

Economics (Chapter 7)

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Motivation



SO FAR BOB, THE ONLY DIFFERENCE I SEE IS THE COST.

Economics and Security, What is the Connection?

- Today, many security system failures aren't due to technical errors so much as to wrong incentives :
 - The people who guard the system are not the people who suffer when it fails
 - Often, security mechanisms are designed deliberately to shift liability, which often leads to trouble
- The incentives in complex systems with multiple owners make economic questions both more important and more subtle for security engineers
 - Look at the internet for example...

Classical Economics

Classical Economics

- ▶ Markets give efficient outcomes when:
 - ▶ Buyers and sellers have full property rights
 - ▶ They have complete information
 - ▶ They are rational
 - ▶ The costs of doing transactions can be neglected
- ▶ But, what happens when those conditions aren't met?

Monopoly Power In Tech

- ▶ 1970 – IBM
- ▶ 1990 – Microsoft and Intel
- ▶ Today - Google, Facebook, Amazon, Microsoft

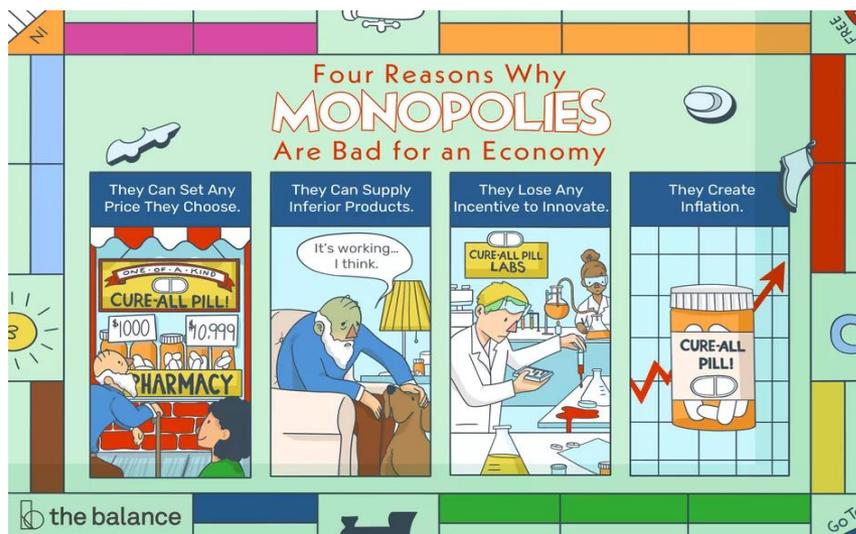
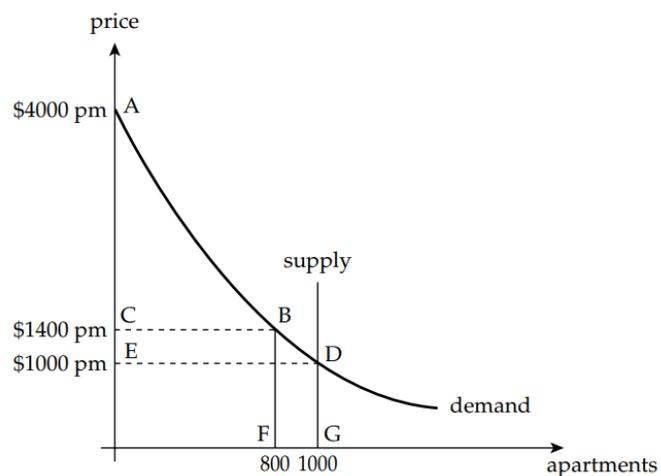


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Monopoly - Explained

- ▶ Textbook case of monopoly:



- ▶ What can a monopolist do?
 - ▶ Charge everyone a different price
 - ▶ Successfully extracts all the consumers surplus

