# AI: Internet Computing

## Lecture 11 — Critical Information Infrastructures

# Learning Objectives

- Become familiar with the evolution of information infrastructures and get to know their roots
- Understand the complex nature of critical information infrastructures and learn how to analyze and design such systems
- Recognize critical infrastructures and critical information infrastructures and distinguish both concepts
- Understand the main properties and functions of critical information infrastructures
- Become acquainted with the key challenges that will be encountered during operation of critical information infrastructures

# Reference to the Teaching Material Provided

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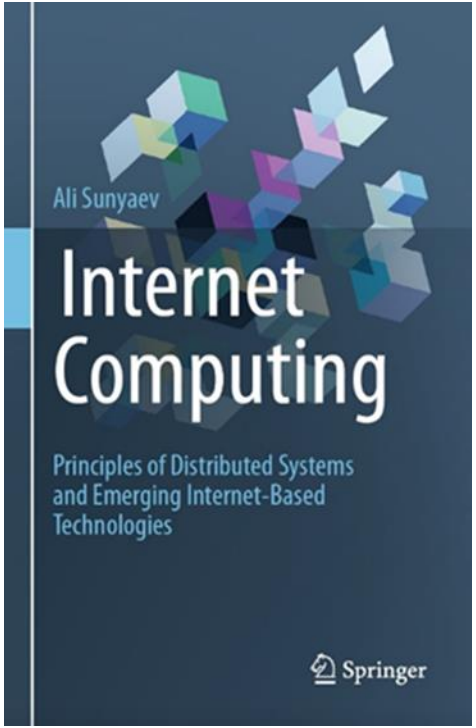


## Chapter 11
## Critical Information Infrastructures

**Abstract**
Information systems have evolved rapidly in the past decades and increasingly take a central role in society. Today, some information systems have become such integral parts of society that their disruption or unintended consequences can have detrimental effects on vital societal functions; that is, they have become critical information infrastructures. This chapter clarifies the concept of 'critical information infrastructures' and distinguishes them from conventional critical infrastructures. After introducing foundational concepts and the evolution of information infrastructures, the chapter discusses salient characteristics, important challenges, main functions, and core tasks for operating critical information infrastructures. Critical information infrastructures, in spite of their vital role in society, often go unnoticed. In this chapter, the reader learns the basics of recognizing, understanding, and operating critical information infrastructures.

**Learning Objectives of this Chapter**
This chapter has five main learning objectives. First, readers should become familiar with the evolution of information infrastructures and get to know where they started. Second, readers should understand the complex nature of critical information infrastructures and learn how to analyze and design such systems. Third, readers should be able to recognize and distinguish between critical infrastructures and critical

# Foundations of CIIs

# Evolution of IT and the Internet

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1890

- Herman Hollerith designs a punch card system
- He establishes a company that would ultimately become IBM

1936

- Alan Turing presents the Turing machine, capable of computing anything that is computable
→ central concept of the modern computer

1937

- J.V. Atanasoff attempts to build the first computer without gears, cams, belts or shafts

1946

- Mauchly and Presper build the UNIVAC (the first commercial computer for business and government applications)

1953

- Grace Hopper develops the first computer language (COBOL)

Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 341, 2020

# Evolution of IT and the Internet

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**1976**

- Steve Jobs and Steve Wozniak roll out the Apple I, the first computer with a single-circuit board

**1981**

- The first IBM personal computer, code-named "Acorn“, is introduced
- It uses Microsoft's MS-DOS operating system
- It has an Intel chip, two floppy disks, and an optional color monitor

**1984**

- August 3, 1984, the first direct e-mail from the ARPANET, the precursor of the Internet, arrived in Germany at the KIT

**1985**

- Microsoft announces Windows
- The first domain name is registered on March 15 (symbolics.com)

**1993**

- The Pentium microprocessor advances the use of graphics and music on PCs

Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 341, 2020

# Evolution of IT and the Internet



**1996**
- Sergey Brin and Larry Page develop the Google search engine

**1999**
- Wi-Fi becomes part of the computing language
- Web 1.0 → active communication or information flow from consumer to producer

