Context Aware Collaborative IoT Services for Smart Everything

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- Cádiz is the oldest inhabited city in Europe.
- Its economic activity is mainly focused on tourism, although it also has some activity in the aeronautical and naval industrial sector in the Bay area (Airbus and Navantia).
- It is the province with the highest unemployment in Spain (25%).

The university of Cádiz has 4 campuses distributed along the province of Cádiz


UCASE
RESEARCH GROUP

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**

Concepts

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.
  - **Desperate hunger for data consumption.**

(Collaborative) Internet of Things

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

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Harald Schöning
"Framework for collaboration"

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 (not only environment)**

Context and Context Awareness

What is it?

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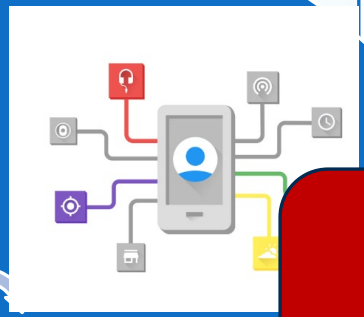
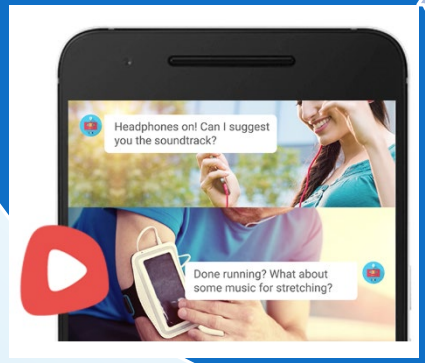
Ella Peltonen
"traffic, weather, road, environment…"



What can we take into account?

Is the service research community providing any facilities to deal with context?



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 from many years ago

Tecnologies

Service Oriented Architecture and RESTful Services

Service Oriented Architecture and Restful services

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).

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)

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.
- When a situation is detected, **actions** can be **triggered** and **services** can be **contextualized** accordingly.

Advantages

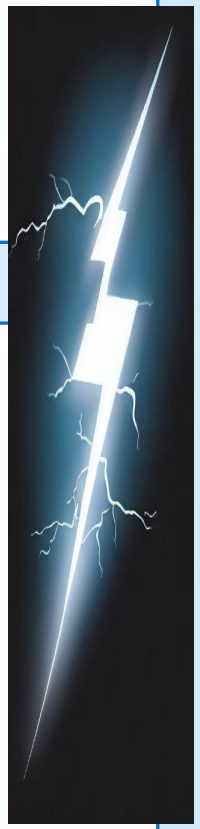
- Improved **quality of decisions and personalization of services**.
- **Rapid** response.
- **Prevention** of information **overload**.
- **Reduction** of human **effort**.

Enterprise Service Bus versus Microservices Architectures

Enterprise Service Bus versus Microservice Architectures

Enterprise Service Bus (ESB)

- ✓ 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 might **reduce** the total **cost** of management and maintenance.
- ❓ The ESB can **consume** a high amount of **resources** and **slow down system latency**.



Microservice-Based Architectures

- 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.

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

Where to deploy the services and to perform the data processing?

- Balance resource consumption versus communication costs
- Balance greater awareness versus data privacy
- Hybrid architectures

