lasaris LAB OF SOFTWARE ARCHITECTURES AND INFORMATION SYSTEMS

MINISTRY OF EDUCATION, YOUTH AND SPORTS

MUNI C4E

Towards Antifragile Critical Infrastructure Systems

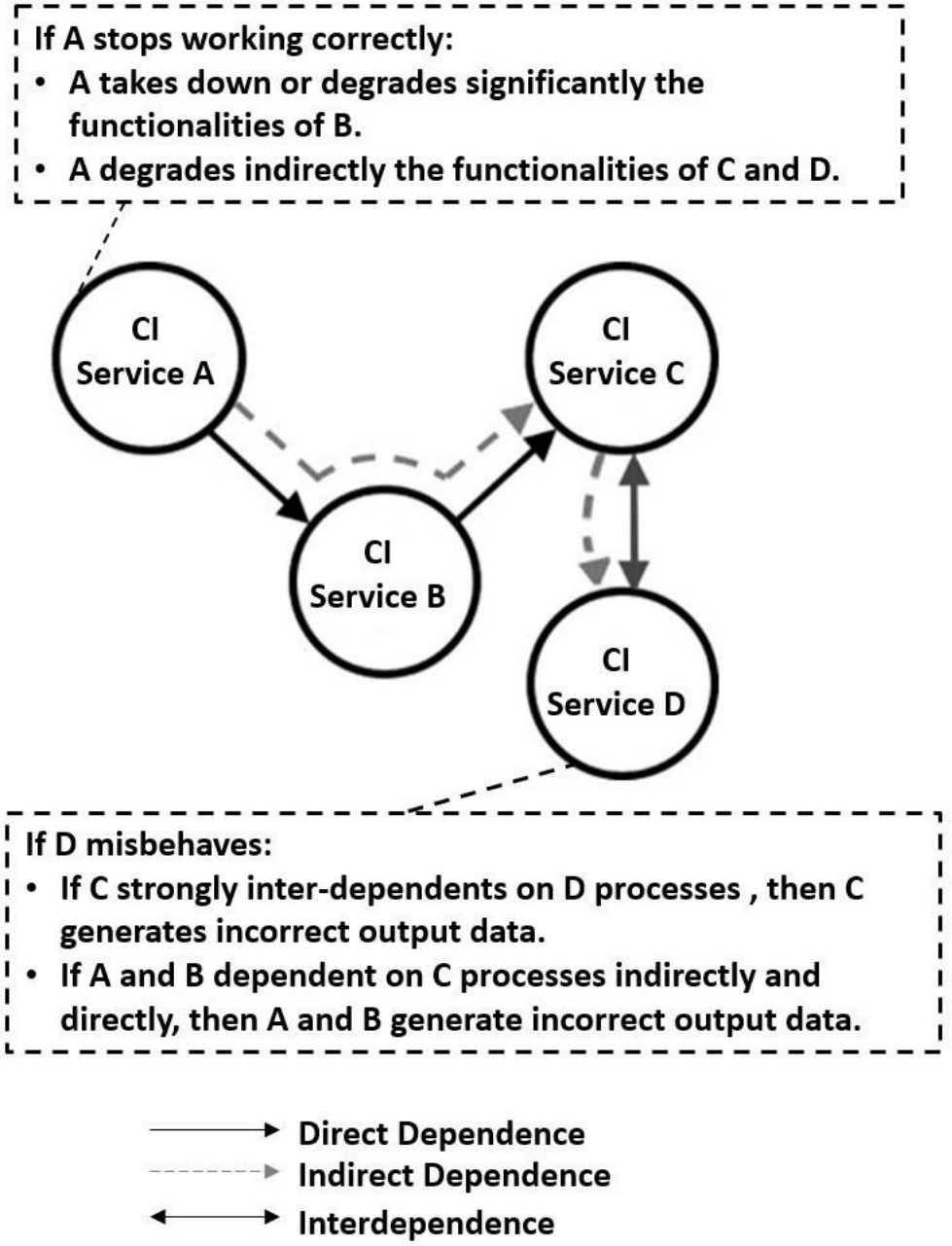
Hind Bangui, Barbora Buhnova, and Bruno Rossi
Faculty of Informatics, Masaryk University, Brno, Czech Republic

Outline

- What is Resilience?
- Why we need to move from Resilience to Antifragility?
- What is Antifragility?
- What are the future directions related to moving from Resilience to Antifragility?

