KIOS Research and Innovation Center of Excellence

Resilience of Critical Infrastructure Systems in the Era of AI

Prof. Marios Polycarpou

Board Chair, KIOS Research and Innovation Center of Excellence

Professor, Electrical and Computer Engineering, University of Cyprus

Founding Member, Cyprus Academy of Sciences, Letters and Arts

CYPRUS ACADEMY OF SCIENCES, LETTERS, AND ARTS

University of Cyprus

Imperial College London

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Critical Infrastructure Systems

A critical infrastructure (or critical entity) is defined as an asset or system, which is essential for the maintenance of vital societal functions **(European Commission)**

Examples:

- Power and energy systems
- Telecommunication networks
- Water systems (clean water and wastewater)
- Transportation systems
- Health systems, Food supply, etc.

Critical infrastructures are interdependent systems that work together to provide the essential services of a modern society

Critical Infrastructure Systems: Motivation

Critical Infrastructure Systems (CIS) are crucial for everyday life and well-being

- Citizens expect/rely that CIS will **always** be available (24/7).
- Citizens expect that they will be managed **efficiently** (low cost).

Critical infrastructure systems do fail

- Natural disasters (earthquakes, flooding)
- Accidental failures (equipment failures, human error, software bugs)
- Malicious attacks (directly, remotely)

When critical infrastructures fail the consequences may be tremendous

- Societal consequences
- Health hazards
- Economic effects

Critical Infrastructure Systems: Motivation

The problem of managing critical infrastructure systems is becoming more challenging

- CIS were not designed to be so large – they evolved due to growing demand
- Deregulation has resulted in more heterogeneous and distributed infrastructures, which make them more vulnerable to failures and attacks
- Renewables and climate change present new challenges
- There are more and more interdependencies between CIS
- By 2050, **64%** of the population in the developing world and **86%** in the developed world will live in urban areas.

CIS are becoming more ***heterogeneous***, **distributed** and ***interdependent***

Resilience of Critical Entities

EU Critical Entities Resilience Directive (CER)

- Three priority areas: *preparedness*, *response* and *international cooperation*
- Member states are required to update their risk assessments to reflect current threats and encourages them to conduct stress tests of entities operating critical infrastructures

→ Aims to make critical entities more resilient against a wide range of threats, including terrorist attacks, insider threats, natural hazards, and public health emergencies

Converting (Big) Data to Smart Decisions

Critical Infrastructure Systems (CIS)

Heterogeneous - Interdependent - Interconnected

Risks, Faults, Attacks

Information Communication Technologies (ICT)

Sensors, Actuators

Big Data, Internet of Things

Intelligent Systems and Networks

Monitoring, Control

Management, Security

Big Data → Smart Decisions

Resilient Monitoring and Control Steps

- Event detection
- Event isolation
- Risk assessment
- Accommodation

Handling Unanticipated Events

- Model based approaches
- Data driven approaches
- Hybrid approaches

KIOS Center of Excellence at a glance

- Established as a Research unit in **2008** and upgraded to a Center of Excellence (CoE) in **2017** - Collaborates strategically with Imperial College, London
- Operates within the University of Cyprus (at the level of Faculty)
  - **232** people at KIOS CoE
- Develops **research infrastructures** (Testbeds)
  - Test technologies under realistic operating conditions
- Creates **synergies**
  - National and international industrial and governmental organizations

The name “KIOS” was inspired from the Greek Mythology, where **KIOS was the titan of “Intelligence”**

KIOS Technical Focus & Specialization

Intelligent monitoring, control, risk management and cyber/physical security of **Critical Infrastructure Systems**