How Are Monopolies Created

- ▶ **Market power** – “how close a merchant is to being a monopolist”.
Under monopoly the merchant is a price setter, while under perfect competition he is a price taker
- ▶ **Information asymmetry** – When the seller or the buyer have more information than the other side. Examples:
 - ▶ A local carpet seller
 - ▶ Airlines

Information Economics

Why Information Markets Are Different

1. The price of information:

- ▶ The price of a good in a competitive equilibrium, is the marginal cost of production
- ▶ The price of information should be its marginal cost of production. But that is almost *zero!*
- ▶ This is why there is so much free information in the internet
- ▶ Today, goods are given away free, and the money comes from advertising (Google, Wikipedia, Facebook...) or a parallel market (Linux make money from support...)

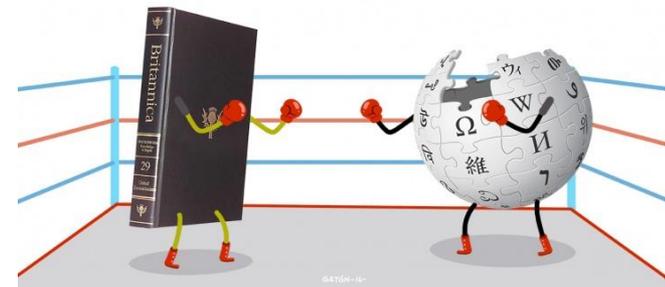


Imagen: César Mejías

Why Information Markets Are Different

2. Network externalities:

- ▶ *Positive feedback* - the value of a network grows more than linearly in the number of users



<https://cargocollective.com/patchklein>



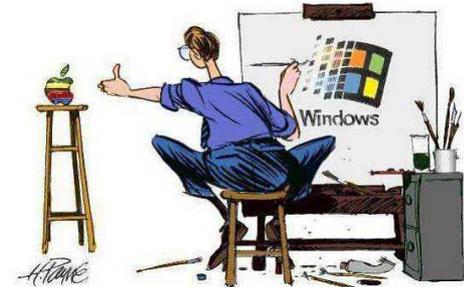
- ▶ *Negative feedback* – loss turns into a route



Why Information Markets Are Different

3. Technical lock-in:

- ▶ Stemming from interoperability, or a lack thereof
- ▶ Once a software firm commits to using a platform such as Windows or Oracle for its product, it can be expensive to change
- ▶ The value of lock-in:
 - ▶ Helps explain the move to the cloud
 - ▶ The reason why so many security mechanisms aim at controlling compatibility



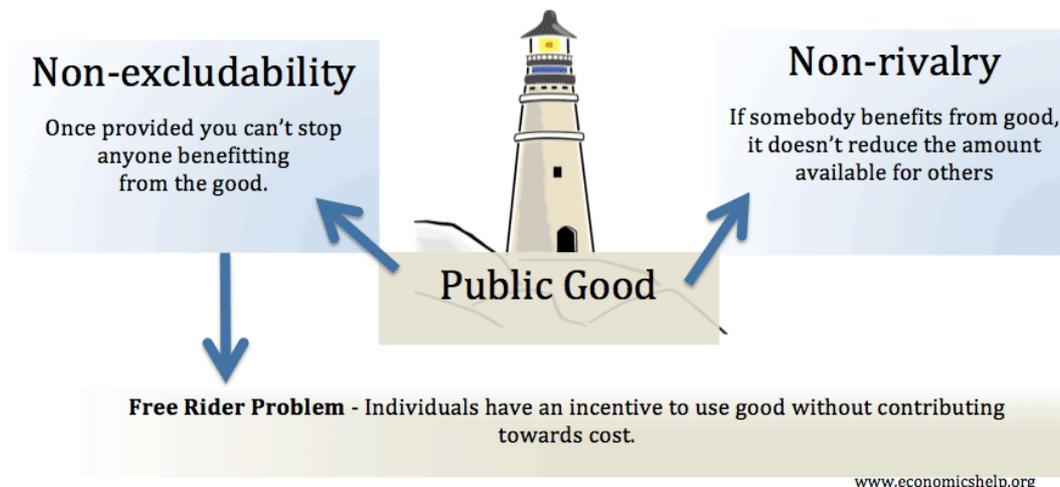
Asymmetric information

- ▶ When users can't tell good from bad, they might as well buy cheap.
- ▶ Hidden information (Adverse Selection) vs Hidden action (Moral Hazard)



