Free and Open Source Software for Geospatial (FOSS4G) Conference Proceedings

Volume 18 *Guimarães, Portugal* Article 5

2018

istSOS Version 3

Cannata Massimiliano
University of Applied Sciences and Arts of Southern Switzerland (SUPSI)

Milan Antonovic
University of Applied Sciences and Arts of Southern Switzerland (SUPSI)

Daniele Strigaro
University of Applied Sciences and Arts of Southern Switzerland (SUPSI)

Mirko Cardoso
University of Applied Sciences and Arts of Southern Switzerland (SUPSI)

1. Introduction

In 2009, to respond to specific needs of Interoperability and monitoring network management the Institute of Earth Science started the implementation of the istSOS (istituto scienze della Terra Sensor Observation Service) software as a data management system compliant with the Sensor Observation Service standard from OGC.

The software would have been used in the coming years a key technology in supporting the local authorities in flood risk management in the area of Locarno (Ticino, Southern Switzerland). The Lake Verbano area (213 km^2) is limited if compared to its basin (6 386 km^2) and for this reason, intense rainfall events due to the limited outlet capacity (2 000 m^3/s) causes inundation of the shores with a return period of about 7 years. Locarno, that is located at a flat delta of the Maggia river, is particularly exposed to this risk and due to the high value of the land extensive costs were registered.

To support the Civil Protection of Locano in managing the risk and reducing the costs an open risk management system based on Service Oriented Architecture (SOA) and Open Standards from the Open Geospatial Consortium (OGC) has been implemented. As illustrated in figure 1, the system makes use of Web Feature Service (WFS), Web Coverage Service (WCS) and Sensor Observation Service (SOS) to provide updated data that are analyzed trough Web Processing Services (WPS). The representation of data and information in Web mapping application allows to better understand the ongoing situation and take appropriate timely actions.

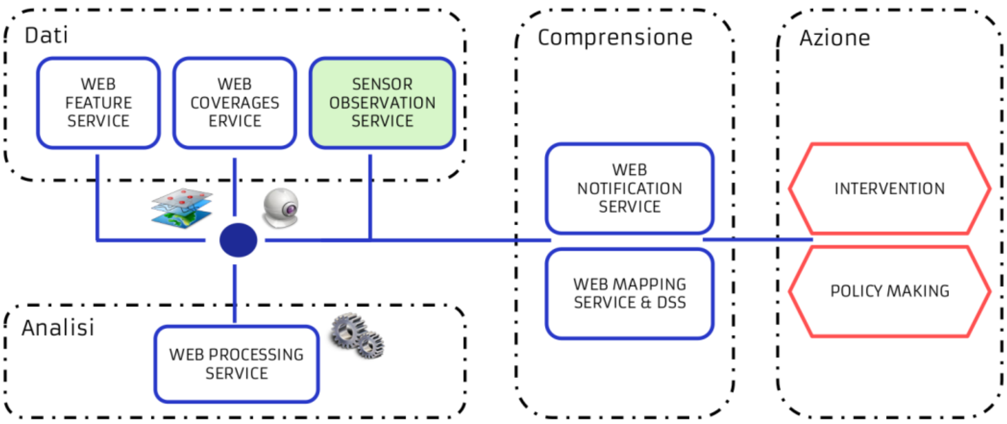

Figure 1 - Open Risk Management System based on Service Oriented Architecture (SOA) and Open Standards from Open Geospatial Consortium (OGC).

The requirement of interoperability in this context was mainly due to the need of managing data from 5 different monitoring networks, owned by different institutions in different regions and countries. The requirement of Openness was due to previous experiences where company market choice of dismissing specific proprietary software led to the failure of a previously implemented solution due to incompatibility with modern hardware and operative systems.

In the years, istSOS gained new features and become a full data management system for in-situ monitoring data characterized by its low dependencies from third packages, easy installation, administrative Web based graphical interface and data viewer. Special features were designed and implemented to permit hydrologists to optimize their work and fit best practices. Among other features, today istSOS manages spatio-temporal reprojection, implements on-the-fly aggregation at server side, supports authentication and authorization, provides natively data quality indexes and validation tools, integrates MQTT protocol, permits the implementation of virtual procedures, offers multiple data output formats. Additionally, to facilitate Web integration, next to the standard SOS in version 1 and 2 which is based on http POST and GET requests and XML formats, istSOS offers a RESTful API offering the same information, and more, in a JSON flavor.

