COSMOS

Grant Agreement Nº 609043

Cultivate resilient smart Objects for Sustainable city applicatiOnS

Newsletter, Issue 3

<19/10/2016>

Introduction

Dear readers,

We are very glad to introduce you the final newsletter of the COSMOS project.

COSMOS is a European project, which is developing a set of methods, tools and techniques to enable smart city IoT applications to take full advantage of its technologies, through three representative scenarios:

Smart Heating Application Scenario (Camden)
Smart Mobility Application Scenario (Madrid)
Smart Energy Management Application Scenario (Taipei)

COSMOS consists of a set of innovative baseline functionalities, which were combined in order to achieve more complex functionalities and a higher application level structure adapted to our Use Cases needs and therefore to produce significant societal impact. To this end, we have defined three main application archetypes derived from our use case scenarios mentioned above: *Smart Event Flows*, *Social Autonomic Applications and Events on Top of Events Archetypes*; Node-Red tool is used for orchestrating flows between the various elementary

components and for building the necessary middleware logic that binds it all together. During the final stage of the project, we enhanced these archetypes by developing new components, functionalities and applications in order to meet significant challenges in the context of IoT.

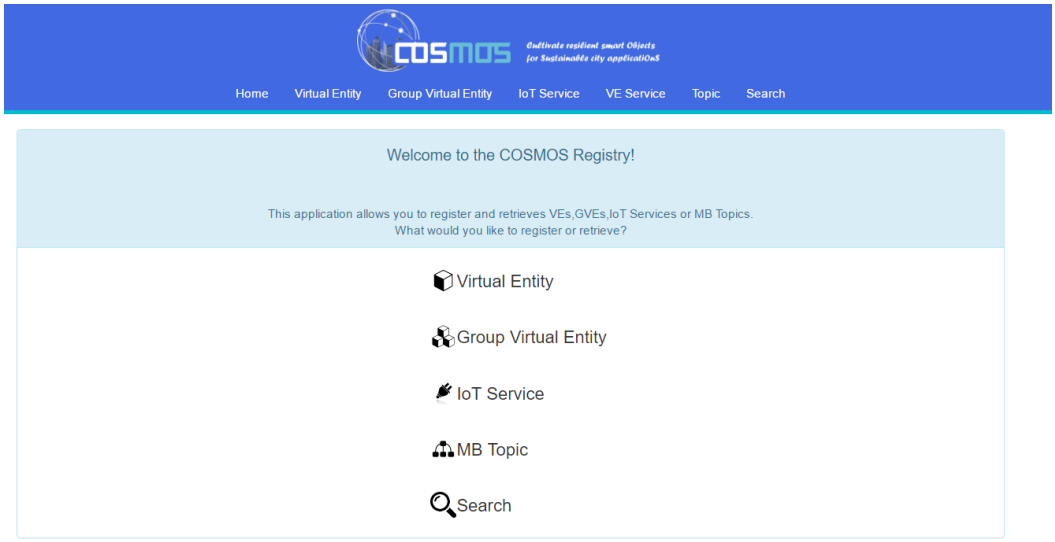
Thank for your interest in our work.
The COSMOS consortium

What is in store for you?

During this period, all major outcomes of the project have been revised according to its objectives:

Complement and extend Things semantics to capture dimensions of their social behaviour

The core semantic description of entities was updated, resulting in the final version of the COSMOS ontology. Moreover, a semantics Things Registry back-end was also developed, including the access API. This, combined with the finalised front-end and the corresponding web application, allows the annotation and discovery of COSMOS entities like Things, IoT-services and interface endpoints as well as its integration with other concepts such as the fuzzification of values for privacy purposes in a per case manner.

