Big and Small Data Processing for Context-aware Smart Cities

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Guadalupe Ortiz is a tenured Associate Professor in the Department of Computer Science and Engineering, at the University of Cadiz and member of the UCASE Research Group.

Currently, her research focuses on trending topics such as the integration **of complex-event processing** in **service-oriented architectures** and facilitating **context-awareness** in the scope of **Internet of Things, Smart Cities** and **Ambient Assisted Living.**

Guadalupe Ortiz, University of Cádiz

Ongoing research projects:

- AWESOME: Advanced Methodologies for **Software System Architectures**, Design and Testing
- DECISION: Platform for graphical modelling, **simulation, monitoring** and intelligent management of water supply networks
- iPREDICE: Investigation of **an Intelligent Platform for Predictive** Infrastructure Maintenance
- ASSENTER: Application of **Advanced Data Processing and Testing** Techniques in Industry
- RCIS: Network in **Service Science and Engineering**

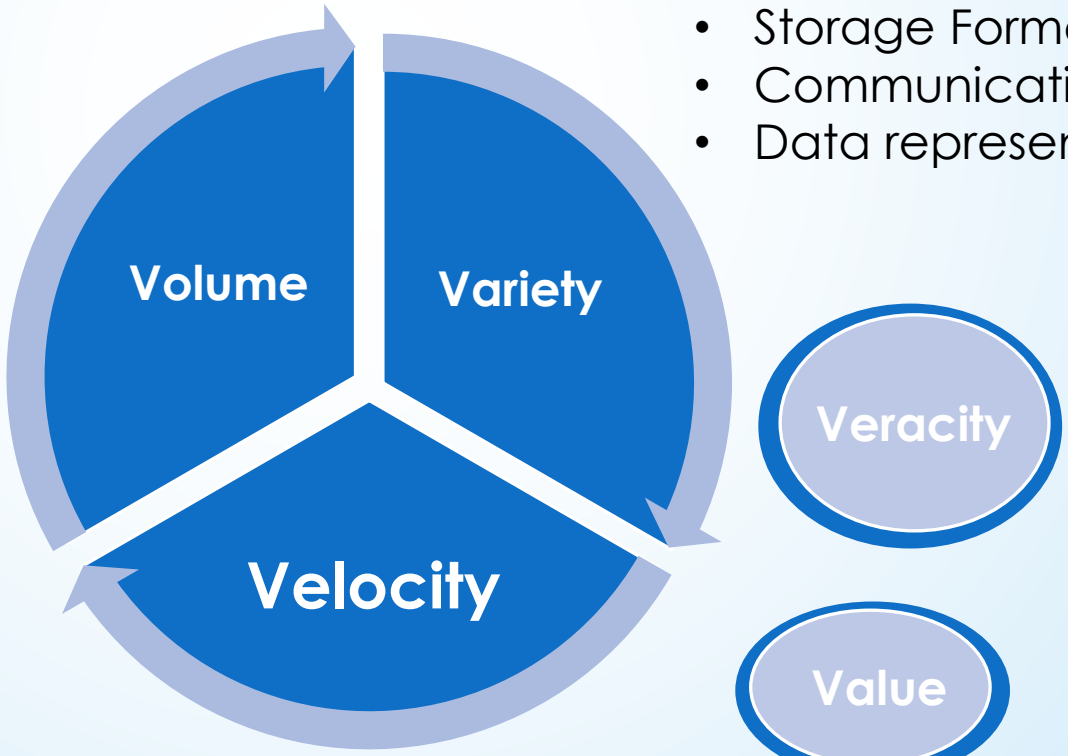
Big data

Small data

Concepts

Big Data

- Internet
- Information Systems
- Cloud
- Social Networks
- Internet of Things



- Storage Format
- Communication protocols
- Data representation

- Social Networks
- Internet of Things
- …Near real-time

Small Data

Why small?