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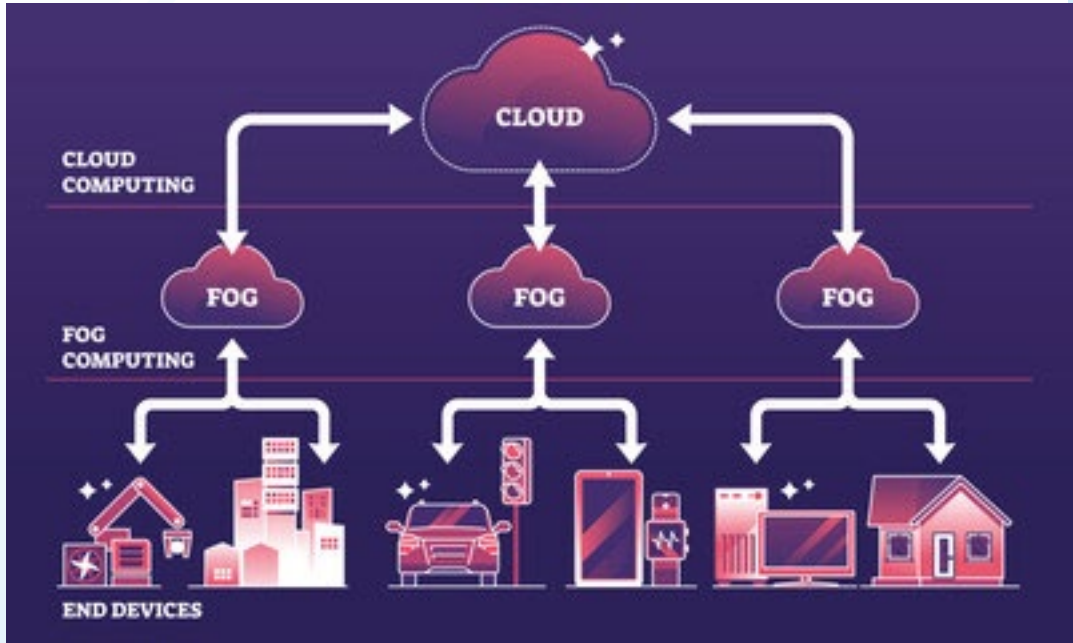
Harald Schöning
"Make use of the hierarchy
Early Filtering"



