## **Complex Networks**

Jorge Finke Dpto. Ciencias de la Ingeniería y la Producción Universidad Javeriana Office: 262 Edificio de Ingeniería

### Lecture 1

## WE HAVE A PROBLEM!

# WE STILL HAVE A PROBLEM!



Wednesday, February 2, 2011

### YOU ARE LEAVING THE AMERICAN SECTOR вы выезжаете из АМЕРИКАНСКОГО СЕКТОРА **VOUS SORTEZ DU SECTEUR AMERICAIN** SIE VERLASSEN DEN AMERIKANISCHEN SEKTOR







Wednesday, February 2, 2011



#### the ethics of globalization

SECOND EDITION

"Timely and thoughtful."-Andres Martinez, New York Times Book Review

# ( ) L $\geq$ **NULX**





### Globalization drivers?

#### Democratization

technological innovation

- computerization
- telecommunication
- miniaturization
- compression technology

- digitization

Democratization

Democratization

technological innovation

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information

- satellite dishes, tv
- internet

Democratization

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information

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#### finance

- creditworthy good-old-boys network
- automated loan kiosks,
- E\*trade,

-individual hold a countries bonds

### Problem = Fall of the wall



### Problem = Globalization



### New: How to cope with the new international system?



by Hugh Dubberly







### e.g.









2009

# iPad

Our most advanced technology in a magical and revolutionary device at an unbelievable price.

Starting at \$499.

Wi-Fi models shipping in late March. 3G models shipping in April.



### e.g.

# Strengths or weaknesses of engineers from the U.S. v. abroad?

U.S. engineers salary demands limited supply lack of industrial experience

source: V. Wadhwa, et al., Where the engineers are. Issues in Science and Technology, Spring 2007.

U.S. engineers salary demands limited supply lack of industrial experience

Indian engineers

inadequate communication skills lack proximity visa restrictions cultural differences lack of specific industry knowledge limited project management skills high turnover rates

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inadequate communication skills lack of proximity visa restrictions cultural differences inadequate experience lack of loyalty intellectual property converts limited "big picture mindset"

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Colombian engineers ???

source: V. Wadhwa, et al., Where the engineers are. Issues in Science and Technology, Spring 2007.



#### El sueño colombiano



#### **El Colombian Dream**

Director: Felipe Aljure Guión: Felipe Aljure Duración: 120 min SINOPSIS:



Ombian

8

J

Relata la historia de unos jóvenes que se van de vacaciones con el propósito de ganar plata fácil. Comienzan vendiendo pastillas alucinógenas y pirateando CDS entre sus clientes. Un hombre interesado en esconder una "mercancía" para sacar ventaja a sus socios, les entrega gran cantidad de pepas a los jóvenes y estos acceden ante la perspectiva de ganarse dinero extra. El sujeto muere de una sobredosis en el momento en que ellos están guardando las pepas, dejándolos ante una gran encrucijada. Los engañados socios del muerto, empiezan una búsqueda desesperada por recuperar su mercancía. Los jóvenes intentan esconderse





COLOMBIANO el colombian dream el colombian dream www.elcolombiandream.com

Green Webrisso Courser LA

Cnempreso

LO MEJOR DEL CINE



# A different type of dream...

Wednesday, February 2, 2011

#### 10 Challenges

- Air pollution
- Guerrilla Conflicts
- Diseases
- Education
- Global Warming
- Malnutrition and Hunger
- Sanitation and Water
- Subsidies and Trade Barriers
- Corruption
- Women and Development

Survey: Priorities among a series of proposals for confronting ten great challenges (grad students)



30.0

Survey: Priorities among a series of proposals for confronting ten great challenges (undergrad students)



30.0

### Corruption is global

Wednesday, February 2, 2011

#### There are many types of corruption and each country's pattern is distinct

Daniel Kaufmann, et al. New frontiers in diagnosing and combating corruption

### Think Global, Act Local

**Patrick Geddes** 

### If you can't measure it, it doesn't exist



It is much easier to make measurements than to know exactly what you are measuring. JWN Sullivan (1928)