- **Accessible, understandable and actionable** in everyday tasks
- Data mining (batch)

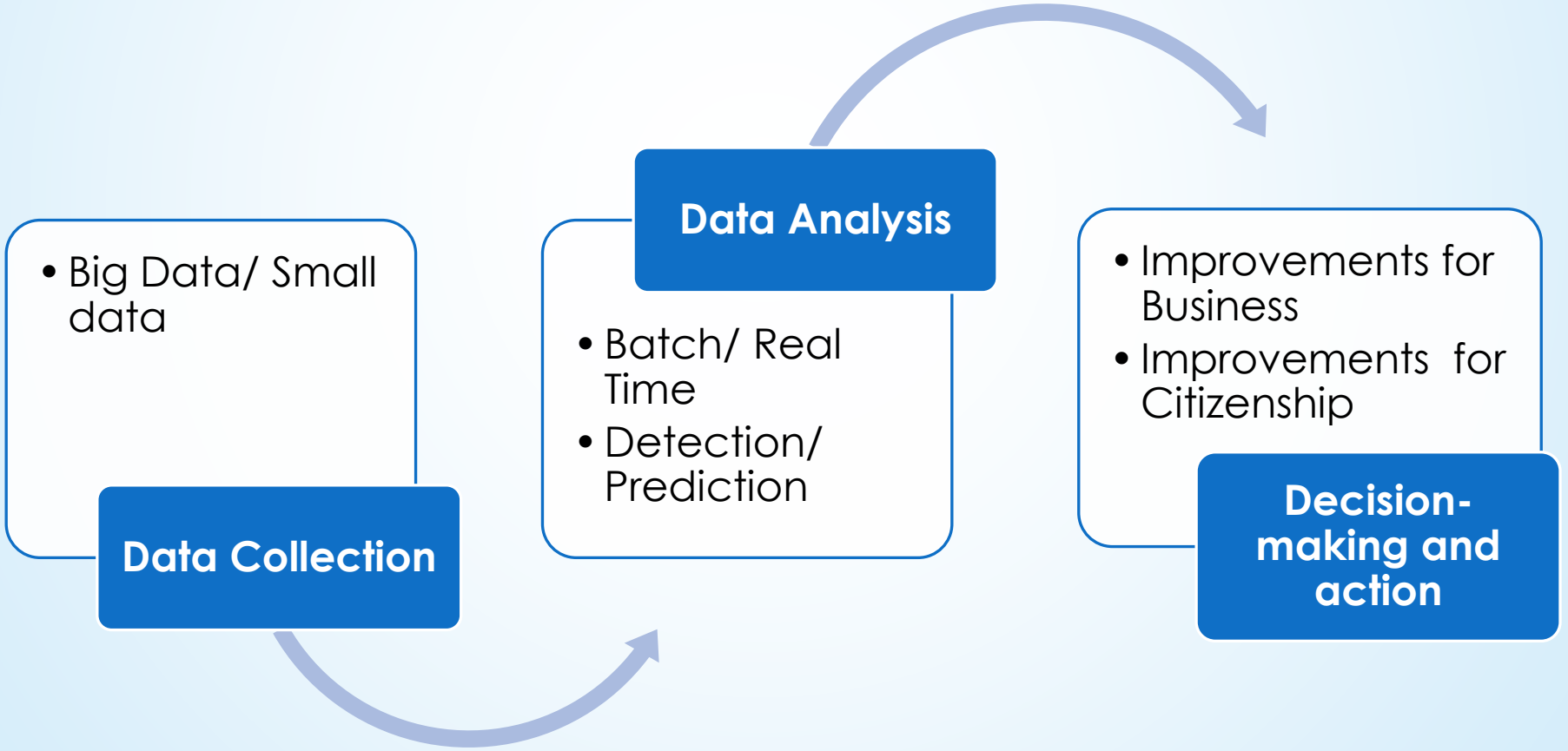
Applications

- Data-driven marketing, CRMs, …

Distinctive features

- **End-user** focused → Context
- **Data democratization** → Collaboration

Smart Data

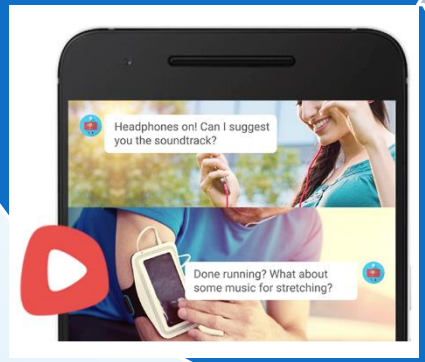

• Big Data/ Small data
Data Collection
Data Analysis
• Batch/ Real Time
• Detection/ Prediction
• Improvements for Business
• Improvements for Citizenship
Decision-making and action

Context and Context Awareness

What is it?

What can we take into account?

Mobile phones do it!



Context type	Example
Time	Current local time
Location	Latitude and longitude
Place	Place, including place type
Activity	Detected user activity (walking, running, biking)
Beacons	Nearby beacons matching the specified namespace
Headphones	Are headphones plugged in?
Weather	Current weather conditions

Google permits programming it

Internet of Things

IoT Nowadays

- It proposes the use of a network of **globally interconnected things** or objects uniquely identified through an address scheme.
- Acompassed with
  - The availability of the Internet 24 hours a day, 7 days a week.
  - The fall in the cost of communications.
  - The democratization of devices with powerful Internet access such as smartphones or tablets.
  - Strong proliferation of sensors and other data providers for the IoT.

(Collaborative) Internet of Things

- Individual-Business-Community/Infrastructure
- Multiple domains: health, logistics, energy
- Collaboration at sensor/situation of interest/services level
- Prioritization

Everything is Smart

Everything is Smart: Context Aware Smart Cities

Requirements

- **Internet of Things**
- **Data Processing.**

Final aim

- **Improved quality of life and living experience**
- **Contextualized and personalized experiences**
- **Sustainable cities**

Challenges

Challenges

- Interoperability
- Sustainability
- Data democratiozation
- Open data

Tecnologies

Service Oriented Architecture and RESTful Services

Service Oriented Architecture

Services

