Worms & Botnets

CS 161: Computer Security

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http://inst.eecs.berkeley.edu/~cs161/

April 21, 2011

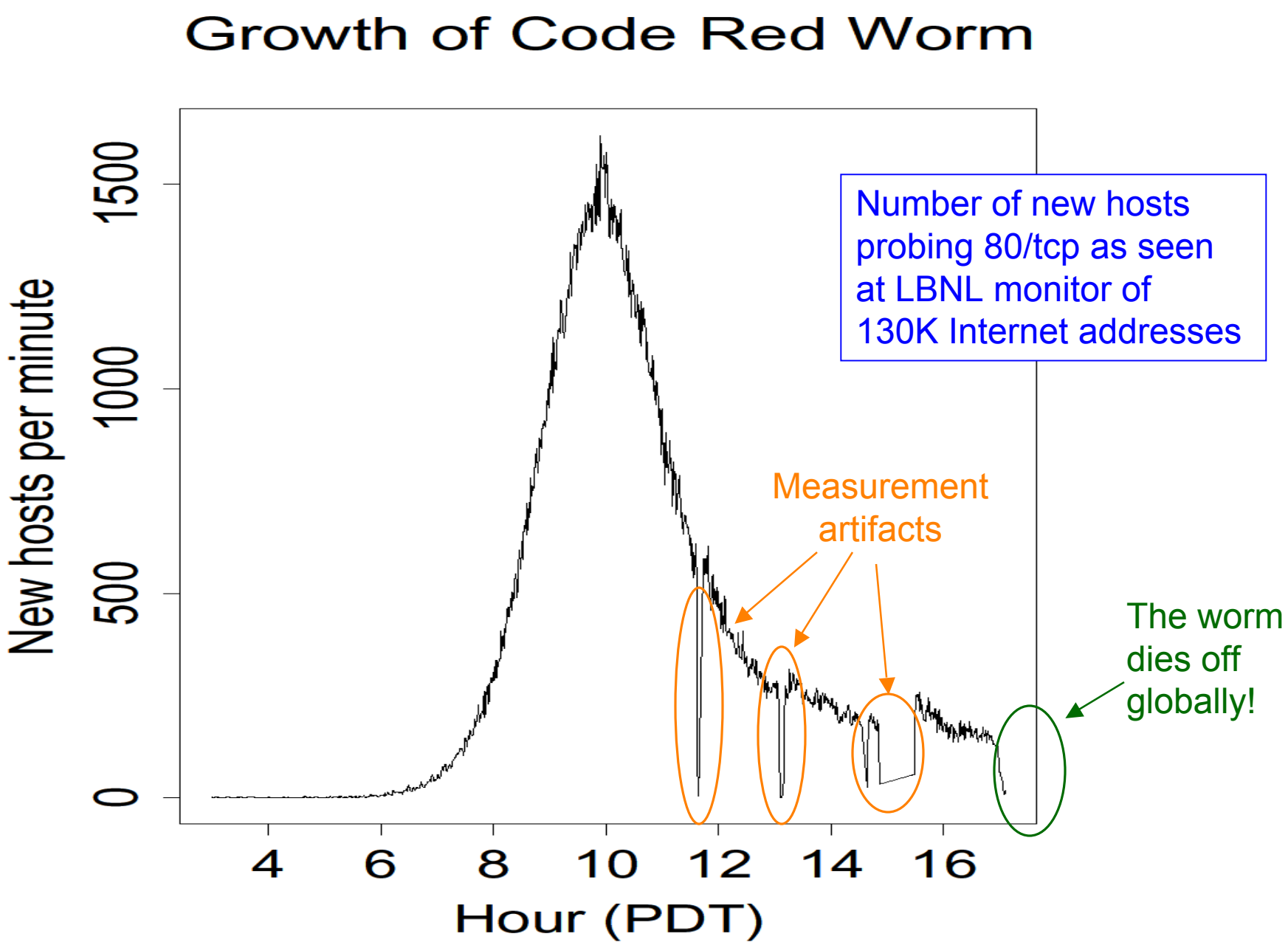
Announcements

- HKN reviewing today, 12:15PM
- Final exam will be in F295 Haas
  - This is **not** Haas Pavilion!
  - Haas School of Business, east side of campus near Gayley
- Course Summary lecture
  - For sure works best if you take advantage of the opportunity to ask questions …
    - … including sending them in advance

Large-Scale Malware

- Worm = code that self-propagates/replicates across systems by arranging to have itself immediately executed
  - Generally infects by altering running code
  - No user intervention required

- Botnet = set of compromised machines ("bots") under a common command-and-control (C&C)
  - Attacker might use a worm to get the bots, or other techniques; orthogonal to bot's use in botnet


Growth of Code Red Worm
New hosts per minute
0
500
1000
1500
4
6
8
10
12
14
16
Hour (PDT)
Number of new hosts probing 80/tcp as seen at LBNL monitor of 130K Internet addresses
Measurement artifacts
The worm dies off globally!

Modeling Worm Spread

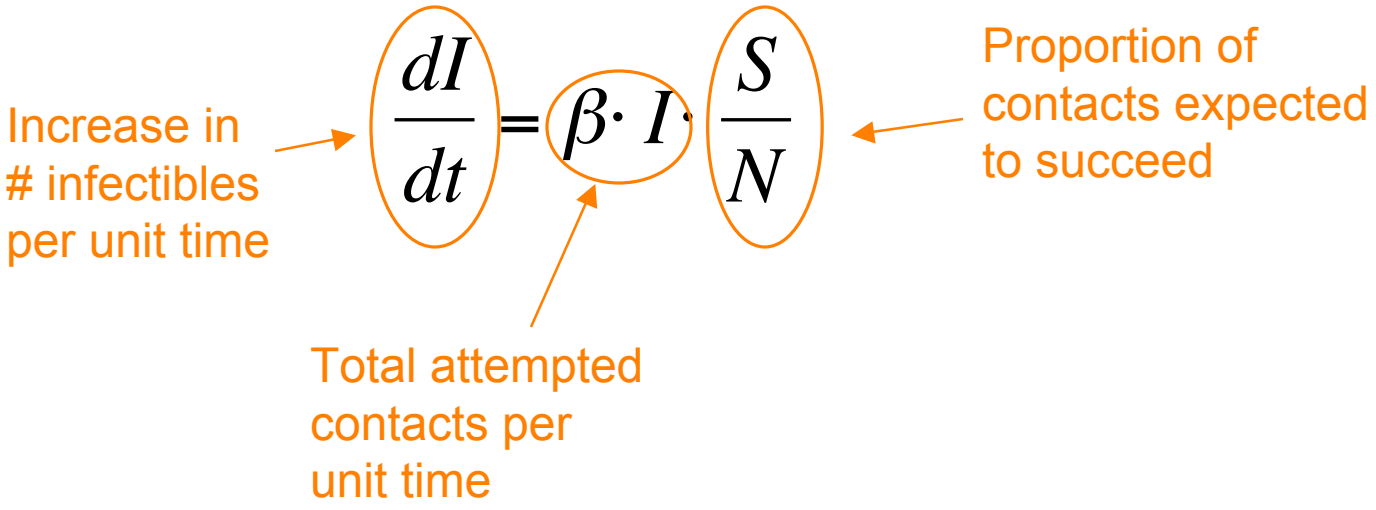
- Worm-spread often well described as *infectious epidemic*
  - Classic SI model: homogeneous random contacts
    - SI = Susceptible-Infectible
- Model parameters:
  - N: population size
  - S(t): susceptible hosts at time t.
  - I(t): infected hosts at time t.
  - β: *contact rate*
    - How many population members each infected host communicates with per unit time
    - E.g., if host scans 10 Internet addresses per unit time, and 2% of Internet addresses run a vulnerable server, then $\beta = 0.2$

$$N = S(t) + I(t)$$
$$S(0) = I(0) = N/2$$

- Auxiliary parameters reflecting the relative proportion of infected/susceptible hosts
  - $s(t) = S(t)/N \quad i(t) = I(t)/N \quad s(t) + i(t) = 1$

