

# Complexity

## and Information Infrastructures

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# Changing IT landscape

- More applications, more use areas
- More integrations – old and new
- New technologies
  - Internet
  - Cloud
  - Internet of Things ...

# Growing complexity

- From applications (a few, stand-alone)
- To applications portfolios
- To Platform Ecosystems
- To Information Infrastructures

# Implications of complexity

- Development projects fail
  - ePrescription, Connecting for Health, Flexus, KA
- Reorganizations fail
  - NAV, new penal law, Oslo University Hospital, ..
- Breakdowns – disasters
  - Telenor Mobile, AHUS, ATMs
- Use/data errors
  - [Patient data](#), ...
- Security
  - cybercrime
    - From 9/11 to Wikileaks ...
    - US presidential election

# Platform ecosystems

- Two definitions
  1. Extensible codebase
    - Platforms and apps:
      - Android and iPhone ecosystems
      - SAP
  2. Marketplace
    - Uber, Airbnb, finn.no, vipps, ..
    - Two- (multi-) sided markets
  3. Combinations: Android, iPhone, ..
- Architecture/governance configuration
  - Stable core, dynamic periphery
  - One platform owner, many app developers

# Industry platforms

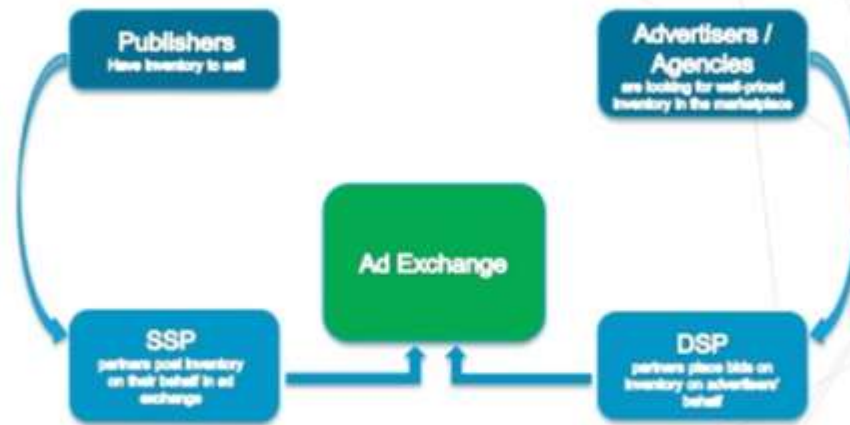
- Internet of Things, machine learning, information sharing, ..
- <https://www.veracity.com>
- <https://www.kognifai.com>
- <https://www.cognite.com>
- <https://www.ge.com/digital/iiot-platform>
- <https://new.abb.com/abb-ability>
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# Information infrastructures

- Many actors, none in control
- Examples
  - Internet
  - National infrastructure for info exchange in health care
  - Supply chain support
  - Corporate infrastructures: many (HSE: 5.700) integrated applications in large distributed organizations
  - Pan-European e-Government infrastructures, ..

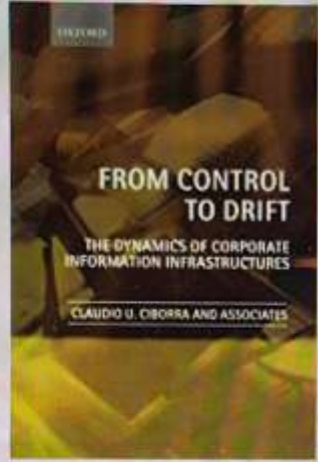
# Example: Programmatic advertising

## Ad Exchange





ANNONSE



**amazon**.co.uk

FROM CONTROL TO DRIFT: THE  
DYNAMICS OF CORPORATE INFORMATION

CLAUDIO U. CIBORRA  
PAPERBACK

See price [prime](#)

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# Jensen snur - gir Stortinget innsyn i notater fra SSB-mø

Vil dele notater fra møter likevel.