- ▶ In information security most stakeholders are not motivated to tell the truth:
 - ▶ Police, intelligence agencies, and security vendors, talk up threats
 - ▶ Software vendors, e-commerce sites and banks downplay them

Public goods



- ▶ People who connect insecure machines to the Internet dump costs on others
- ▶ Maybe use a centralized defense strategy, find the bad guys and throw them in jail
- ▶ Or imagine a government tax on vulnerabilities...

Game Theory

Game Theory

- ▶ The study of problems of cooperation and conflict among independent decision makers
- ▶ **'Matching Pennies'**: Alice's gain is Bob's loss.

		Bob	
		H	T
Alice	H	-1,1	1,-1
	T	1,-1	-1,1

This is an example for a *Zero-Sum game*

Game Theory - strategies

- ▶ **Dominant strategy equilibrium:** each player has an optimal choice regardless of what the other does.

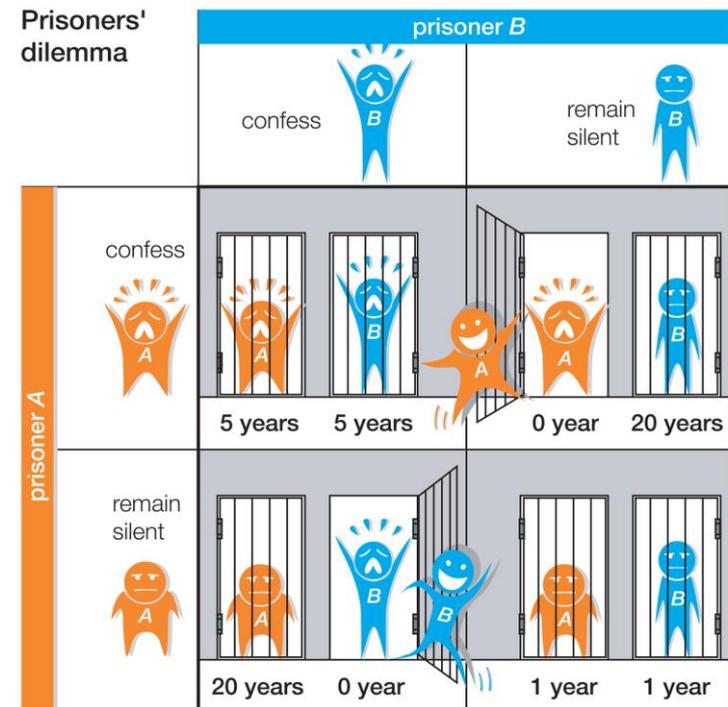
		Bob	
		Left	Right
Alice	Top	1,2	0,1
	Bottom	2,1	1,0

- ▶ **Nash equilibrium:** each player's optimal strategy depends on what the other player does, or what they think the other player will do

		Bob	
		Left	Right
Alice	Top	2,1	0,0
	Bottom	0,0	1,2

The Prisoners' Dilemma

- ▶ Logically, Each prisoner should confess regardless of what the other does.
- ▶ But, if they had agreed to keep quiet then they'll get a year each, which is a better outcome for them!
- ▶ **So what's the solution?**
So long as it is a single game, and this is the only game in town, there isn't a solution.



