Requirements and architecture design principles for a smart city experiment with sensor and social networks integration

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ABSTRACT
Smart city infrastructures offer unique testbeds ground for innovative experimentation and services offering. Sensors networks in cities with integrated social networks activities can improve people-centric services, while improving infrastructures setting. This work summarizes the principles and priorities chosen in a smart city experiment, entitled SEN2SOC which bridges sensor measurements and social networks interactions for supporting smart city services. SEN2SOC prioritizes requirements along particular categories which cover data collection, users sensing along with applications implementation and architectural concerns. These requirements are correlated with the suggested components in an architecture which is flexible enough in order to permit various activities control flow in terms of data preprocessing, conditions detection, statistical analysis as well as applications development and social data mining.

Categories and Subject Descriptors
H.3.5 **[Online Information Services] :** data sharing and Web-based services, H.5.3 **[Group and Organization Interfaces] :** synchronous interaction, Web-based interaction

General Terms
Measurement, Performance, Experimentation, Human Factors, Standardization, Verification.

Keywords
smart city, sensors data management, social networks mining, collective aware applications

1. INTRODUCTION
Internet has rapidly evolved to allow accessing on an abundant scale of information under a pervasive, ubiquitous, and multimodal manner. Internet of Things (IoT) expresses today's emerging reality, with the multiplicity of devices and infrastructures increasing and improving to offer services and applications in a dynamic and evolving manner [1], [15]. Such IoT environments enabled smart cities developments and currently smart cities offer ground for experimentation and testbeds offering. In an "Internet of everything" setting, devices (such as sensors) become information broadcasters and storehouses, capable of collecting and transmitting real-time data. Utilizing such data can majorly impact smart cities services in a short-term and long-term perspective.

Sensors are widely used in the smart cities to gather measurements of physical parameters which impact citizens' life in terms of their transportation, activities and well being. Under appropriate methodologies, such sensor data can be exploited to identify particular incidents (such as traffic congestions or atmospheric pollution at a particular area/time period). Smart city short-term (e.g inform/alert citizens and especially vulnerable social groups) or long-term (e.g. understanding the progress of the phenomena and trying to address them in order to improve the city's conditions) policy making can leverage such data production.

Recently, European IoT platforms have emerged with infrastructures like the ones offered by the SmartSantander project (http://www.smartsantander.eu/) inline with the Europe's growing need and interest in smart city innovation highlighted by the Commission (report on "Internet of Things in 2020: A roadmap for the future"). In such smart urban environments, crucial role is placed on innovative human-centric applications, including social networking, smart data collection, city information models etc. At the same time, the rapid evolution and adoption of social media and Web 2.0 technologies offer wide information production and sharing. Harvesting social networking data and interaction activities can largely contribute to the improvement of smart urban living environments. Up to now, typically smart sensor networks provide information about some parameters of a given incident without considering its effects on humans and on citizens sensing. It is now important to extend typical sensor networks with inclusion of "human-networks" which will "sense" and provide information for the same or similar facts [14]. This work focuses on the principle of utilizing sensor data and social networking interactions towards offering individual and collective beneficial smart city applications and services.

In this context, this paper focuses on an ongoing experiment which is motivated by the fact that it is now time to go beyond quantitative outcomes, since people are primarily interested in qualitative human-oriented solutions. The presented experiment framework (SEN2SOC)[1] is implemented under the smart city setting of the SmartSantander infrastructure. SEN2SOC considers reciprocities in quantitative sensor-generated data along with qualitative human-generated data exposed in social networking platforms [17] . With such an approach "listening" by networked

[1] *This work is supported by the EU Smart Santander project under its 2nd call for experiments under the experiment "SEN2SOC : bridging SENsor measurements and SOCial networks interactions via natural language generation for supporting smart city services", implemented by Aristotle University, 2013.*

objects (sensors) is enhanced and vetted by human sensing, thereby getting closer to realizing collective awareness tasks and collaborations. The present work aims at clarifying the requirements needed to support an effective architecture which will permit the experiment's realization and its successful usage.