Computing How An Epidemic Progresses

- In continuous time:

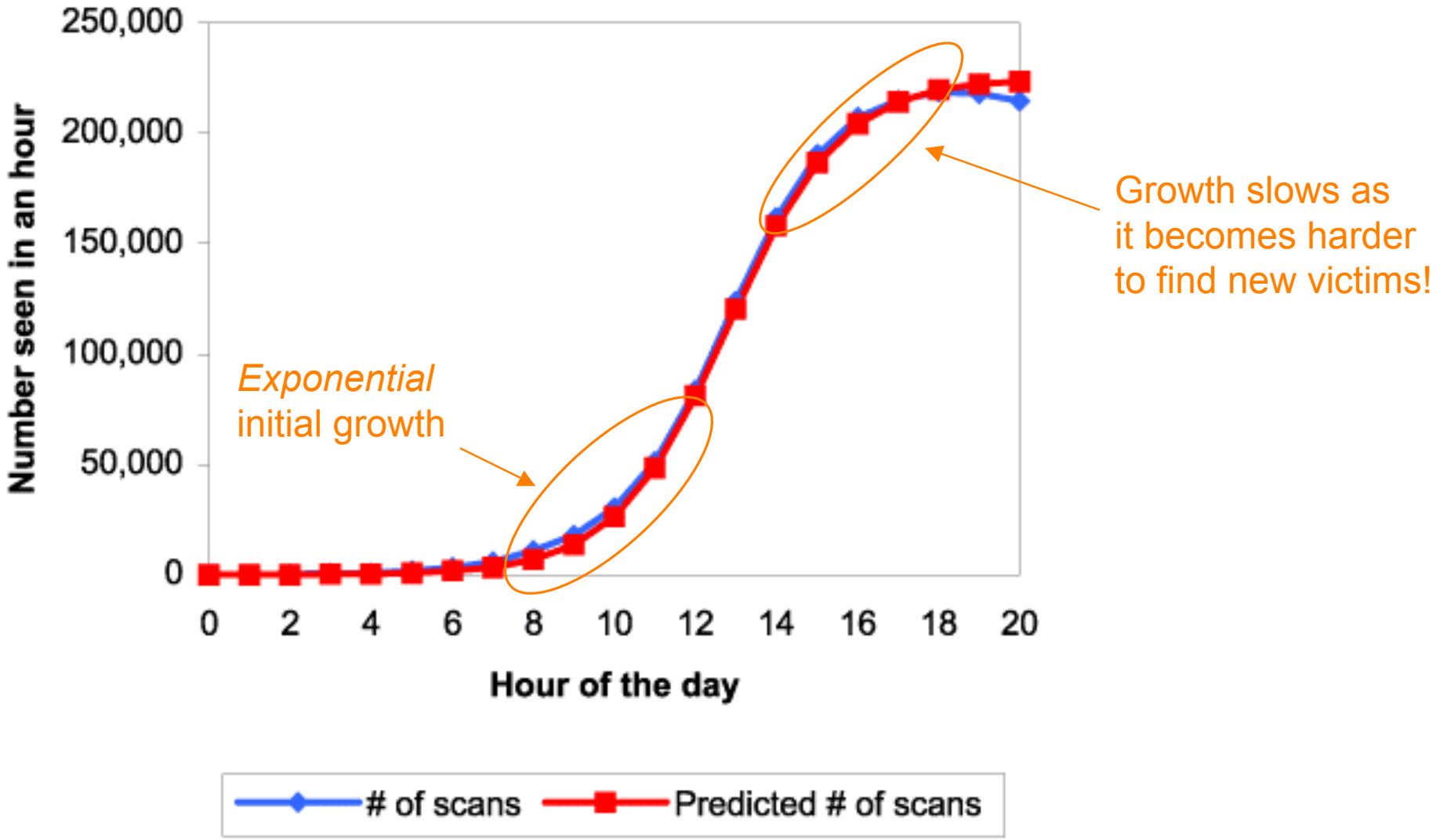


- Rewriting by using i(t) = I(t)/N, S = N - I:

$$\frac{di}{dt} = \beta i(1-i) \quad \Rightarrow \quad i(t) = \frac{e^{\beta t}}{1+e^{\beta t}}$$