Energy & Power Systems

Smart Water & Environmental Systems

Intelligent Transportation Systems

Telecommunication Systems & Networks

Emergency Management Response

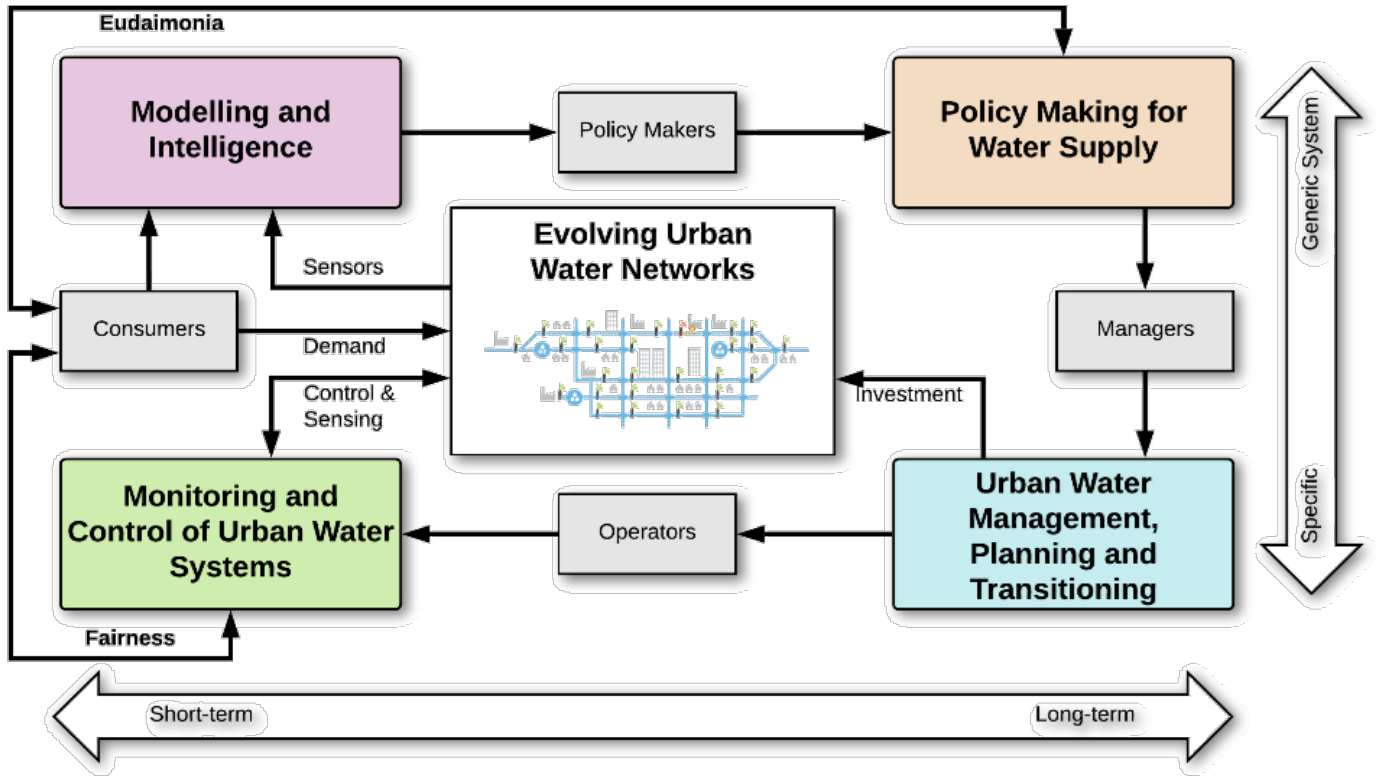
Smart Healthcare Systems

KIOS provides solutions to real-life problems and brings knowhow and tools that make large-scale infrastructures smarter, more efficient, secure, and sustainable

ERC Synergy project: Water-Futures

European Research Council
Established by the European Commission

- **Water-Futures: Smart Water Futures: designing the next generation of urban drinking water systems**
- **Beneficiaries:**
  - University of Cyprus (Cyprus) – **M. Polycarpou**
  - Bielefeld University (Germany) – **B. Hammer**
  - AUEB (Greece) – **P. Koundouri**
  - KWR (Netherlands) & Univ of Exeter (UK) – **D. Savic**



Cyprus Digital Twin (CyDT) – KIOS flagship project

Power Networks

Drinking Water and Wastewater Networks

Intelligent Transportation Systems

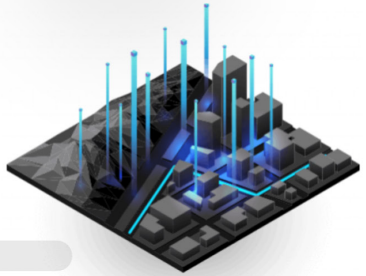
Telecommunication Networks

Emergency Response

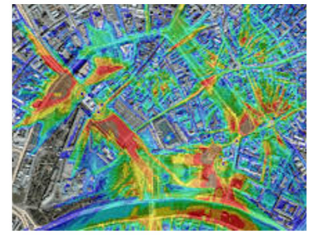
Cyprus Digital Twin

Demo Video

Decision Support



Impact Assessment



Risk Estimation

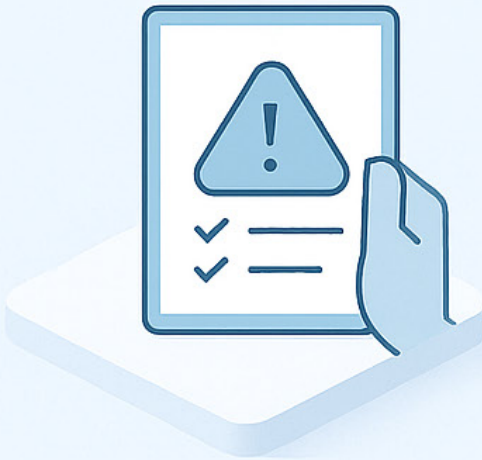
‘What-if’ Scenarios

CyDT Stakeholders

Envisioned Services for Stakeholders

Decision support

Situational awareness



Risk estimation

Impact assessment

What-if scenarios

Key Challenges in Utilizing AI for Critical Infrastructures

- More heterogeneous data
- Developing trustworthy machine learning algorithms
- Human-Machine interaction
- Developing distributed algorithmic approaches
- Causal vs Correlation
- Poor quality of data

Required for research in Intelligent Infrastructures

- AI/ML/CI methods
- System Theory, Graph Theory, Feedback Control, etc
- Domain Expertise
- Social Sciences and Economic Perspective

Thank you!

Discussion….