

A Crawler-based Study of Spyware in the Web

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What do we mean by spyware?

- Difficult to define spyware precisely
 - No clean line between good and bad behavior
- Spyware is a *software parasite* that:
 - Collects information of value and relays it to a 3rd party
 - Hijacks resources or functions of PC
 - Installs surreptitiously, without user consent
 - Resist detection and de-installation
- Spyware provides value to others, but not to you

Spyware today

- Most Internet PCs have, or have had, spyware
- Harsh consequences for victims
- Explosion of anti-spyware software market
- We have very little quantitative data on spyware

The goal of this work

- Quantify the nature and extent of the spyware problem from the Internet point of view
- Example questions:
 - How prevalent is spyware on the Web?
 - What Web categories are most infected?
 - What are the spyware trends over time?

Talk overview

- We studied the two methods by which spyware infects victims
 - Spyware piggy-backed on executables
 - E.g., Kazaa ships bundled with multiple spyware programs
 - Drive-by download installation
 - Malicious web content exploits browser flaws to install spyware
- We repeated each study to understand the trends
 - May 2005, October 2005
 - We present data for October

Popularity of sites in our study

- Does anyone visit any of the sites we've examined?
 - Popularity ratings (using Alexa) confirm that we have crawled sites across all popularity rankings
 - A few very popular sites
 - Many popular sites
 - Intuition
 - Companies will put adware in popular, easy-to-reach places

Outline

- Introduction
- Executable file study
- Drive-by download study
- Related work and conclusions

Crawling for executables

- Measure spyware prevalence in sites people tend to visit
- We defined 10 interesting Web categories
 - E.g., games, news, celebrities, pirate, wallpaper
- For each category, we:
 - Used Google to identify several hundred domains
 - Crawled each domain (to depth 3) to find executables
 - Downloaded executables for offline analysis
- Crawled about 20 million URLs over 2,500 domains
- Collected 20,000 executables
 - 19% of domains had downloadable executables

Analyzing executables

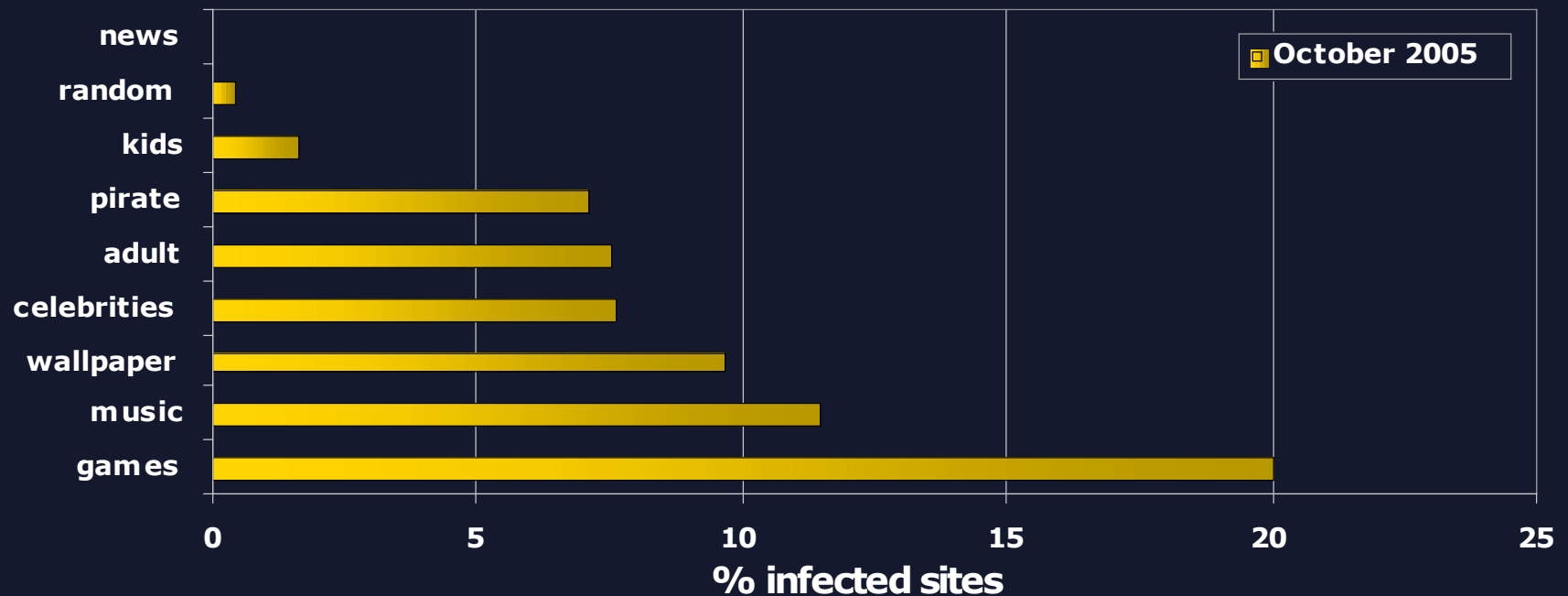
- For each executable, we:
 - Cloned a clean WinXP virtual machine (VMware)
 - Automatically installed the executable into the VM
 - Ran an anti-spyware tool to look for infections
 - We used Lavasoft Ad-Aware
- Automating installation required some heuristics
 - E.g., pressing "Next," agreeing to EULAs, ...
- An executable is *infected* if Ad-Aware finds spyware
 - Limited to what Ad-Aware can detect
 - We found choice of the tool rarely matters

