

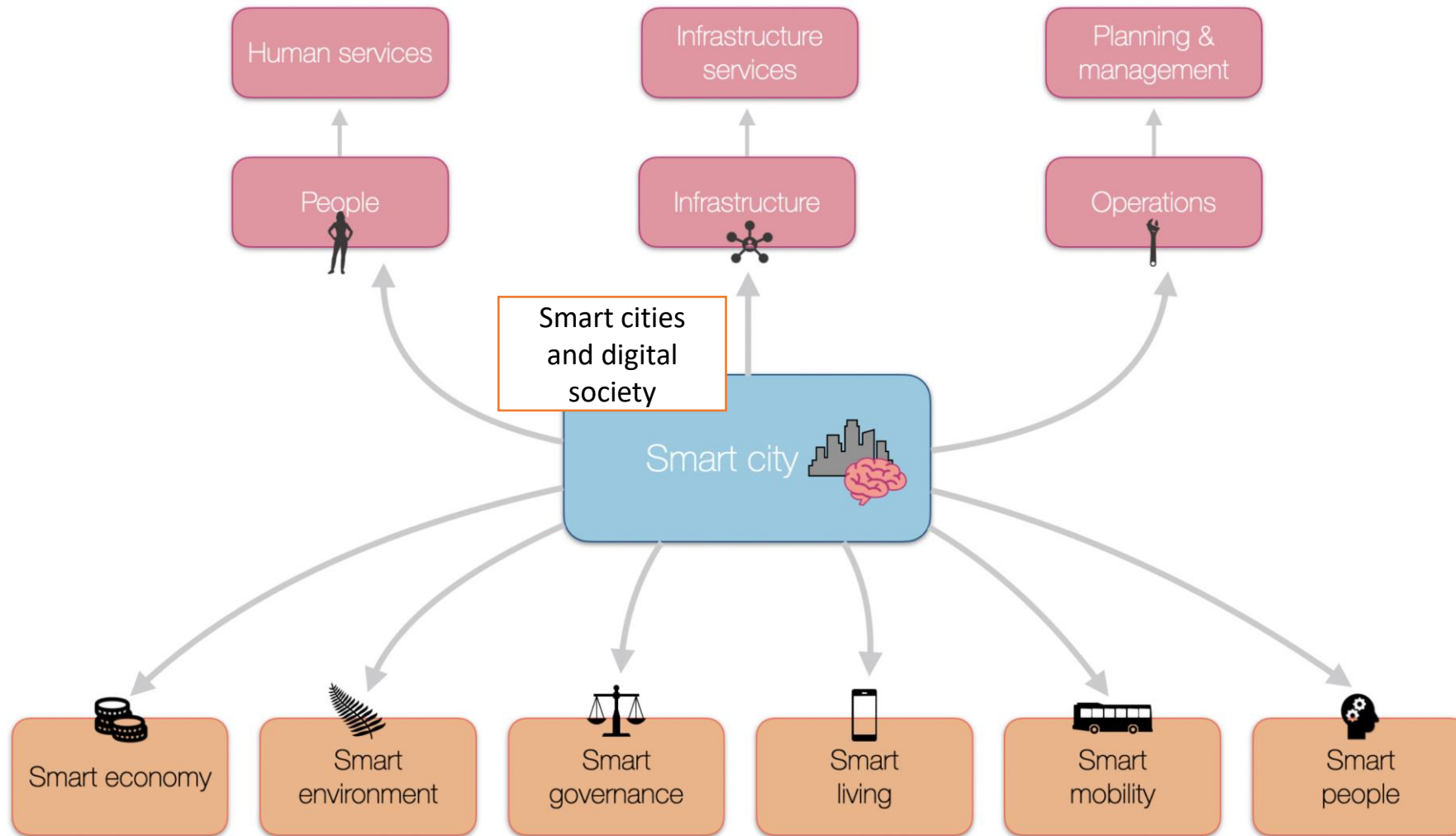


Centro Nazionale di Ricerca in HPC,
Big Data and Quantum Computing

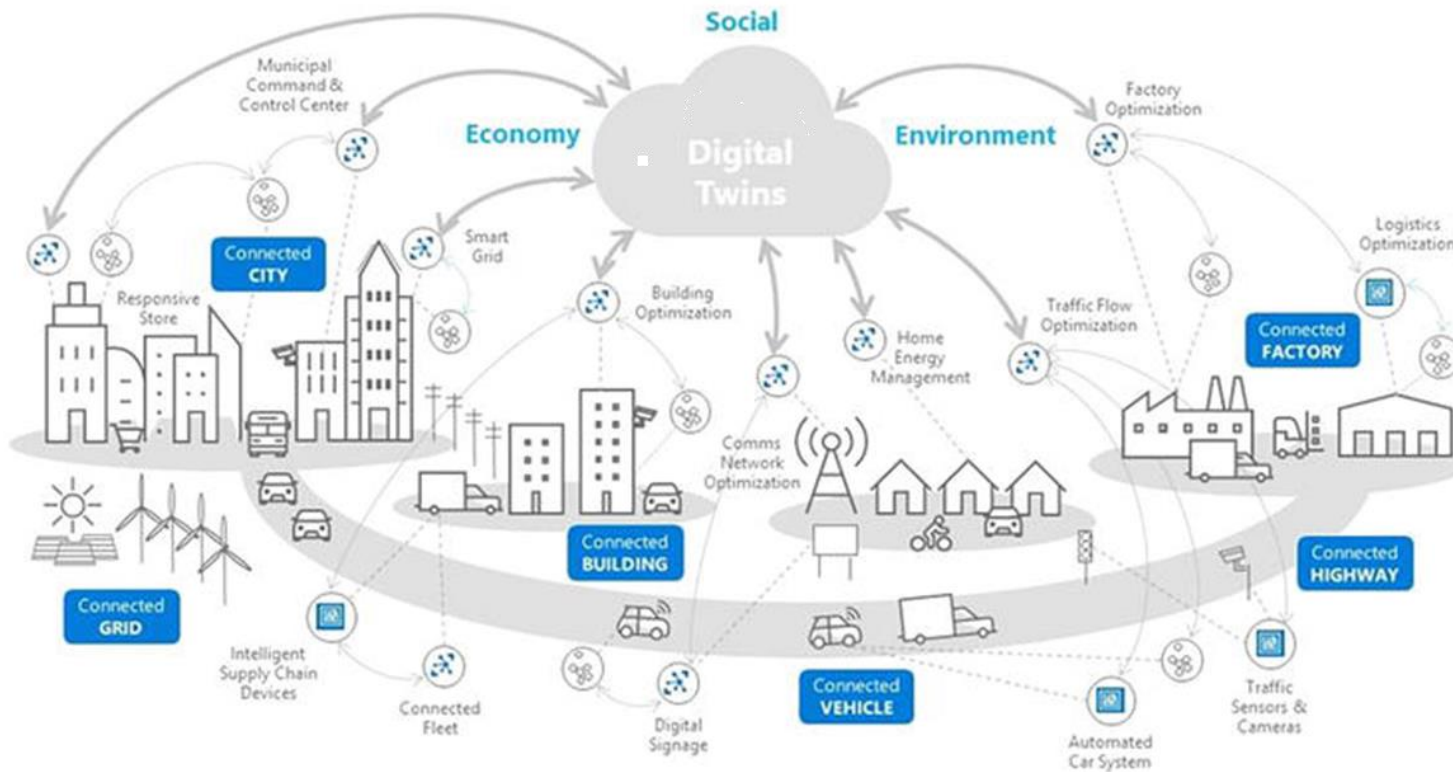
Spoke 9 - Smart city & digital society

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Smart cities and digital societies



Facing the complexity of smart cities with Digital Twins



- The aim is to create a faithful digital representation of social and organizational structures of cities and communities and of their citizens, and of the physical and virtual contexts where they operate and interact

Spoke 9 - Digital Society & Smart Cities: structure

Digital Society and Smart Cities CN1 Spoke

WP1 - Modelling
FBK
UniNa, UniCt

WP1 GOALS

- State of industrial applications
- analytical and simulation models
- environments and tools for the analysis of complex systems
- management and maintenance of smart city applications

WP2 - Computing platforms
UniNa
UniCt, UniBO, FBK, UniSal, CRS4

WP2 GOALS

- Industrial applications
- modelling and design of hw/sw architectures based on cloud&edge systems
- sensor network design
- twin system design
- prototyping architectures
- performance evaluation metrics

WP3 - Software systems
UniMiB
UniAq, UniNa, UniBO

WP3 GOALS

- Industrial applications
- software development cycles
- software specification and maintenance
- definition of system software platforms
- algorithms
- AI applications
- prototyping