Such a twofold experiment embeds major scientific, research and technical challenges as follows :

- SEN2SOC essentially forms a complementary platform to SmartSantander since it will extend the existing capabilities of SmartSantander infrastructure by engaging citizens and visitors of Santander into the smart city environment. In essence, SEN2SOC's added value lies in the transformation of complex machine- and user-generated data (sensor recordings and social network user activity) into meaningful, easily understandable, and user-friendly information or services destined to members of Santander community;
- SENS2OC experiment challenges revolve around data processing demands. Indeed, SEN2SOC experiment relies on functions such as: continuous sensor data recording; real-time data processing and analysis; and combination of heterogeneous data coming from various data sources (SmartSantander sensor network, SEN2SOC mobile application users, social network activity, etc.).
- Particular concern is placed on privacy issues. For instance, current position information or desired destination for mobile application users (when offered route or place recommendations) associated with that specific user profile information will never be stored in SEN2SOC database systems. SEN2SOC will impose anonymity and privacy preservation in all management tasks relevant to data collection and user information. This will be implemented by embedding rigorous privacy guarantees, while exploiting conclusions drawn from relevant studies that enable privacy-aware useful services

The rest of the paper is structured as follows. Section 2 reviews the current state regarding Internet of Things in smart environments and natural language processing approaches that will leverage sensor to human interactions. Section 3 presents the relevant scenarios and the requirements setting whereas in Section 4 the architecture design along with its components are described and explained. Finally Section 5 highlights experiment's impact and future adoption plans.

2. Related Work

Providing effective scalable applications and services which will exploit existing smart city infrastructures is still at an initial stage due to their recent emergence and applicability. Monitoring of such new IoT infrastructures can exploit data that capture conditions (environmental and other) and can lead to improved information analysis, which is vital for significantly enhancing collective awareness and policy making. The SEN2SOC dual nature imposes the need to exploit current approaches in emerging and evolving scientific fields, such as the IoT in smart contexts, awareness and recommendations on location-aware frameworks as well as mobile applications and services. The proposed framework is inline with the principles set in [14], where sensor data production is utilized for social networks exposure.

Sensors of all kinds are key sources of numerical and non-textual data, embedding knowledge that has to be extracted. Statistical and data mining methods are used to manipulate the data; however there is always the need for humans to receive the raw data or the results of their processing in a language that can easily understand. That is why a relatively recent research area is evolving, aiming to the communication and interaction between the sensor data and the humans through Natural Language Generation systems. Natural Language Generation (NLG) systems generate texts in human language from non-linguistic data. A number of data-to-text systems have been developing for more than a decade now and there are already several applications of data-to-text systems and the research is ongoing and challenging as the available data become more and more complex (http://www.nlg-wiki.org/systems/).

Important research work on NLG and their applications in decision support has been done by researchers at Aberdeen University in a series of papers spanning more than a decade ([12],[18],[11],[5]). Applications involve the production of textual summaries based on different disciplines (such as data from gas turbines, medical applications, etc). Moreover, applications utilize NLG for geographical and spatio-temporal information for geographic descriptions, route directions and wheather forecasts ([14],[8]). In [10] the problem of generation of narrative summaries of daily events, based on sensor data from various sources is tackled. Specifically, in this paper a 'clustering' of data into events facilitates choices on the basis of user 's interests. Research on NLG is directed also towards more theoretical and formal issues. In [7] a uniform mobile terminal software framework is presented for providing systematic methods for acquiring and processing useful context information from a user's surroundings, through multiple sources and sensors, and giving it to applications. Research has been conducted also on technical issues and performance of NLG systems and specifically of sentence planners [3] and [2].

In SEN2SOC the goal of the proposed natural language processing is to convert sensor and other numerical data to sentences that can be understood by humans. The text produced by such an NLG approach will be in the form of a short summary of limited text (i.e. a posting).

3. SEN2SOC Experiment Design Principles

SEN2SOC is based on the idea of bridging sensor measurements and social networks interactions via natural language generation for supporting smart city services. As explained above it is motivated by the fact that utilizing smart interconnected objects (sensors) along with social networking activity contributes in collective awareness and intelligent urban landscapes. The SEN2SOC experiment will support a dual side platform which will utilize sensors data production and social networks interactions and it will increase collective awareness for various audiences and communities. An overview of the SEN2SOC platform is depicted in Figure 1. SEN2SOC platform functionality is summarized in supporting:

- *a back-end module* for sensor data retrieval and analysis, which among other things, detects extreme sensor measurements (e.g., very low temperature, high humidity, etc.) and incorporates a sensor-to-social interpretation mechanism that generates relevant alerts (in the form of social media postings or mobile application alert messages) when extreme environmental conditions are observed;

- *a front-end module* that monitors and analyzes social networking activity and also provides SmartSantander-related services to Santander citizens, visitors, and city authorities.