**2003**
- The first 64-bit processor, AMD's Athlon 64, becomes available to the consumer market

**2004**
- Web 2.0, the "read-write" web has the ability to contribute content and interact with other web users
- Facebook and other social networking services launch

**2006**
- Web 3.0 "read-write-execute" web the basis of semantic markup and web services

**2007**
- Web 4.0—"Mobile Web"
- iPhone brings many computer functions to the smartphone

**20xx**
- Web 5.0—"Emotional Web"
- Will be about the emotional interaction between humans and computers

Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 341, 2020

# Case: Web Search

## Context

- Searching information on the internet
- Most commonly used search engine: **Google**
  - Initially: passive, purely technical project to ease information retrieval
  - Now: use in everyday language: *„to google“*


## Sociotechnical perspective

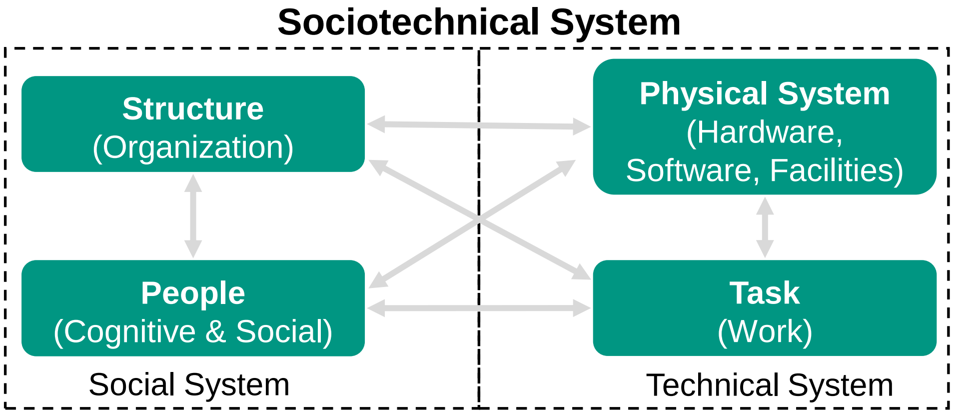
- Search results are dependent on
  - fit with search query (technical)
  - page rank—links to other websites (social)
- Search results emerge through entanglement of code produced by Google‘s engineers, and actions of people on the internet
- Several risks come from such entanglement
- Example: **Filter Bubbles**
  - Search results are tailored to the information that a provider has about users
  - Users are only confronted with information they already know—limited opportunity to learn or be confronted with new world views (*echo chambers*)
  - Possible avenues for manipulation or propaganda

Source: Orlikowski, Organization Studies, 28(9), 2007

Image source: [Search Engine Google] by Photo Mix, November 7th 2016. Pixabay License.

# Sociotechnical Systems

- Sociotechnical systems consist of *social* and *technical* components
- These components follow different rules but are closely related and correlated
- CIIs are sociotechnical systems



Adapted from Bostrom & Heinen, MIS Quarterly, 1(3), 1977

## Levels of sociotechnical systems

| | |
|---|---|
| Primary Systems | A system which carries out a set of activities as subsystem of an organization (e.g., a group) |
| Whole Information System | Systems which persist by maintaining a steady state with their environment (e.g., corporations) |
| Macrosocial System | Systems operating at the overall level of a society (e.g., media) |

Source: Trist, Perspectives in Organization Design and Behavior, 32–47, 1981.

# Definitions

**Definition**

A Critical Infrastructure is an asset or a system that is essential for the maintenance of vital societal functions or the health, safety, or economic and social well-being of people.

Source: Adapted from Council of the European Union (2008) Council Directive 2008/114/EC on the Identification and Designation of European Critical Infrastructures and the Assessment of the Need to Improve Their Protection. Official Journal of the European Union L 345(75)