WP4 - Health and lifestyle
UniTn, FBK, UniCT, CRS4

WP5 - Mobility
UniCT, FBK, UniNa

WP6 - Socio-economical analysis
PoliBa, UniNa, UniAq, UniMiB, FBK, UniSal

WP7 - Infrastructures and utilities
UniAq, UniNa, UniTN, UniSal, CRS4

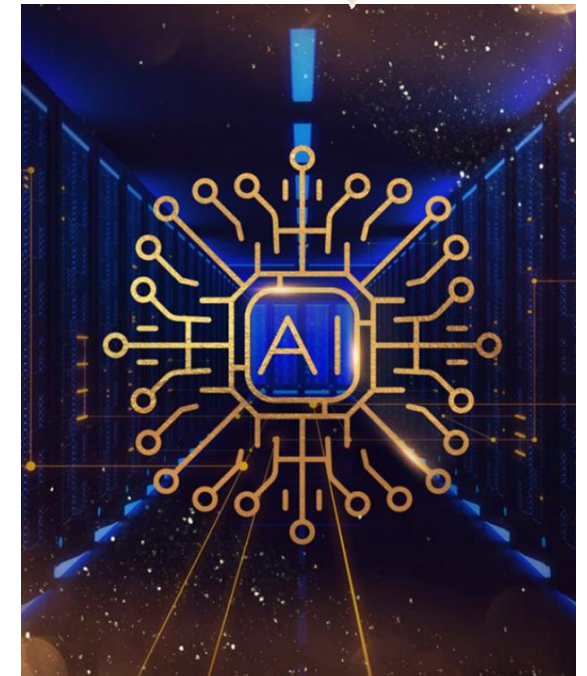
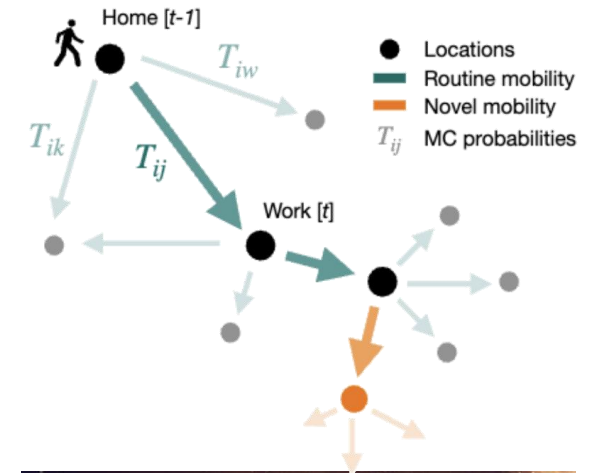
WP8 - Environment
UniSal, UniNa, UniMiB

WP4 - WP8 GOALS

- state of industrial applications
- modelling of hw/sw architectures
- algorithms
- human-in-the-loop approaches
- prototyping and demonstration
- support to open science and innovation
- impact analysis

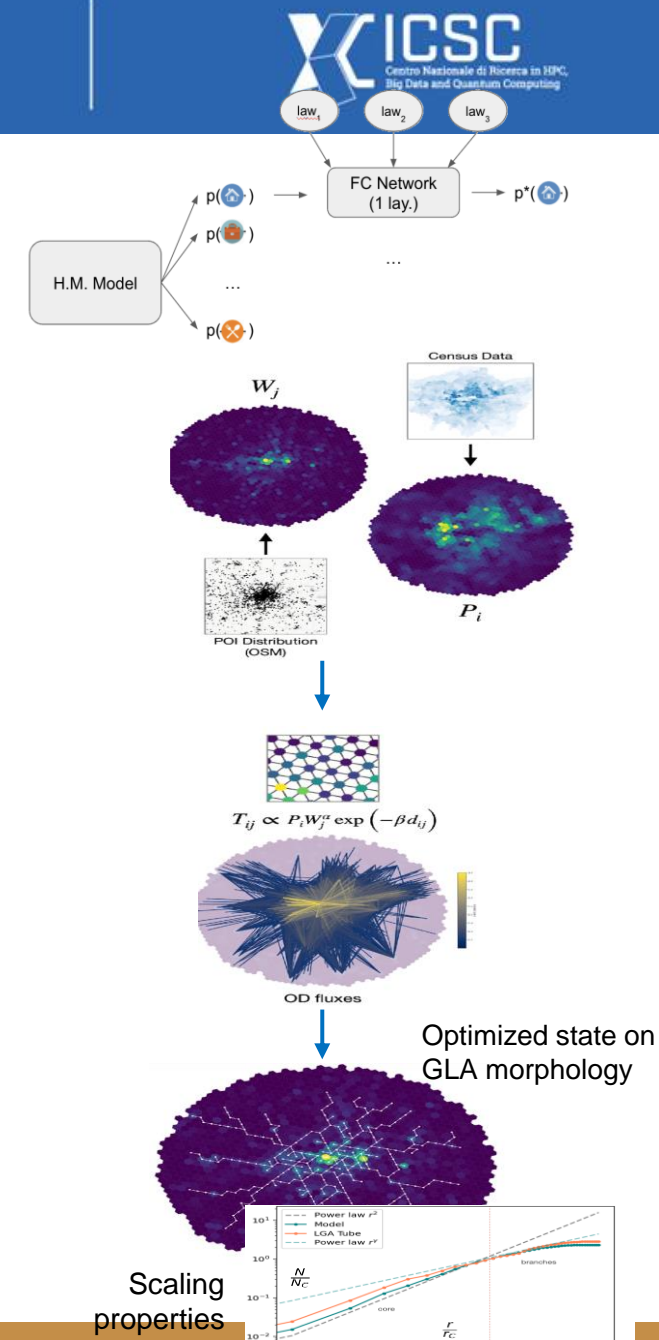
WP1 - Modelling

- *Participants:* FBK, UniNA, UniCT
- **Objectives:** developing innovative machine learning and deep learning methods and novel approaches, and methodologies from computational social science, complex networks, complex systems, control theory, in order to **model, predict, and simulate** complex societal phenomena on digital twin systems