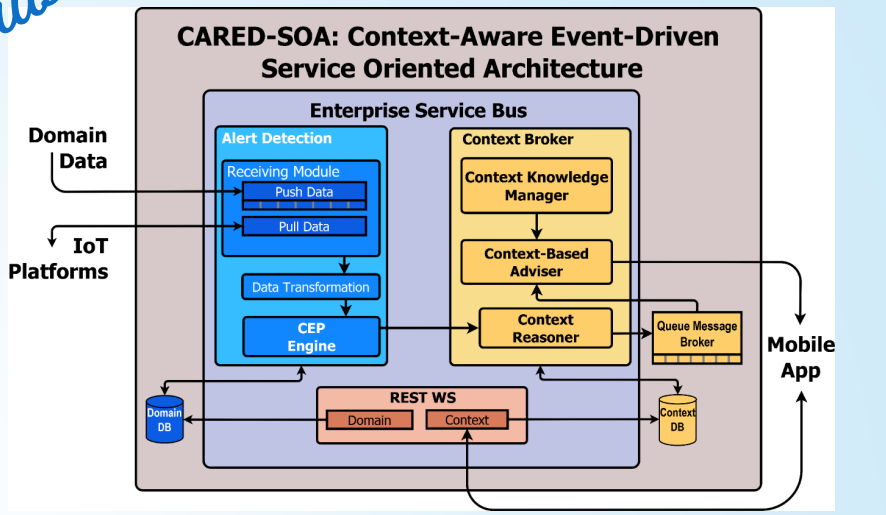
Challenges

Challenge1
Interoperability

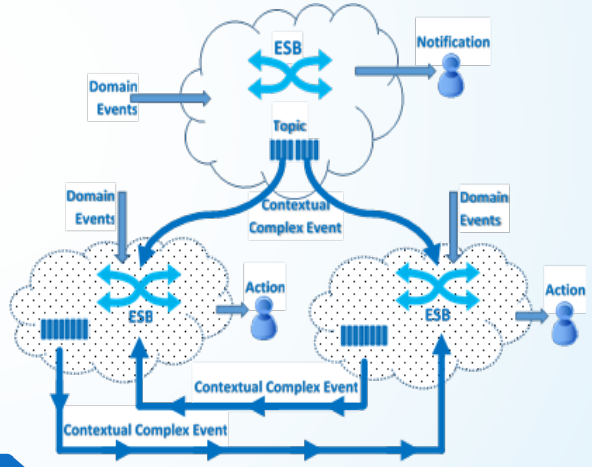
SOA 2.0 Architectures &CEP

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

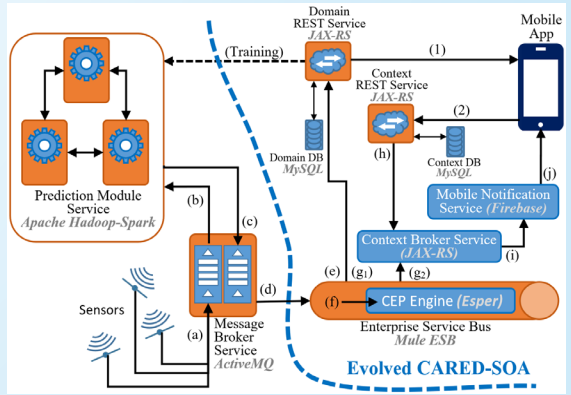
Context-aware



Collaborative



Microservice and predictive



Performance Evaluation

- It dependes on the final architecture (ESB/microservices), the pattern operators (data/time windows consume more memory), bróker, network.
- Difficult to compare to other proposals.

Intel Xeon Silver 4210R processor, 32 GB of RAM.
Ubuntu 22.04 LTS
Pre defined benchmark.
Input rate 20 000 events/second.
Latency: 0.01ms.

DOI: 10.1109/JIOT.2021.3130498
DOI: 10.7717/peerj-cs.1437 (pending publication)