# Types of Critical Infrastructures

Oil

Electric Power

Water


Transportation

Natural Gas

Telecom

Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 346, 2020

# What means ‘Critical’ in Critical Infrastructures?

- **Critical Magnitude**: What would be the impacts & consequences of failure?
  - Direct human harm (e.g., harmed people, death)
  - Economic loss (e.g., industries are damaged)
  - Economic markets will fail or be seriously damaged (e.g., stock market crashes)
  - ‘Hard’ or capital-intensive technologies will be rendered useless or be seriously damaged (e.g., emergency services will fail or be seriously damaged)
  - Impacts will harm the society such as failures in nuclear power plants
- **Critical Breadth**: Who will be impacted by the consequences?
  - Will affect people directly
  - Widespread impact (e.g., countries)
  - Infrastructure ‘backbone’ for other critical systems (e.g., power plants)
  - Cascading effects, impacting interconnected systems
- **Critical Duration**: How long lasts the impact?
  - Duration of outage
  - Mean Time to Repair / Recovery / Functionality

Source: Egan, Anticipating Future Vulnerability: Defining Characteristics of Increasingly Critical Infrastructure-like Systems, 15, 2007; Fekete, Common Criteria for the Assessment of Critical Infrastructures, 18,19, 2011

# Information Processing and Flows is the Focus of Critical Information Infrastructures

Oil

Transportation

Natural Gas

Information

Electric Power

Water

Telecom

Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 345, 2020

# Example: Criticality of Google

How is Google a Critical Information Infrastructure?

# Example: Criticality of Google

- **Online Gateway**:
  - Platforms that can be used to link buyers and sellers
  - Examples: Amazon in books or Google in search
- **Mandatory Participation Third Party Payer Systems** (MP3PP)
  - Google is a Mandatory Participation Third Party Payer Systems (MP3PP)
  - Party-1 (the customer)
  - Party-2 (the platform)
  - Party-3 (the merchant or service provider)
  - Platform of Party-2 is so important for Party-1, and therefore Party-3, that Party-3 subsidizes the platform use of Party-1
  - Party-2 can almost arbitrarily charge Party-3 because Party-3 cannot afford to not be found
- **Search results and quality scores**
  - Ranking is based on two factors: bid and quality score
  - Quality score is calculated by Google

Source: Clemons: New Patterns of Power and Profit, 135-160, 2019

# Example: Criticality of Google

- **Critical Magnitude**: What would be the impacts and consequences of failure or malicious behavior?
  - Google can use its position and quality scores to charge arbitrary prices
  - Google can ‘hide‘ services and merchants, eventually forcing them out of business
  - Consumers do not get the best possible search results
- **Critical Breadth**: Who will be impacted by the consequences?
  - Google had a market share of over 88% in 2019
  - Most suppliers are found via Google and therefore affected
  - Most consumers use Google for their searches
  - Increasing integration of Google ecosystem: YouTube, Maps, Android, Nest
- **Critical Duration**: How long lasts the impact?
  - Monopolistic position regarding search → more data and competitive advantage
  - Difficult to compete with Google due to market entry barriers

Google → **Google becomes critical through its market power**

Source: https://www.statista.com/statistics/216573/worldwide-market-share-of-search-engines
Clemons: New Patterns of Power and Profit, 135-160, 2019

# Definitions

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**Definition**

A Critical Infrastructure is an asset or a system that is essential for the maintenance of vital societal functions or the health, safety, or economic and social well-being of people.

**Definition**

A Critical Information Infrastructure is an **information system** whose disruption or **unintended consequences** can have detrimental effects on vital societal functions or the health, safety, security, or economic and social well-being of people.

Source: Adapted from Council of the European Union (2008) Council Directive 2008/114/EC on the Identification and Designation of European Critical Infrastructures and the Assessment of the Need to Improve Their Protection. Official Journal of the European Union L 345(75)

# Differences between Critical Infrastructures and Critical Information Infrastructures

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| Dimension | Nature | Platform | Governance | People | Data | Initial Cost | Deterioration | Evolution | Consequences |
|---|---|---|---|---|---|---|---|---|---|
| **Critical Infrastructures** | Tangible | Hardware | Public | Beneficiaries | Optional | Expensive | Constant | Slow | Assessable |
| **Critical Information Infrastructures** | Intangible | Software | Private | Direct Interaction | Essential | Negligible | None | Rapid | Unde-terminable |