Repeated and Evolutionary Games

- ▶ If a game is repeated, there may be an incentive to cooperate:
 - ▶ *Tit-for-tat* –
Cooperate in round one, and at each subsequent round you do to your opponent what he or she did in the previous round
 - ▶ *'Hawks' and 'Doves'* –
The population has aggressive and docile individuals coexisting. The proportion of aggressive individuals is a function of the costs of aggression



Auction Theory

THE FUNDAMENTAL
WAY OF DISCOVERING
PRICES FOR UNIQUE
GOODS

Traditional Types of Auction

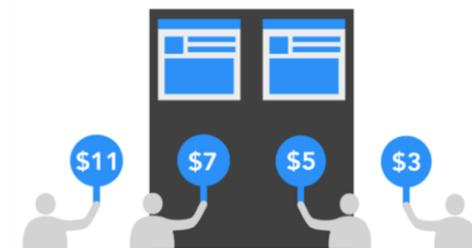
Ascending-bid auction	Descending-bid auction	First-price sealed-bid auction	Second-price sealed-bid auction (VCG)	all-pay auction
the auctioneer starts at a reserve price and raises the price until only one bidder is left	the auctioneer starts out at a high price and cuts it gradually until someone bids	each bidder is allowed to make one bid. After bidding closes, all the bids are opened and the highest bid wins	sealed bids and the highest bid wins, but that bidder pays the price in the second-highest bid.	every bidder pays at every round, until all but one drop out
Art	Flowers	government contracts	Ad auctions, eBay	Litigation, market race

Auctions Can Go Wrong

- ▶ **Bidding rings**, all the buyers collude to lowball the auction
- ▶ **Entry detection**, bidders can find out who else is bidding and use the information to lower prices
- ▶ **Entry deterrence**, bidders declare that they will top any other bid
- ▶ **Risk aversion**, if you prefer a certain profit of \$1 to a 50% chance of \$2, you'll bid higher at a first-price auction
- ▶ **Budget constraints**, if bidders are cash-limited, all-pay auctions are more profitable

Ad Auctions

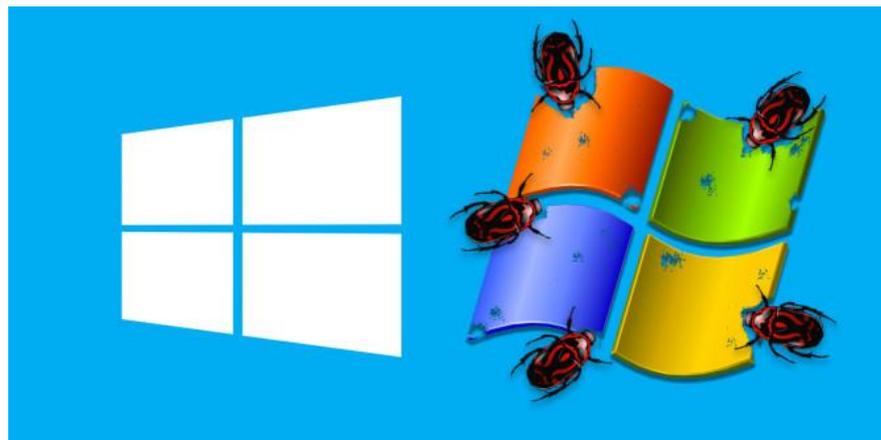
- ▶ Big business!
- ▶ Google, Facebook and Amazon making about \$50bn, \$30bn and \$10bn respectively in 2019
- ▶ Second-price auction tweaked to optimize revenue:
 - ▶ Bidders offer prices b_i
 - ▶ The platform estimates their ad quality as e_i
 - ▶ It then calculates 'ad rank' as $a_i = b_i e_i$
 - ▶ If I have five times your ad quality, I bid 10c and you bid 40c, then I get the ad and pay 8c
- ▶ Can you think of possible attacks?