WP1 - Modelling

- Task 1.1 - Trustworthy AI models for dealing with challenges and needs of Smart Cities and Digital Societies
 - **Data-driven modeling, analysis and design of crowd dynamics:** The objective of this research activity is to advance research beyond the state-of-the-art in the field of crowd dynamics with a focus to shared spaces by integrating theoretical advances ranging from agent-based modeling with numerical analysis of large-scale systems.
 - **Modeling Smart Cities as Graphs:** The objective of this research activity is to model different aspects of Smart Cities (e.g., energy, waste management, etc.) as *Temporal Heterogeneous Graphs* where different entities of a city are modeled as nodes that can interact with the other ones by different relationships which can change over the time.
 - **Modeling SMART Mobility:** The objective of this research activity is to combine the theme of technological innovations with the modern statistical methodologies of Data Mining and Statistical Learning, and the computational models of Deep Learning, thus defining a new paradigm of Intelligent Data Analysis for the Smart City Mobility



WP1 - Modelling

- Task 1.2 - Models for a Social and Cooperative AI
 - **Mixing individual and collective behaviors for modeling uncertain urban mobility:** Predicting future whereabouts of individuals is of paramount importance in many scenarios; however, there are cases in which individual mobility is unpredictable. For this reason the objective of this activity is to design mechanisms to dynamically reweigh individual-level with collective-level mobility so that models that deal with unpredictable individual patterns can automatically leverage a “wisdom of crowds” effect by integrating collective behaviors.
 - **Physics-inspired reranking of recommended next-locations:** The objective of this activity is to design some physics-inspired deep learning models that integrate some well-known physical laws known to model collective mobility accurately (e.g., gravity laws).
 - **Leveraging generalizable foundation models for urban data science:** The recent diffusion of the so-called foundation models is opening a set of unprecedented possibilities. The objective of this activity is to investigate how we can fine-tune LLMs to make them useful for a set of urban data science tasks (e.g., predictive tasks like next-location prediction).
 - **Adaptability of vision transformers to traffic flow prediction:** The goal of this activity is to test if pre-trained vision transformers can be effectively used for solving collective level tasks like predicting and/or generating flows in cities.
 - **Complex network models for urban network optimization:** The goal of this activity is to study the emergence of complex network topologies from the flow-weighted optimization of urban networks.

WP2 - Computing Platforms

- Participants: **UniNA**, FBK, UniSAL, UniBO, CRS4
- **Objectives:** identify and study the key underlying **building blocks** for the computing platforms of interest in Digital Society and Smart Cities

Digital Twin platform

- Virtual representation of social and organizational structures of cities and communities, and of the physical and virtual contexts where they operate and interact

Distributed data collection & processing & communication infrastructure

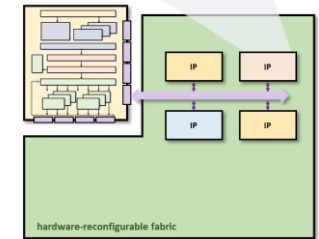
- Computation and networking devices and resources that collect, process and share data generated by the smart city subsystems (mobility, health, economy, social interaction, etc.)

Data Space

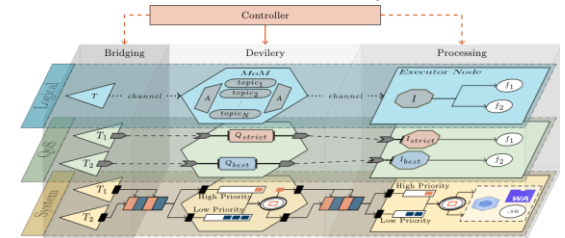
- Decentralized ecosystem for data collection, storage, preparation, sharing

WP2 - Computing Platforms - activities

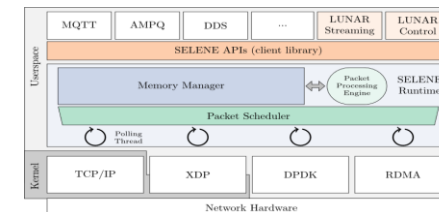
- T2.1 (UNINA): Architectures and platforms targeted at Smart City applications.
- T2.2 (UNIBO): Developing an optimization middleware for allocation and scheduling of cloud continuum resources.
- T2.3 (UNISAL): Developing a data space of a Smart City for a digital twin platform.
- T2.4 (FBK): Developing HPC-enhanced AI-based city monitoring solutions.
- T2.5 (CRS4): Introducing methodologies for rapid creation of 3D interior models.