Fraction infected grows as a *logistic*

Fitting the Model to Code Red



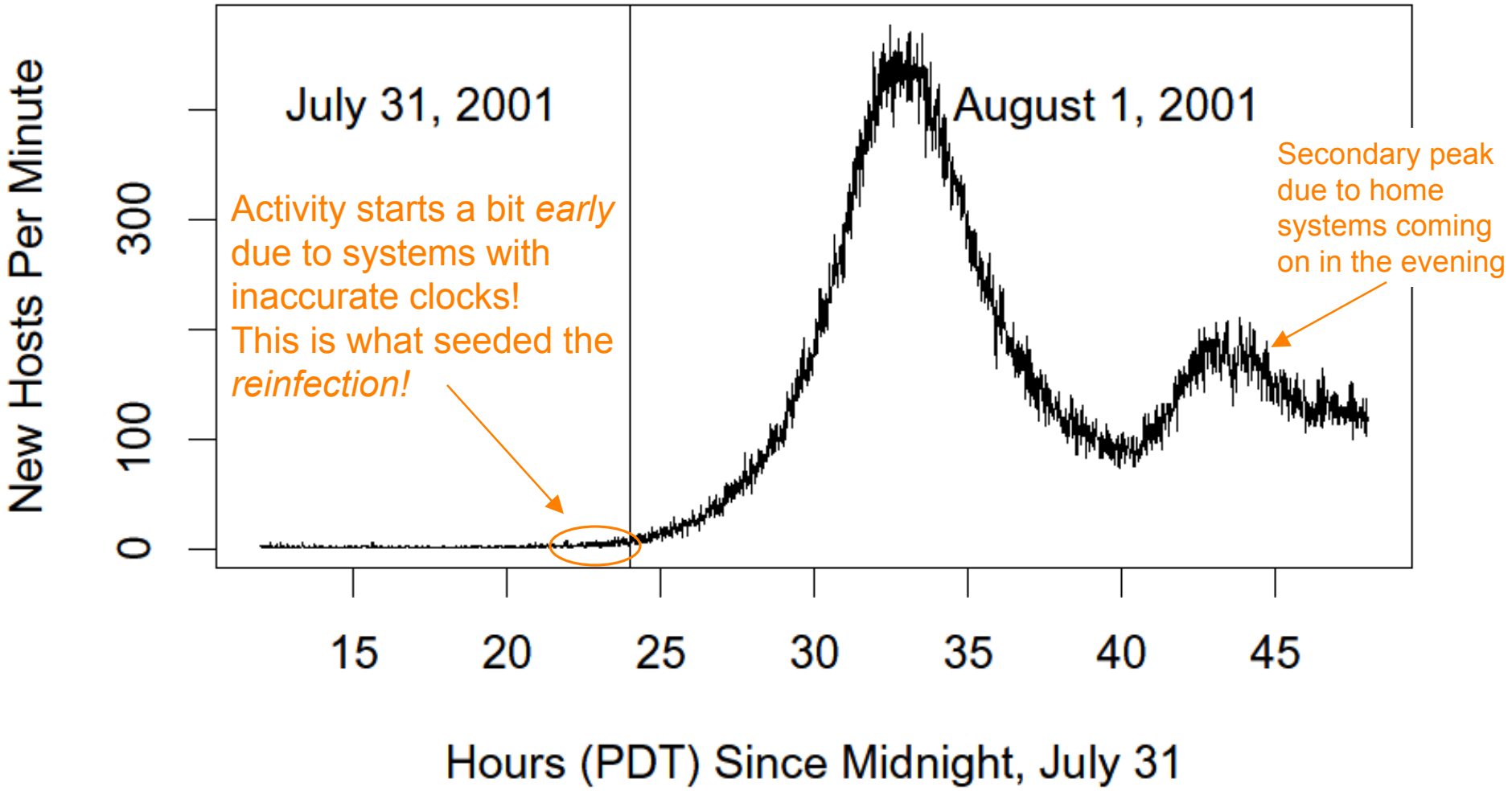
Spread of Code Red, con't

- Recall that # of new infections scales with contact rate β

$$\frac{dI}{dt} = \beta \cdot I \cdot \frac{S}{N}$$

- For a scanning worm, β *increases* with N
  - Larger populations infected more quickly!
    - More likely that a given scan finds a population member
- Large-scale monitoring finds 359,104 systems infected with Code Red on July 19
  - Worm got them in 13 hours
- That night ($\Rightarrow 20^{th}$), worm dies due to DoS bug
- What happens on August 1st?

Return of Code Red Worm



(Again from LBNL monitoring)

Reinfection about 1/2 as big as original

Code Red 2

- Released August 4, 2001 (*3 days later!*)
- Exploits same IIS vulnerability
- String inside the code: “Code Red 2”
  - But in fact completely different code base.
- Payload: a root backdoor, resilient to reboots.
- Bug: crashes NT, only works on Win2K.
- Kills original Code Red.
- *Localized scanning*: prefers nearby addresses.
- Safety valve: programmed to die Oct 1, 2001.