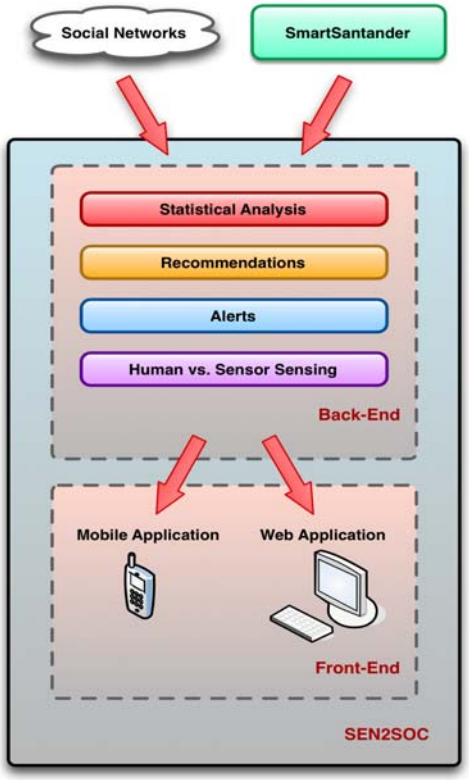

Figure 1. The SEN2SOC Platform overview

The main strategic objective of the SEN2SOC experiment is to establish a unified system than exploits SmartSantander sensor network, offers innovative mobile and Web user services (for Santander citizens, visitors, and city authorities), and interacts with social networks. In particular, SEN2SOC experiment key objectives are summarized next :

- refine and integrate sensor and social data collections;
- enhance sensor data analysis and monitoring;
- implement efficient data mining techniques that integrate heterogeneous sensor measurements and social networking interactions;
- leverage social networking interactions to activate Santander citizens, visitors, and city authorities, who in turn can utilize social networks to enhance human versus sensor environmental conditions capturing;
- offer route and place recommendations to Santander citizens and visitors based on sensor measurement and social media information;
- present valuable information to city authorities, such as sensor data information, sensor data statistical analysis results, and generated alerts about extreme environmental conditions;
- demonstrate and promote SmartSantander experimentation infrastructure capabilities, and increase awareness and understanding of SmartSantander benefits;
- disseminate SmartSantander capabilities and corresponding SEN2SOC results in the appropriate conferences and journals;
- initiate a vibrant social network community of interest stimulating the involvement of key stakeholders.

3.1 Stakeholders and scenarios

The key stakeholders that will be involved in the context of SEN2SOC experiment are smart city citizens, visitors and authorities along with the SmartSantander consortium as described next :

- Citizens. They move around the city on a daily base for various reasons (such as work, leisure, etc.). SEN2SOC will place special emphasis on exploiting sensors' measurements and citizens' social networking information to support real-time adaptive recommendations for citizens, e.g. place or route recommendations based on their current location and desired destination as well as based on current environmental conditions (temperature, humidity, noise, CO level, etc.). Moreover, citizens, acting like sensors, will declare in the social network their own observations/feeling on the sensor measured values (by qualitative characterization for weather or environmental conditions), thus providing complementary information to sensors' measurements.
- City visitors. They are occasional city visitors interested in city exploration and POI visiting. SEN2SOC will provide POI recommendations to city visitors based on their actual location and POI popularity, as well as suggestions on pleasant and interesting city "walks" characterized by favorable environmental conditions. The suggested areas of interest will be selected based on both social activity (POIs highly evaluated by users explicitly or through the analysis of their social network activity) and sensor activity (e.g., noise-free areas characterized by favorable temperature or humidity level). Similarly to citizens, city visitors will also provide their observations that will be used complementary to sensors' measurements.
- Authorities. They include the city council, city's policy makers, emergency services, police, etc. SEN2SOC will enable monitoring of the Santander's major environmental parameters (such as noise, temperature, and CO level). More specifically, SEN2SOC will provide a web-based visualization interface that presents valuable information to city authorities, such as: sensor data information (current or past), sensor data statistical analysis results, generated alerts when extreme environmental conditions are present, etc.
- SmartSantander project consortium. SEN2SOC experiment can greatly contribute in improving the SmartSantander and as an added value to SmartSantander platform, SEN2SOC platform will divide the geographic region of Santander into a number of geographic areas and perform sensor data aggregation (i.e., one aggregated sensor value per geographic area). Sensor data aggregation is useful for sensor data analysis, presentation, and visualization (e.g., chromatic maps); can improve the efficiency of mobile/web applications involving SmartSantander sensor data; and could be deemed important to other project partners and their services/applications too. Furthermore, SEN2SOC comparison of recorded sensor measurements and "user-perceived" environmental conditions can reveal sensor data anomalies or Santander areas that are not adequately covered by the SmartSantander sensor network.