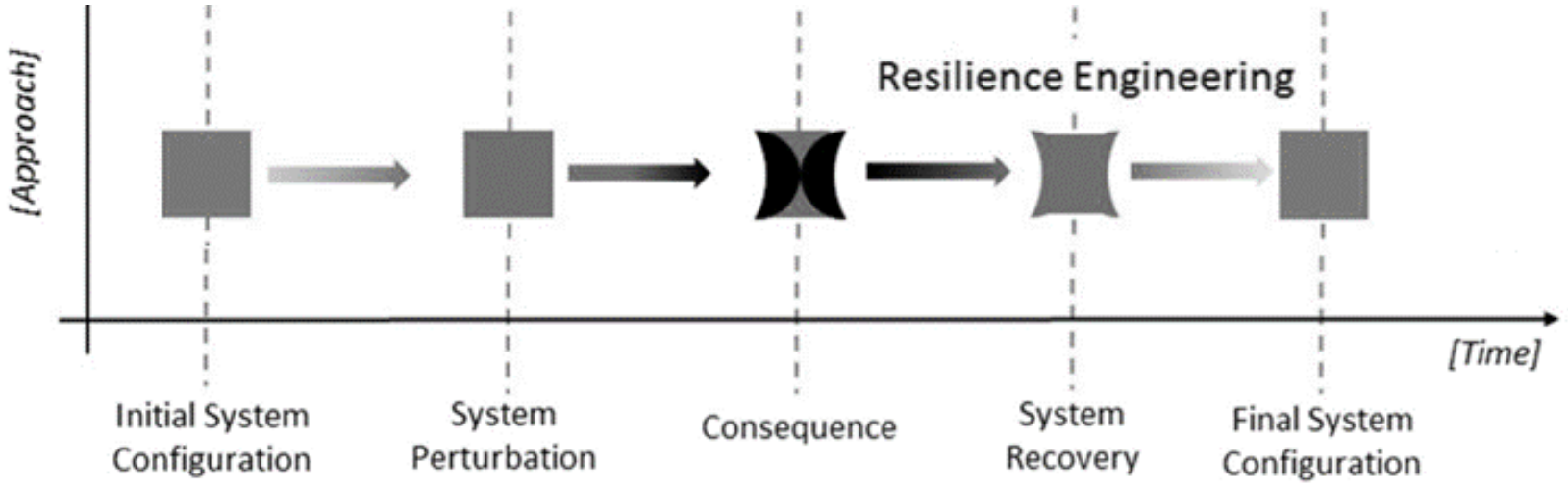
What is Resilience?

- Critical Infrastructure (CI) may be understood as a large number of assets, systems, networks, and facilities that contribute to the lives of people and the economy of a country as a whole.
- The state of one critical system can directly or indirectly influence others.
- It is almost impossible to protect an infrastructure without establishing a prioritization of essential services and identifying its vulnerabilities.