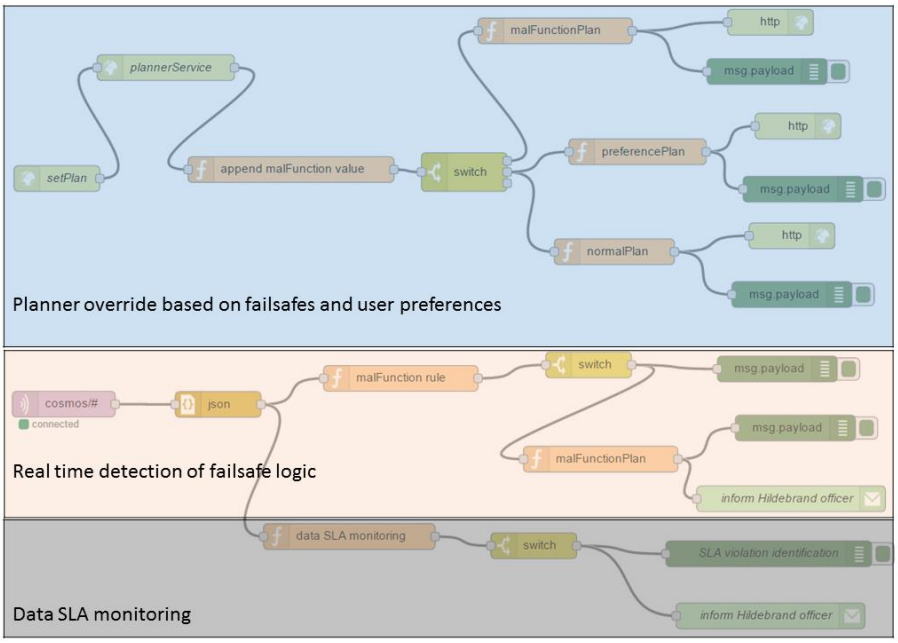


Furthermore, in the context of Social ranking of Things, the COSMOS Trust & Reputation model designed to evaluate the benevolence of Things and their QoS has been finalised. The social ranking indexes the evaluation of Things have been refined and new simulations using TRSim-WSN verified the improved performance and efficiency of the model.

Reliable objects on top of volatile Things

During Year 3, inclusion of failsafes during operation has been incorporated, both at the platform level, through increased health checks and monitoring of the data feeds, and at the Things level, incorporating identification of failures and execution of corrective measures. This information is used by the Planner functional component, so that untrusted data sources are not taken into consideration for the Thing's operation until periodic checks no longer detect

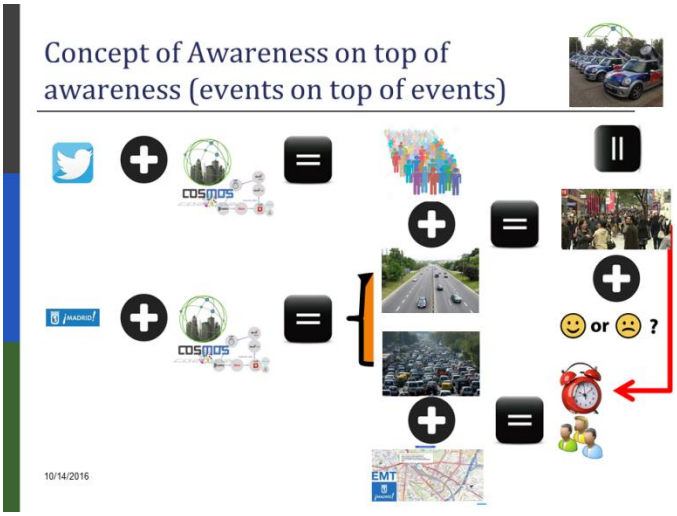
malfunctioning behaviour and to runtime monitor the expected behaviour of the elements. Reliability has also been extended in terms of increased efficiency in how data are maintained and released, according to consent management and privacy policies. What is more, our work in standardization relevant to the emerging ISO 19086-2 draft has shown that existing Cloud based metrics models can be applied in the IoT domain, an aspect that could significantly improve the expression of guarantees in QoS of Things as well as its coordinated monitoring and evaluation.



Objects able to learn and adapt to different situations

The Case Base Reasoning approach for autonomic and socially enriched problem solving has been applied on real data in order to create a smart heating and schedule creation application that will support end users in the setup and configuration of their heating systems, in order to minimize energy consumption and cost. This approach has also been applied in a Sound Detection scenario, with different problem definition and context, enabling the use of the Planner in a generic manner in this case for assisting people with hearing impairment in identifying surrounding sounds.