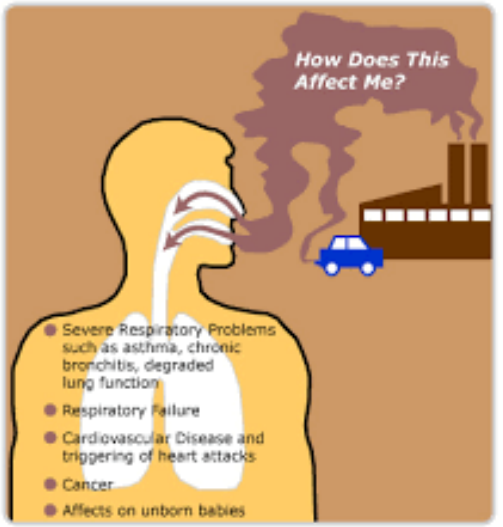
Challenge 2
Sustainability

Sustainable Development Goals

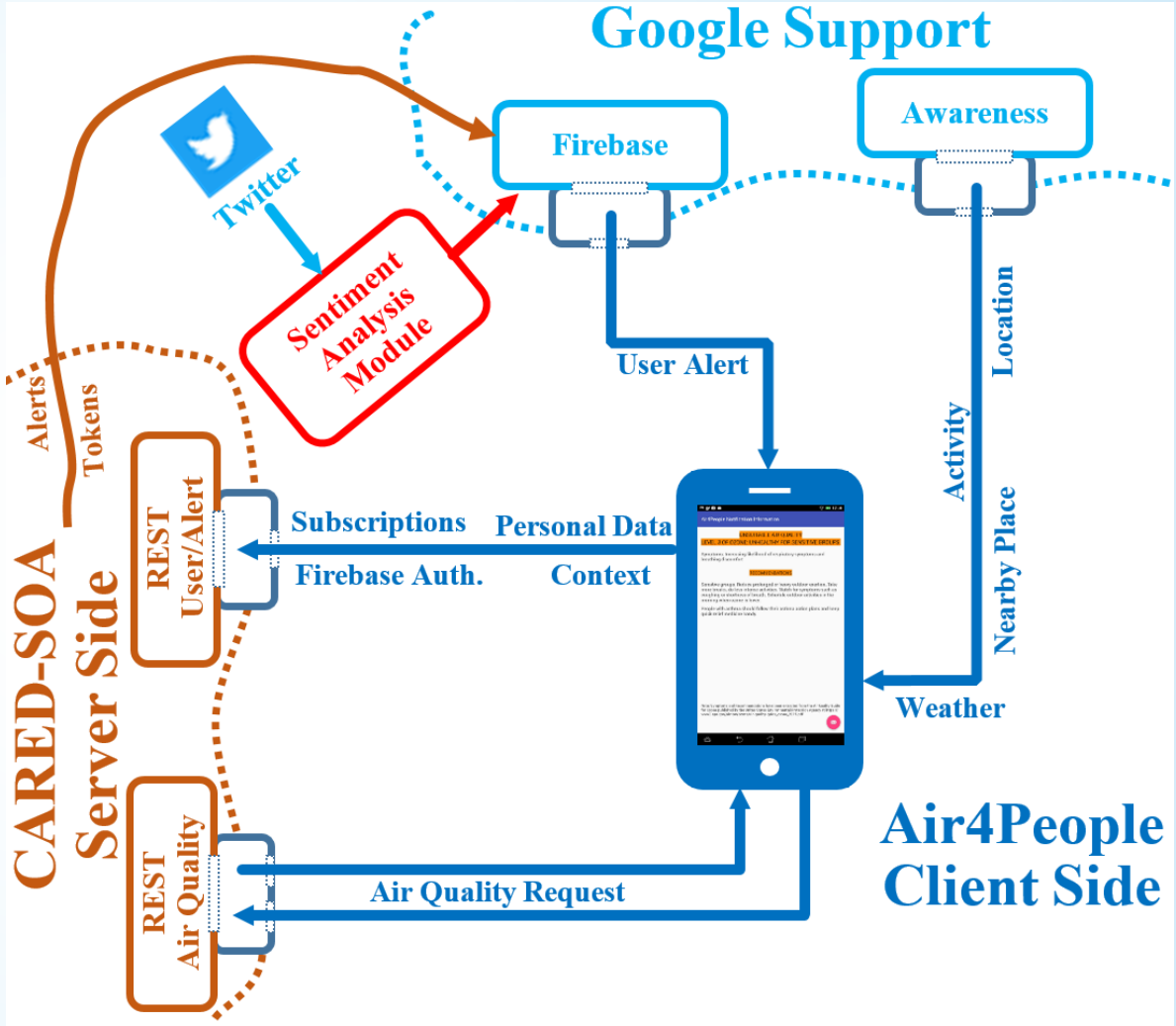
- United Nation SDGs
- Several SDGs can be dealt with IoT technologies and software architectures, such as those related to
  - Health
  - Energy
  - Water and sanitation
  - Industry and innovation
  - Sustainable communities and cities
  - Climate

Climate, Allergy and E-Health: Air4People (Motivation)