**differences in design characteristics** (Nature, Platform, Governance, People, Data)

**differences in operational characteristics** (Initial Cost, Deterioration, Evolution, Consequences)

# CII in the Wild — WannaCry

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Wana Decryptor screenshot

- WannaCry is a ransomware worm that spread rapidly across a number of computer networks in May of 2017
- After infecting a Windows computer, it encrypts files on the PC's hard drive, making it impossible for users to access them, then demands a ransom payment in Bitcoin in order to decrypt them
- The WannaCry ransomware consists of multiple components, it arrives on the infected computer in the form of a *dropper,* a self-contained program that extracts the other application components embedded within itself
- Once launched, WannaCry tried to access a hard-coded, unregistered URL (killswitch), if it can't, it proceeds to search for and encrypt files in important formats, ranging from Microsoft Office files to MP3s and MKVs, leaving them inaccessible to the user.
  It then displays a ransom notice, demanding $300 in Bitcoin to decrypt the files.

Source: Fruhlinger.; What is WannaCry ransomware, how does it infect, and who was responsible?;
https://www.csoonline.com/article/3227906/ransomware/what-is-wannacry-ransomware-how-does-it-infect-and-who-was-responsible.html 2018
Image source: [WannaCry Hack] by So5146, June 1st 2017. Licensed under CC BY-SA 4.0.

# WannaCry — Attacked Parties

## Fallout

Up to 70.000 devices affected in the National Health Service Hospitals in England and Scotland, including computers, MRI scanners, blood-storage refrigerators and surgery room equipment, may have been affected

Nissan Motor Manufacturing in England halted production after the ransomware infected some of their systems. Renault also stopped production at several sites in an attempt to stop the spread of the ransomware

At Deutsche Bahn, around 450 computers were infected. This led to failures in train stations, video surveillance systems, and a regional control center in Hannover.

A total of 327 payments totaling $130,634.77 USD had been transferred

Image source: [Worldmap] by OpenClipart, October 6th 2013. Pixabay License.

# CII in the Wild — GPS Truck Crashes on Arkansas 43



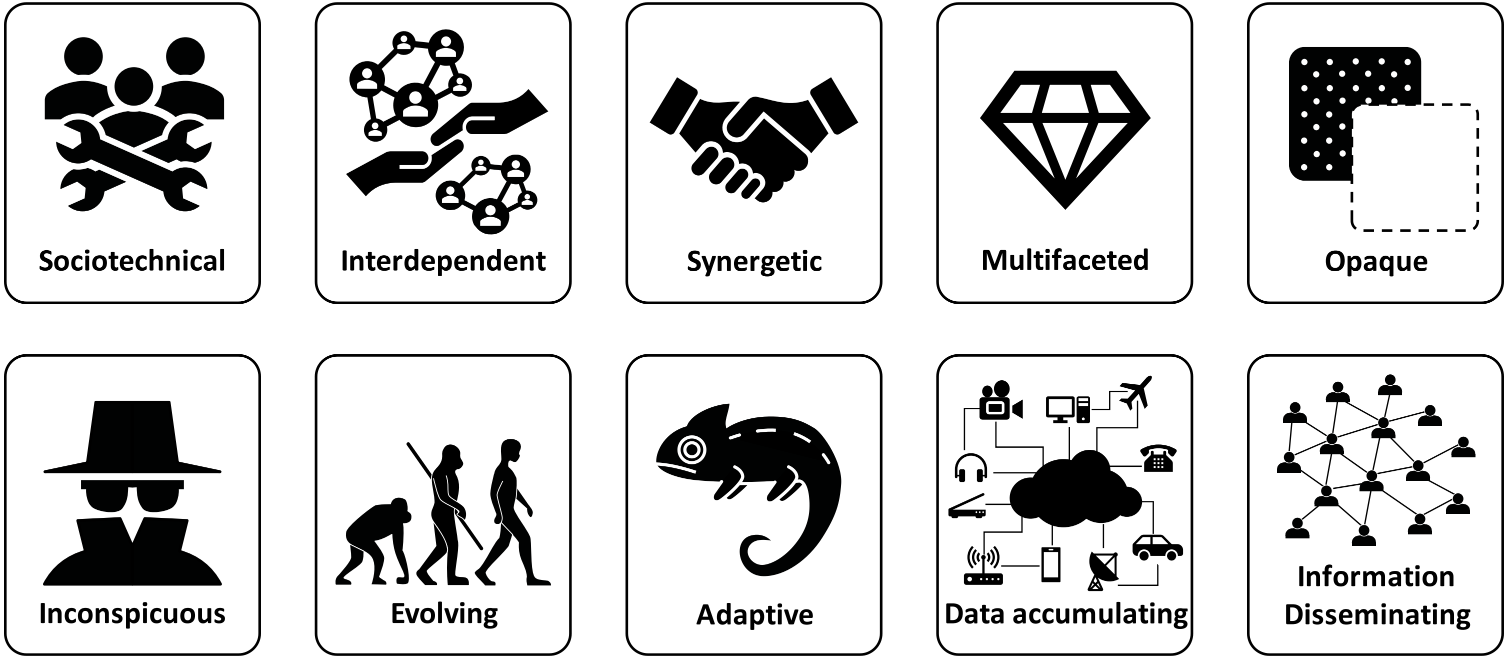
- In Arkansas, a federal state of the US, a highway appears to be straight on the GPS of truck drivers but doesn't tell the drivers that there is a 1,300-foot drop in elevation from the intersection of Arkansas 103 into Ponca. And there are two big curves on Arkansas 43 before the hill flattens out at Ponca
  → It doesn't look like that on Google Maps
- From 2014 to 2016 seven trucks wrecked on a 2-mile stretch of Arkansas 43 just north of Ponca
- Three of those seven truck drivers managed to negotiate the first curve heading south on Arkansas 43, but they had burned up their brakes by the time they reached the second curve. As a result, the runaway trucks hit the ditch across the highway from Lost Valley Canoe & Lodging and rolled over