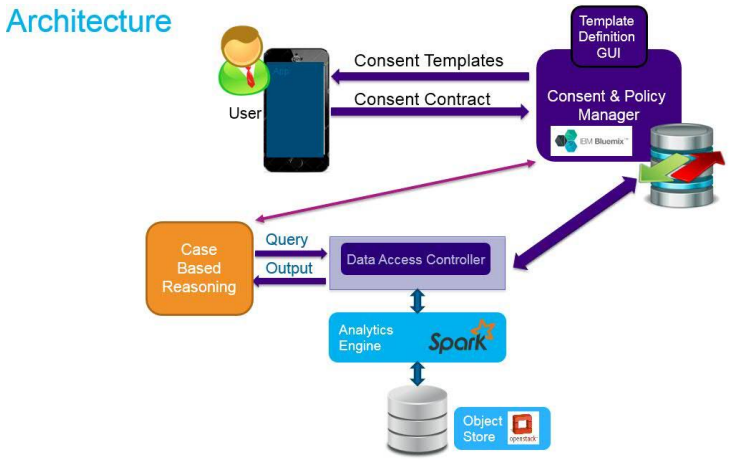
Furthermore, the Situational Awareness process has been extended to include various data sources (such as Social Network data i.e. Twitter) in order to identify city events (e.g. Large Crowd Concentration, Traffic State probability identification) and has worked towards the definition of the Events on Events archetype, a conceptual approach that aims to build in an abstractive manner knowledge on top of knowledge, through creating layers of events, further fine-grained in each step. Thus the possibilities are increasing through the usage for example of external sentiment analysis services and functionalities that can be embedded in the produced events in order to enrich the produced information. By combining one level's event with another piece of information (e.g. another event or data source) a new more detailed event may easily be created, without having knowledge of the details of how each individual event is generated.



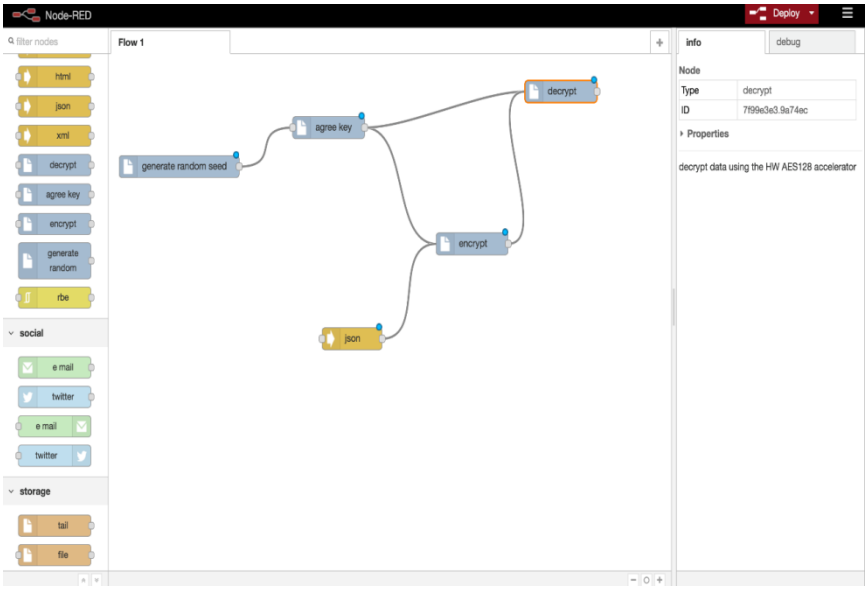
Finally, also the business aspects and the level of granularity of an Events Marketplace (Eventflows), with Producer and Consumer roles and registration per event, have been taken under consideration in order to apply them to the back end messaging system of Eventflows, through properly configuring and maintain the Access and Control levels, enabling the technical implementation of the data distribution scheme. This entity mainly aims to exploit the Smart Events flows and Events on Events archetypes mentioned.

End-to-end security and privacy in and across networks of Things

During Year 3 of the project, our work in privacy and data security was focused on the notion of consent management whereby an application developer specifies a consent template for the given application and a user specifies which data fields from the template can be shared and for what purpose. This information is stored as a consent contract, enforced by a Data Access Controller (DAC) and audited. For COSMOS we implemented a special purpose DAC which protects access by the application to the cloud storage in OpenStack Swift via Apache Spark SQL.