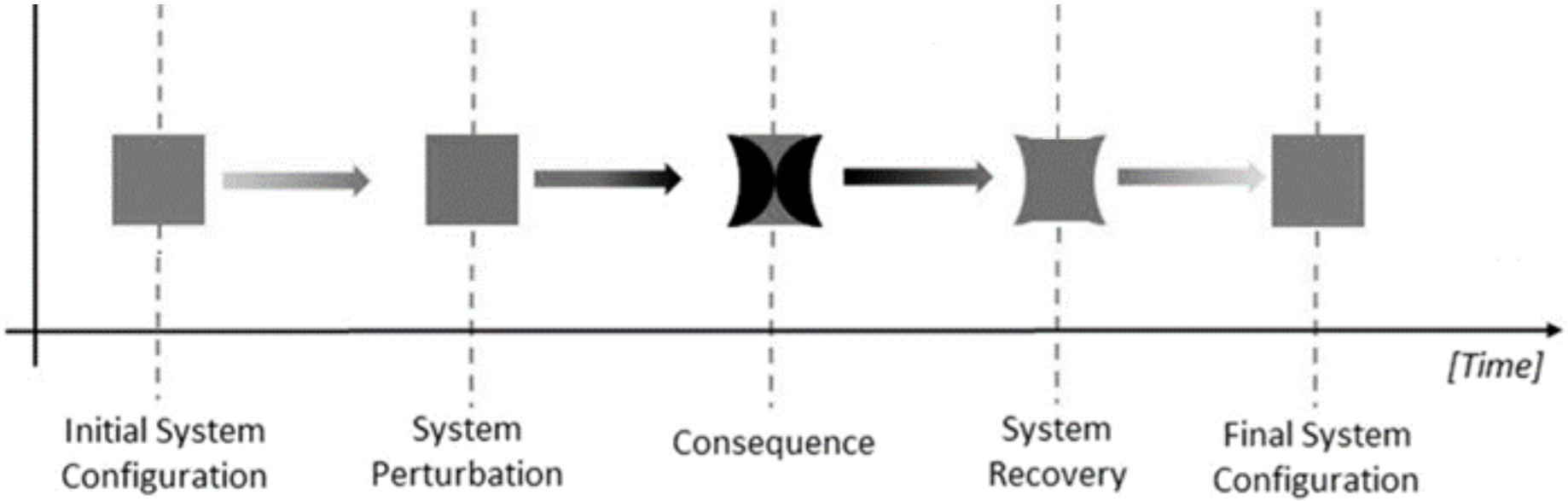


What is Resilience?

- Main Representative keywords of Resilience:
  - **Robustness:** It refers to how a system is able to manage increasing complexity, stressors, and challenges.
  - **Rebound (Recovery):** It refers to how a system rebounds from disrupting or traumatic events and **returns to previous** or **normal activities**.
  - **Adaptability:** It refers to the ability of a system to manage/regulate adaptive capacities to continuously function well, when it will face **predictable** changes and challenges across its life cycle.



What is Resilience?



Resilience Engineering: It aims to create a system able to **stretch** its boundaries to find its **adaptability** and **robustness after** perturbations.

Why we need to move from Resilience to Antifragility?

- The Covid-19 virus has rapidly spread across the world, and most countries have struggled to contain it.
- Covid-19 is causing significant disruptions to countless different industries.
- The impact of the Covid-19 pandemic continues to ricochet across globe despite the efforts made by governments, the public sector and individual businesses to halt its detrimental effect on health and on the economy.

Why we need to move from Resilience to Antifragility?

Global transformation caused by the coronavirus

	Response / Impact	Response	Underlying technology/operation
Education	Widespread closure of educational institutions; access to labs is restricted; projects have been mothballed; fieldwork interrupted	Virtual learning environment (online teaching, presentation, assessment, and consultation); convocation online	Online video conferencing software, virtual labs on cloud
Healthcare	Overcrowded hospitals, inability to meet the demands on them	Contact tracing, forecasting resource requirements, allotment of scare resources based on a patient's survivability, COVID-19 vaccine development, telehealth (online consultation with a doctor or medical professional);	AI, cloud computing, chatbot
Industry	Closure of some industries	Work from home, remote operations, automation and autonomous operation	Robots, automation, 3-D printing
Retail	Stores closed, only online service, avoidance of retail shopping	Online shopping, home delivery	The Web, online payment, contactless payment
Personal life and social interaction	Lockdown	Indoor activities	Phone, audio and video chats, streaming, online gaming

Why we need to move from Resilience to Antifragility?

Challenges during the pandemic

- Educational activities were switched to remote learning platforms and this migration came with several logistical challenges.
- Pandemic-related anxiety had negative effects on student academic performance,
- Academic performance of students might be affect by economic and resource differences,
- The larger parts of instructors were not effectively ready to deliver high-quality instruction remotely.
- Resilience in the face of uncertainty.
  - No **previous** training, no **prior** strategic **planning** knowledge, no **prior** operational experience, and no former decision-making skillset has prepared anyone for this pandemic.