→ In this case, the GPS and Google maps, which served as information infrastructure, failed!

Source: Bowden, GPS blamed for surge in runaway trucks in small Arkansas town, https://www.arkansasonline.com/news/2017/jan/02/steep-drop-big-curves-at-ponca-stun-tru/, 2017.
Image source: [Truck] by Unknown, n.d. Licensed under CC0.

# Properties of CIIs

# Characteristics of Critical Information Infrastructures




Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 349, 2020

# Characteristics of Critical Information Infrastructures

- **Sociotechnical**

Consist of various social and technical components, including technical structures, human staff, organizational processes, laws and regulations, and the environment (e.g., natural resources).

- **Interdependent**

Operation and resulting consequences of CII depends on the functioning of its parts.

- **Synergetic**

The value produced by CII is greater than the sum of the value produced by its parts.

- **Multifaceted**

Serve diverse purposes for various stakeholders. Without any central governing authority.

- **Opaque**

Consist of a large number of parts with complex interconnections and modes of operation.

- **Inconspicuous**

Operate often unnoticed. Importance becomes apparent when adverse consequences manifest.

- **Evolving**

Subject to technological and societal evolution. Over time, the performance and purpose of CII changes.

- **Adaptive**

The coupled social and technical parts allow for adaption to events in the inner or exterior environment.

- **Data Accumulating**

Generate large amounts of data.

- **Information-Disseminating**

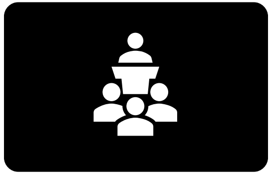
Information newly obtained is quickly disseminated within and beyond CII.

# Functions of CIIs

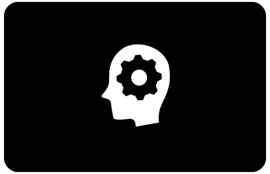
# Functions of Critical Information Infrastructures

- **Communication**
  Infrastructures communicating information

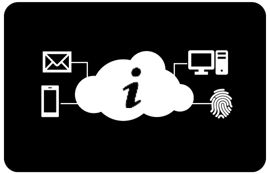
- **Governance**
  Information systems governing infrastructures



- **Knowledge Management**
  Infrastructures that preserve information for future uses



- **Information Collection**
  Infrastructures that collect information



Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 354, 2020

# Critical Information Infrastructures for Communication



- **Machine**

  Communication between machines (e.g., satellite navigation systems, such as Galileo or GPS)


- **Private**

  Communication within a limited group of persons (e.g., chats)