- A **contract** (user benefits).
- Particular **discoverable functionality** describing what it can do and how to interact with it.

Service Oriented Architecture (SOA)

- Software architecture that defines a **decoupled model** of services to support business process requirements.
- They provide functions that can be **reused** by different clients (they only need to know the service description).

RESTful Web Services

RESTful services

- REST: Representational State transfer
- REST is an **architectural style** for services using **web standards.**

REST Communications

- Everything can be identified as a **resource** and each resource can be identified by a **URI**.
- A resource can be represented in **multiple formats**, defined by a **media type**.
- Standard **HTTP methods** are used to interact with the resource: mainly GET, POST, PUT and DELETE.
- Communication between the client and the endpoint is stateless.

Event-Driven Architecture, SOA 2.0 and Complex Event Processing

Event-Driven Architecture

Events

- A **change** in the **state** of something.
- **Something that occurs (or does not occur).**
- A **detectable** condition.

Event-Driven Architecture (EDA)

- Particular style of **event processing**.
- Architectural style in which one or more components of a software system are activated upon detection of an event and where these components are **decoupled**.
- It is based on the **publish/subscribe** mechanism.

Event-Driven Service Oriented Architectures (SOA 2.0)

ED-SOA or SOA 2.0

- **Communications** between users, services and applications are **event-driven.**
- Event-driven communication allows a **faster response** to changes in **real time.**
- **Events** in the system **trigger** the launch of **system services**.

Complex Event Processing

Complex Event Processing (CEP)

- Technology that allows **processing, analysing and correlating** large quantities of events.
- To detect and respond in **real time** to **critical** or relevant business **situations**.
- **Event patterns** will infer new, more complex events ("**situations**") with greater semantic meaning.