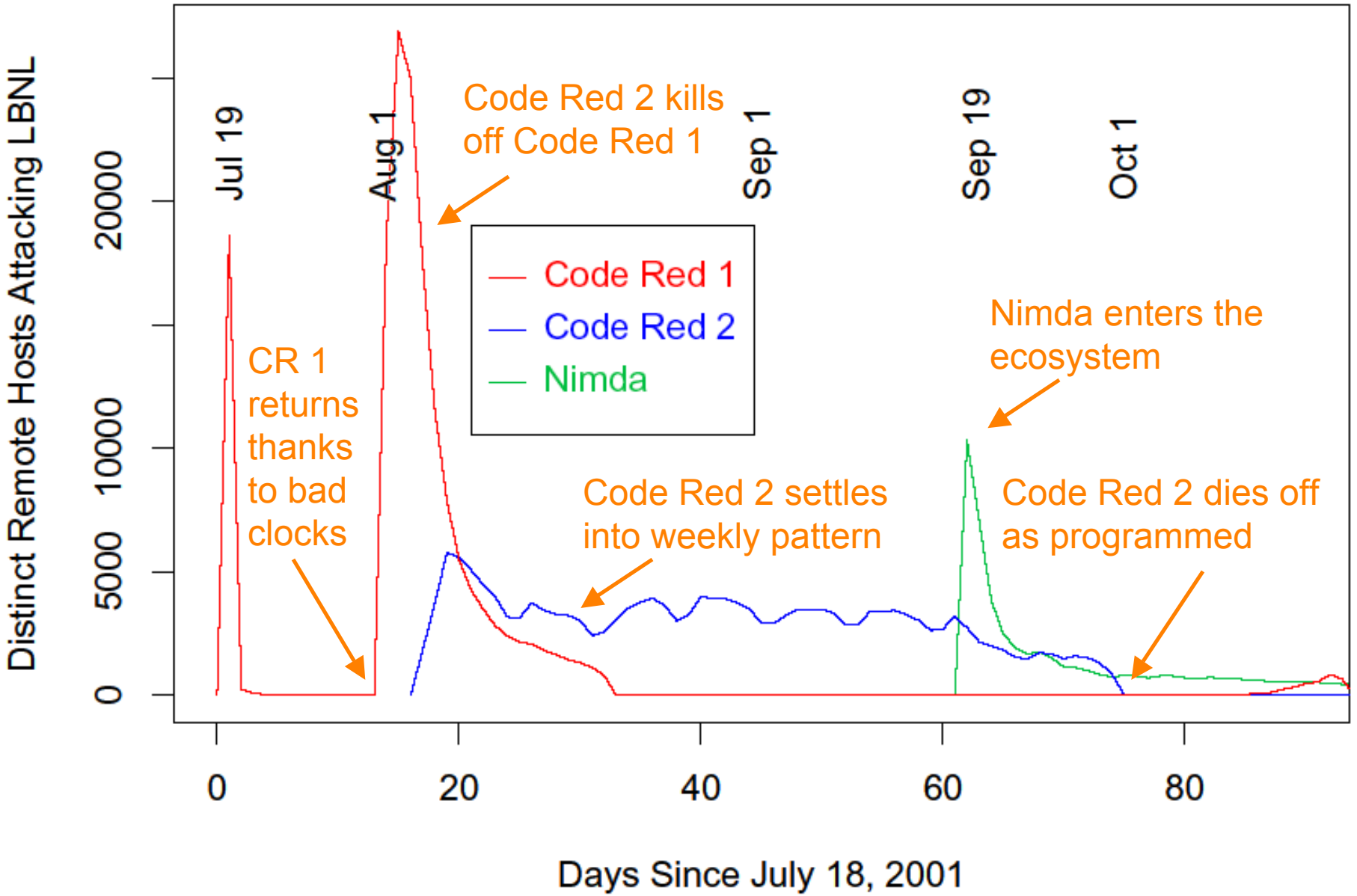
Striving for Greater Virulence: *Nimda*

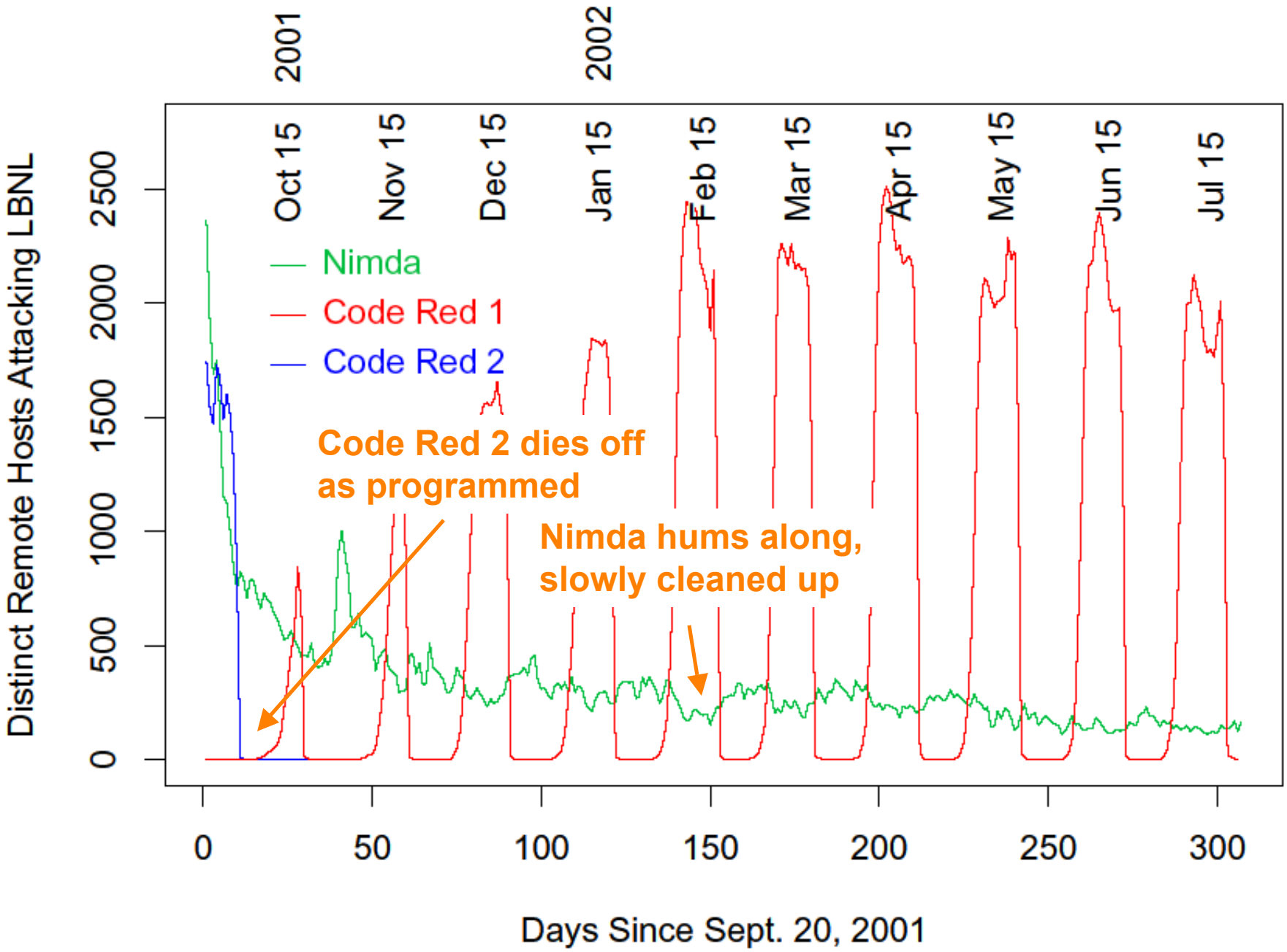
- Released September, 2001.
- Multi-mode spreading:
  - attack IIS servers like Code Red & Code Red 2
  - email itself to address book as a virus
  - copy itself across open network shares
  - modify Web pages on infected servers with browser exploit
  - scan for Code Red 2 backdoors (!)

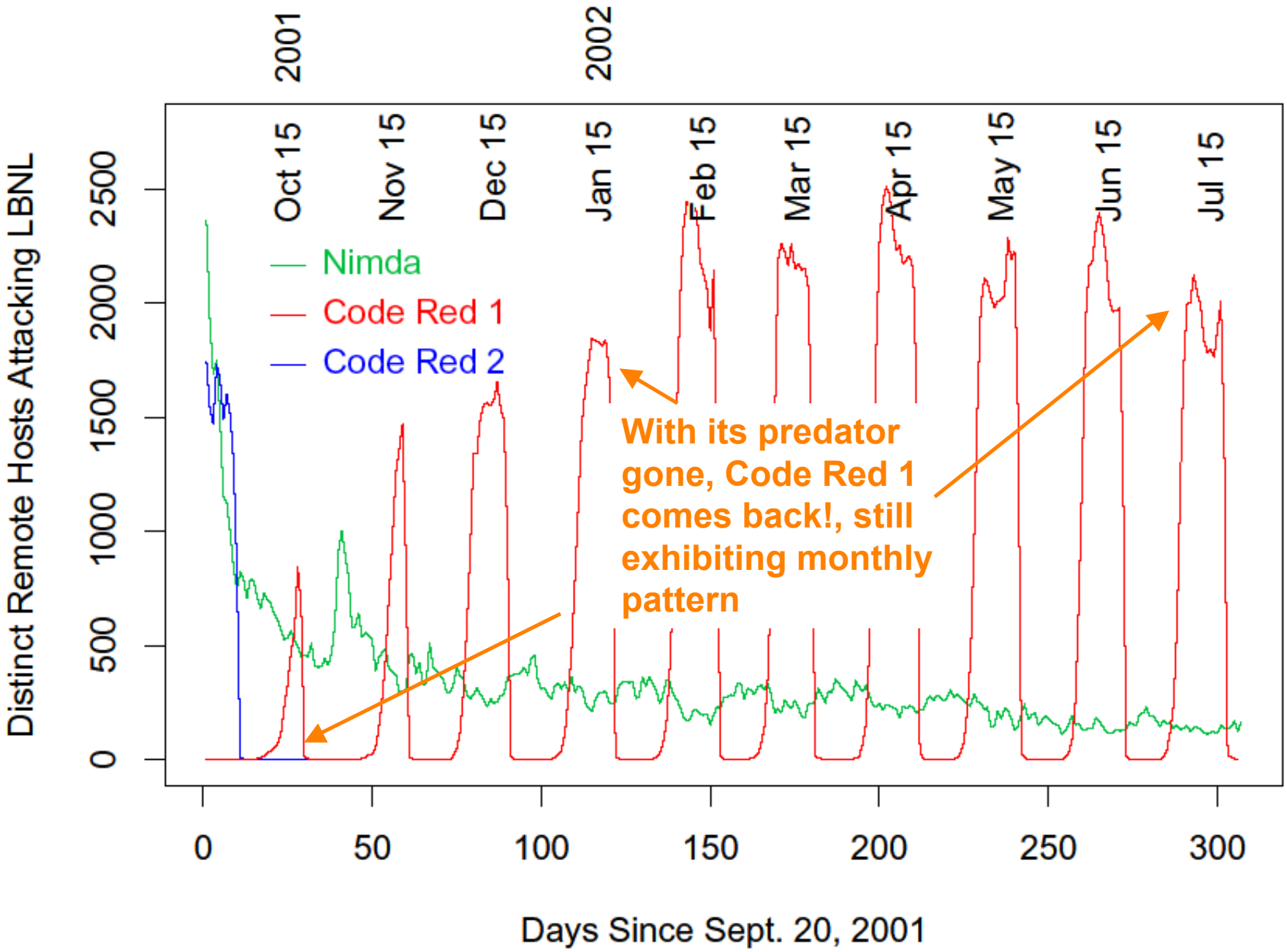
    ⇒ Worms form an *ecosystem*!

Note: in some ways a virus, in some ways a worm.