DOI: 10.3217/jucs-024-07-0846

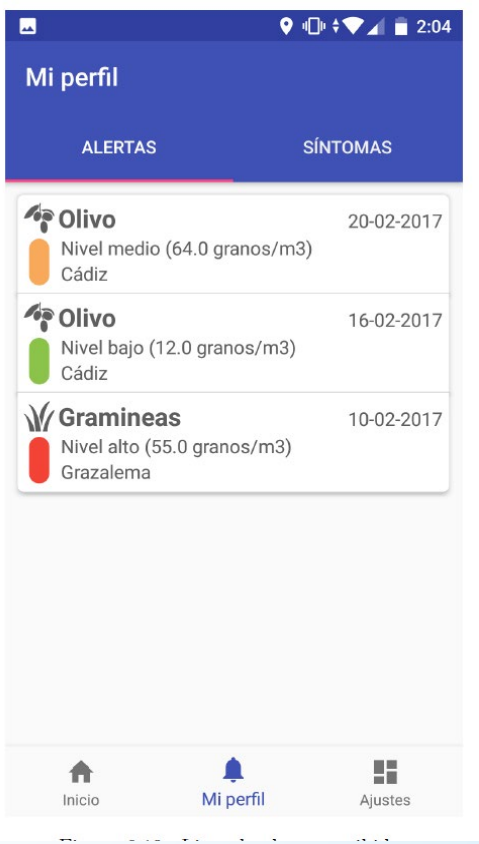


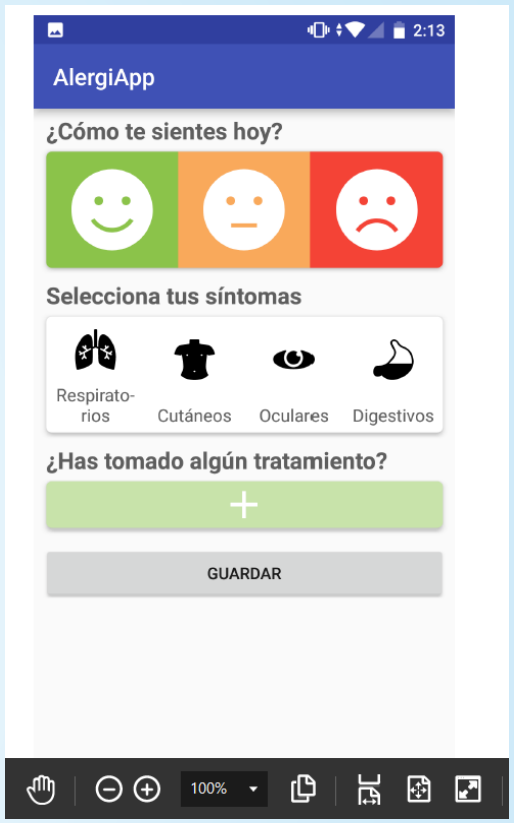
Climate, Alergy and E-Health: Air4People (Architecture)



DOI: 10.3217/jucs-024-07-0846

Climate, Alergy and E-Health: AllergiApp (Architecture and App)