[2]

- **Public**

  Communication intended for public consumption (e.g., emergency broadcasts, news)

[3]

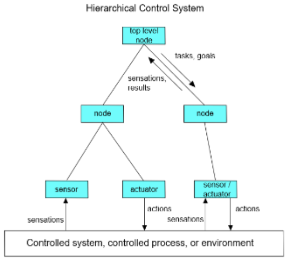
Image source[1]: [Industry 4.0] by Altmann Gerd, September 11th 2017. Pixabay License.
Image source[2]: [Chat bubble] by Yogyakarta, June 11th 2017. Pixabay License.
Image source[3]: [Wifi] by Samuel, January 6th 2016. Pixabay License.

# Critical Information Infrastructures for Governance

## Control Information Systems

Information systems ensuring that infrastructure stays within defined control parameters (e.g., supervisory control and data acquisition (SCADA) systems)

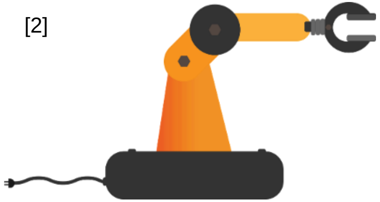
[1]




## Highly-Autonomous Information Systems

Information systems performing tasks within an infrastructure with a high degree of autonomy (e.g., high-frequency trading, collision avoidance systems)

[2]



## Monitoring Systems

Systems monitoring control parameters and raising alerts in case of violations (e.g., passive intrusion detection systems)

[3]

Image source [1]: [Control Information Systems] by Stephen L. Reed, June 2009. Licensed under CC BY 3.0
Image source [2]: Adapted from [Robot] by Kasri Niran, August 18th 2018. Pixabay License.
Image source [3]: [Heartbeat] by Clker-Free-Vector-Images, April 18th 2012. Pixabay License.

# Critical Information Infrastructures for Knowledge Management

- **Decision Support**
  Systems that support decision making
  (e.g., clinical decision support)

[1]

- **Information Retrieval**
  Systems that retrieve and discover information
  (e.g., Google web search)


[2]

- **Knowledge Repositories**
  Systems that maintain data, information, and knowledge
  (e.g., Wikipedia)

WIKIDATA
[3]

Image source [1]: [GPS System] by Clker-Free-Vector-Images, June 10th 2014. Pixabay License.
Image source [2]: [Spy] by Hassan Mohamed, June 16th 2018. Pixabay License.
Image source [3]: [Wikidata Logo] by Wikidata, n.d. Public Domain.

# Critical Information Infrastructures for Information Collection

- **Sensors**
  Hardware collecting information (e.g., air quality monitor)


[1]

- **Surveys/Polls**
  Social mechanisms collecting information (e.g., political votes)

[2]

- **Data Aggregation**
  Generation of information from data stream (e.g., Google Flu Trends)


[3]

# Operation of CIIs

# CII Challenges

- Social Responsibility
- Fairness
- Privacy
- Security
- Durability
- Ripple Effects
- Accountability
- Algorithmic Decision-Making
- Governance
- Single Points of Failure
- Structural Scalability

Source: Sunyaev, Critical Information Infrastructures. In Internet Computing, 361, 2020

# Challenges of Critical Information Infrastructures

| Social Responsibility |
|---|
| Fairness |
| Privacy |
| Security |
| Durability |
| Ripple Effects |
| Accountability |
| Algorithmic Decision Making |
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| Single Points of Failure |
| Structural Scalability |

- CII fulfill important roles in society
- Impacting health, safety, security, or economic and social well-being of people
- CII can be opaque and inconspicuous governance infrastructures that monitor and regulate our everyday lives
  - Examples: Traffic control systems and information systems managing the provision of electricity and water
- CII operators must act in a socially-responsible way and cannot solely strive for economic value creation

# Challenges of Critical Information Infrastructures

- Social Responsibility
- **Fairness**
- Privacy
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- CII should impact all people equally and should not violate human rights
- **Distributive justice**

  Focuses on the distribution of outcomes so that no actor in society is advantaged or disadvantaged
- **Procedural justice**

  Focuses on the (decision) processes that were used to distribute outcomes instead of the distribution of outcomes
- **Interactional justice**