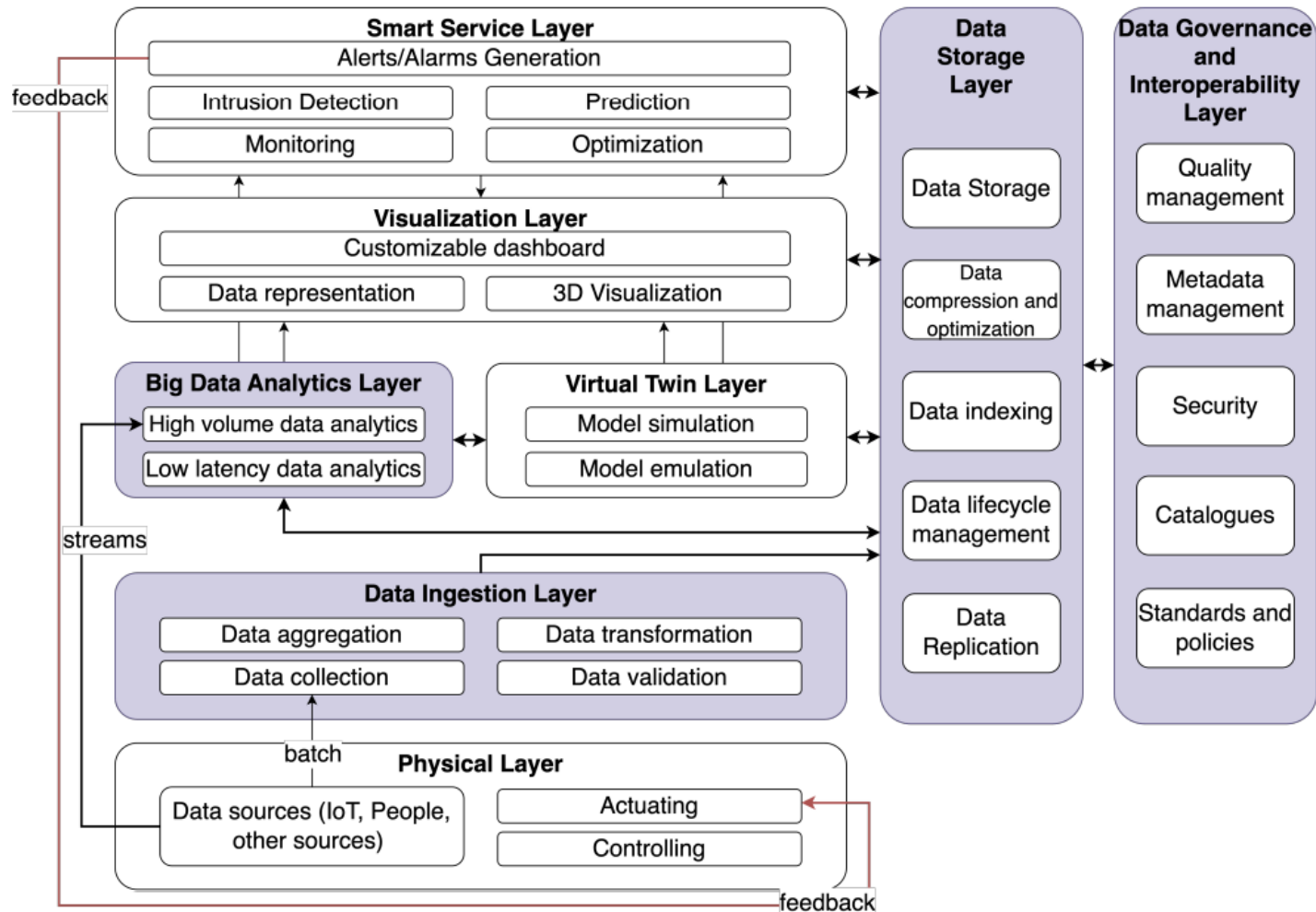
Time-Effective Middleware for Priority Oriented Serverless