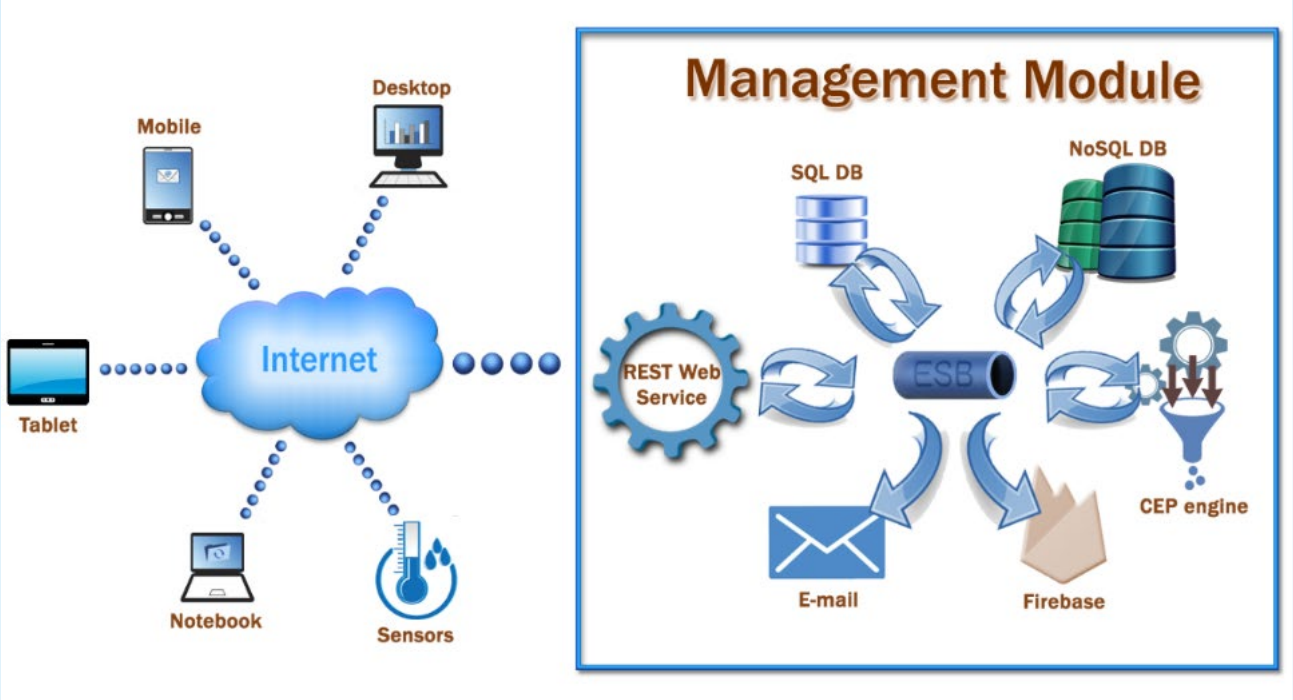




DOI:10.1007/s11042-021-10759-6

Sustainable Communities and Cities: SWAT (Motivation)

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

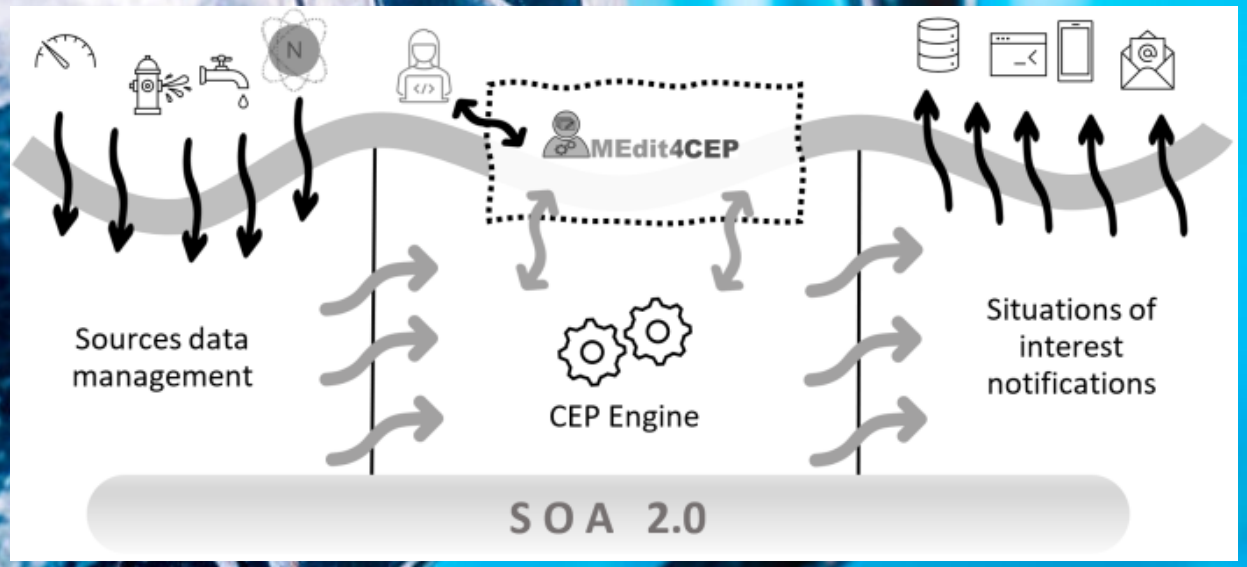


Sustainable Communities and Cities: SWAT (Software Architecture)

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

Water and Sanitation

DECISION Project: https://ucase.gitlab.io/public/Decision/indexeng.html



- Leak
- Fraud
- Consumption monitoring

Water and Sanitation

- Project **iPredice Fase 2.**
- Smart City Cluster: Alliance of companies and public and private institutions.
- GEN (**Water supply network management company): data**.
- UCA: **SOA 2.0.**
- ITELLIGENT: **Enrichment** of relevant situations detected with **contextual data and natural language processing**.
- WATTABIT: **Local actions** and end-user communication and **alerts contextualization.**

Water and Sanitation

- Project **iPredice Fase 3.**
- Spillways
  - Salinity
  - Tides
  - Wind
  - Rain.