High-level results

- We found a lot of piggy-backed spyware
 - 1 in 20 executables contained spyware
 - 1 in 25 domains were infectious
- We observed few spyware variants
 - We encountered 1,294 infected executables but only 89 spyware programs
- No significant change in amount of piggy-backed spyware from May 2005 to October 2005

Where is the spyware found?

- Spyware is concentrated on specific popular Web zones
 - High-profile organizations tend to have spyware-free sites
 - Downloads from unknown sources are risky



Spyware on c|net

- We examined 2,000 executables on download.com
 - In May, we found spyware in 110 programs (4.6%)
 - In October, we found spyware in only 6 programs
- c|net implemented a no-spyware policy between our crawls
 - Mostly effective
 - Some programs can still fool the filters

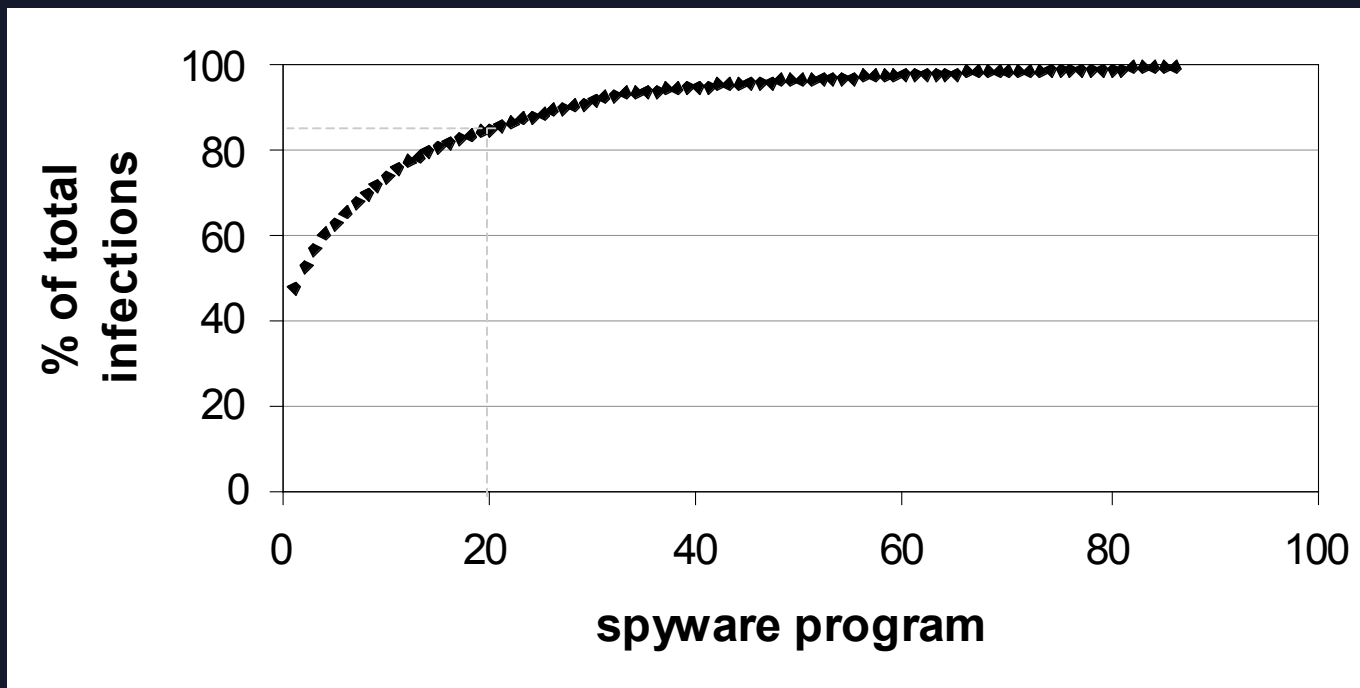
How is spyware distributed across sites?