The Economics of Security and Dependability

SYSTEM SECURITY FAILS
BECAUSE THE PEOPLE
GUARDING THE SYSTEM
AREN'T THE PEOPLE
WHO SUFFER THE
COSTS OF FAILURE

Is Windows Secure



- ▶ Products are insecure at first, and although they improve over time, many of the new security features are for the vendor's benefit as much as the user's

Managing the Patching Cycle

- ▶ How to manage the patching cycle?
 - ▶ Directly publish the discovered vulnerability
 - ▶ Force the vendor to patch
 - ▶ Users stay vulnerable for months
 - ▶ Report the vulnerability privately
 - ▶ Get a lawyer's letter shutting you up
 - ▶ Vendor doesn't patch
- ▶ Solution – *responsible disclosure*
- ▶ Commercial vulnerability markets emerged

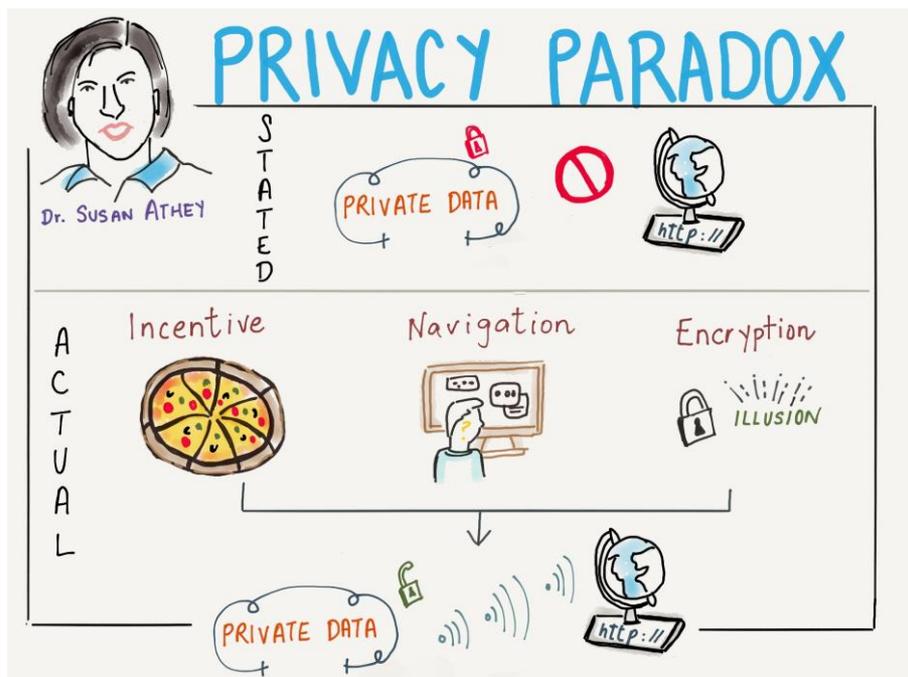


Weakest Link, or Sum of Efforts?

- ▶ The dependability of information systems - performance can depend on:
 - ▶ *The minimum effort* - everyone will be vulnerable via the laziest
 - ▶ *The best effort* - most people free-ride behind the heroes
 - ▶ *The sum-of-efforts*
- ▶ As more agents are added, systems become more reliable in the total-effort case but less reliable in the weakest-link case

Economics of Privacy

- ▶ **The privacy paradox** - people say that they value privacy, yet act otherwise



The Privacy Paradox - Factors

- ▶ **Different types of privacy harms:**
 - ▶ Discrimination in employment, credit and insurance
 - ▶ Cybercrime as payment fraud
 - ▶ Personal crimes such as stalking and non-consensual intimate imagery
- ▶ **“The power of context”:**
 - ▶ Are you in a secure environment?
 - ▶ Do you feel amongst friends?
- ▶ The industry understands the paradox, and goes out of its way to make privacy risks less salient

The Privacy Paradox – Overall Effect

- ▶ The public is gradually learning the risks
- ▶ Look at:
 - ▶ The proportion of Facebook users who opt to use privacy controls
 - ▶ The “Snowden” effect on the US public
 - ▶ The GDPR in the EU

Summary

- ▶ Today, many systems fail because the incentives are wrong, rather than because of some technical design mistake
- ▶ As a result, security engineers need to understand basic economics as well as the basics of crypto, protocols, access controls and psychology...



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