Challenge 3
Collaboration & Data Democratization

Handicaps and open issues

Convincing multiple people and entities to share their data

Ensuring data security and privacy

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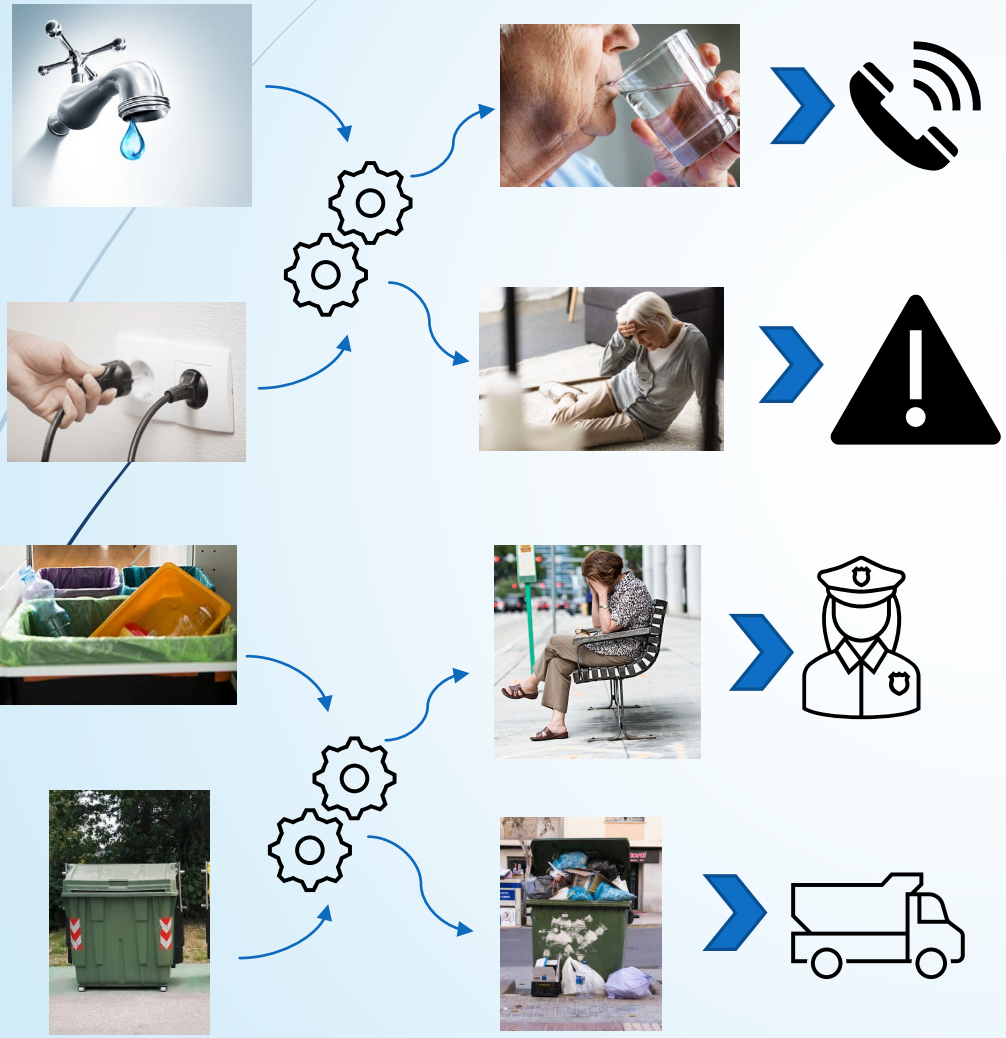
Boris Sedlack
"data frictian, trust, catalog, privacy …"