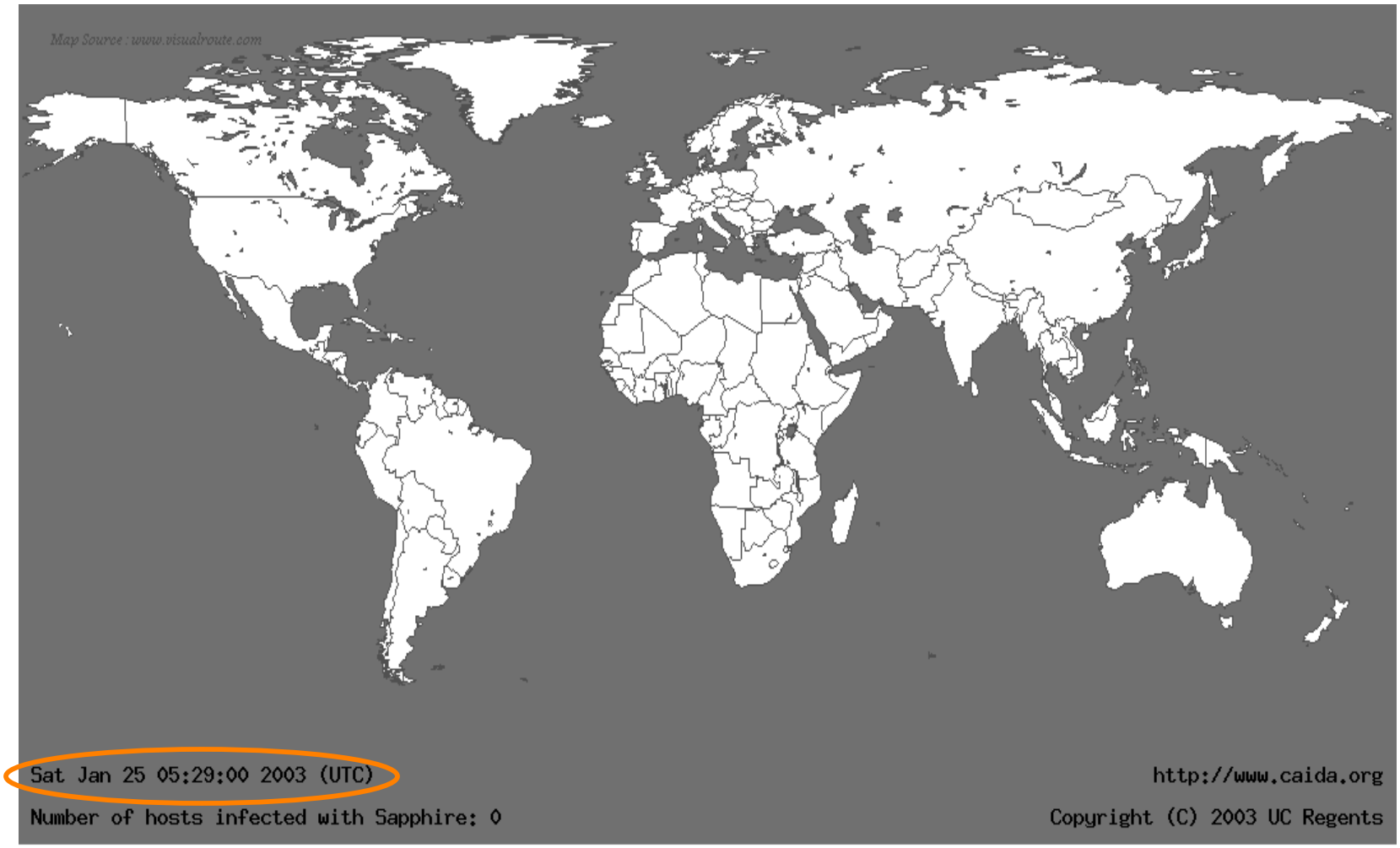
- Leaped across firewalls
  - Ravaged sites that lacked “institutional antibodies”


Distinct Remote Hosts Attacking LBNL
0
5000
10000
20000
Jul 19
Aug 1
Sep 1
Sep 19
Oct 1
Code Red 2 kills
off Code Red 1
Code Red 1
Code Red 2
Nimda
CR 1
returns
thanks
to bad
clocks
Code Red 2 settles
into weekly pattern
Nimda enters the
ecosystem
Code Red 2 dies off
as programmed
0
20
40
60
80
Days Since July 18, 2001

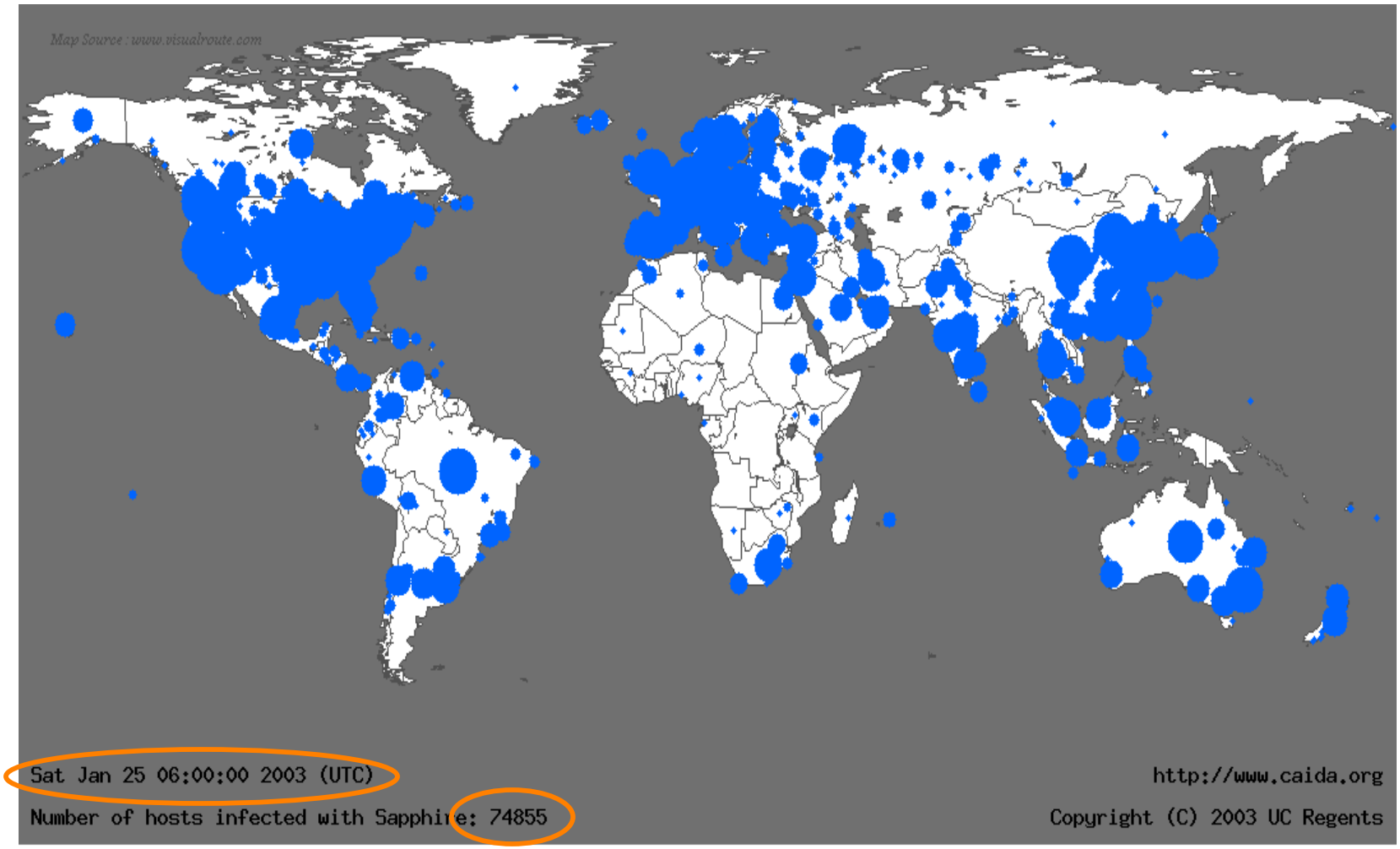

2001
2002
Oct 15
Nov 15
Dec 15
Jan 15
Feb 15
Mar 15
Apr 15
May 15
Jun 15
Jul 15
Nimda
Code Red 1
Code Red 2
Code Red 2 dies off
as programmed
Nimda hums along,
slowly cleaned up
Distinct Remote Hosts Attacking LBNL
0
500
1000
1500
2000
2500
0
50
100
150
200
250
300
Days Since Sept. 20, 2001