Transforming these experienced challenges during the pandemic to opportunities

- Providing models to accommodate the contemporary changes in online learning,
- Reviewing the process of digital transformation of institutions,
- Modelling Student Behaviour in Synchronous Online Learning,
- Designing more scalable and personalized online learning models,
- Redesign the learning process.

Why we need to move from Resilience to Antifragility?

Global transformation caused by the coronavirus

	Response / Impact	Response	Underlying technology/operation
Education	Widespread closure of educational institutions; access to labs is restricted; projects have been mothballed; fieldwork interrupted	Virtual learning environment (online teaching, presentation, assessment, and consultation); convocation online	Online video conferencing software, virtual labs on cloud
Healthcare	Overcrowded hospitals, inability to meet the demands on them	Contact tracing, forecasting resource requirements, allotment of scare resources based on a patient's survivability, COVID-19 vaccine development, telehealth (online consultation with a doctor or medical professional);	AI, cloud computing, chatbot
Industry	Closure of some industries	Work from home, remote operations, automation and autonomous operation	Robots, automation, 3-D printing
Retail	Stores closed, only online service, avoidance of retail shopping	Online shopping, home delivery	The Web, online payment, contactless payment
Personal life and social interaction	Lockdown	Indoor activities	Phone, audio and video chats, streaming, online gaming

Why we need to move from Resilience to Antifragility?

Personal life and social interaction

Confined Symphony

Why we need to move Resilience to Antifragility?

- Definition of Critical Infrastructures (CI): “Organizational and physical structures and facilities of **such vital importance to a nation's society and economy** that their failure or degradation would result in sustained supply shortages, significant disruption of public safety and security, or other dramatic consequences“.
- **CHANGING NATURE OF CRITICALITY**
  - Some industries have been able to shift production from **non-essential** to **essential** products.
  - A Healthcare Example**: Parks** are typically considered a **non-essential service**. However, during COVID-19, parks have proven their value by serving as field hospitals, providing alternative shelters for socially vulnerable groups, and promoting physical, emotional, and mental well-being.

Why we need to move Resilience to Antifragility?