# The Washington Post

February 15, 2018

Democracy Dies in Darkness

Editors: U.S. & World | Regional

In the News Sen. Warren Rob Porter Dying words Breast feeding Autism 'cure' Flu epidemic George Washington Lena Dunham Killer's texts NFL draft Steve Kerr Rajon Rondo

## 'A horrific, horrific day': At least 17 killed in Florida school shooting



▶ "There really are no words" 1:22

Photo: The Washington Post, photo: Matt McClary/The Post

The violence at Marjory Stoneman Douglas High, located in a suburb northwest of Fort Lauderdale, Fla., was among the nation's deadliest school shootings. The suspect, identified as Nikolas Cruz, 19, had been expelled from the school. The shooter carried an AR-15 rifle and "countless magazines," authorities said, and was taken into custody after a manhunt.

By Lori Rizza, Moriah Beringt, William Wan and Mark Berman · 1 hour ago

- **Video: Suspect taken into custody**
- **Photos: Rescuers respond, parents wait for information**
- **Graphic: Mass shootings in the United States**

### For shooting suspect, a life of guns, depression and trouble

Nikolas Cruz had reportedly been fighting depression both before and after his adoptive mother died in November, and he had a fascination with guns, those who know him say. An Instagram account that appeared to belong to

## Bipartisan group reaches deal on immigration, but Trump pushes for GOP plan

Word of the agreement, which fulfills some demands sought by President Trump, came as debate on immigration policy is set to intensify today in the Senate. But Trump sought to preemptively undercut the proposal by delivering an ultimatum: Pass my plan or risk a veto.

By Ed O'Keefe, David Nakamura and Mike DeBonis

## As White House counsel, McGahn walks a fine line protecting, mollifying Trump

Donald McGahn's central role in White House controversies, and his failure to shape events to the president's wishes, have led to ongoing tensions with Trump and left him increasingly isolated in the West Wing.



By Josh Dawsey, Rosalind S. Felderman and Matt Zapotosky

- **Amid Porter scandal, Trump declares he's 'totally opposed to domestic violence'**

## 'This isn't a handout or a luxury to me — we would literally not survive without benefits'

About 90 million low-income Americans rely on Medicaid, housing subsidies or food stamps. Families depending on those programs fear how they may be affected by President Trump's proposed rules to the safety net.

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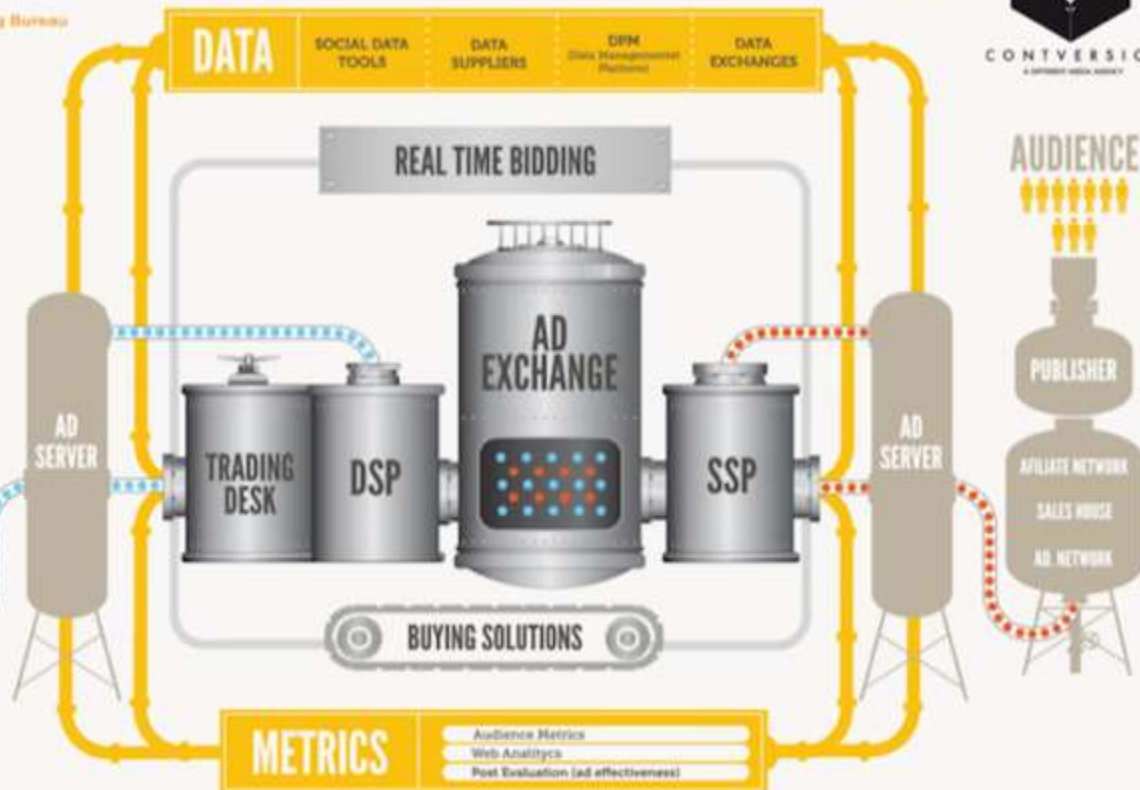
## PROGRAMMATIC BUYING ECOSYSTEMS