Selective acceleration at the Network Edge



WP2 - Computing Platforms: A reference DT architecture

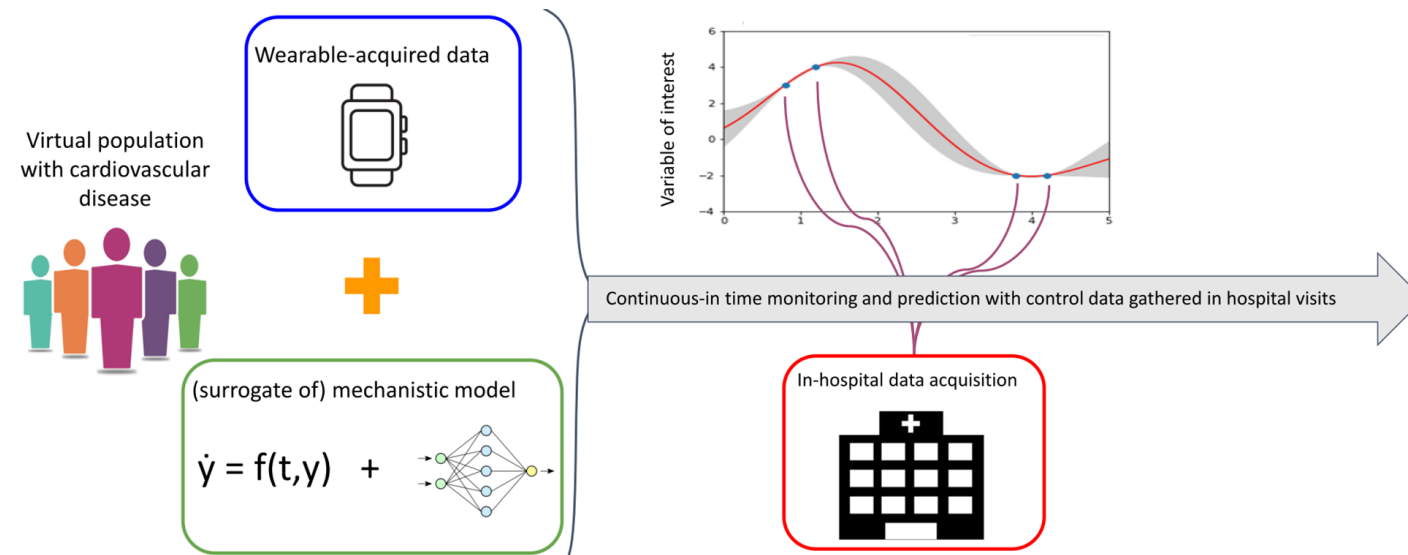


WP3 - Software Systems

- Participants: **UniMiB**, UniAQ, UniBO, UniNA
- **Objectives:** develop innovative software systems for the Digital Society and Smart Cities. Software engineering and AI techniques will be devised to develop and operate infrastructures and platforms for the management of all the layers between the Cloud and the IoT; new middleware solutions for the automated management of DevOps for machine learning components in distributed digital twins for Smart Cities will be provided; new synthesis methods for the automated generation of centralized or distributed application-layer connectors for the correct coordination of multi-party interaction protocols will be defined and realized.
- 6 tasks:
 - T3.1 Automated synthesis of multi-party protocol coordinators (leader: UniAQ)
 - T3.2 ML-based Quality-driven microservice discovery (UniAQ)
 - T3.3 Dependable Software for Smart Cities (leader: UniMiB)
 - T3.4 Design and Development of novel Deep Learning modeling techniques and AI algorithms for dealing with the challenges and needs of Smart Cities and Digital Society (leader: UniMiB)
 - T3.5 Machine Learning DevOps (MLOps) for digital twins in urban areas (leader: UniBO)
 - T3.6 User trust and behavioral reactions in exploiting on-line applications (leader: UniMiB)

WP4 - Health and lifestyle

- Participants: **UniTN**, FBK, CRS4, UniMiB, UniSAL, UniNA, UniCT
- **Objectives:** support citizen health and welfare through both digital twin systems of health structure and services and pathology-targeted digital twins
- 2 tasks:
 - T4.1 Smart City Digital Twins (leader: UniTN)
 - T4.2 Digital Twins and HPC for Health (leader: UniTN)



WP4 activities: the Digital Twin for Health and Lifestyle

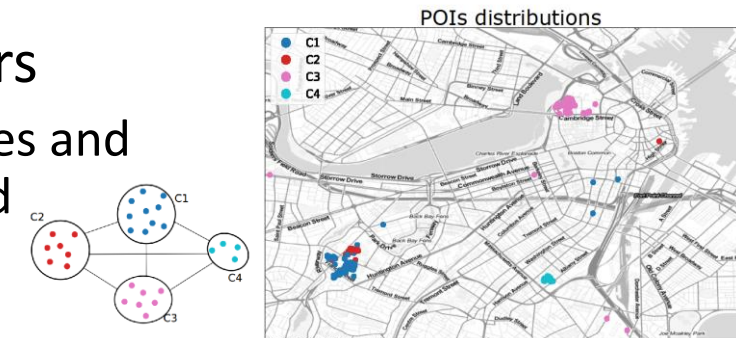
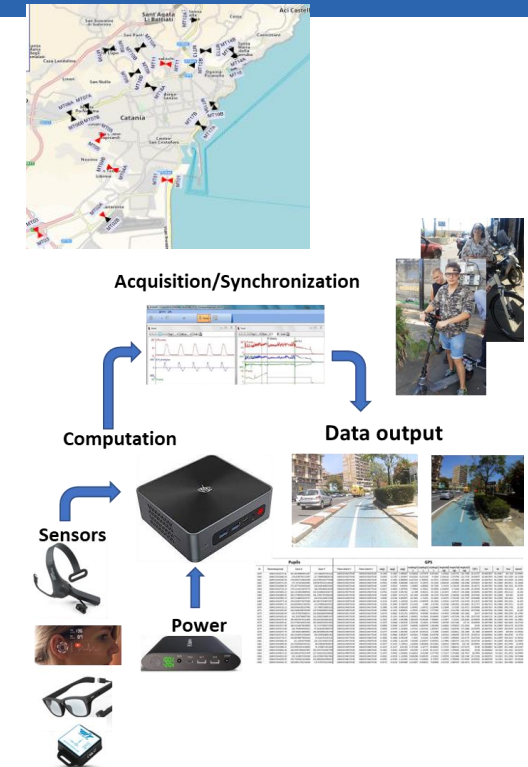
- Video of demonstrator:
- https://drive.google.com/file/d/14HUt3momRK-suFRctc_IR3BGEvAl0YcS/edit