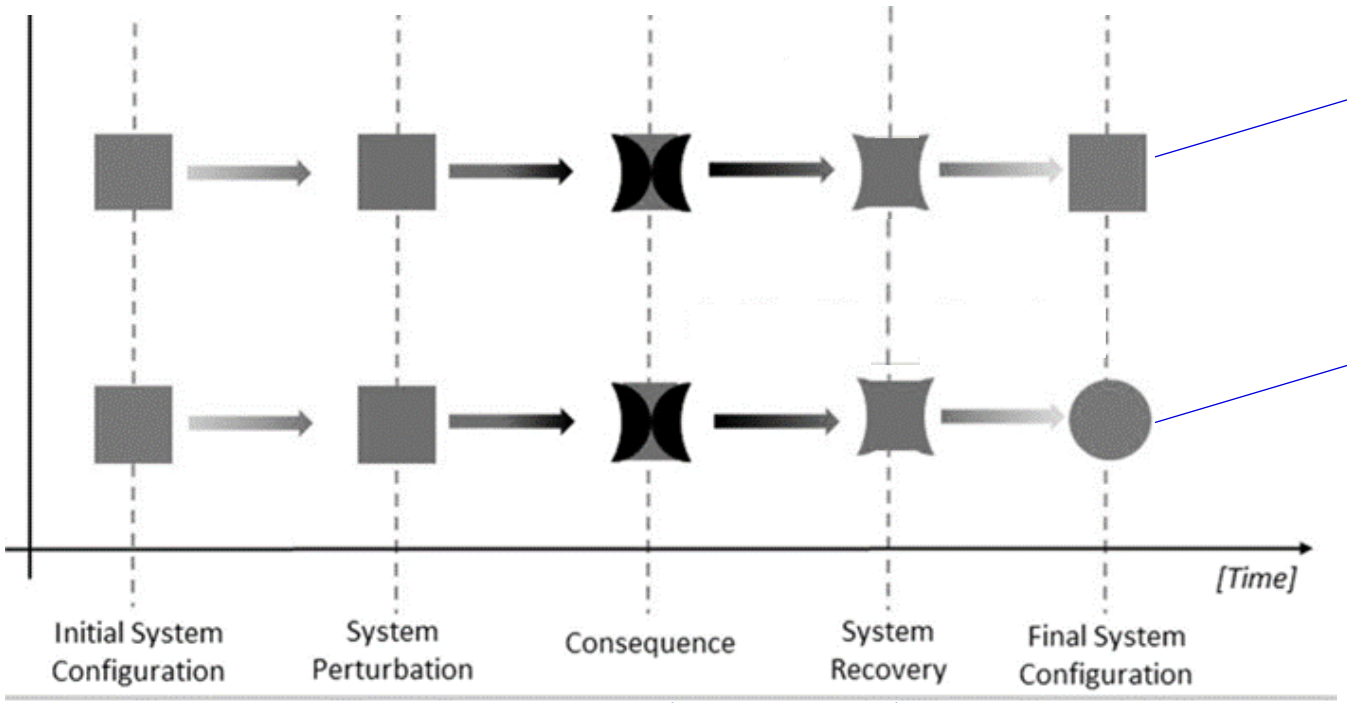
- Definition of Critical Infrastructures (CI): “Organizational and physical structures and facilities of such **vital importance to a nation's society and economy** that their failure or degradation would result in sustained supply shortages, significant disruption of public safety and security, or other dramatic consequences“.
- **CHANGING NATURE OF CRITICALITY**
  - Defining which systems are CI results in **a prioritization** of resources **during** extreme events.
  - Critical infrastructure definitions should account for the changing services and functions of industries during hazards.
  - Treating criticality as **dynamic** appears crucial to identifying how to meet basic needs through infrastructure changes as hazards vary.

Why we need to move from Resilience to Antifragility?

- Critical Systems are those which not only survive shocks but also actively **“employ”** them to become stronger.
- Critical Systems adapt to volatility and learn from experiences, faults, and incidents, for instance, through a **“learning by doing**” process how to thrive as conditions evolve (i.e., adaptability and evolvability).
- Going **beyond the traditional target of resilience.**
  - Bringing a new perspective of sustainability to complex adaptive systems.

Why we need to move from Resilience to Antifragility?

Resilience Engineering: It aims to create a system able to **stretch** its boundaries to find its **adaptability** and **robustness after** perturbations.



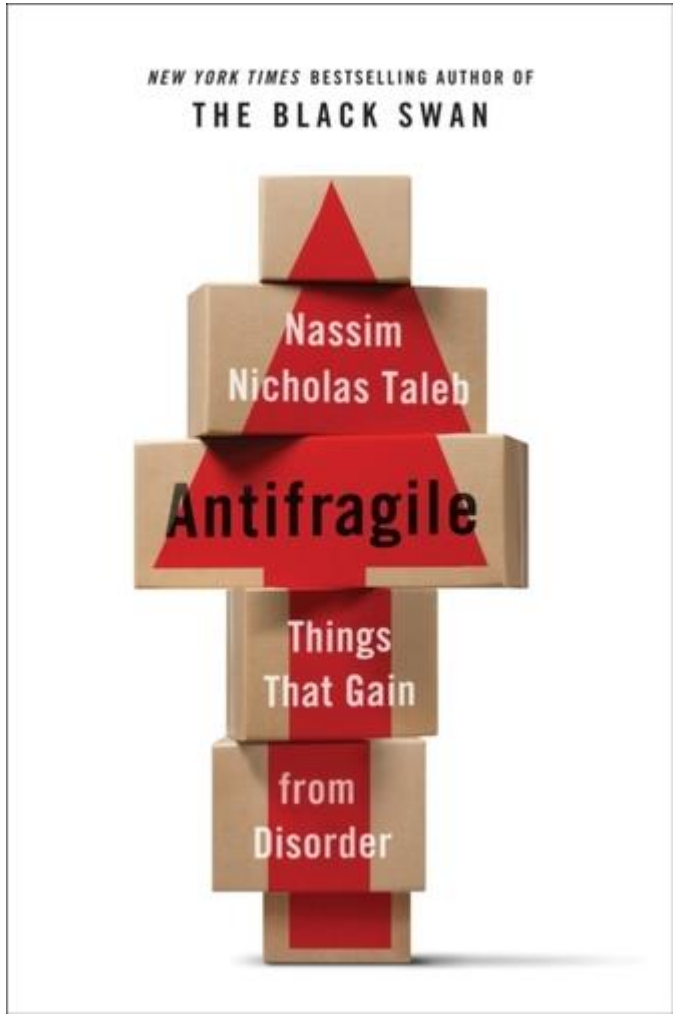
- **Resilience focuses only on ex post adaptation, which often comes too late.**
- **The resilient entity resists shocks and stays the same.**