2001
2002
Oct 15
Nov 15
Dec 15
Jan 15
Feb 15
Mar 15
Apr 15
May 15
Jun 15
Jul 15
Nimda
Code Red 1
Code Red 2
With its predator gone, Code Red 1 comes back!, still exhibiting monthly pattern
Distinct Remote Hosts Attacking LBNL
0
500
1000
1500
2000
2500
0
50
100
150
200
250
300
Days Since Sept. 20, 2001

Life Just Before Slammer



Life Just After Slammer



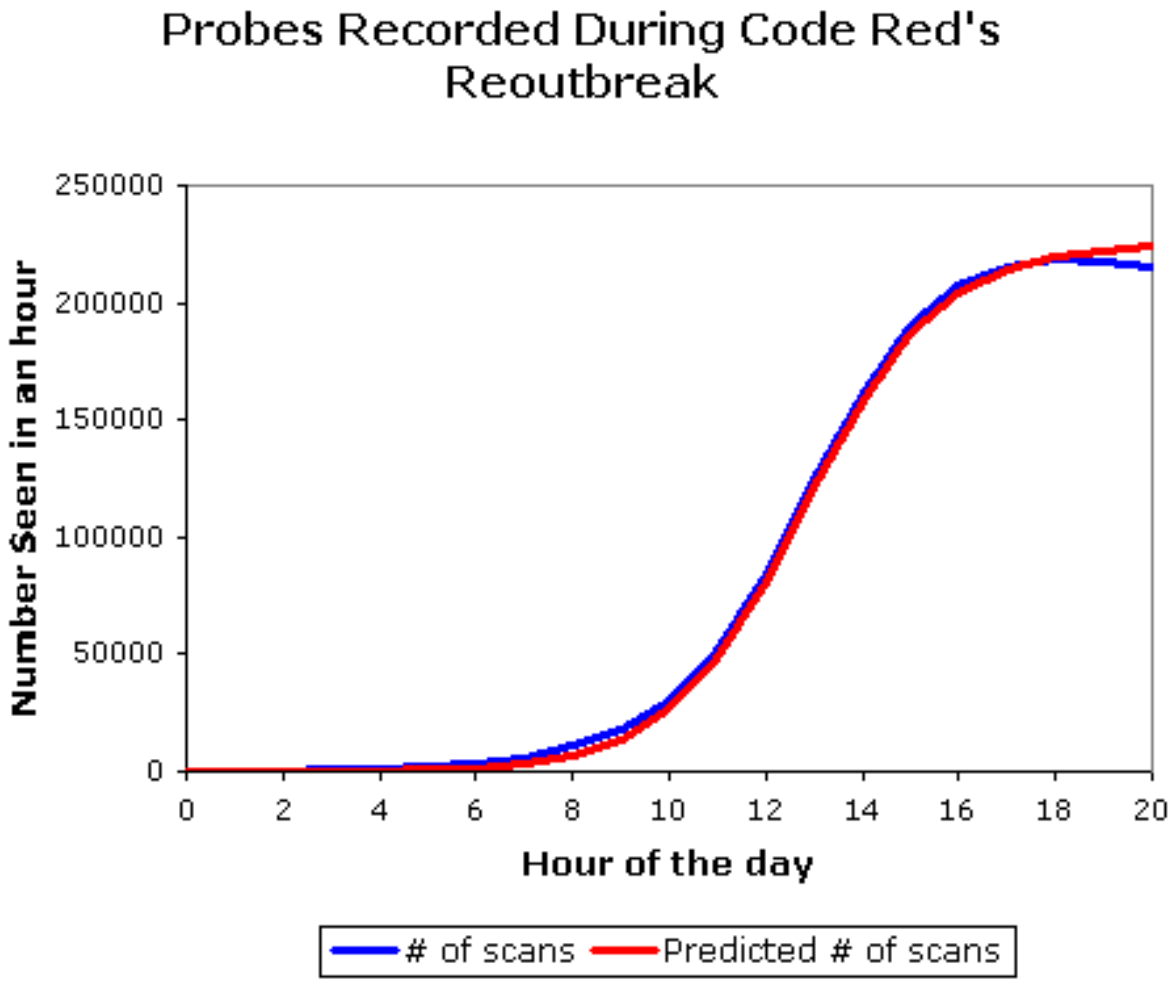
Going Fast: *Slammer*

- Slammer exploited connectionless UDP service, rather than connection-oriented TCP
- *Entire worm* fit in a single packet!

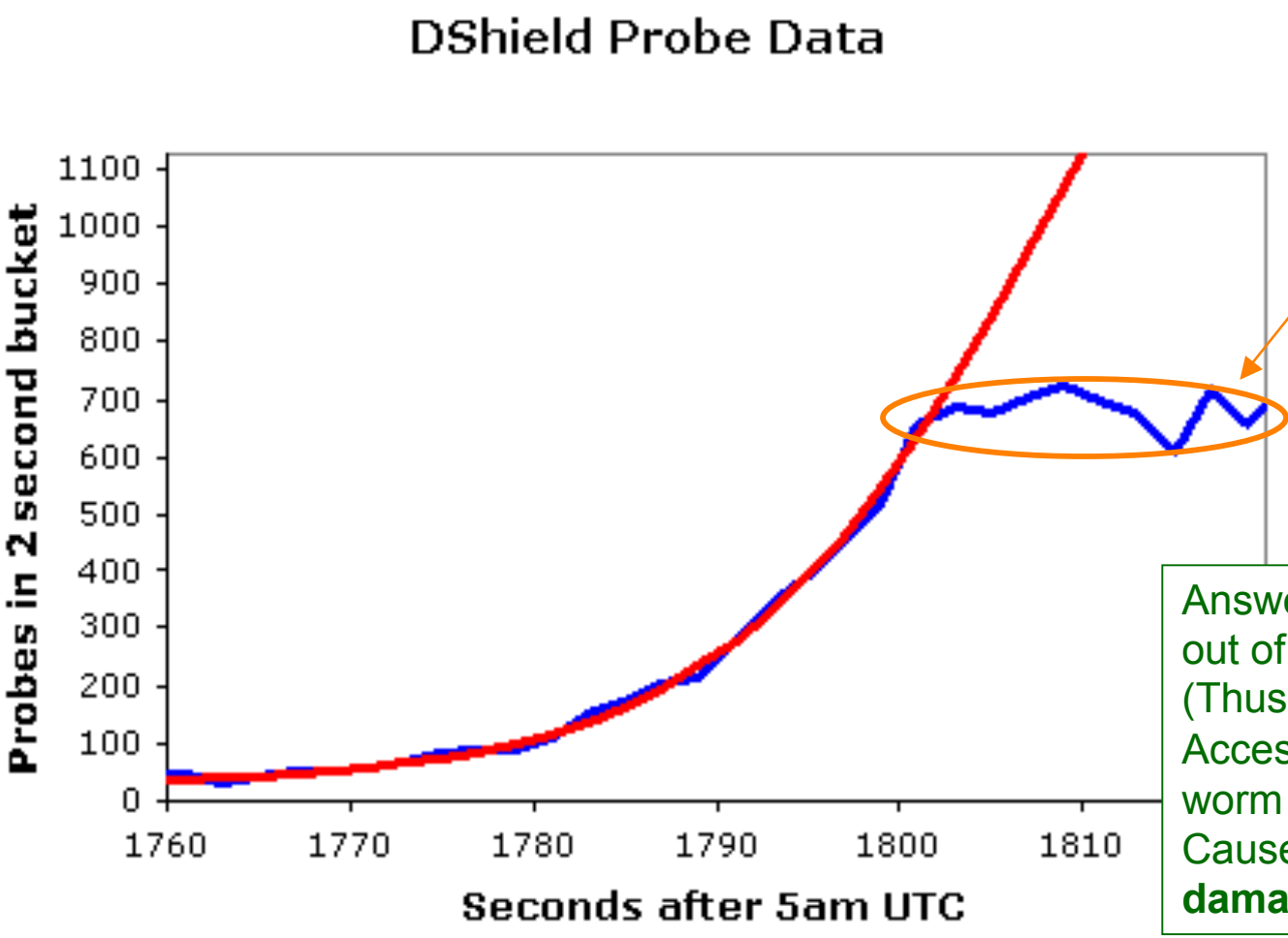
⇒ When scanning, worm could "fire and forget"
Stateless!