WP5 - Mobility

- Participants: **UniCT**, UniNA, FBK, UniBO
- **Objectives:** definition of services to be used for decision making in urban mobility management.
- 3 tasks:
 - T5.1 Transport Models (leader: UniCT)
 - T5.2 Real time monitoring and proactive safety of Mobility users (leader: UniCT)
 - T5.3 Prediction Models of the Citizen Urban Mobility Behaviors (leader: FBK)

WP5 – Mobility activities

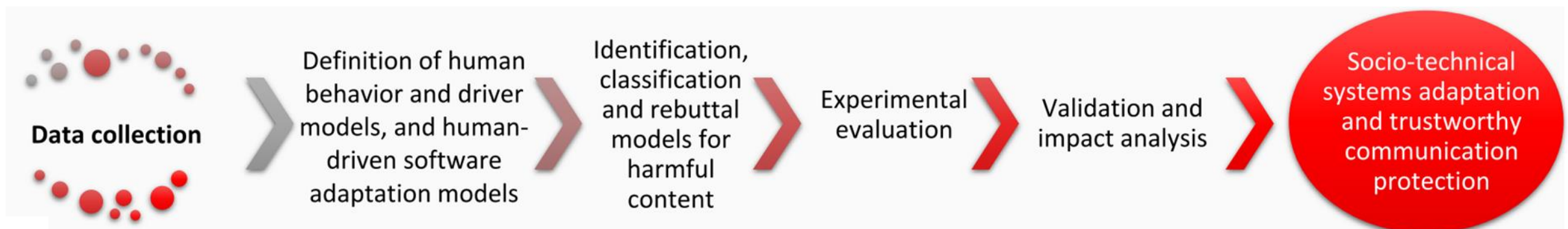
- T5.1 - Transport Models:
 - prediction of traffic flows in urban area
 - two-level machine learning approach to extract patterns from big data generated by fixed traffic sensors (clustering phase) installed in the city of Catania and to forecast traffic flows for similar roads lacking sensor data
- T5.2 - Real time monitoring and proactive safety of Mobility users
 - high-precision and high-resolution vehicle path tracking based on advanced mobile sensors
 - Detection of anomaly manoeuvres by bicyclists from GPS and other sensors data
- T5.3 - Prediction Models of the Citizen Urban Mobility Behaviors
 - Study of mobility behaviour of familiar strangers for detecting anomalies and predict future locations where users will meet (to improve mobility and transportation services)



