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.
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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
- Batch/ Real Time
- Detection/ Prediction

Data Analysis

- Improvements for Business
- Improvements for Citizenship

Decision-making and action

Data Collection
Context and Context Awareness

What is it?

What can we take into account?

Mobile phones do it!

Google permits programming it

<table>
<thead>
<tr>
<th>Context type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Current local time</td>
</tr>
<tr>
<td>Location</td>
<td>Latitude and longitude</td>
</tr>
<tr>
<td>Place</td>
<td>Place, including place type</td>
</tr>
<tr>
<td>Activity</td>
<td>Detected user activity (walking, running, biking)</td>
</tr>
<tr>
<td>Beacons</td>
<td>Nearby beacons matching the specified namespace</td>
</tr>
<tr>
<td>Headphones</td>
<td>Are headphones plugged in?</td>
</tr>
<tr>
<td>Weather</td>
<td>Current weather conditions</td>
</tr>
</tbody>
</table>
Internet of Things
IoT Nowadays

- It proposes the use of a network of **globally interconnected things** or objects uniquely identified through an address scheme.

- Accompanied 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

- Smart Health
- Smart Data
- Smart Houses
- Smart Energy
- Smart Phones
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 democratization
- 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
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 (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

- 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.

Features

Advantages

- Scalability, evolution, maintenance
- Security, consistency, data traffic
Challenge 1
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
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)

DOI: 10.3217/jucs-024-07-0846
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

- Leak
- Fraud
- Consumption monitoring
Water and Sanitation

- PROJECT DECISION (P20_00865)
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

Contextual Event Definition

Entity 1
- Contextual Events Domain 1

Entity 2
- Contextual Events Domain 2

Entity N
- Contextual Events Domain N

API

Application Service A
- Correlation of contextual events 1 & 2

Application Service B
- Correlation of contextual events 3..N
Multiple Scenarios
iPredice Fase 2
“Research on an Intelligent Platform for predictive maintainance of infrastructures”
Conclusion
SMART CITIES require COLLABORATION
One Step Forward Towards Context-Aware Smart Cities
Big and Small Data Processing for Context-aware Smart Cities

- Thank-you very much for your attention
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