The developing countries are rightly condemned for not doing more about corruption, but they also rightly criticize the advanced industrial countries for facilitating corruption by providing safe haven for corrupt officials and secret bank accounts for their money

> Free Fall Joseph E. Stiglitz



#### Inicio / Revista de radio

🔜 imprimir 💌 enviar 💭 comentar 🗁 guardar ★ favoritos - A + A 🦘

🖬 Delicious 🖾 Digg 📑 Facebook Ġ Google 🧱 Mister Wong 😤 My space 🥰 Meneame 💝 Twitter

#### Corrupción en Colombia ensucia cada vez más manos

REVISTA DE RADIO La mayoría de entidades públicas presentan altos índices de vulnerabilidad a un fenómeno que le hace perder al país anualmente 4 billones de pesos, según Transparencia por Colombia. Miércoles 9 Diciembre 2009



Fabio Posada Simbolo de las manos limpias como rechazo a la corrupción en Colombia. (Cali 2005)

En materia de corrupción el balance del 2009 para Colombia no es bueno. Según un informe revelado por Transparencia por Colombia, para este año se retrocedió al puesto 75 entre 180 países. La situación resulta preocupantes pues durantes los últimos siete años Colombia se había estancado en su calificación. MÁS LEIDOS MÁS COMENTADOS

- 1. Opinión Yo tengo ya la casita
- 2. Opinión Una guerra en el Bicentenario
- Nación "Todo era por orden de la Casa de Nariño"
- 4. Vladdo Vladdo
- 5. Nación ¿Era necesario?



#### ENTREVISTA

"Parte de Colombia fue robada por Roosevelt"



Noam Abraham Chomsky, intelectual gringo padre de la lingüística y polémico activista por sus posturas contra el intervencionismo militar de Estados Unidos, visitó Colombia para ser homenajeado por las comunidades indígenas de Cauca. Habló en exclusiva con Semana.com

Enlaces patrocinados - PauteFacil.com

Crucial Solutions - XCIAL (Software) Soluciones de Seguridad Informática

### Local solution?















State	Citizens In Charge Foundation	Ballot Initiative Strategy Center
Alabama	F	-
Alaska	D	D
Arizona	C+	F
Arkansas	B+	D
California	B+	F
Colorado	C+	A
Connecticut	D	-
Delaware	F	-
Florida	C-	F
Georgia	D	-
Hawaii	D	-
Idaho	C	D
Illinois	D	F
Indiana	F	
lowa	F	_
Kansas	D	
Kentucky	F	
Louisiana	, D	
Maino	C	D
Mandand	D	U
Magaaabuaatta	C	-
Massachusetts	0-	Ę
Michigan	В	F
Minnesota	D	-
Mississippi	F	F
Missouri	A-	D
Montana	C+	D
Nebraska	С	F
Nevada	B+	F
New Hampshire	D	-
New Jersey	D	-
New York	D	-
North Carolina	F	-
New Mexico	D	
North Dakota	C+	F
Ohio	A-	D
Oklahoma	C+	F
Oregon	В	С
Pennsylvania	F	-
Rhode Island	D	_
South Carolina	D	
South Dakota	В	D
Tennessee	D	
Texas	D	100
Utah	C-	F
Vermont	D	-
Virginia	F	
Washington	C+	F
West Virginia	F	
Wisconsin	D	-
Wyoming	F	D
District of Colum	nhia D	-
District of Colum	ibid D	-



hotlines, boxes for whistleblowers, citizen report cards, codes of conduct, financial controls, procedures for accounting, procurement, asset and personal management...