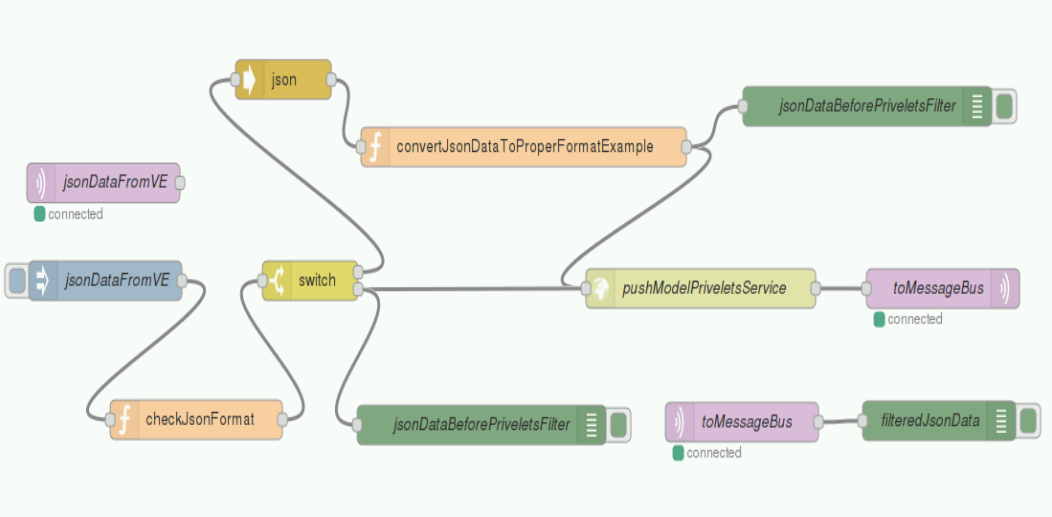


Furthermore, hardware based security aspects include developed random number generators, enhanced by a dedicated hardware testing unit which adds statistical testing functionality meant to identify attacks on the module as well as a prime number testing unit which is used to identify prime numbers. We focused on mitigating common security attacks by means of a statistical analysis performed over the generated numbers. The statistical analysis is able to identify repeating numbers or patterns within the random sequence. Samples which do not meet the necessary criteria, such as entropy threshold are removed and the random number generator is re-triggered. Samples which pass the statistical tests are further passed through a prime number testing unit. Samples which are not prime are deleted and the random number generator is re-triggered. Dedicated Node-RED nodes have been developed in order to facilitate the usage of the hardware components, completely abstracting from the underlying details.



Finally, we enhanced the Privelets functional component by adding the fuzzification functionality, giving the VE developers the capability to also tag a data field as fuzzy. In this case, the user does not provide the real value of the field, but a fuzzy one, which is randomly selected within a range defined by the application developer and according to the privacy level (low, medium or high) of the specific field, which corresponds to the user's privacy preference. All the Privelets functionalities (including configuration, push and pull model) are exposed

through Node-Red flows to enable developers to configure the component on an application level and based on the range needs of each field.



Scalable data and information management exploring the interplay between storage and computation

During Year 3, Madrid city traffic data usage was extended, annotated with metadata and integrated with social media (twitter) and weather data. We undertook combined analysis of these data sources using Spark SQL and Machine Learning. We also developed a mechanism to capture Madrid council traffic engineer feedback and treat it as just another data source. We developed an improved architecture for the Spark SQL driver, which can apply to any data format supported by Spark SQL and supports distributed query execution. We undertook further work on the data mapper including porting to Kafka 9 and 10, running as a Docker container, and testing.

Autonomous management of the network of Things

The extension of the Situation Awareness framework facilitates developers applying the necessary information for assessing and analysing a current situation in order to provide derived value-added knowledge from multiple data sources, that can further be used for smarter decision making. The ability also to dynamically set rules boundaries may enhance the runtime adaptability of this process. Furthermore, the inclusion of a combinatorial middleware layer logic through Node-RED and the associated flows have enabled the combinations of various features based on a per case basis, along with the specialization of the functionalities offered by a respective application.

Current developed applications (e.g. Smart Heating Management) act as an instantiation for the processing of centrally stored data once (in cooperation with the privacy management aspects) in order to extract the cases used in the management of the Things and migrating these to the Things side, and enables the decoupling of the centralized platform from the runtime operation of the Things.

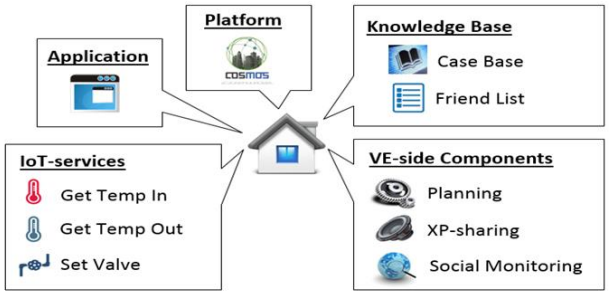
The inclusion of PM2 framework into our work provides us with the ability to manage and monitor the components running at Things and Cloud level for the micro Complex Event Processing engine (with launch, restart, reconfigure instances abilities). A Docker Container to facilitate the deployment outside COSMOS was also developed.