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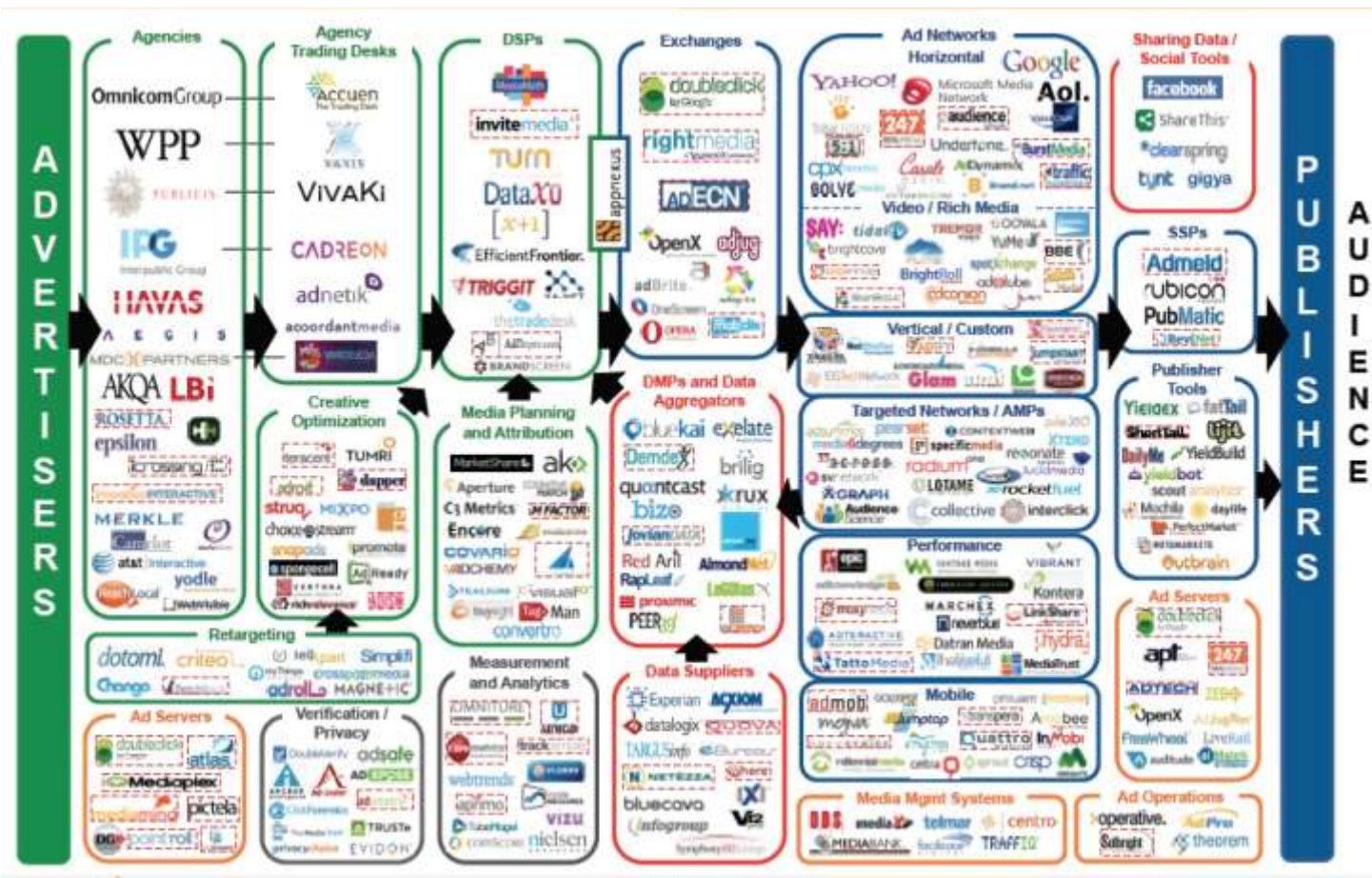