2. State of the art

In the era of ubiquitous Web with the explosion of micro/nano-electronics devices the Internet of Things (IoT) is the key technology that together with artificial intelligence is building future smart systems where data driven applications will improve the people life. IoT is not only a sector with expected enormous impact on people life but also with an incredible market potential value of as much as USD 11·trillion a year in 2025 (Manyika et al., 2015). In their analysis, Manyika et al., identified the interoperability among IoT systems as one of the priority with a potential value of USD 4 trillion per year in 2025 since over 60% of the application that was studied required the analysis of data from different data sources.

Despite the growing number of IoT deployments the majority of proposed IoT applications tend to be self-contained, thereby forming application silos (Schiele et al., 2014) and most of the time the only integration is based on supporting third vendor's systems. As a possible solution, Grubitzsch et al. (2017) proposed the concept of an IoT Intercloud Broker (IB) to enable interoperability between IoT cloud infrastructures from different vendors (i.e.: Google Nest, AWS IoT, MS Azure IoT Suite, Kiwigrid, etc.) that are primarily PaaS solutions for data consumption, device control and management.

This solution represents a tightly coupled approach where separate systems are interconnected by means of a translator which may not necessarily be updated when a single system is modified. Differently, a fully integrated approach where each single system supports a common Standard Interface (SI) (see Figure 1), provides a direct integration among the services and the users.

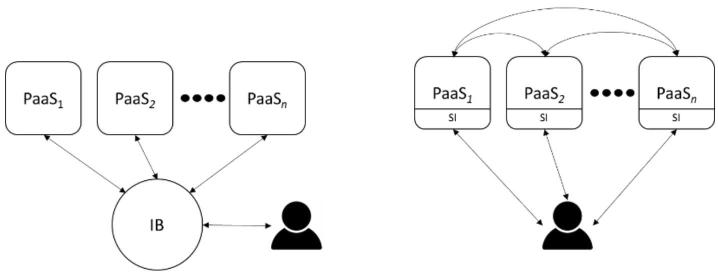

Figure 2 - Tightly coupled and fully integrated approaches
(IB=Intercloud Broker, SI=Standard Interface).

The SOS standard concept, has the potential to become the above referenced common standard interface capable of providing interoperability between IoT platforms. In fact, it has the ability to abstract the data production and data usage segments enriched with sufficient information and metadata for appropriate filtering. This potential is fully recognized by the European Union that accepts SOS version 2 as an INSPIRE compliant service for providing observation data (EU, 2016). Unfortunately, SOS does not implement those protocols that currently represent the state of the art of IoT communication which are RESTful APIs based on HTTP and the Websocket. Methods and protocols specifically designed for high frequency data updates and low throughput.

To quantify the istSOS capability in supporting IoT applications the software was evaluated with a number of load service tests that estimated its Quality of Service (Cannata et al., 2018). The tests were conducted on three different monitoring networks mimicking real systems characterized by small amount of sensors (20) and large numbers of observations (100 million), medium amount of sensors (160) and large numbers of observations (1 700 millions) and large amount of sensors (5 100) and small numbers of observations (1.7 million). As a result, it was demonstrated that istSOS version 2 (istSOSv2) is capable to meet the INSPIRE requirements in most of the cases but shows a limitation with high concurrency, which is a typical expected situation in IoT applications. istSOSv2's implemented strategies, communication protocols and used programming techniques have been identified as bottlenecks: while data integrity checks consume extra time in each data insertion, the sequential programming queues the requests with increasing waiting times.

To overcome issues with communication protocols alongside the SOS istSOS has developed istSOS-wa (Cannata et al., 2015): a RESTful (Representational State Transfer) API that uses JSON format (JavaScript Object Notation) instead of XML. A year later, OGC announced a new standard, the SensorThings API (iang et a., 2016). Similarly to istSOS-wa, it provides a standardized way to offer SOS concepts using a RESTful service and a JSON format.

As a result, SOS is a mature standard capable to fully describe sensor/data/user interaction thanks to the usage of rich data models (SensorML, O&M, etc.) with exhaustive metadata. Additionally, is accepted by INSPIRE and thus it is very relevant in the European context. However, IoT requires modern protocols and formats capable to support high performance under big data and high concurrency scenarios that SOS can't fulfill.

3. istSOS version 3 (istSOSv3)

After 9 years, istSOS required an upgrade to take advantage of the latest technologies and to improve its quality of service to support increasingly performance demand operations and IoT needs. Additionally, Python version 2 that is the pillar of istSOS will be deprecated from April 2020.