Advantages

- Improved **quality of decisions**.
- **Rapid** response.
- **Prevention** of information **overload**.
- **Reduction** of human **effort**.

Enterprise Service Bus versus Microservices Architectures

Enterprise Service Bus

Enterprise Service Bus (ESB)

- **Integration** element (multi-protocol and multi-purpose) in SOA.
- It combines web services, messaging, transformation, data routing and enrichment, security policies, among others.

Advantages

- They can **integrate EDA** and **SOA**.
- Ideal for working in **heterogeneous** environments: different technologies and protocols: from the most modern to the most conventional (legacy).
- They **reduce** the total **cost** of management and maintenance.

Microservice Architectures

Features

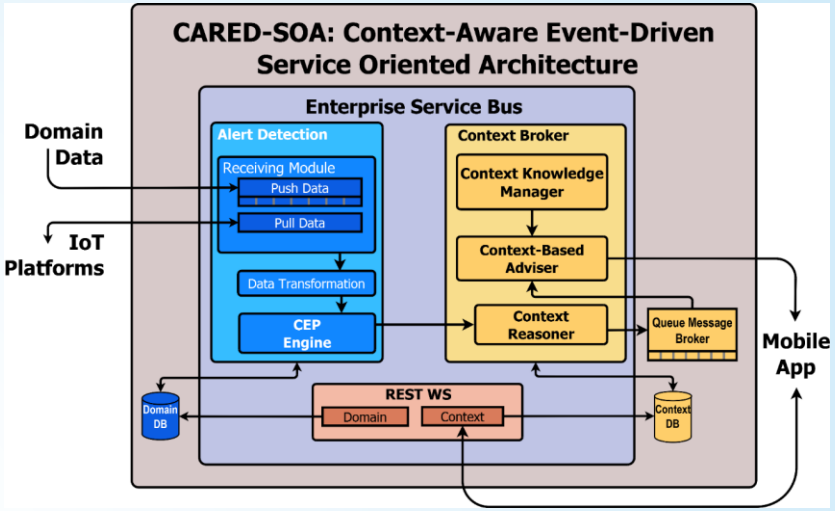
- A single application as a set of **small services**.
- Each service runs in its own process.
- Services communicate with **lightweight mechanisms** (REST API over HTTP).
- **Deployment is independent**.
- There is hardly any centralized management.

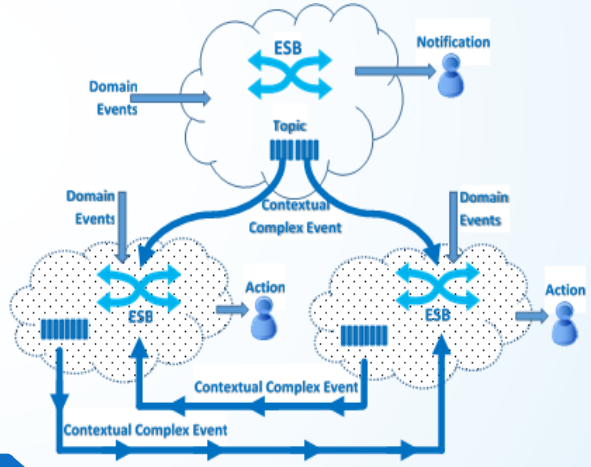
Advantages

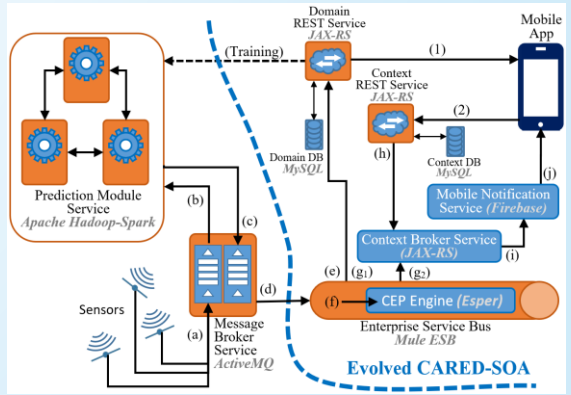
- ✓ **Scalability, evolution, maintenance**
- Security, consistency, data traffic

