The Future Internet PPP and its Usage Areas: A Sensor Web for the Environment in Europe

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We provide this position statement as a de-facto or virtual organization including representatives from the public sector including scientific institutes, as well as Small and Medium-Sized Enterprises (SMEs). We first met at the 'Future Sensor Web for the Environment in Europe' workshop held on 28 and 29 of January 2010 in Ispra, Italy. The text below represents our common findings. A longer version is available on request.

Europe faces a growing demand for near real time data, better interfaces for data users, and intelligent collaborative reporting. At the same time, the available infrastructures and users are changing. "Internet supported services are entering a new phase of mass deployment which brings a huge number of new opportunities but also new challenges in terms of scalability, capacity, throughput, mobility and trust" [1].

This particularly applies to geospatial sciences and their applications, where data and service provision and consumption changed significantly over the past years, leading to idea of a Single Information Space for the Environment in Europe (SISE), where users can plug in their own use cases and leverage a transparent capacity (i.e. a backend system of systems) [2]. This digital infrastructure (e-Infrastructure) needs to manage and serve more than measurements and data: it must support modeling resources, and allow ad hoc, on demand service chaining in cross-domain applications.

The Sensor Web Enablement (SWE) initiative of the Open Geospatial Consortium (OGC) already addresses at least part of the issues mentioned above, through the provision of Service Oriented Architecture (SOA) using standards with service interfaces, encodings and data models for interoperable sensor service networks [3]. Although initially developed with a focus on physical sensors and sensor networks, the SWE definition of a sensor gradually evolved to include 'virtual sensors' that is arbitrary processes which produce sensor-like data [4]. Some examples of virtual sensors include e.g. simple algorithms for algebraic and numerical post-processing of the sensor data, as well as smart models capable of forecasting environmental processes [5]. Further challenges include:

- Holistic interdisciplinary approaches for developing web-based Environmental Information Systems accessible and usable by *multiple stakeholders* in *real-time*;
- Integration and quality assurance of bottom-up VGI with top-down 'official' information and services;
- Novel spatio-temporal analytical techniques to exploit real-time or quasi-real-time sensor information leading to high level *situation awareness*;
- Management of heterogeneous resources– in particular *modeling* resources (e.g., forecast modeling services, modeling procedures, modeling algorithms);
- *Data fusion* with advanced presentations of new knowledge for decision makers; and
- Novel means for *communication and collaboration* (e.g. Virtual Globes, Linked Data).

In the following, we relate our work on these areas to the topics to be addressed during the upcoming 'Future Internet PPP and its Usage Areas' meeting.

(1) Use case and scenario for large-scale experimentation with the Future Internet

We identified environmental applications as a highly appropriate scenario for experimenting with the Future Internet (FI) platform, and especially the integration of sensors into the FI. This approach will be beneficial for a rich set of applied areas, including marine ecosystem environmental monitoring and management, climate change impact on ecosystems and biodiversity, urban industrial activities and geo-hazards management, enhanced traffic management, and green smart cities.

(2) Important innovative Internet functionality and technologies

Applications related to each of the areas mentioned before would benefit from the integration of sensors, sensor networks and sensor data into the Future Internet. This technology will allow gathering information about the environment (including sensor measurements, expert simulations/models and emerging Volunteered Geographic Information (VGI) [6]). It will enrich monitoring, hazard-management and other key applications through a real-time view of the world. As this will generate very large volumes of sensor observation and processed data, discovering, understanding, and extracting knowledge from such 'hyper large' amounts of (geospatial) data will be a central Internet functionality. This can be provided by Advanced Knowledge-Base Services that combine standard Sensor Web Enablement (SWE) [7] services, environmental models interoperability services (applying the 'Model Web' principles), context aware intelligent data management, handling of large volume of data using data mining and fusion services [8], as well as estimation, communication, and propagation of uncertainty along processing chain.

(3) Expected functionalities of Future Internet core technology platform

Robustness, *scalability*, and *quality* of services are the keys to success, and therefore have to be built in the FI core technology platform. We believe that the architectural design of the underlying infrastructure should realize an extended and hybrid Service Oriented Architecture. Extensions will include broker components to implement mediation functionalities (essential for implementing a complex and heterogeneous system of systems); hybrid aspects will manage the elements of the Event Driven Architecture [7, 9], being capable of handling the streams of hyper large data. Information is made available on demand to a large community of collaborative users and others, with the creation of a vast information network which continuously analyzes the present and future state of the environment. An event driven service environment thereby provides the foundation to react to critical situations, saving much needed time to take appropriate actions. These actions may be taken autonomously by the system but also involve humans to make decisions at critical stages. Furthermore, the core technology platform should support semantically rich and extendible data models, as well as de-centralized and community contributed meta-information management [10].

(4) Requirements for an experimentation environment and prototype platform

In order to ensure an efficient and meaningful large scale testing of the developed platform, it will be necessary to bring together participants from a wide range of communities: researchers, commercial enterprises, public institutions as well as users of the technology. Within such an environment it will become possible to test thoroughly the components and technology developed and to gain insights about their practical applicability. Consequently, participants from all of these areas are represented in our group.

We will test and develop further existing solutions for capacity, throughput and scalability, and develop an overarching architecture. By doing so, we will support the FI with large scale geospatial information space that are based on Sensor Web Service as well as model discovery and uncertainty-enabled chaining of services for analysis and modeling of real-world environmental systems. In addition, we aim to encompass the socio-economic and organizational dimensions of the development, in order to facilitate the creation of added-value services, motivate 'actors' (such as SMEs, research institutions, and public organizations) to develop and market innovative services in a competitive context, and motivate 'data owners' and 'environmental model owners' to market their resources.

(5) Potential role of our organization in the FI-PPP

We bring together stakeholders from a broad range of backgrounds. This reaches from users, sensor data providers, environmental model providers, technology providers to researchers and public institutions. As a whole, we are able to advance the topic of sensor and model integration into the FI taking into account very different perspectives and thus ensuring an application driven approach. Members will be able to contribute their experience and knowledge in areas like the development, application and standardization of the Sensor/Model Web, Research on new interoperability solutions for environmental models, research on new Smart Sensor Web concepts, and development of Sensor Web oriented generic knowledge base services.

In the context of its contribution to the FI PPP, our organization could deploy the Future Sensor (and Model) Web infrastructure and take into account of the existing standards for geospatial information, provide the requirements for FI core service platform, and build/reuse test platform(s) in the context of air quality monitoring, Industrial risks management, geospatial services for the European citizen in order to test and demonstrate the FI platform.

As our virtual organization consists of many diverse institutions, we would like to participate at the meeting with a consortium of few representatives. We provide an overview of some core competences below:

Representative	Organization	Core Interest(s)
Drs Z. Sabeur or Colin Upstill (to be confirmed)	IT Innovation Centre, University of Southampton	Advanced Knowledge Base Services for Sensor Web decision-support applications
Paolo Mazzetti	Institute of Methodologies for Environmental Analysis	Model Web; Uncertainty; Extended SOA approaches for Multi-disciplinary interoperability.
Kym Watson	Fraunhofer - IOSB	Data streams; in-network processing of sensor data; context aware services
Bernard Stévenot	Spacebel	Socio-economic perspectives
Denis Havlik or Gerald Schimak (to be confirmed)	AIT Austrian Institute of Technology GmbH	Robust and secured time series processing; distributed meta-information management; systems and data integration
Sven Schade	European Commicion - Joined Research Centre	Contribution to and use of INSPIRE (data models); Research on 'virtual' (human/models) as sensors and SWE

Table 1: Proposed meeting participants.

References

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