The identified key requirements of istSOSv3 are:

- Better performance in supporting big-data and high concurrency
- Expandable communication interface to support IoT
- Abstracted data layer to support multiple databases
- Compliance with INSPIRE
- Support of SOS version 2
- Independence from the container
- Expandable architecture to support plug-in and other APIs

To improve the flexibility of custom application creation istSOSv3 implements Python API (istSOSv3-api) and Web Javascript Packages (istSOSv3-web) that includes core and viewer components. This allows to combine components and packages in preferred Web environments to customize applications while minimizing code rewriting (see Figure 3).

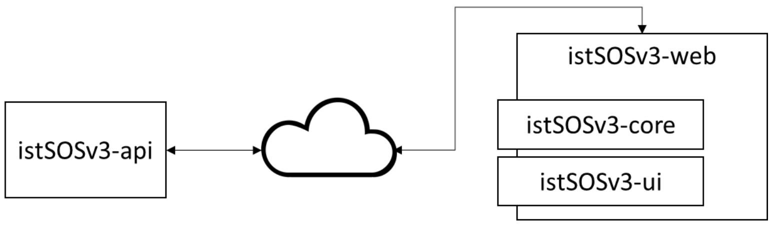

Figure 3 - istSOSv3 architecture

The selected core technologies of istSOSv3-api are Python 3.X and asynchronous programming while the programming paradigm follows the “Chain of Responsibility Pattern”. In this pattern the data is represented by an *Entity* while a process is executed within an *Action*. As illustrated in Figure 1, several *Action* can be concatenated to create a *CompositeAction* that executes a complex process. *Action* and *CompositeAction* have *before*, *process* and *after* methods to maximize code reuse in class extensions (Figure 4). This approach boosts code reuse and facilitates the creation of new expansion (istSOS-plug-in).

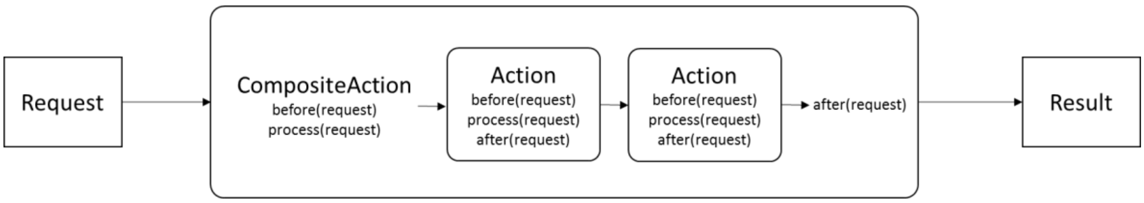

Figure 4 - istSOSv3-api architecture

The above described architecture of istSOSv3-api is implemented as a Python module that can be integrated in the preferred environment. The istSOSv3-api could be integrated in different databases, different Web or Desktop application and different communication protocols: in Figure 5 different options are depicted, in light grey not yet implemented but planned components while in dark grey possible future expansions.

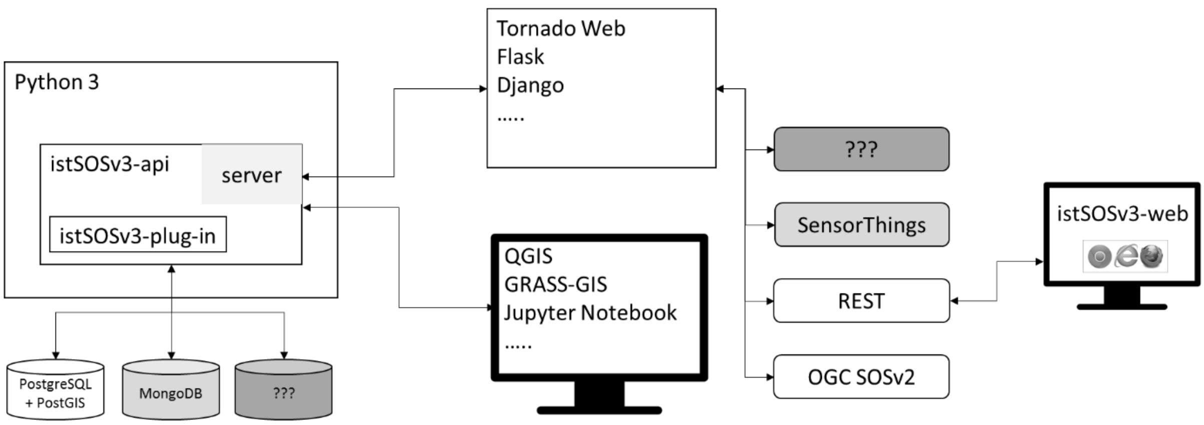

Figure 5 – Possible options for istSOSv3 deployment
(light gray planned components, dark grey future expansions).