## technology



iBreath Breathalyzer/FM Tx Breathalyzer/FM Tx C MeM MeM Evr

Breath analyzer

Ticketer







Surveillance cameras



**Drug Testing** 

Body scan

Surveillance micro UAVs





Electronic voting



**THE TRUTH BE TOLD?** [left] When the author was asked whether he had ever feigned illness to escape an obligation, his prefrontal cortex showed no unusual activity. **LIAR, LIAR?** [right] When the author was asked whether he had ever padded an expense report, his prefrontal cortex became highly active [areas highlighted with hot colors]. Souce: MRI Lie Detectors

#### fMRI lie detectors?

### information technology

Citizens carries both rights and obligations. Usually we focus on just our rights, such as the right to own property or pursue happiness. More important in the current discussion are our obligation as citizens to become informed, engaged, and mindful of the general welfare.

> C. J. Andrews. From Professional Ethics to Technological Citizenship, IEEE International Symposium on Electronics and the Environment, 2006

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engaged, and mindful of the general welfare.

C. J. Andrews. From Professional Ethics to Technological Citizenship, IEEE International Symposium on Electronics and the Environment, 2006

#### Engineers are technically informed citizens

# Understand systems rather than simply technologies involved

## As the tools become more sophisticated, the focus will shift from technology toward discovery

## Research issues will emerge from the rapid introduction of new technologies in institutions





### New problem = Corruption


#### Everyday Corruption: How Intensifying Market Competition Leads to Abuses of Public Trust, and What Should Be Done

Robert Reich Professor of Public Policy, University of California, Berkeley

Monday, 05 April 2010 04:30 PM Location: TBD



# Technology = Part of the solution

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# Technology is anything invented after you were born

Alan Kay

# Technology is anything that doesn't work yet

Danny Hillis

#### tech•nol•o•gy |tek'näləjē|

noun ( pl. **-gies**)

the application of scientific knowledge for practical purposes, esp. in industry

- machinery and equipment developed from such scientific knowledge.
- the branch of knowledge dealing with engineering or applied sciences.

[Is it true], perhaps, that, regardless of how much information we compile or the speed of our processors, when it comes to human activity, we a bound to fail predicting it?

A. L. Barabasi

# Beginning of a conversation...

#### TED talk by Simon Sinik

Theories about how to combat corruption in the judiciary have varied from decade to decade. We belief in the power of technology to fight corruption



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Theories about how to combat corruption in the judiciary have varied from decade to decade. We belief in the power of technology to fight corruption

Collecting data, finding patterns and developing models that allow us to identify fraud, disincentives, conflicts of interests, bribes, abuse of entrusted power for personal gain, etc.

#### TED talk by Simon Sinik



Theories about how to combat corruption in the judiciary have varied from decade to decade. We belief in the power of technology to fight corruption

Collecting data, finding patterns and developing models that allow us to identify fraud, disincentives, conflicts of interests, bribes, abuse of entrusted power for personal gain, etc.

Anti-corruption policy design

Develop a course to lay the foundation to think about systemic global issues

#### technology

#### society

#### Model socio-technological systems to face them

# Institutional corruption

### assumptions

#### 1. Influences within an institution

individuals respond to incentives, rational or not

1.legal

2.financial

3.expectational

4.etc.

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"economy of direct influences"

range of significant incentives that capture how individuals behave

#### 1. Influences within an institution

individuals respond to incentives, rational or not

1.legal

2.financial

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4.etc.

"economy of direct influences"

range of significant incentives that capture how individuals behave

diverse + complementary/conflicting

#### 2. Influences upon an institution

institutions are affected by public perception

1.confidence

2.ethical behavior

3.fair play

4.etc.

#### 2. Influences upon an institution

institutions are affected by public perception

1.confidence

2.ethical behavior

3.fair play

4.etc.

economy of indirect influences













Purpose: to police the safety and effectiveness of food and drugs





## focus

#### Institutional Corruption

Corruption:

"the misuse of entrusted power for private gain"

Leads to economies of influences which...

- weaken effectiveness
- weaken public trust

Do it in the context of particular institutions!!

