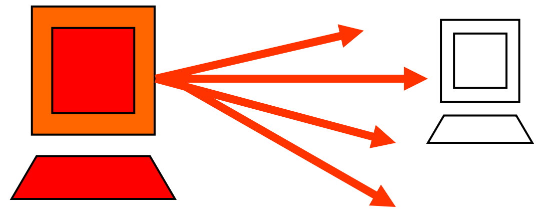
1 Mb upload bandwidth →
280 scans/second

100 Mb upload bandwidth →
28,000 scans/second

Any reasonably small TCP worm can spread like Sapphire

Needs to construct SYNs at line rate, receive ACKs in a separate thread





Backup Slides

Fred Cohen’s Work: 1983

First documented work with viruses

Cohen’s PhD advisor, Leo Adelman, coined the term “virus”

Virus: “a program that can infect other programs by modifying them to include a … version of itself”

Viruses can quickly (~30 min) spread through a networked file system

Dissertation (1986) conclusion: "universal" detection of a virus is undecidable

No 100% guaranteed detection for virus/worm

Early Mail Virus: Happy99 (1999)

One of the earliest viruses that propagated automatically when an infected attachment is executed

Did not infect files, only email user accounts

Email sent from infected person to others in address book (novelty at the time)

Morris Worm

best known classic worm

released by Robert Morris in 1988

targeted Unix systems

using several propagation techniques

simple password cracking of local pw file

exploit bug in finger daemon

exploit debug trapdoor in sendmail daemon

if any attack succeeds then replicated self