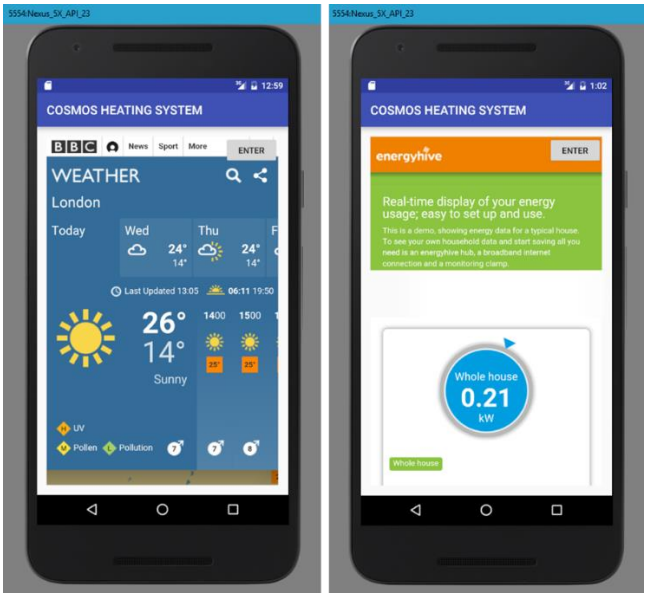
How to put COSMOS in place?

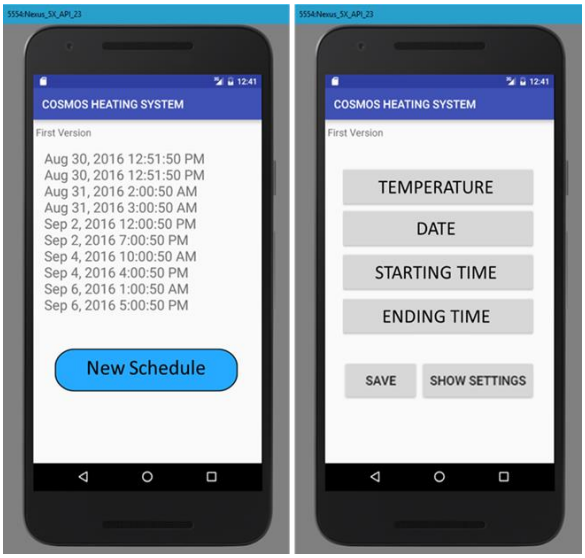
Smart Heating Application Scenario (Camden)

The proposed scenario takes into account that the End Users typically desire an increased amount of cost efficiency, without having to be manually acting in order to provide feedback or actuation to a heating schedule of their flat. A manual or suggestive approach is time consuming and will eventually alienate users even if the data is provided in understandable monetary terms and not in consumption metrics. Thus the COSMOS side autonomic app, running on a Raspberry Pi, handles the creation of the schedule, by splitting the problem in smaller fragments. If information on a specific fragment is not available locally, it then triggers the social mechanisms to recover it from one of the peers in the network (other flats). The returned solution is evaluated after actuation and the relevant social metrics are updated. During the final stage of the project, we enhanced the scenario by incorporating a set of overrides in the normal planning activities in order to address either user-centric preferences, as these were identified through surveys where Camden residents have been participated, or specific technical challenges that arise from a runtime operation of the system under realistic conditions and may relate to (un)expected circumstances such as a sensor malfunction (failsafes). In these cases, normal Planner operation needs to be integrated with the failsafe logic in order to reach a final decision regarding the actuation to be performed (typically through a relevant IoT service). Validation based on real data has been performed, indicating a significant cost saving through the automated management of the heating schedule.

The application scenario exploits some of the COSMOS technologies like Case-Based Reasoning, Trust & Reputation Model, Privelets, Registry and Privacy & Consent Management.