Community detection and location visited from communities

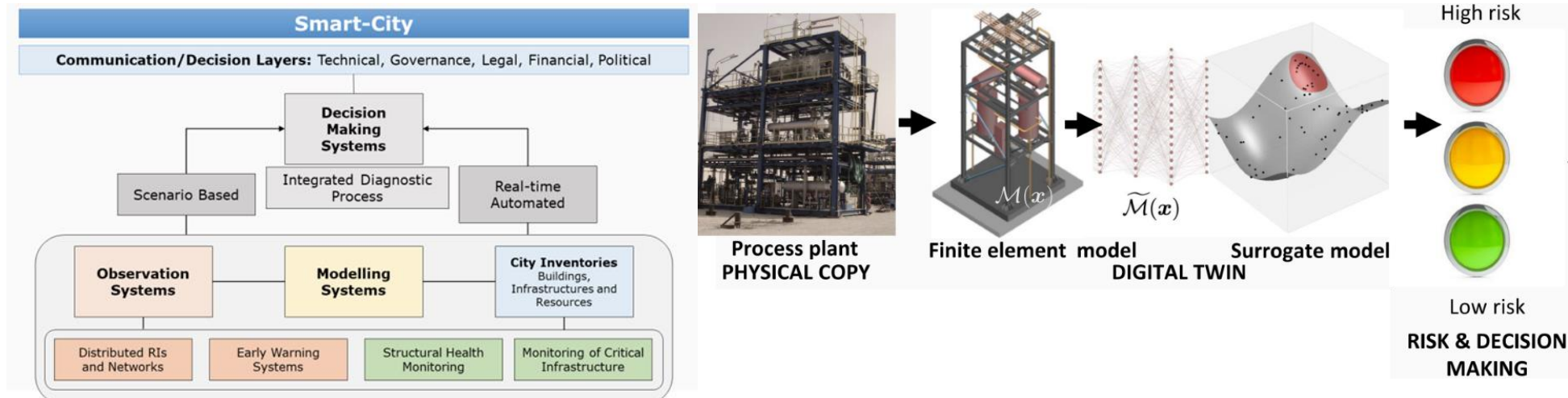
WP6 - Socio-economical analysis

- Participants: **PoliBa**, UniNa, UniAq, UniMiB, FBK, UniSal
- **Objectives:** socio-economical analysis of smart cities through emerging technologies
 - T6.1 Urban and Territorial Safety (leader: UniAQ)
 - T6.2 Impact Analysis of Emerging Technologies on Smart Cities and Communities (leader: PoliBa)
 - T6.3 Human and Social Factors of Smart Communities (leader: UniMiB)
 - T6.4 Regulatory and Financial Factors of Smart Communities (leader: UniNa)



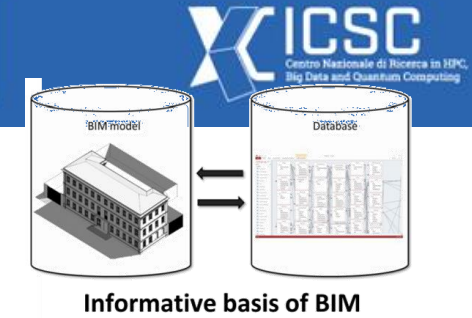
WP7 - Infrastructures and utilities

- Participants: **UniAQ**, UniNa, UniSal, CRS4, UniTn
- **Objectives:** enable the development of resilient and robust infrastructures and utilities for smart cities.

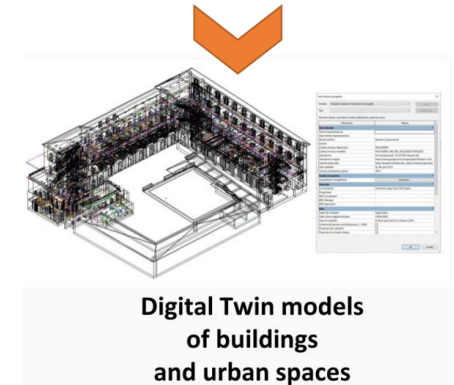


WP7 activities

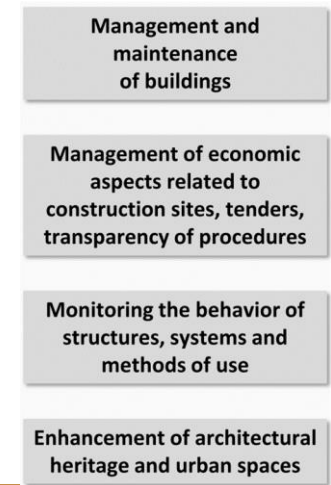
- T7.1 - Techniques and tools for energy consumption modeling, prediction, and control
 - renewable energy supply forecasting and demand forecasting
 - energy consumption design patterns and anti-patterns, and microservice applications and their energy consumption
 - design of data-driven models for prediction of energy consumption for HVAC systems
- T7.2 - Models for structural monitoring and risk analysis techniques for urban scenarios
 - integration of BIM models with real-time data from sensors for the realization of Digital Twins and definition of related **case studies**
 - evaluating methodologies to assess seismic risk at regional scale
- T7.3 Risk-based models of resilience for analyzing critical infrastructures and structures, and virtual fences realization
 - evaluating methodologies for crowd management
 - improving the resilience of critical infrastructures
 - identifying criticalities and issues in seismic risk assessment and maps
 - classifying attacks to IoT infrastructures



Informative basis of BIM



Digital Twin models of buildings and urban spaces



Management and maintenance of buildings

Management of economic aspects related to construction sites, tenders, transparency of procedures

Monitoring the behavior of structures, systems and methods of use

Enhancement of architectural heritage and urban spaces

WP8 - Environment

- Participants: **UniSal**, UniNa, UniMib, UniTn
- **Objectives:** develop novel models and tools for collecting urban environmental data for analysing and forecasting air pollution, noise, flooding and urban heat zones; investigate AI methods to ease the recycling of plastic materials; investigate models and simulators for urban air/terrestrial vehicles dynamics taking into account environmental, sustainability and health impact
 - T8.1 Definition of models and development of decision support systems for urban flooding and surface and subsurface water pollution risks (leader: UniTN)
 - T8.2 Development of Hybrid AI/physics-based models of multimodal car/VTOL dynamics for achieving environmental goals and for improving car sharing (leader: UniSAL)
 - T8.3 Development of a digital twins platform for climate neutral and climate change ready cities, including novel Artificial Intelligence aided methods to ease the recycling of plastic materials from urban wastes (leader: UniSAL)