4. Results and Discussion

To verify the improvement of performance of istSOSv3 against the istSOSv2, a small test was executed comparing latency (response time) and throughput (requests per second) of the two versions installed on a standard PC (8 processor i7, 16GB ram, 500 SSD). The WKT benchmarking tool (https://github.com/wg/wrk) was used to perform the tests. A single thread and single connection evaluated an SOS's getObservation request in JSON output format on a single sensor observing a single observed property every 10 minutes.

Different time intervals were requested:

- 1 week = 1,080 observations,
- 1 month = 4,320 observations,
- 2 months = 8,640 observations
- 6 months = 25,920 observations
- 1 year = 51,840 observations

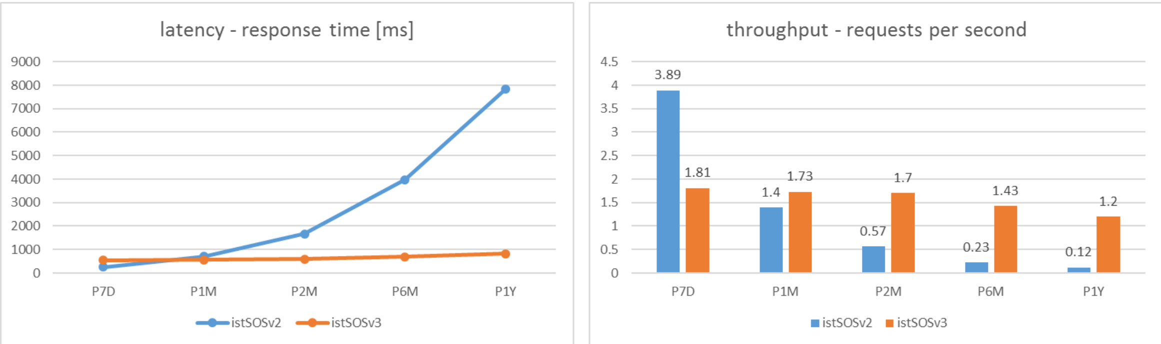

Figure 6 – Load test results comparing latency and throughput of istSOSv2 and istSOSv3.

As illustrated in Figure 6, istSOSv3 performs better than istSOSv2 and show a linear decrease of performances with increasing data volume with very low gradient. In contrary, istSOSv2 shows an exponential decrease of throughputs and increase of latency. This is clearly a first evaluation of the newly implemented istSOS version, but results are very promising and suggests that the selected approach and technologies are appropriate.

5. Conclusion

The implementation of future cyberphysical systems cannot be fully exploited without an interoperable Internet of Things. Despite some standards and solutions have been proposed in literature, no standard is currently widely applied. SOS offers a valuable conceptualization of the IoT standardization with fully metadata enriched to fill this gap but it lacks of required streamlined protocols and formats supporting the efficiency and immediacy needs of modern applications. istSOSv3 aims at implementing a flexible system that uses all of the modern technologies to provide high performances while still supporting mature standard accepted by INSPIRE. While complete tests are required to fully understand quality of service that can be offered by istSOSv3, preliminary tests are promising and confirmed the high potential of istSOSv3.

References

Manyika, J., Chui, M., Bisson, P., Woetzel, J., Dobbs, R., Bughin, J. and Aharon, D., 2015. Unlocking the Potential of the Internet of Things. McKinsey Global Institute.

Schiele, G., Soldatos, J., Mitton, N., 2014. Towards Interoperable IoT Deployments in Smart Cities-How project VITAL enables smart, secure and cost-effective cities. ERCIM News, 2014(98).

Grubitzsch, P., Springer, T., Hara, T., Braun, I., & Schill, A., 2017. A Concept for Interoperable IoT Intercloud Architectures.

Cannata, M., Antonovic, M., Molinari, M., & Pozzoni, M., 2015. istSOS, a new sensor observation management system: software architecture and a real-case application for flood protection. Geomatics, Natural Hazards and Risk, 6(8), 635-650.

Cannata M., Antonovic, M.,.Cardoso, M., 2018. Evaluation of the quality of service of istSOS version 2. Presented at the GIT conference 2018, Sarzana, Italy.

EU, 2016. Technical Guidance for implementing download services using the OGC Sensor Observation Service and ISO 19143 Filter Encoding. Online resource: https://inspire.ec.europa.eu/id/document/tg/download-sos

Liang, S., Huang, C. Y., & Khalafbeigi, T. (2016). OGC SensorThings API-Part 1: Sensing. OGC® Implementation Standard. http://docs. opengeospatial. org/is/15-078r6/15-078r6. html.