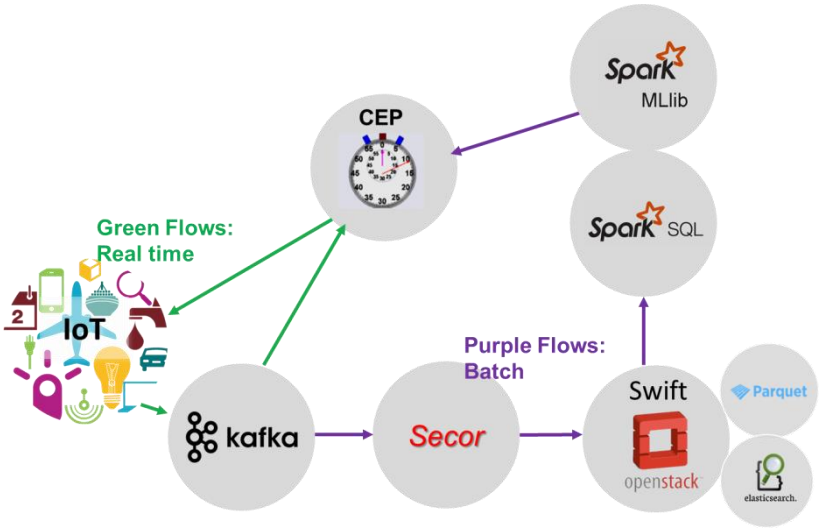


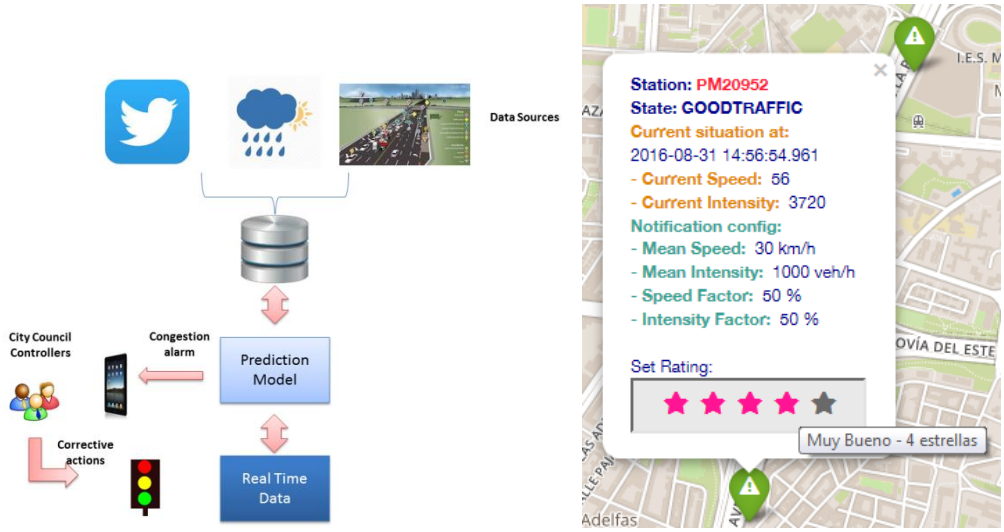
Smart Mobility Application Scenario (Madrid)

Citizens that have special needs such as children, elderly, disabled and the like, may choose to use the bus system if they can get assistance on the beginning and end of their journey. Assistance would come in the form of a caregiver who might help to plan the journey and track the passenger's progress. However, a number of events might occur that influence the user's journey and this is where COSMOS kicks in, in order to optimize user experience. In this case the caregiver plans the route and the COSMOS environment tracks the user through its journey. At the same time, city wide information, including traffic incidents or large crowd concentration in a target location may influence a user's journey. In case the app logic detects that the specific measurement point in which the event occurs is near the user, relevant notifications are produced to the involved parties. During the final stage of the project, we enriched our data sources by ingesting weather and social media (Twitter) historical data. The usage of external data services is very useful from an application creation point of view, in order to enhance application scope but also to extend in combinatorial reasoning and/or data analytics aspects.

The flow of the scenario (which consists of the main blocks of the Smart Events flow) consists of the following steps:

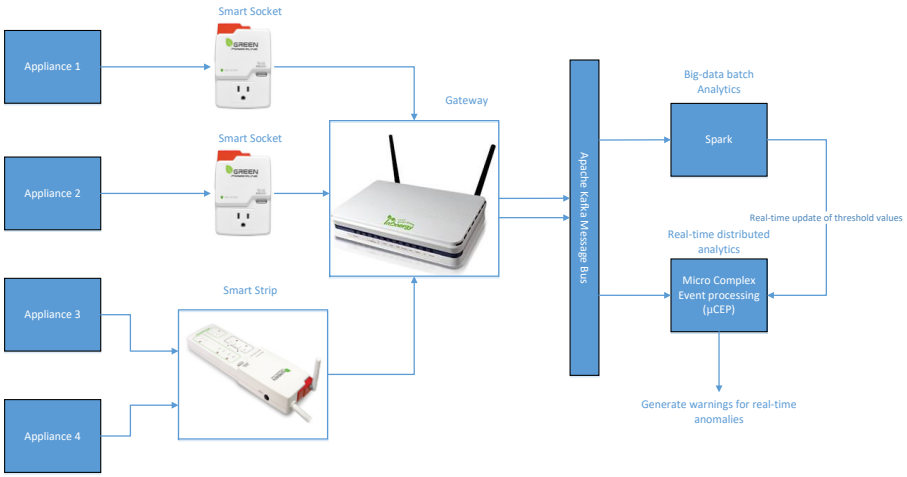
- Ingestion & Analytics
  - Collect data from devices and sources
  - Aggregate into objects with metadata
  - Index the metadata
  - Clustering based on time of day, location
  - Analysis to identify the boundaries of an event triggering
- Real Time Response
  - Definition of CEP rules
  - Apply what was learned on real time data stream; take action