- Worm infected 75,000+ hosts in 10 minutes (despite broken random number generator).
- At its peak, **doubled every 8.5 seconds**

The Usual Logistic Growth



Slammer's Growth



What could have caused growth to deviate from the model?

Hint: at this point the worm is generating *55,000,000 scans/sec*

Answer: the Internet ran out of carrying capacity! (Thus, β decreased.) Access links used by worm completely clogged. Caused **major collateral damage**.

Further Worm Developments

- Malicious payloads (disk-trashing)
- Global outbreaks within 24 hours of vulnerability disclosure
- "Server" exploited for infection is a NIDS
- Single outbreak of > 15 million infectees
- "*Counterworm*" released to clean up original worm …
  - … oh and install a root backdoor
- DoS'ing *Windows Update* as a worm spreads
- Worms that use Google to search for victims

"viewtopic.php" Search Advanced Search

Web Show options... Results **1** - **10** of about **153,000,000** for **"viewtopic.php"**. (**0.23** seconds)

Step-By-Step Guide: Embedded Windows Media in Firefox ...

Jan 26, 2005 ... For pre-1.0 versions of Firefox (also under Windows), see this earlier version of this guide: http://forums.mozillazine.org/**viewtopic.php**?t=140828. ...
forums.mozillazine.org/**viewtopic.php**?t=206213 - Cached - Similar

- [Ext] Fission 0.8.9 [Sep 25] • mozillaZine Forums - 15 posts - Jan 19, 2006
- [Ext] Console² 0.1 to 0.3.6.2 • mozillaZine Forums - 15 posts - Sep 17, 2005
- Quicktime/Real/Windows Media Player Issues ... - 3 posts - Jan 25, 2005
- keyconfig 20080929 • mozillaZine Forums - 15 posts - Jul 29, 2004

More results from forums.mozillazine.org »

phpBB • View topic - howdark.com exploits - follow up

1 post - 1 author - Last post: Nov 18, 2004
In the mean time we strongly, and I mean strongly! urge all our users to make the following change to **viewtopic.php** as a matter of urgency. ...
www.phpbb.com/community/**viewtopic.php**?t=240513 - Cached - Similar

- phpbb • View topic - [2.0.19] Youtube Video bbcode - Apr 29, 2007
- phpbb • View topic - Preventing SPAM - Bots ... - Mar 19, 2007
- phpBB • View topic - phpBB 2.0.16 released - Jun 26, 2005

More results from phpbb.com »

GREYSCALE & COLOUR CALIBRATION FOR DUMMIES

Written by Kal, Editor/Webmaster www.CurtPalme.com Home Theater Last updated on June 6, 2009 (fixed some minor typo's) ...
www.curtpalme.com/forum/**viewtopic.php**?t=10457 - Cached - Similar

Stuxnet

- Discovered July 2010. (Released: Mar 2010?)
- Multi-mode spreading:
  - Initially spreads via USB (virus-like)
  - Once inside a network, quickly spreads internally using Windows RPC
- Kill switch: programmed to die June 24, 2012
- Targeted *SCADA* systems
  - Used for industrial control systems, like manufacturing, power plants
- Symantec: infections geographically clustered
  - Iran: 59%; Indonesia: 18%; India: 8%

Stuxnet, con't

- Used four *Zero Days*
  - Unprecedented expense on the part of the author
- "Rootkit" for hiding infection based on installing Windows drivers with valid digital signatures
  - Attacker stole private keys for certificates from two companies in Taiwan
- Payload: do nothing …
  - … unless attached to particular models of frequency converter drives operating at 807-1210Hz
  - … like those made in Iran (and Finland) …
  - … and used to operate centrifuges for producing enriched Uranium for nuclear weapons

Stuxnet, con't

- Payload: do nothing …
  - … unless attached to particular models of frequency converter drives operating at 807-1210Hz
  - … like those made in Iran (and Finland) …
  - … and used to operate centrifuges for producing enriched Uranium for nuclear weapons
- For these, worm would slowly increase drive frequency to 1410Hz …
  - … enough to cause centrifuge to **fly apart** …
  - … while sending out fake readings from control system indicating everything was okay …
- … and then drop it back to normal range

Israel Tests on Worm Called Crucial in Iran Nuclear Delay

By WILLIAM J. BROAD, JOHN MARKOFF and DAVID E. SANGER
Published: January 15, 2011

*This article is by **William J. Broad, John Markoff** and **David E. Sanger.***

Enlarge This Image

Nicholas Roberts for The New York Times

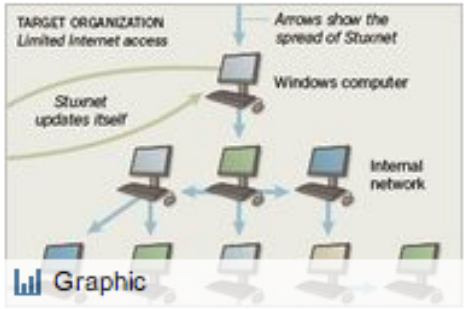
Ralph Langner, an independent computer security expert, solved Stuxnet.

The Dimona complex in the Negev desert is famous as the heavily guarded heart of Israel's never-acknowledged nuclear arms program, where neat rows of factories make atomic fuel for the arsenal.

Over the past two years, according to intelligence and military experts familiar with its operations, Dimona has taken on a new, equally secret role — as a critical testing ground in a joint American and Israeli effort to undermine Iran's efforts to make a bomb of its own.