Challenge1
Interoperability

SOA 2.0 Architectures &CEP







DOI: 10.1109/ACCESS.2017.2679338
DOI: 10.1016/j.eswa.2017.05.034
DOI: 10.1109/ACCESS.2019.2960516

Challenge 2
Sustainability

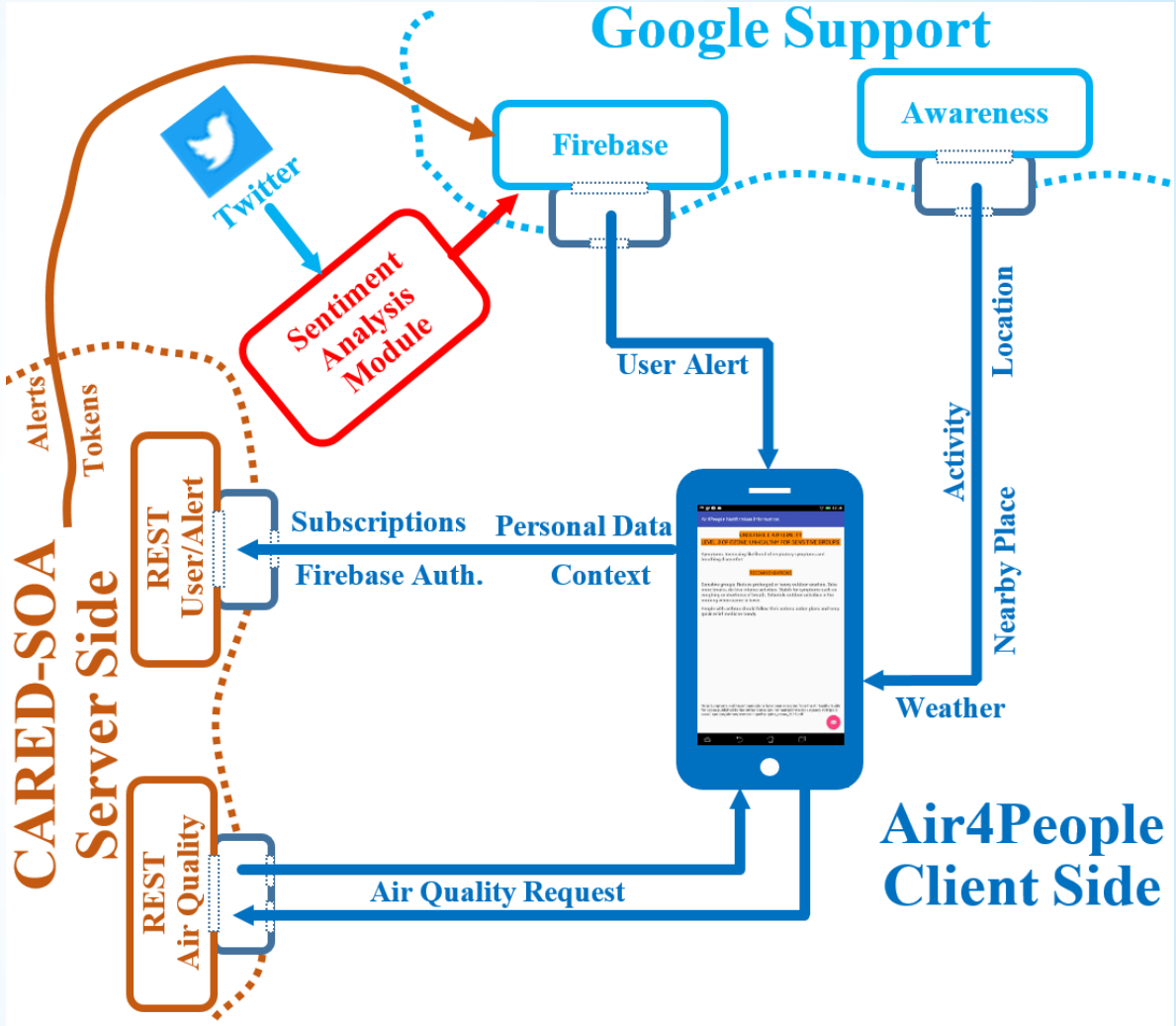
Sustainable Development Goals

- United Nation SDGs
- Several SDGs can be dealt with IoT technologies and software architectures, such as those related to
  - Health
  - Energy
  - Water and sanitation