Smart Energy Management Application Scenario (Taipei)

In Taipei, III is providing services to hundreds of houses with thousands of devices connected to their smart sockets. Smart sockets provide the users about real-time energy usage in order to make them more aware of their energy consumption. Different appliances are connected to smart gateways with the help of smart plugs. Smart plugs monitor real-time electricity consumption data which are published in real-time on the specific topic in apache Kafka Message Bus. These data are being collected and analysed in Apache Spark (similar to the previous case of Madrid) in order to calculate their statistical properties and the normal working range of appliances which is used as threshold values for CEP rules. The latter are analysed in real time through the µCEP engine of COSMOS. Anomalies for a specific appliance are highly dependent on time as well. For example, switching on the TV in an evening is a normal behaviour whereas switching it on during midnight can be an anomaly. Analytics on historical data enable to have specific characteristics with respect to particular user or appliance. It helps to understand the behaviour of users in a better way.



Did you know that?

COSMOS has published more articles related to our research goals. Following, a list of the new publications is included.

Publications

- Eleftherios Kokoris-Kogias, Orfefs Voutyras and Theodora Varvarigou. TRM-SIoT: A Scalable Hybrid Trust & Reputation Model for the Social Internet of Things. In Proceedings of the 10th International Workshop on Service-Oriented Cyber-Physical Systems in Converging Networked Environments and IEEE Xplore.
- Adnan Akbar, Abdullah Khan, Francois Carrez and Klaus Moessner. Predictive Analytics for Complex IoT Data streams. The paper was submitted in IEEE Internet of Things Journal and is currently under review.

Attended Events

There is a wide range of events in which COSMOS has participated during 2016, in order to reach audiences and demonstrate our work and results:

SIdO 2016 Event and Coorganized Workshop with IoT-EPI

COSMOS participated in the SIdO 2016 event with a booth as a member of the IERC village. Furthermore, COSMOS researchers participated actively in the panel of the session "Jump-start your IoT-project with the European Platforms Initiative" in a collaborative activity with IoT-EPI and H2020 AGILE (http://www.sido-event.com/conferences/conf/121.html). The target of the session was for representatives of EU-funded research and innovation activities to explain how they build an ecosystem, focusing on developers, entrepreneurs and end-users.

IoT Week 2016

For the IoT Week 2016 event, COSMOS pursued and achieved its participation in three sessions including relevant presentations and demonstrations from the project outcomes. In detail the following sessions and points were covered

- **From FP7 to H2020 Projects: Security, Trust and Governance session.** COSMOS participated with a slot "Security and privacy trade-offs in the COSMOS IoT: HW vs SW, isolation vs participation and accuracy vs confidentiality" demonstrating the advancements in h/w security, Trust and Reputation Model and Privelets.
- **From FP7 to H2020: Main tangible outcomes and lessons learnt** in which we presented the main COSMOS exploitable outcomes, such as the Smart Events flows, the Social Autonomic Apps concepts and the Eventflows marketplace concept.
- **IoT-EPI:** project objectives, approaches and how to leverage FP7 outcomes, in order to feed the main points of the previous slot on tangible outcomes.
- **IoT, Data Analytics and Big Data** in which we presented the slot “From smart homes in Taipei to intelligent transportation in Madrid: An IoT analytics architecture applicable to multiple real world use cases”.

COSMOS also participated in the event with a booth and continuous presence in order to inform audiences on the project outcomes.

IBM Interconnect Conference 2016

Hillel Kolodner from IBM gave a talk on 21/2/2016 at IBM Research Day in the IBM Interconnect Conference titled “Using Spark and Open Source for Smart City Planning on BlueMix”: http://www.research.ibm.com/articles/interconnect2016.shtml.

Geospatial World Forum

COSMOS gave also a presentation at http://geospatialworldforum.org/. The session is ‘Public Safety and Emergency Response’ and the title ‘Predictive Analysis for Pro-Active Traffic Management’ (http://www.iot-cosmos.eu/node/2019).