#### Government

- Legislatures
- Judiciaries
- Agencies

#### Academy

- Schools
- Universities

#### Professions

- Legal professions
- Health professions
- Journalism

#### **Public institutions**

- Think-tanks
- Libraries

#### Systemic



<u>srn.com/abstract</u>

# strategy

#### 1. Data about incentives

gather data to quantify influence within an institution

frequent questions:

- what are the sources of income?
- how have those sources changed?
- what policies does the institution use to police these sources of income?
- how careful are they enforced?

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map economy of influence

use data to identify historical techniques e.g., to develop and sustain independence

#### 2. Data about perceptions

- track public perception  $\rightarrow$  trust of the institution
- role in institution's success
  - private institutions
  - public institutions

frequent questions:

 how does public trust of the FDA evolve? improved/weaken?

#### 2. Data about perceptions

- track public perception  $\rightarrow$  trust of the institution
- role in institution's success
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frequent questions:

 how does public trust of the FDA evolve? improved/weaken?

map the relevant public

use data to develop historical understanding of different perceptions e.g., independence in attitudes

#### **Measuring Corruption: Myths and Realities**

Daniel Kaufmann, Aart Kraay, and Massimo Mastruzzi,

The World Bank<sup>1</sup>

#### December 2006

Over the past decade measuring corruption has become an ever-growing empirical field. Since the mid-nineties, we have undertaken various projects to measure corruption at the aggregate and disaggregated level. At the aggregate level, we have been constructing the Worldwide Governance Indicators that capture six dimensions of governance: Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. These indicators cover over 200 countries for the decade 1996-2005, and are based on the views of a very diverse group of sources, including survey respondents, commercial risk rating agencies, NGOs, and multilateral organizations. With the latest release of the Worldwide Governance Indicators, we have also for the first time made available on our website (www.govindicators.org) data from virtually all of the 31 individual data sources underlying the aggregate indicators. This represents one of the largest collections of freely-available data on governance in the world.

Kaufmann, D., Kraay, A. and Mastruzzi, M. (2006) 'Measuring Corruption: Myths and Realities', Development Outreach 8 (2):124-37. - challenges 1. data-gathering technologies
2. privacy issues
### 3. Models of causation

measure causation

→ explore and capture economies of influence - hard!

frequent questions:

- how do influences affect the work product?
- how do influences affect public trust?

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measure causation

→ explore and capture economies of influence - hard! frequent questions:

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develop quantitative analysis of the independence of actors within an institution

Understand dependencies!!

### 3. Models of causation

measure causation

→ explore and capture economies of influence - hard! frequent questions:

- how do influences affect the work product?
- how do influences affect public trust?

develop quantitative analysis of the independence of actors within an institution

Understand dependencies!!

- challenges 1. useful frameworks
2. validate/invalidate models
3. models as evidence?

## objectives

### General objectives

To apply objective, independence, evidence-based tools to combat the phenomenon of corruption holistically, advancing our understanding about the causal links among major players within a particular institution and the public at large.

### Specific objectives

- implications of new technology
- set of practical quantitative tools
  - identify corruption (whether and when)
  - respond to corruption
- strategies to address corruption
- tradeoffs that might seem compromising

#### Focus

How technological systems operate in conjunction with the social organizations:

- Technological systems
  - dynamic
  - large-scale
  - decentralized
- Social organizations (develop and use technology)
  - healthcare: hospital
  - business context: enterprise, bank, or insurer
  - educational context: school, or university
  - political context: government agency, Congress, political party, or think-tank

#### Project

To study the structure and function of complex networks to:

### Project

To study the structure and function of complex networks to:

1. understand and minimize the incentives for corruption

### Project

To study the structure and function of complex networks to:

- 1. understand and minimize the incentives for corruption
- 2. develop technologies to prevent / minimize

Proper framework to reveal underlying patterns that may have been hitherto but not formally quantified?