- A small # of sites have a large # of infected executables
 - Easy to detect and blacklist, given our tool

| Top spyware sites | # infected executables |
|-----------------------|------------------------|
| scenicreflections.com | 503 |
| gamehouse.com | 164 |
| screensavershot.com | 137 |
| screensaver.com | 107 |
| hidownload.com | 50 |
| games.aol.com | 30 |
| appzplanet.com | 27 |
| dailymp3.com | 27 |
| free-games.to | 27 |

Distribution of spyware programs

- A few offenders are responsible for most infected executables
- Top offenders are well-known (e.g., WhenU)
- Many spyware programs are rare
- Signature-based detection should be effective



What kinds of spyware do we find?

- We measured the prevalence of five spyware functions:
 - Keyloggers
 - Dialers
 - Trojan downloaders
 - Browser hijackers
 - Adware
- Adware and browser hijackers are most common (86%)
- Trojan downloaders pose a risk (13%)
- Keyloggers and dialers are more rare (1%)

Piggy-backed spyware summary

- A large number of executables are infected (1 in 20)
- Spyware is focused on a small number of popular sites
- Most of it is benign
- Only a few variants matter
- Implications:
 - Easy to identify and defend against the main culprits
 - Signature-based techniques should be effective

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Drive-by download study

- First study examined downloadable executables
- Next, we look at Web pages with drive-by downloads
 - Web content exploits browser flaws to install spyware
 - Victims are infected just by visiting a malicious page

Methodology

- Goal: find malicious Web pages automatically
- Detect attacks as they happen in practice
 - Crawl our Web categories
 - Render each page in an unmodified Web browser inside a clean VM
 - Internet Explorer (6.0, unpatched)
 - Mozilla Firefox (1.0.6)
 - Run anti-spyware check to look for spyware