  Focuses on dignity and respect in the relationship between decision makers and the people affected by the decisions


Source: Cropanzano et al., Journal of Vocational Behavior, 58(2), 2001

# Challenges of Critical Information Infrastructures

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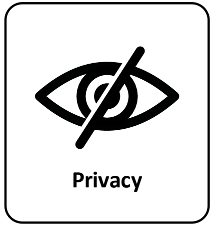
- Complex and increasingly ubiquitous information flows make it hard to ensure the appropriateness of information flows
- Today's perspective: Information privacy as a social contract. There exist a diversity of users' information-privacy needs
  - Information privacy is treatment of information by information handlers in a way that aligns with social norms and expectations that individuals who made the information available have
- CIIs have to ensure that information should flow appropriately in a given context
  - Example: It's appropriate to share health data with a physician but not with your employer




Source: Martin & Nissenbaum, Columbia Science and Technology Law Review 18:176–218, 2016

# Challenges of Critical Information Infrastructures

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- Fairness
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- **Security**
- Durability
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- CII have many links where the confidentiality, integrity, or availability of information could be compromised
  - Example: DDoS attacks, insider attacks, equipment failures, information transmission issues, espionage, etc
- *Confidentiality* refers to ensuring that information is not accessed by and not disclosed to unauthorized parties
- *Integrity* refers to guarding against improper information modification "or destruction
- *Availability* refers to ensuring timely and reliable access to and use of information


Source: National Institute of Standards and Technology, NISTIR 7298, 2013

# Challenges of Critical Information Infrastructures

- Social Responsibility
- Fairness
- Privacy
- Security
- **Durability**
- Ripple Effects
- Accountability
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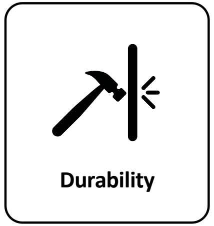
- Single Points of Failure
- Structural Scalability

- CIIs operate for decades
- Accordingly, long-term effects must be reflected for their sustainable design, operation, and governance
- How to deal with fast technology lifecycles and agile development methods?
  - Cloud computing started to emerge in 2007
  - Today, cloud services have matured into a fundamental technology
- Implement processes to identify and handle emerging trends and threats
  - For example, current encryption techniques might be outdated in the future (e.g., not quantum safe)



# Challenges of Critical Information Infrastructures

| |
|---|
| Social Responsibility |
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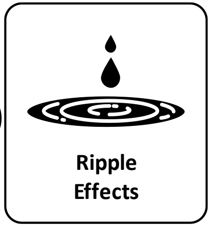
| Accountability |
| Algorithmic Decision Making |
| Governance |
| Single Points of Failure |
| Structural Scalability |

- CIIs are usually embedded in complex networks
- Changes to or disruptions of a CII may create effects that ripple over to other systems
- CIIs can exhibit three types of interdependencies
  - Up-stream dependencies (e.g., internet access)
  - Internal dependencies (e.g., number of users and hardware in social networking services)
  - Downstream dependencies (e.g., traffic and navigation systems often depend on GPS)
- Dependencies can surface in four different forms
  - Physical (e.g., electrical grid links)
  - Geographical (e.g., natural disasters)
  - Cyber (e.g., links in an information retrieval system)
  - Logical (e.g., legal system)




Source: Rinaldi et al., IEEE Control Systems Magazine 21:11–25, 2001

# Challenges of Critical Information Infrastructures

- Social Responsibility
- Fairness
- Privacy
- Security
- Durability
- Ripple Effects
- **Accountability**
- Algorithmic Decision Making
- Governance
- Single Points of Failure
- Structural Scalability

- Consequences of CII are the result of complex interactions
- This makes it hard to determine what human or technical parts are responsible for adverse consequences
- *Who will be held responsible for consequences of ripple effects?*
- Four barriers impeding accountability
  - The problem of many hands—diverse actors
  - Bugs are unavoidable in software
  - The computer is used as a scapegoat
  - Software ownership without liability