  - Industry and innovation
  - Sustainable communities and cities
  - Climate

Climate and E-Health: Air4People (Motivation)

DOI: 10.3217/jucs-024-07-0846

Climate and E-Health: Air4People (Architecture)



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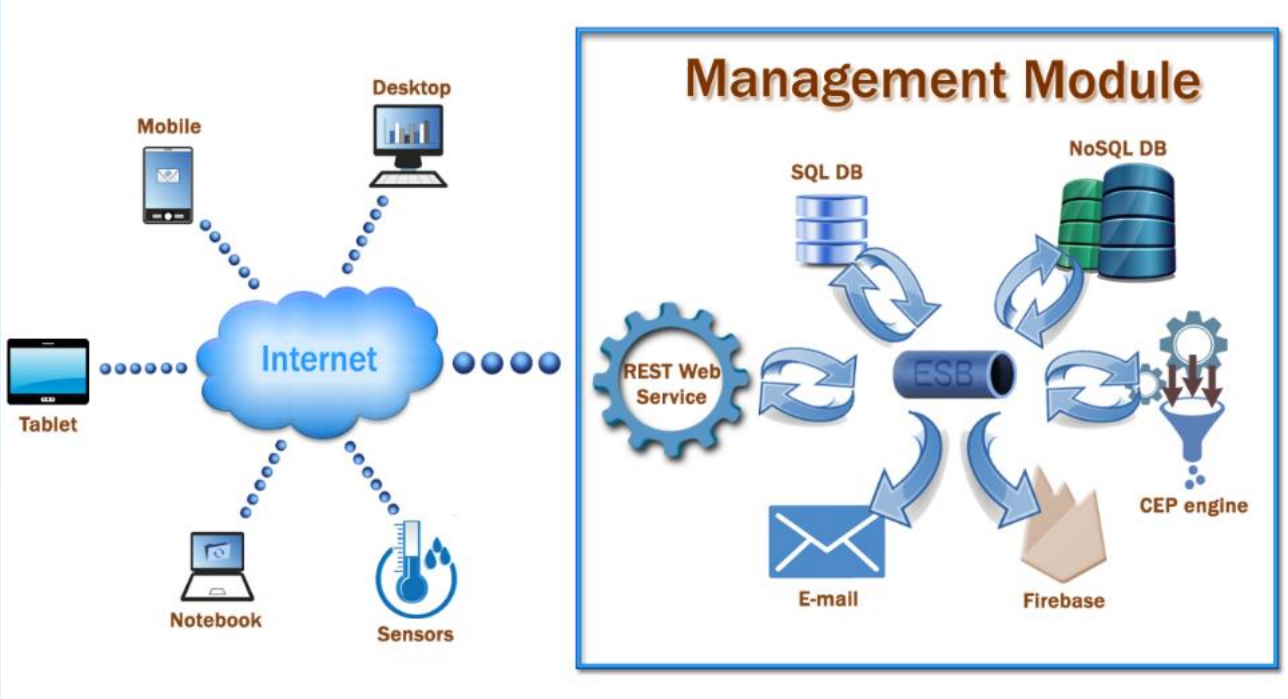
Sustainable Communities and Cities: SWAT (Motivation)

DOI: 10.1007/978-3-319-91764-1_18



Sustainable Communities and Cities: SWAT (Software Architecture)