AUDIENCE



**METRICS**

- Audience Metrics
- Web Analytics
- Post Evaluation (ad effectiveness)



# Complexity

- Complexity: Socio-technical, globalization
- Complexity (-ies) = Number of *types* of components\*number of *types* of links\**speed* of change
- Key issues: incomplete knowledge, ***side-effects*** (=history), unpredictability, out-of-control
- Complexity theories
  - Actor network theory:
  - Complexity Science: self-reinforcing processes, driven by side-effects (network externalities)
  - Reflexive Modernization: Self-destructive processes

# Ultra Large Scale Systems

Ultra-Large-Scale (ULS) systems (will push far beyond the size of today's systems and systems of systems by every measure:

- number of technological components of various kinds;
- number of people and organizations employing the system for different purposes;
- number of people and organizations involved in the development, maintenance and operations of the systems;
- amount of data stored, accessed, manipulated, and refined; and
- number of connections and interdependencies among the elements involved.



ULS systems will change everything; that ULS systems will necessarily be decentralized in a variety of ways, developed and used by a wide variety of stakeholders with conflicting needs, evolving continuously, and constructed from heterogeneous parts. Further, people will not just be users of a ULS system; they will be elements of the system. The acquisition of a ULS system will be simultaneous with its operation and will require new methods for control. These characteristics are emerging in today's systems of systems; in the near future they will dominate.

ULS systems presents challenges that are unlikely to be addressed adequately by incremental research within the established paradigm. Rather,

***they require a broad new conception of both the nature of such systems and new ideas for how to develop them.***

We will need to look at them differently, not just as systems or systems of systems, but as ***socio-technical ecosystems***.

<http://www.sei.cmu.edu/uls/>

# Global CEO & Leaders Study Results



## Capitalizing on Complexity

*Insights from the  
Global Chief Executive  
Officer Study*

**IBM**

- **Escalation of complexity:** The world's private- and public-sector leaders believe that a rapid escalation of “complexity” is the biggest challenge confronting them. They expect it to continue—indeed, to accelerate—in the coming years.
- **Not Equipped to Respond:** They are equally clear that their enterprises today are not equipped to cope effectively with this complexity in the global environment.
- **Creativity is Key:** Finally, they identify “creativity” as the single most important leadership competency for enterprises seeking a path through this complexity.

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# Why Information Infrastructures?

- Infrastructures last forever, big and heavy
- Evolving *installed base*, not designed from scratch
- II development
  - Not designing dead material – shaping the evolution
  - Cultivating living organisms

# What is an information infrastructure?

- An info. infra. is a
  - shared,
  - Evolving & open,
  - heterogeneous,
  - **installed base**, which is also
  - (and standardized in one way or another).
  
  - **No life cycle**
- Opposite of Information/Software systems
  - Stand-alone, simple, designed from scratch, unique for the user group