Antifragility Engineering: It aims to enable a system not merely to tolerate adverse conditions and stretch its boundaries but rather to strengthen and learn in the process.

- **Learning and Adapting fragile systems to the real unexpected circumstances.**
- **Accelerating the digital transformation.**

What is Antifragility?

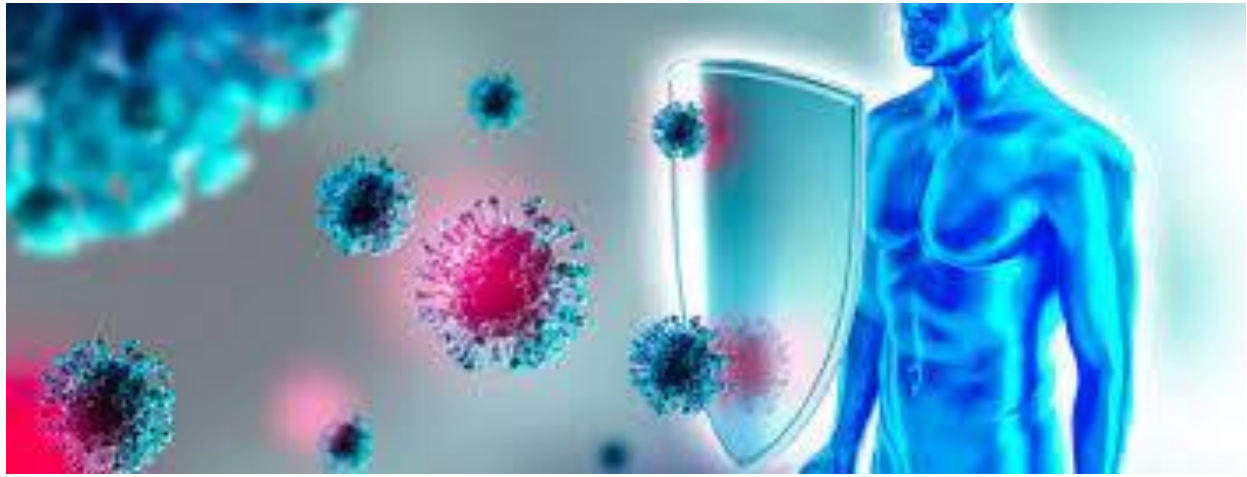
- The concept of antifragility was proposed by **Nassim Nicholas Taleb** in his book "**Antifragile: Things that gain from disorder**", published in **2012**.
- Fragile object definition*: "If these perturbations can only harm, damage or break the object, then the object is **fragile**. Give it enough time, and a perturbation of a sufficient magnitude will eventually take palce to damage or break it. A **fragile object is an object likely to get damaged or to break with time.**"*



What is Antifragility?