Providing the means to facilitate different source data interoperability

Providing a framework to facilitate the correlation and contextualization of data from several domains

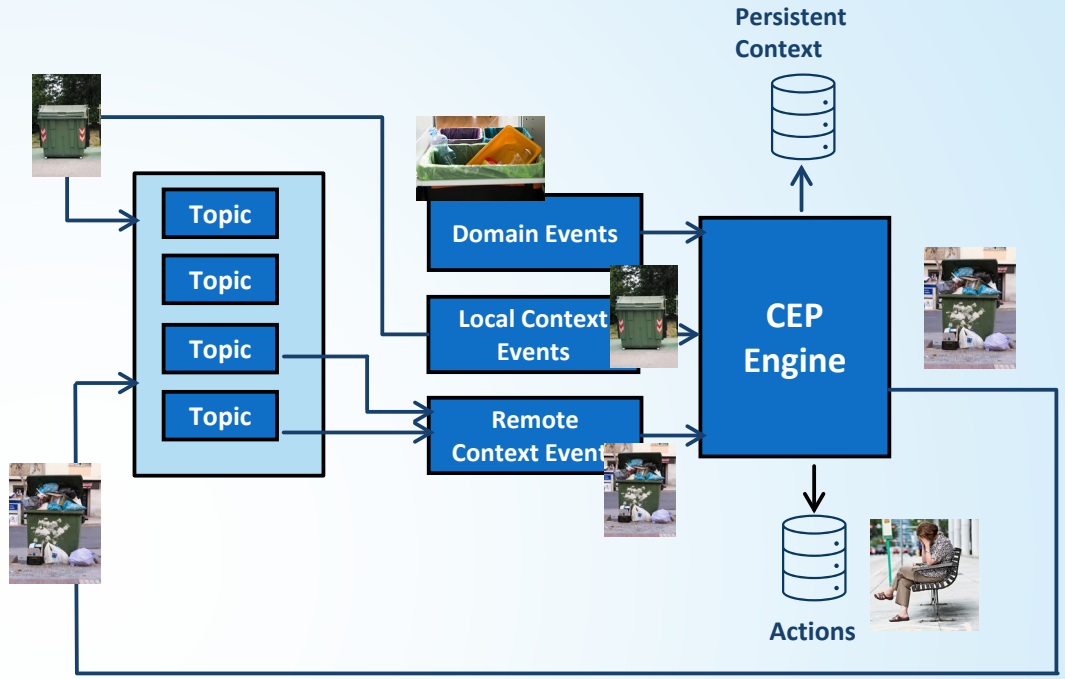
Illustrating Scenarios



Work in Progres: Providing the means to facilitate different source data interoperability

- Definition of a taxonomy for smart everything
- Providing a common JSON structure according to the taxonomy
- Facilitating data ingestion and correlation through complex event processing

Work in Progres: Providing a framework to facilitate the correlation and contextualization of data from several domains



SummerSoC Service Oriented Computing

Harald Schöning
"Make use of the hierarchy
Early Filtering"

SummerSoC Service Oriented Computing

Christian Becker
"Edge is heterogenous"

SummerSoC Service Oriented Computing

Ella Peltonen
"Realtime learning from smaller data"

Conclusion

One Step Forward Towards Context-Aware Smart Everything

Endless Case Studies and Application Domains

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

SMART EVERYTHING requires COLLABORATION

Data privacy and security

Data format standarization

Data sharing and democratization

Systems and data interoperability

Sustainable Software!

Context Aware Collaborative IoT Services for Smart Everything

- Thank-you very much for your attention
- Guadalupe Ortiz, UCASE Software Engineering Group
- guadalupe.ortiz@uca.es

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