Economics of Information Security

CS 594 Special Topics/Kent Law School:

Computer and Network Privacy and Security: Ethical, Legal, and Technical Considerations

Robert Sloan, based heavily on Richard Anderson's Crypto 2007 Keynote paper and slides

Traditional View of Infosec

- People used to think that the Internet was insecure because of lack of features – crypto, authentication, filtering
- So worked on providing better, cheaper security features – AES, PKI, firewalls …
- About 1994–2000, some prominent players started to realize that this is not enough

People, Law, Economics Trump!

- Bruce Schnier,
  - 1994, *Applied Cryptography*, <u>the</u> book on doing crypto
  - 2000, *Secrets and Lies*: “I have written this book partly to correct a mistake. Seven years ago I wrote another book … The weak pints had nothing to do with [cryptography].”
- 1970s, Diffie & Hellman invent public-key crypto; 1998, Diffie & Landau publish *Privacy on the Line: The politics of Wiretapping and encryption*

Then came Economics

- 1994: Anderson publishes about U.K. banks’ economic incentives
- 2000 lots of stuff
- 2001–: Econ of Security annual conference

Economics and Security

- Since c. 2000, started applying economic analysis to IT security and dependability
- It often explains failure better!
- Electronic banking: UK banks were less liable for fraud, so ended up suffering more internal fraud and more errors
- Distributed denial of service: viruses now don’t attack the infected machine so much as using it to attack others
- Why is Microsoft software so insecure, despite market dominance?

New View of Infosec

- Systems are often insecure because the people who guard them, or who could fix them, have insufficient incentives
  - Bank customers suffer when poorly-designed bank systems make fraud and phishing easier
  - Casino websites suffer when infected PCs run DDoS attacks on them
- Insecurity is often what economists call an '**<u>externality'</u>** – a side-effect, like environmental pollution

New Uses of Infosec

- Xerox started using authentication in ink cartridges to tie them to the printer – and its competitors soon followed
- Carmakers make engine modding harder, and plan to authenticate major components
- DRM: Apple grabs control of music download, MS accused of making a play to control distribution of HD video content

IT Economics (1)

- The first distinguishing characteristic of many IT product and service markets is **network effects**:
- Metcalfe’s law – the value of a network is the square of the number of users:
- Real networks – phones, fax, email
- Virtual networks – PC architecture versus MAC, or Symbian versus WinCE
- Network effects tend to lead to dominant firm markets where the winner takes all

IT Economics (2)

- Second common feature of IT product and service markets is high fixed costs and low marginal costs
- Competition can drive down prices to marginal cost of production
- This can make it hard to recover capital investment, unless stopped by patent, brand, compatibility …
- These effects can also lead to dominant-firm market structures

IT Economics (3)

- Third common feature of IT markets is that switching from one product or service to another is expensive
- E.g. switching from Windows to Linux means retraining staff, rewriting apps
- This lock-in is major part of value of SW companies
- So major effort goes into managing switching costs – once you have $3000 worth of songs on a $300 iPod, you’re locked into iPods

IT Economics and Security

- High fixed/low marginal costs, network effects and switching costs all tend to lead to dominant-firm markets with big first-mover advantage
- So time-to-market is critical
- Microsoft philosophy of ‘we’ll ship it Tuesday and get it right by version 3’ is not perverse behavior by Bill Gates & Steve Ballmer but quite rational
- Whichever company had won in the PC OS business would have done the same

IT Economics and Security (2)

- When building a network monopoly, you must appeal to vendors of complementary products
- That’s application software developers in the case of PC versus Apple, or now of Symbian versus Linux/Windows/J2EE/Palm
- Lack of security in earlier versions of Windows made it easier to develop applications
- So did the choice of security technologies that dump costs on the user (SSL, not SET c. 1998)
- Once you’ve a monopoly, lock it all down!

Lemons Market Here

Adverse Selection

- Undesirable situation in markets where due to information asymmetries, “bad” product or customer more likely to be selected
- E.g., Smokers more likely to buy health, life insurance, if insurance companies can’t distinguish smokers from non-smokers

Moral Hazard

- You act differently because you are (or believe you are) insulated from risk
- Less careful with insured risk
- Subprime mortgage mess?
- Current mess with special auction municipal-type bonds?