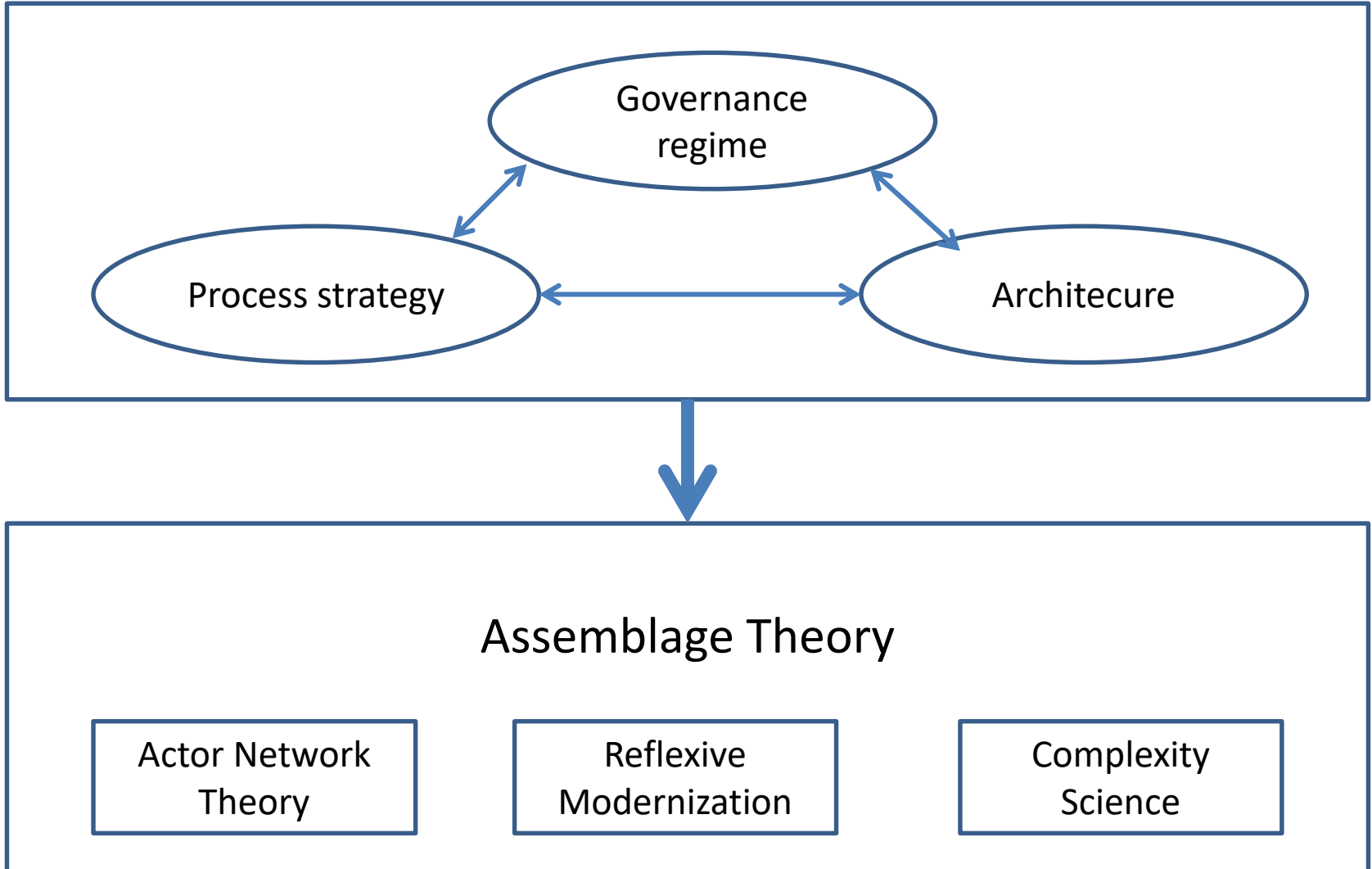
# From IS to II: A new paradigm

- From
  - Tool (individual)
  - System (closed)
  - Design (from scratch)
- To
  - Infrastructure (shared)
  - Network (open)
  - (Installed base)  
Cultivation

# Information Infrastructure Theory

- Why theory?
- Real phenomena like other parts of our nature and society
- Everywhere, everything depends on ICT
- Design theory & process theory!
- Understanding how II's evolve and how to shape their evolution
  - Kernel theory: The role of
    - Strategy
    - Architecture
    - Organizing/governance regime
  - Design principles and guidelines
    - Strategy
    - Architecture
    - Organizing/governance regime

# Information Infrastructure Theory



# Examples: Internet and telecom

	Internet (lightweight)	Telecom (heavyweight)
Process strategy	Experiemntal, evolutionary, bottom-up	Specification driven, top- down, "anticipatory standardization"
Architecture	Distributed "End-2-end"	Cetralized "Intelligence in the center"
Governance regime	Loosely coordinated network, open source, communication technology	Hierarchical, open standards + proprietary technology (patents)

# **Complexity Theory**

**Some basic concepts**

# Complexity

- Complexity: Socio-technical (Internet, globalization)
- Complexity (-ies) = Number of types of components\*number of types of links\*speed of change
- Key issues: emergence, ***side-effects*** (=history), incomplete knowledge, unpredictability, out-of-control
- Complexity theories
  - Actor network theory:
  - Complexity Science: self-reinforcing processes, driven by side-effects (network externalities)
  - Reflexive Modernization: Self-destructive processes
  - Assemblage Theory: stabilizing and destabilizing processes



# Emergence

- Events (car crash, explosion, ...)
- “order”
- De-facto standard (TCP/IP, Windows, QWERTY ..)
  