Two indicative SEN2SOC scenarios involving city authorities and citizens are described next to highlight experiment's impact.

City authorities scenario: It was 9am in the morning when the Spanish minister of culture suddenly announced that in 2 hours he will arrive to Santander in an unofficial visit (since he was visiting a nearby location) and he expressed his wish to communicate mostly with the University students. The City Council had to respond effectively both for organizing his moving around the city (from his arrival at the Railway Station to the City Council, and then to all of his visits) and for publicizing his talk to the University of Cantabria students. For this purpose, city council officers access the SEN2SOC Web application (authorities' monitor deck) and they get all of the minister's routes nearby sensors and human postings pertaining to environmental parameters (noise, CO level, etc.) for the last 6 hours. City council officers noticed that there was a red alert posting coming out of the Calle de Alfonso sensors in terms of the CO and noise levels, and this was also verified by the feedback of the SEN2SOC mobile application users, so they immediately deviated his transport route via a neighborhood with more favorable environmental conditions.

Citizens scenario: It was noon time when Carlos, a junior student for the degree in History at the University of Cantabria (Santander, Spain) who is enrolled at the "Early Contemporary Spanish History" course, was at the University campus when the posting for the Minister's talk arrived at the Facebook account of his class. He noticed that this talk was scheduled to be held at the Biblioteca y Casa-Museo de Menéndez Pelayo at 2pm. Along with his classmates he decided to go to the talk but since Carlos suffers from acute chronic asthma attacks he had to look for the atmospheric conditions in downtown Santander in order not to deteriorate his health. Therefore, he accessed SEN2SOC mobile application (citizens recommender) to get summaries of sensors' measurements in relevance to humidity, temperature and CO level, which greatly influence his health. He noticed that there was a posting ("Hay mucho ruido en la playa.") that was posted one hour ago from the sensors located at Plaza de Toros. That posting was verified by about 10 more users in Twitter (via the retweet mechanism), whereas there were no alerts associated with an alternate route from his current location (University) to his destination (Biblioteca), which he eventually decided to pick. Since there were no reports of environmental parameter measurements exceeding the permitted limits for his health condition, he decided to join his classmates and attend the talk.

3.2 Requirements Setting

SEN2SOC experiment requirements should initially differentiate into functional and non-functional along with specifying each requirement's relevant description, comments, indicative priority, and also list components involved. Moreover, depending on requirements importance and criticality to successful project outcome, requirements are prioritized as:

- *mandatory*: these requirements must be necessarily implemented and need to be addressed prior to any consideration of requirements of the other categories. They correspond to features that are essential for the implementation of the SEN2SOC experiment and the support of the envisioned services in general.
- *desirable*: these requirements correspond to features that are not required for the realization of the SEN2SOC experiment but would provide additional functionalities to the SEN2SOC applications, if implemented. These requirements will be accommodated as far as possible, within the resources and technological constraints pertaining to the project.
- *optional*: these requirements correspond to features with the lowest priority with respect to the needs of the user groups addressed by SEN2SOC. The implementation of such features could be examined after addressing the mandatory and desirable requirements, again in the context of the project's resources and technological constraints.

SEN2SOC has identified the requirements specific categories which are summarized in Table 1.