Products worse than useless

- Adverse selection and moral hazard matter (why do Volvo drivers have more accidents?)
- Application to trust: Ben Edelman, ‘Adverse selection on online trust certifications’ (WEIS 06)
  - Websites with a TRUSTe certification are more than twice as likely to be malicious
  - The top Google ad is about twice as likely as the top free search result to be malicious (other search engines worse …)
  - Conclusion: ‘Don’t click on ads’

Privacy

- Most people say they value privacy, but act otherwise. Most privacy ventures failed
- Why is there this privacy gap?
- Hirshleifer – privacy is a means of social organization, a legacy of territoriality
- Varian – you can maybe fix privacy by giving people property rights in personal information
- Odlyzko – technology makes price discrimination both easier and more attractive
- Acquisti – people care about privacy when buying clothes, but not cameras (phone viruses worse for image than PC viruses?)

Conflict theory

- Does the defense of a country or a system depend on the least effort, on the best effort, or on the sum of efforts?
- The last is optimal; the first is really awful
- Software is a mix: it depends on the worst effort of the least careful programmer, the best effort of the security architect, and the sum of efforts of the testers
- Moral: hire fewer better programmers, more testers, top architects

Open versus Closed?

- Are open-source systems more dependable? It’s easier for the attackers to find vulnerabilities, but also easier for the defenders to find and fix them
- Theorem: openness helps both equally if bugs are random and standard dependability model assumptions apply
- Statistics: bugs are correlated in a number of real systems (‘Milk or Wine?’)
- Trade-off: the gains from this, versus the risks to systems whose owners don’t patch

How Much to Spend?

- How much should the average company spend on information security?
- Governments, vendors say: much much more than at present
- But they’ve been saying this for 20 years!
- Measurements of security return-on-investment suggest about 20% per annum overall
- So the total expenditure may be about right. Are there any better metrics?

Security metrics

- Insurance markets – can be dysfunctional because of correlated risk
- Vulnerability markets – in theory can elicit information about cost of attack
- iDefense, Tipping Point, …
- Further: derivatives, bug auctions, …
- Stock markets – in theory can elicit information about costs of compromise
- Stock prices drop a few percent after a breach disclosure

Skewed Incentives

- Why do large companies spend too much on security and small companies too little?
- Research shows an adverse selection effect
- Corporate security managers tend to be risk-averse people, often from accounting / finance
- More risk-loving people may become sales or engineering staff, or small-firm entrepreneurs
- There's also due-diligence, government regulation, and insurance to think of

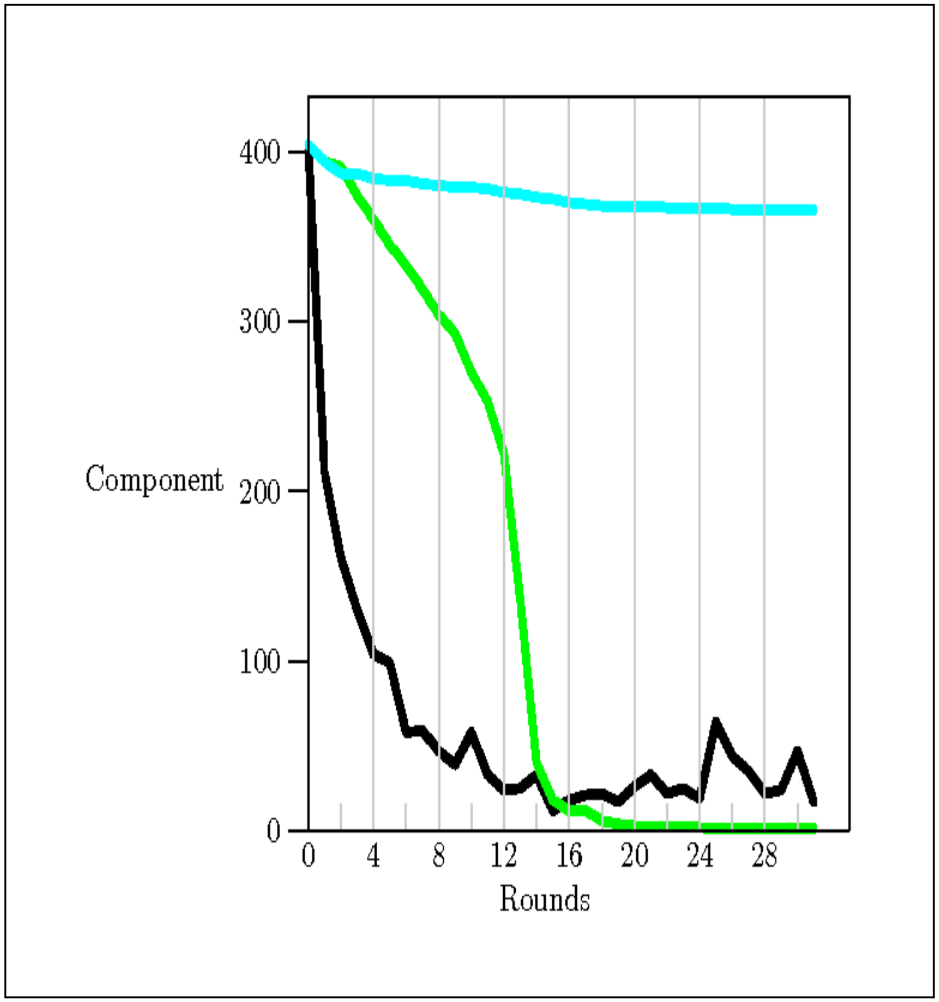
Skewed Incentives (2)