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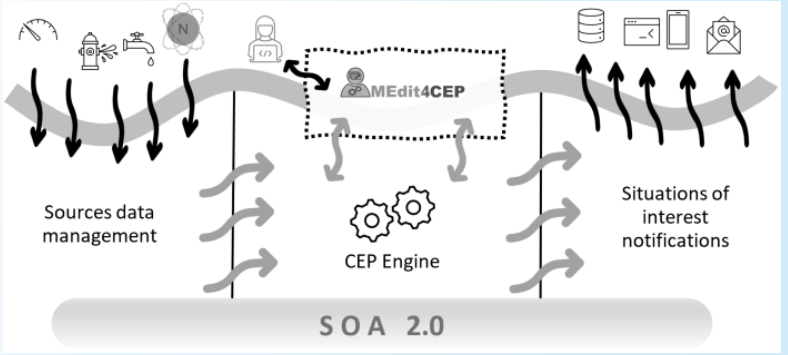
Water and Sanitation

- Leak
- Fraud
- Consumption monitoring

Water and Sanitation

- PROJECT DECISION (P20_00865)
https://ucase.gitlab.io/public/Decision/indexeng.html



Endless Case Studies and Application Domains

E-Health domain
Sustainability
Energy consumption
Natural resources management
Mobility
Traffic
Pollution
Emergencies
Economy
Governance
Security
Wellness
…

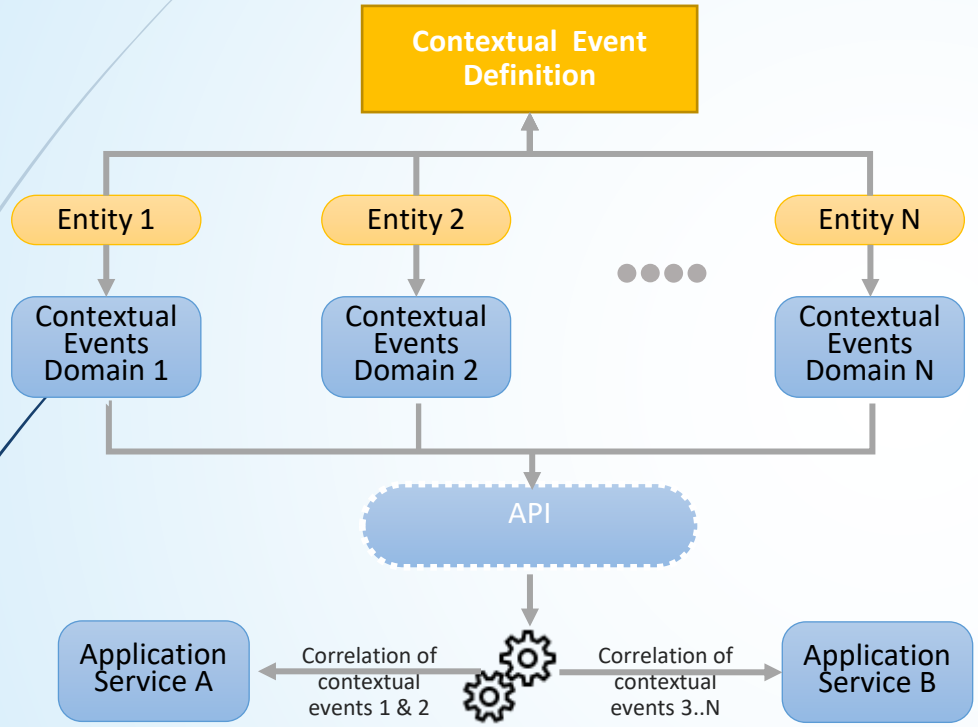
Challenge 3
Collaboration & Data Sharing