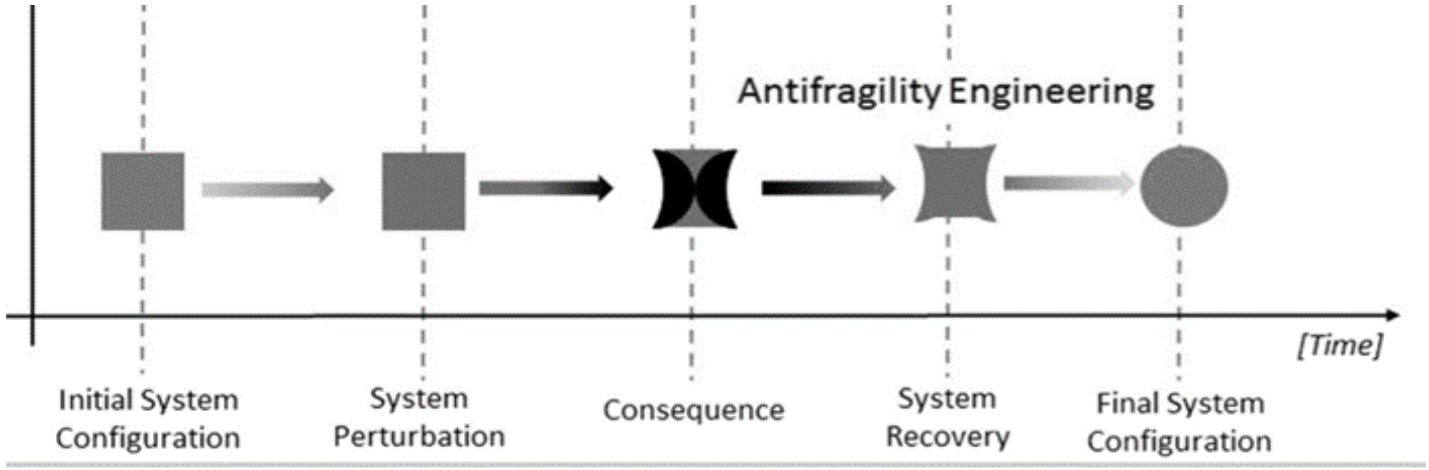
- **“Things that gain from disorder”** => Appreciate, some level of stressors, failures and mistakes to obtain better performance over a longer time horizon.

- The human immune system is an example of an antifragile system, as it becomes stronger from regular exposure to germs.



What is Antifragility?

- Antifragility actively seeks to inject volatility in systems to expose fragility.
- Unlike robust systems, antifragile systems learn from failures how to adjust themselves to limit the impact of future failures and become stronger in a continually changing environment.
- An antifragile system is able to evolve its identity and improve itself systematically in its operating context.



Future Directions

- COVID-19 reveals several important limitations to how we approach and manage our critical infrastructures in a complex and uncertain world.
- COVID-19 is a window of opportunity for laying new foundations for how we design, operate, and manage infrastructure

Challenge : How to build an antifragile system ?

- **Antifragility is an emphasis on learning and creativity:**
  - An antifragile system is able to shift from leadership in stable to unstable conditions.
  - Antifragility actively seeks to inject volatility in systems to expose fragility.
  - A self-improving system should be capable of collecting its own training data and learning from it.
  - Applications of artificial intelligence have the potential to support creativity in antifragile systems.

Needs → Acceleration of the digital transformation process in Critical Infrastructures.

Needs → Adoption of digital technologies that are the main driving forces of digitalization, such as Internet of Things

Future Directions

- **The adoption of IoT** is still in its infancy and many business sectors are still **reluctant** to adopt IoT due to the lack of consumer acceptance.
  - The COVID-19 pandemic has accelerated the **digital transformation** of many organisations.
- **Increase in IoT Threats and risks** : **57%** of IoT devices vulnerable to severe attacks (**Source: Palo Alto Networks**)
- **Security and Privacy** are the major barriers to wider IoT adoption: **85% of** the survey of **170** IoT industry leaders believe that security and privacy concerns remain a major barrier to IoT adoption (**Source: OMDIA**)

Result: Increased lack of trust in IoT services and products

Slowed incorporation of IoT innovations

Slowed adoption of Antifragile systems

Challenge 1: Addressing trust management issues in digital world ➔ **Challenge 2:** Building Antifragile Systems

Thank you for your attention