Source: Nissenbaum, Science and Engineering Ethics 2:25–42, 1996

# Challenges of Critical Information Infrastructures

- Social Responsibility
- Fairness
- Privacy
- Security
- Durability
- Ripple Effects
- Accountability
- **Algorithmic Decision Making**
- Governance
- Single Points of Failure
- Structural Scalability

- Algorithmic decision making often affects human and machine actors, especially, with the rise of machine learning
- Several factors can cause biased decision making
  - Embedded values
  - Opacity
  - Repurposing of data and algorithms
  - Lack of auditing standards
  - Power and control
- Example: **“Smart” soap dispenser**
  - Soap dispenser uses image recognition to detect hands
  - AI does not recognize hands with dark skin tones


Source: Caplan et al., Algorithmic Accountability: A Primer, 2018; Chukwuemeka Afigbo, https://twitter.com/nke_ise/status/897756900753891328

# Challenges of Critical Information Infrastructures

- Social Responsibility
- Fairness
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- Durability
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- Accountability
- Algorithmic Decision Making
- **Governance**
- Single Points of Failure
- Structural Scalability

- CIIs are huge, complex, and evolving networks with uncertain cause-and-effect relationships
- The dynamic nature makes it difficult to maintain, control, and regulate CIIs
- Regulations are typically way behind the current level of technology
- Three steps:
  - Evaluate CIIs
  - Plan changes to CIIs
  - Implement and monitor changes


Source: Juiz & Toomey, Communications of the ACM 58:58–64, 2015

# Challenges of Critical Information Infrastructures

| |
|---|
| Social Responsibility |
| Fairness |
| Privacy |
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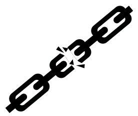
| Ripple Effects |
| Accountability |
| Algorithmic Decision Making |
| Governance |
| **Single Points of Failure** |
| Structural Scalability |

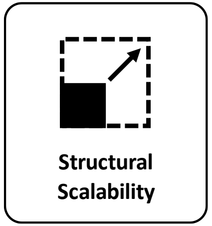
- Some parts of a CII serve redundant purposes, others are essential for successful operation
- Redundancy can exist in technical and human components
- A single point of failure is a part of a system that, if it fails, will stop the entire system from working
- The plethora of parts within a CII make it hard to identify all the essential CII parts requiring increased levels of protection



# Challenges of Critical Information Infrastructures

| |
|---|
| Social Responsibility |
| Fairness |
| Privacy |
| Security |
| Durability |
| Ripple Effects |
| Accountability |
| Algorithmic Decision Making |
| Governance |
| Single Points of Failure |
| **Structural Scalability** |

- Criticality is often accompanied by increases in workload because the breadth of CIIs increases
- CIIs have to be scalable
- 4 types of scalability:
  - Load scalability—avoiding unnecessary delays and resource consumption
  - Space scalability—scale without unmanageable increases in memory requirements
  - Space-time scalability—scale without severe losses in performance
  - Structural scalability—scaling not prevented through implementation or architecture specification
- Structural scalability is the most important type as changes to a CII's implementation or architecture may result in errors in interconnected systems




Source: Bondi, Proceedings of the 2nd International Workshop on Software and Performance, 2000

# Summary

- Information technology has rapidly developed since the 1960s
- Certain information systems have become **critical information infrastructures (CIIs)**, their disruption or their unintended consequences could result in adverse consequences of critical magnitude, breadth, and duration
- CIIs are inherently sociotechnical so that a sociotechnical perspective must be considered when dealing with CIIs
- CIIs are related to critical infrastructures but different
- CIIs are complex information systems involving a wide range of actors and different technical elements
- CIIs serve various functions and exist in various forms. The four main functions offered by CIIs are communication, governance, knowledge management, and information collection
- Effective operation of CIIs requires operators to master not only technical challenges but also ethical, legal, and social challenges → interdisciplinary effort

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# Questions

# Questions

1. What are critical information infrastructures?
2. What are the differences between critical infrastructures and critical information infrastructures?
3. How does the importance and relevance of the main properties of critical information infrastructures differ between different types of critical information infrastructures?
4. Who should be in charge of critical information infrastructure operation?
5. What would be an example for a critical information infrastructure that performs subfunctions of three different main functions of critical information infrastructures?

# Further Reading


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