Handicaps

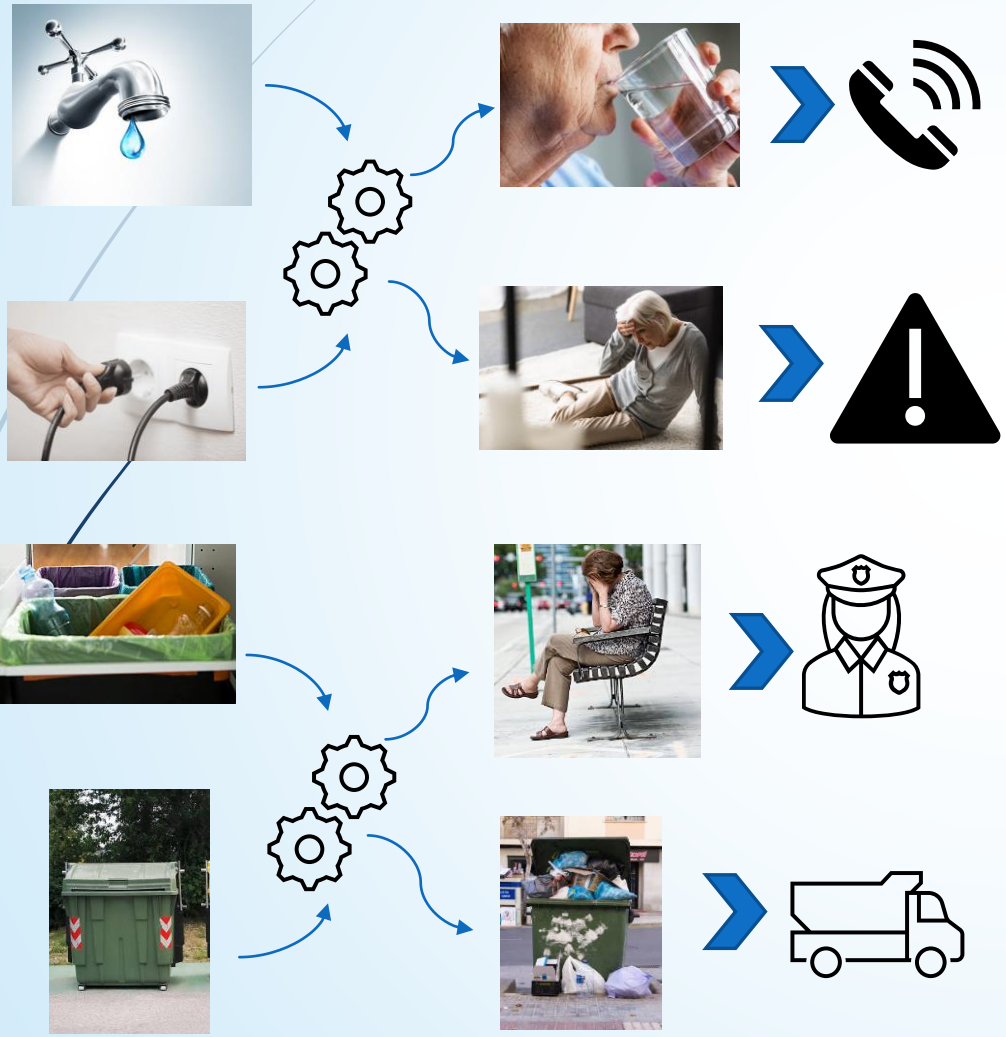
Convincing multiple people and entities to share their data

Ensuring data security and privacy

Current Trends



Multiple Scenarios



iPredice Fase 2 “Research on an Intelligent Platform for predictive maintainance of infrastructures”

SmartCity Cluster · GEN grupo energético · WATTABIT Energy Management Solutions · ITELLIGENT · UCA Universidad de Cádiz

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Plan de Recuperación, Transformación y Resiliencia

Financiado por la Unión Europea NextGenerationEU

Conclusion

SMART CITIES require COLLABORATION

One Step Forward Towards Context-Aware Smart Cities

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- Thank-you very much for your attention
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