- New species: Panda with thumb
- Order in a beehive
- Arab spring
- Financial crises
- Climate change

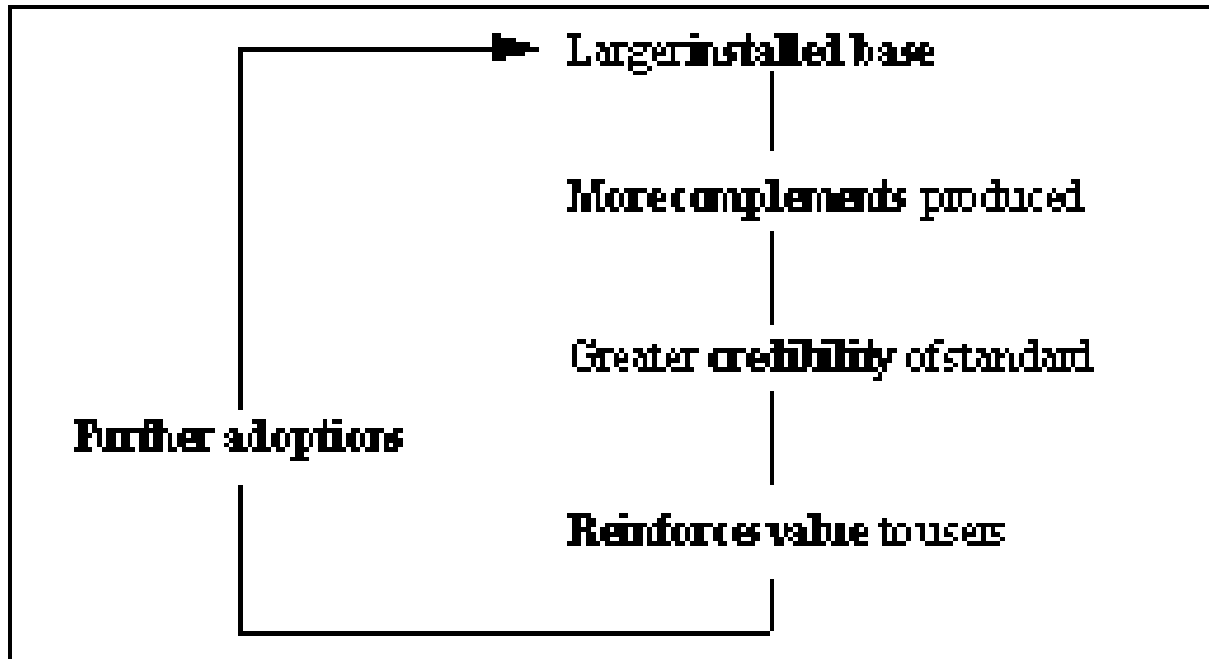
# Complexity & Control/Risk

- Complexity = limited knowledge/understanding = risk
- Charles Perrow: Normal Accidents Theory
  - Chemical plants, air traffic control, nuclear power plants, ..
  - Tight couplings
  - Interactive complexity
- Risk management/mitigation = reducing complexity
- Internet resilience

# Complexity Science

- Origin: Natural sciences, economic (history)
- Autonomous systems
- Emergent order (not designed)
- Non-linearity (ex: History of Microsoft)
- Network externalities
- Increasing returns/Attractor
- Path dependency
  1. Diffusion of standards, competition
  2. Change of standards: Backward compatibility
  3. Chain of events
- Lock-ins
- The 2 laws of historical evolution
- II = Installed base as complex evolving system (=assemblage)

# A self-reinforcing installed base



# 'Multidimensional' critical mass

- Granovetter's pedestrians: distribution of individual preferences.
- Diversity of users (motivation, knowledge, style, ...)
- Heterogeneity of use areas and of technologies.
- Networks of networks

# Design dilemmas

- Take-off
- Lock-in

The end!