Using Event Triggers

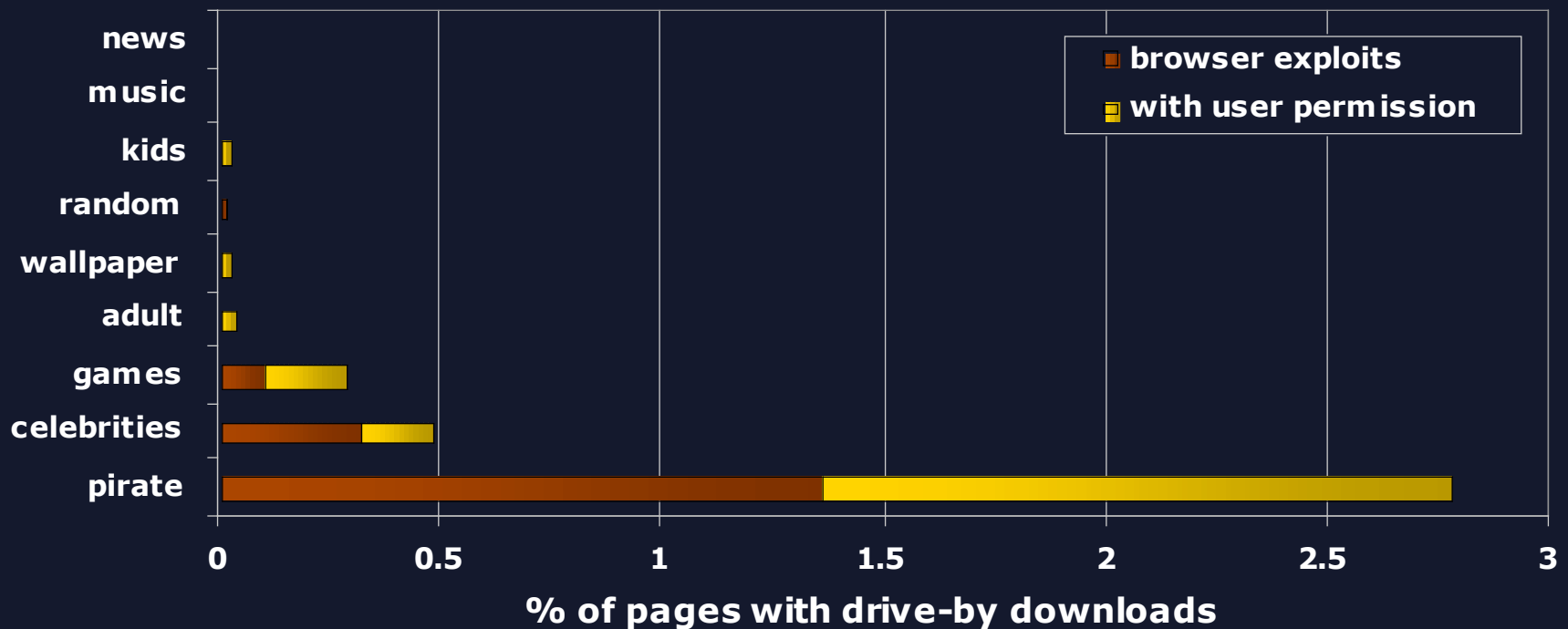
- Event triggers are a performance optimization
- Triggers detect suspicious activity
 - Process creation
 - Suspicious registry modifications
 - Files written outside browser temp. folders
- Run Ad-Aware check *only* when a trigger fires
 - No false negatives
 - 41% false positives
 - Benign software installations
 - Background noise
 - Spyware not detected by Ad-Aware

High-level results

- There are many Web pages with drive-by downloads
 - 0.4% of Web pages are infectious
- 50% of attacks exploited browser flaws
 - These bypass the browser security framework
- Little variation
 - Only 36 spyware programs responsible for 186 attacks
- Different threats than piggy-backed spyware programs