Behind Dimona's barbed wire, the experts say, Israel has spun nuclear centrifuges virtually identical to Iran's at Natanz, where Iranian scientists are struggling to enrich uranium. They say Dimona tested the effectiveness of the Stuxnet computer worm, a destructive program that appears to have wiped out roughly a fifth of Iran's nuclear

Multimedia



How Stuxnet Spreads

Worm Take-Aways

- Potentially enormous reach/damage
  ⇒ *Weapon*
- Hard to get right
- Emergent behavior / surprising dynamics
- Institutional antibodies
- Remanence: worms stick around
  - E.g. Nimda & Slammer still seen in 2011!
- *Propagation faster than human response*
- What about fighting a worm using a worm?
  - "White worm" spreads to disinfect/patch
  - Experience shows: likely not to behave predictably!
  - Additional issues: legality, collateral damage, target worm having already patched so white worm can't access victim

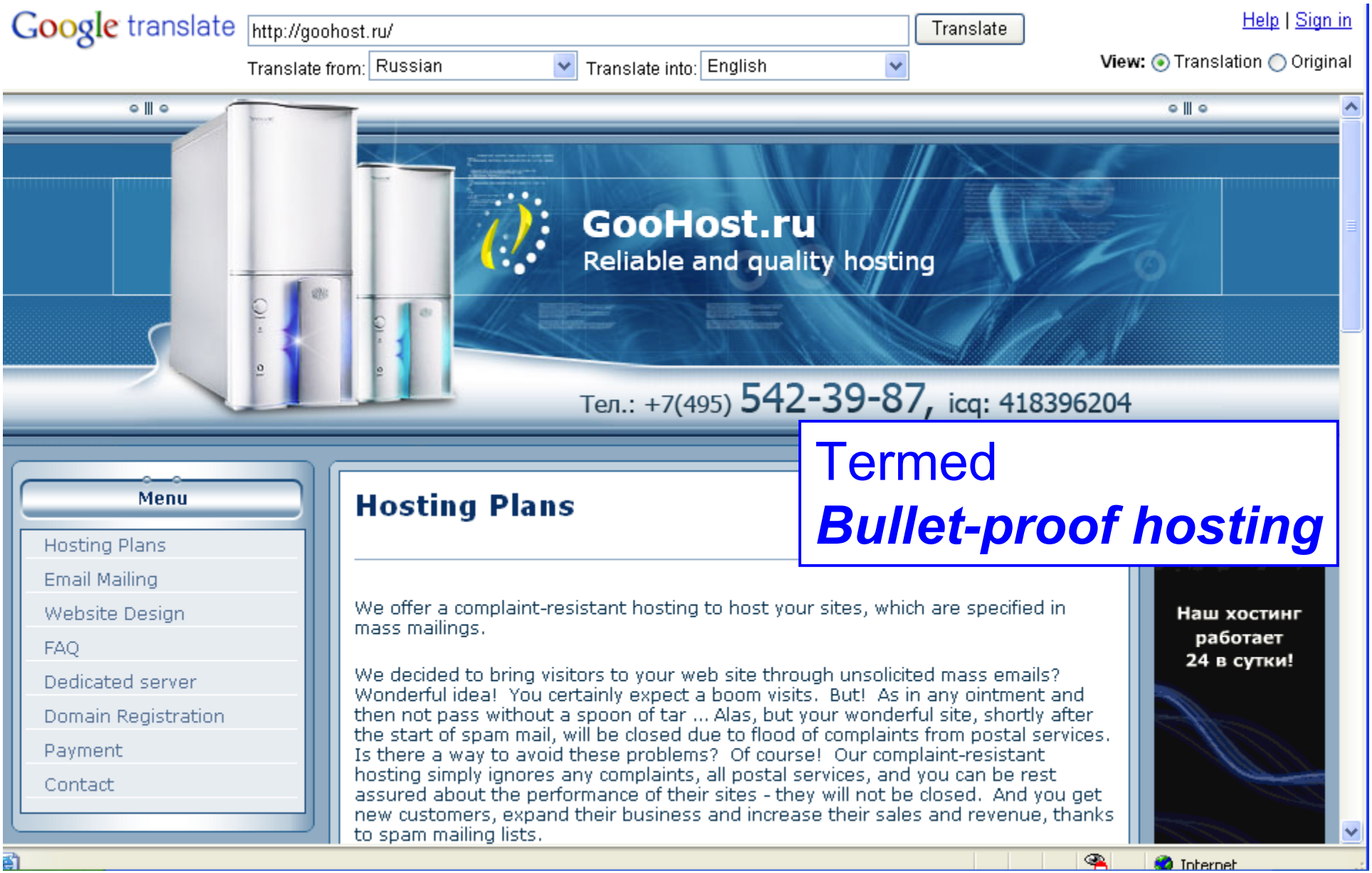
Botnets

Botnets

- Collection of compromised machines (bots) under (unified) control of an attacker (botmaster)
- Method of compromise decoupled from method of control
  - Launch a worm / virus / drive-by infection / etc.
- Upon infection, new bot "*phones home*" to rendezvous w/ botnet *command-and-control* (**C&C**)
- Lots of ways to architect C&C:
  - Star topology; hierarchical; peer-to-peer
  - Encrypted/stealthy communication
- Botmaster uses C&C to push out commands and updates

Fighting Bots / Botnets

- How can we defend against bots / botnets?
- Approach #1: prevent the initial bot infection
  - Because the infection is decoupled from bot's participation in the botnet, this is equivalent to preventing malware infections in general …. HARD
- Take down the C&C master server
  - Find its IP address, get associated ISP to pull plug
- Botmaster countermeasures?
  - Counter #1: keep moving around the master server
    - Bots resolve a domain name to find it
    - Rapidly alter address associated w/ name ("fast flux")
  - Counter #2: buy off the ISP …


Google translate
http://goohost.ru/
Translate
Translate from: Russian
Translate into: English
Help | Sign in
View: Translation Original
GooHost.ru
Reliable and quality hosting
Тел.: +7(495) 542-39-87, icq: 418396204
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Hosting Plans
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FAQ
Dedicated server
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Payment
Contact
Hosting Plans
We offer a complaint-resistant hosting to host your sites, which are specified in mass mailings.
We decided to bring visitors to your web site through unsolicited mass emails? Wonderful idea! You certainly expect a boom visits. But! As in any ointment and then not pass without a spoon of tar ... Alas, but your wonderful site, shortly after the start of spam mail, will be closed due to flood of complaints from postal services. Is there a way to avoid these problems? Of course! Our complaint-resistant hosting simply ignores any complaints, all postal services, and you can be rest assured about the performance of their sites - they will not be closed. And you get new customers, expand their business and increase their sales and revenue, thanks to spam mailing lists.
Termed
Bullet-proof hosting
Наш хостинг работает 24 в сутки!
Internet

Obuzoustoychivy hosting is more expensive than usual, but you will have the full guarantee that your site no one ever closes, it will always be available to your customers!

MINI PLAN	
Volume disc	400 MB
Domains	1
Traffic *	Unlimited
FTP-access	there is
MySQL database	there is
Control panel	there is
COST	4 000 rub. / 1 month.

STARTER PLAN	
Volume disc	500 mb
Domains	3
Traffic *	Unlimited
FTP-access	there is
MySQL database	there is
Control panel	there is
COST	5 000 rub. / 1 month.
BUSINESS PLAN	
Volume disc	1000 mb
Domains	7
Traffic *	Unlimited
FTP-access	there is
MySQL database	there is
Control panel	there is
COST	7 000 rub. / 1 month.
PREMIUM PLAN	