IBM Research Australia

Paula Ta-Shma gave a talk at IBM Research in Melbourne on the COSMOS architecture and the Madrid Traffic use case on 25/7/2016.

Object Workshop

Goetz Mensel from IBM gave a talk at the Object Workshop in Ehningen Germany, July 5th, 2016 (50 attendees) covering aspects of the Madrid Traffic Use Case and our architecture.

EclipseCon North America

Trent Gray-Donald from IBM gave a talk at eclipsecon in March 2016 called "Introduction to Apache Spark for IoT" which covered several topics including our COSMOS work on the Madrid Traffic use case https://www.eclipsecon.org/na2016/session/introduction-apache-spark-iot

Guest Lecture at the Technion

Paula Ta-Shma gave a guest lecture in June 2016 at the "Smart Cities" graduate student course taught by Professor Pnina Plaut. She covered the COSMOS data management architecture and the Madrid Traffic use case.

DataPalooza

Paula Ta-Shma from IBM gave a talk at the DataPalooza Event in May 2016 in Tel Aviv, with the title "Spark for IoT and Smart Cities: A Traffic Management Use Case for Madrid Council".

The Humboldt Colloquium

Shelly Garion from IBM gave a talk in September 2016 titled "Privacy Enabled Big Data Analytics in the Cloud": https://mi.conventus.de/online/avh-israel-ec-2016.do.

Mobility Management Events:

- **Busworld Academy Congress, Istanbul (April 15th, 2016)**: The audience was mainly transport operators, transport authorities, bus manufacturers, consultants and researchers;
- **11th ITS European Congress, Glasgow (June 8th, 2016)**: The audience was mainly transport operators, transport authorities, its consultants and researchers;
- **III Conference on Sustainable Development in Energy "The Sustainable City", Madrid (April 26th, 2016)**: The audience was mainly students and PhD postgraduates;
- **Busworld Academy Congress, Beijing (May 24th, 2016)**: The audience was mainly transport operators, transport authorities, bus manufacturers, consultants and researchers;
- **European Conference in Mobility Management, ECOMM, Athens (June 2nd, 2016)**: The audience was mainly city officials, consultants and researchers.

COSMOS Organized Events

In 2016, COSMOS has also driven its own organized events, either in the context of a wider event (e.g. EuCNC 2016) or as standalone:

EuCNC Special Session on Abstractions and Use Cases of converged Big Data, Telecom and IoT technologies

COSMOS was the main organizer of a special session/workshop during the EuCNC 2016 event that was held in Athens from 28-30 June 2016).

The title of the workshop was "Abstractions and Use Cases of converged Big Data, Telecom and IoT technologies" and COSMOS was present with two slots; the Predictive Analysis for Pro-Active Traffic Management, exploiting COSMOS Smart Event identification flows, and the joint work with H2020 SLALOM project on the benchmarking of ongoing standardization efforts (such as ISO's 19086-2 draft standard) relating to the definition of Cloud SLAs and their metrics and how they can also be applied in the IoT context for the respective features of interest. Presentations are also available through the project website (http://www.iot-cosmos.eu/node/2066) and the event website.

NTUA Hackathon

Starting at 23rd of May, a COSMOS based workshop/hackathon has been organized in Athens, in NTUA premises in order to give developers the chance to utilize COSMOS outcomes and provide a set of indicative solutions to two given scenarios. The scenarios are focused around the Internet of Things, Smart Homes and Smart cities concepts. Application implementations needed to utilize one or more of COSMOS project tools or outcomes and to be integrated primarily through the Node-RED environment: http://iot-cosmos.eu/node/1998.

Madrid Hackathon

In order to let developers enrich COSMOS project, we organised a hackathon (https://mobilitylabs.emtmadrid.es/portal/index.php/hackaton-2016/) so COSMOS architecture and functionalities would be used to develop new services. The hackathon started on July 11th, taking place at Medialab Prado facilities, in Madrid and was designed in two phases:

- 1st phase: from July 11th up to August 8th at 23:59 hours; to develop data collections
- 2nd phase: from August 12th up to September 9th; to let the previous winning teams to develop the service prototypes

There were 109 attendants, with 93 active participants (developers): http://iot-cosmos.eu/node/2110.

Do you want to be part of it or know about it?

Register with our newsletter through the website (http://iot-cosmos.eu/), contact us in andrea.rossi(at)atos.net or:

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