- If you are DirNSA and have a nice new hack on XP and Vista, do you tell Bill & Steve?
- Tell – protect 300 million Americans
- Don’t tell – be able to hack 400 million Europeans, 1 billion Chinese,…
- If the Chinese hack US systems, they keep quiet. If you hack their systems, you can brag about it to the President
- So offence can be favored over defense

Security and Sociology

- There’s a lot of interest in using social network models to analyze systems
- Barabási and Albert showed that a scale-free network could be attacked efficiently by targeting its high-order nodes
- Think: rulers target Saxon landlords / Ukrainian kulaks / Tutsi schoolteachers /…
- Can we use evolutionary game theory ideas to figure out how networks evolve?
- Idea: run many simulations between different attack / defense strategies

Security and Sociology (2)



Vertex-order attacks with:

- Black – normal (scale-free) node replenishment
- Green – defenders replace high-order nodes with rings
- Cyan – they use cliques (c.f. system biology …)

Psychology and Security

- Phishing only started in 2004, but in 2006 it cost the UK £35m and the USA perhaps $200 million
- Banks react to phishing by ‘blame and train’ efforts towards customers – but we know from the safety-critical world that this doesn’t work
- We really need to know a lot more about the interaction between security and psychology

Psychology and Security (2)

- Security usability research just beginning
- Most products don’t work well or at all!
- Train people to keep on clicking ‘OK’ until they can get their work done
- Systems designed by geeks for geeks discriminate against women, the elderly and the less educated

Psychology and Security (3)

- Social psychology has long studied obedience!
  - Solomon Asch showed most people would deny the evidence of their eyes to conform to a group
  - Stanley Milgram showed that 60% of people will do downright immoral things if ordered to
  - Philip Zimbardo's Stanford Prisoner Experiment showed roles and group dynamics were enough
- The disturbing case of 'Officer Scott'
- How can systems resist abuse of authority?

Risk perception, terrorism, & security

- Actual security different from feeling of security
- Food poisoning: 5,000 US deaths/year
- Autos: 40,000 US deaths/year
- 9/11 2,973 deaths *once*
- Risk perception biases plus “Availability heuristic” in human’s probability estimation: easy to imagine = probable

Psychology and Security (4)

- Evolutionary psychology may eventually explain cognitive biases. It is based on the massive modularity hypothesis and the use of FMRI to track brain function
- ‘Theory of mind’ module central to empathy for others’ mental states
- This is how we differ from the great apes
- It helps us lie, and to detect lies told by others
- So are we really homo sapiens sapiens – or homo sapiens deceptor?

Conclusion?

- The online world and the physical world are merging, and this will cause major dislocation for many years
- Security economics gives us some of the tools we need to understand what’s going on