## Three premises

Many complex systems are actually well-structured networks

César A. Hidalgo

## No single model can account for all corrupt behavior

## All models are wrong but some are useful

George E. P. Box

### e.g.

## Which vertex would proof most crucial?







## Which vertex would proof most crucial?

# Which vertex would proof most crucial?

## What percentage of vertices need to be removed to affect connectivity?

#### Robustness

- Topological: If you "knock out" x% of nodes/ edges, does the network maintain its structural properties
- Functional: If "knock out" x% of nodes/edges, by how much do functions degrade (%-wise)?

traditional graph theory

traditional graph theory

traditional graph theory

statistical mechanics



statistical mechanics
=> statistical properties of graphs















undirected


directed



degree: number of edges connected to a vertex



degree: number of edges connected to a vertex

geodesic path: shortest path from one vertex to another



degree: number of edges connected to a vertex

geodesic path: shortest path from one vertex to another

diameter: length in number of edges of the longest geodesic path



## Aims

- Statistical Properties (structure+behavior)
- Models to understand meaning
- Predict behavior based on structure + local rules
- Example:
  - Contact networks
  - Financial networks

# Outline

- Introduction, empirical studies (social, information, technological, biological) - (week 1)
- Common properties (weeks 2-3)
  - how to measure them?
- Network visualization (4-5)
- Mathematical modeling (weeks 6-9)
  - Random
  - Small World

- Scale-free
- Processes on networks (weeks 10-14)
  - Network failure
  - Epidemic processes
  - Epidemics of corruption
- Presentations

## Grading

- Homework (40%)
- Final project (40%)
- Final exam (20%)

# Office hours

Fri: 2:00p.m. - 3:00p.m.

## Textbook (Collection of papers)

M. Newman, A.L. Barabasi, D. Watts, The structure and dynamics of networks. Princeton University Press, 2006

#### References

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- R. Albert, H. Jeong & A.-L. Barabási, <u>Error and attack tolerance of complex</u> <u>networks</u>. Nature 406, 378–382, 2000.
- Ph. Blanchard, A. Krueger, T. Krueger, P. Martin <u>The Epidemics of Corruption</u>. arXiv:physics/0505031v1, 2005.

## Types of networks

- Social
- Information
- Technological

# Examples?

	network	type	n	m
social	film actors	undirected	449 913	25516482
	company directors	undirected	7 673	55 392
	math coauthorship	undirected	253339	496489
	physics coauthorship	undirected	52909	245300
	biology coauthorship	undirected	1520251	11803064
	telephone call graph	undirected	47000000	80 000 000
	email messages	directed	59912	86 300
	email address books	directed	16 881	57029
	student relationships	undirected	573	477
	sexual contacts	undirected	2810	

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rmation	WWW nd.edu	directed	269504	1497135
	WWW Altavista	directed	203549046	2130000000
	citation network	directed	783 339	6716198
nfo	Roget's Thesaurus	directed	1022	5103
i	word co-occurrence	undirected	460902	17000000

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i	word co-occurrence	undirected	460902	17000000
	Internet	undirected	10697	31 992
al	power grid	undirected	4 941	6594
technologic	train routes	undirected	587	19603
	software packages	directed	1 439	1723
	software classes	directed	1 377	2 213
	electronic circuits	undirected	24097	53248
	peer-to-peer network	undirected	880	1 296

	network	type	n	m
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ogic	train routes	undirected	587	19603
nolc	software packages	directed	1 439	1723
echi	software classes	directed	1 377	2 2 1 3
te	electronic circuits	undirected	24097	53248
	peer-to-peer network	undirected	880	1296
	metabolic network	undirected	765	3686
biological	protein interactions	undirected	2115	2240
	marine food web	directed	135	598
	freshwater food web	directed	92	997
	neural network	directed	307	2359

# Real networks are not random!

- 1. Possible mechanisms guiding network formation
- 2. Ways to exploit structure to achieve certain aims

## Next class

**Common Properties:** 

- small-world effect
- transitivity or clustering
- degree distribution
- network resilience
- mixing patterns
- degree correlation
- community structure
- network navigation

...if we as a global community want to build up a toolkit for what works in fighting corruption , some systematic experiments must be an essential part of our efforts

Economic Gangster Fisman and Miguel