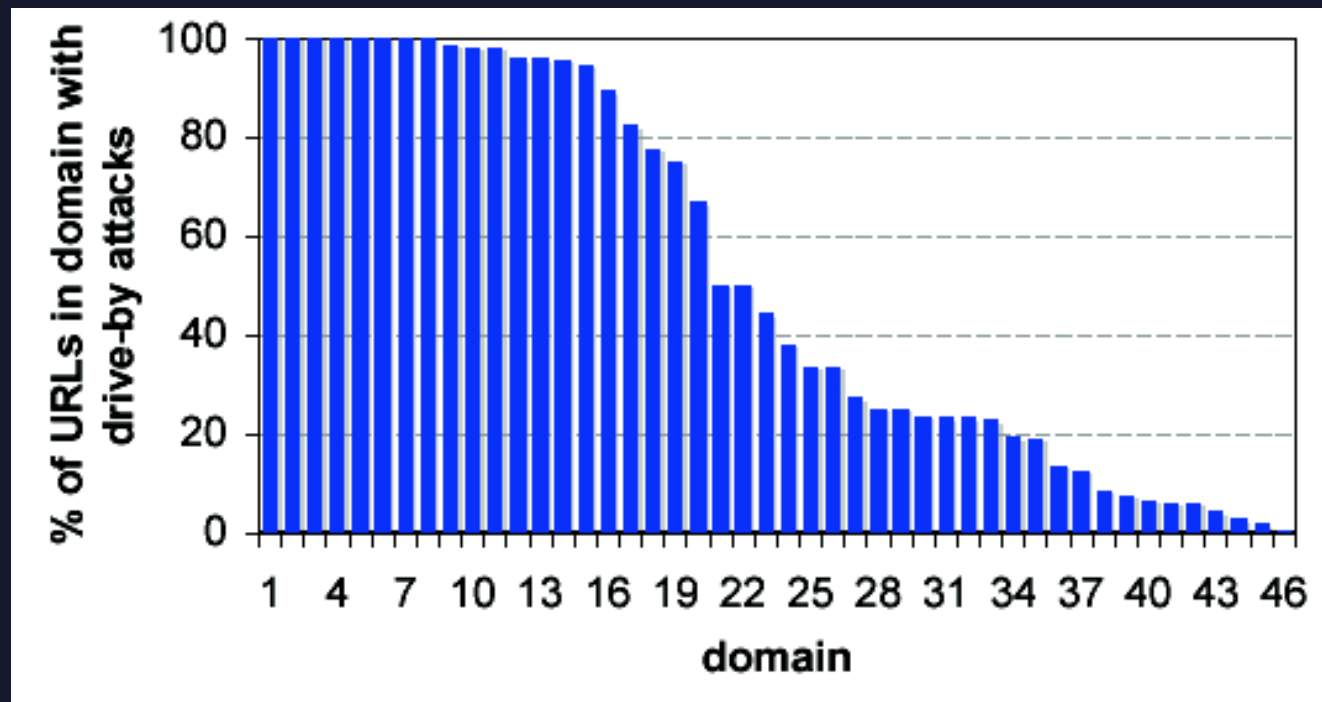
Where are drive-bys found?

- Non-uniform distribution
- Surprisingly many browser exploits!



Spyware prevalence in infectious domains

- Infectious sites often attempt attacks on a large number of their Web pages
 - Sufficient to identify bad sites, rather than bad pages



Is the Firefox browser susceptible?

- Successful drive-by downloads appeared on 0.08% of pages
 - All require user consent
 - All are based on Java
- Firefox is *not* 100% safe, but it is *safer to use* than IE
 - Firefox flaws are not yet being exploited
 - We found 13 times more attacks for IE than for Firefox

Drive-by download trends

- The number of pages with drive-by downloads is decreasing
 - All categories experienced a decrease from May to October
 - Overall, Web page infection decreased 93%
- Our results suggest spyware is past its prime
- Possible reasons:
 - Success rate of attacks is declining
 - Widespread adoption of anti-spyware tools
 - Recent lawsuits discouraging attackers

Drive-by download summary

- Despite the decline, there are still many infectious pages
- 50% of these pages infect *without* user consent
- Malicious content is focused on a small number of sites
- Only a few variants matter
- Firefox is also susceptible
- Implications:
 - Patching security holes is important
 - Automated crawler-based tools are effective at finding sites with malicious content

How big is our Ad-Aware limitation?

- We relied on Ad-Aware to identify known spyware
 - How much spyware are we missing by not using other tools?
- For drive-by downloads, triggers limit how much we miss
 - Upper bound: 41% false positives when a trigger fires
- For piggy-backed spyware, we compared Ad-Aware to Webroot Spy Sweeper
 - Of 100 random executables, only 1 was missed by Ad-Aware

| | | Spy Sweeper | |
|----------|----------|-------------|----------|
| | | clean | infected |
| Ad-Aware | clean | 90 | 1 |
| | infected | 1 | 8 |

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Related Work

- Honeypots
- Strider HoneyMonkey
 - Tool to find Web pages with browser exploits
 - Method similar to our trigger-based VM approach
 - We focus more on analysis
- Webroot Phileas, Sunbelt
 - Automated web crawling for new spyware variants
- SiteAdviser
 - Upcoming commercial service to rate safety of Web sites

Conclusions

- We addressed key questions about spyware:
 - Prevalence
 - Location
 - Trends
- Takeaway lessons:
 - Despite the decreasing trend, spyware is still a big problem
 - Spyware is usually not as dangerous as people claim
 - Signature-based defenses should be effective
 - Need automated tools to identify what matters in practice
 - Opt-in schemes for browser security are not effective

Questions?