Table 1. Requirements abbreviations and description

Requirement ID	Description
DAT	Sensor Data
REC	User Recommendations
STA	Sensor Data Statistical Analysis
WEB	Web Application
USR	Users as Sensors
ALR	Alerts
SOC	Social Media Analysis
EXP	Experimentation
ACC	User Access to SEN2SOC Applications
ARC	SEN2SOC Architecture
EVL	Evaluation of SEN2SOC Experiment

Such categorization enabled the definition of the specific requirements for each case as the ones which are indicatively presented in Table 2 with the indication of architecture components described in Section 4..

Table 2. Indicative SEN2SOC Requirements

Requirement No.:	**DAT-1**
Name:	Access to SmartSantander sensor data.
Description:	SEN2SOC must be able to retrieve current and past SmartSantander sensor data including type of parameter sensed, sensor measurement, sensor node ID, and sensor GPS coordinates.
Reason/Comments:	SEN2SOC applications and functionality in general need access to sensor measurements and the respective geographic location (permanent/current) of both static and mobile SmartSantander sensors.
Indicative Priority:	Mandatory.
Components Involved:	Sensor Data Monitoring.
Requirement No.:	**DAT-2**
Name:	Specification of geographic areas.

Description:	The geographic region of the city of Santander should be divided into a number of geographic areas.
Reason/ Comments:	Santander division into geographic areas constitutes a required element of the SEN2SOC platform that will support various functions, such as sensor data aggregation, visualization and route/place recommendations to SEN2SOC application users. Granularity of geographic areas should align with the distribution of available SmartSantander sensor network nodes and accommodate restrictions imposed by SEN2SOC.
Indicative Priority:	Mandatory.
Components Involved:	Sensor Data Monitoring.
Requirement No.:	**REC-2**
Name:	Place recommendations based on social media information.
Description:	SEN2SOC mobile application should provide users with place recommendations based on social media information.
Reason/Comments:	Popular places will be identified within Santander based on the analysis of social media geolocated content. Mobile application users will receive suggestions for such places based on their current location, date, and time of day.
Indicative Priority:	Optional.
Components Involved:	Social Data Observer, Mobile Application.
Requirement No.:	**USR-1**
Name:	User feedback on environmental conditions.
Description:	SEN2SOC mobile application users will be requested to provide input on how they "perceive" various environmental conditions of their current area. User input will be given in a simple, intuitive scale of qualitative values designed for each environmental parameter.
Reason/Comments:	This feature is mandatory to combine human subjective perception of the environmental conditions they experience within the city with the values measured by the sensors. This combination will lead to the calculation of humans-sensors levels of agreements on each area.
Indicative Priority:	Mandatory.
Components Involved:	Mobile Application.
Requirement No.:	**EXP-2**
Name:	Provision of Santander insights derived from social media analysis.
Description:	SEN2SOC mobile application will provide users with Santander insights based social media analysis results and current user location.
Reason/Comments:	Examples of Santander insights include the following. Images: provision of images related to the surrounding area. Tag clouds/popular topics: information relevant to the most-discussed issues in the area. Popularity of places: information in relevance to the most popular places in the area.
Indicative Priority:	Mandatory.
Components Involved:	Social Data Observer, Mobile Application.
Requirement No.:	**ACC-2**
Name:	Support for different user roles (citizens, city visitors, city authorities).
Description:	SEN2SOC platform will support three different user groups, namely: citizens, city visitors, and city authorities. City authorities will be the users of the web application, whereas citizens and city visitors will be the users of the mobile application and registered to the SEN2SOC user database.
Reason/Comments:	The role of "city visitor" or "citizen" will not be associated with a given user profile, but instead mobile application users will be able to select between the two roles each time they log in the mobile application. Mobile application users will be able to use either the "city visitor" or "citizen" interface so that they can benefit from the functionalities designated for each role, depending on their current needs.
Indicative Priority:	Desirable.
Components Involved:	Mobile Application, Web Application.

4. ARCHITECTURE DESIGN AND COMPONENTS

SEN2SOC project will implement innovative mobile and web applications that engage Santander citizens, visitors, and city authorities in various ways. In particular, SEN2SOC applications utilize SmartSantander sensor measurements, inform about environmental conditions, generate alert messages, provide route/place recommendations, and interact with social network users. SEN2SOC platform architecture follows the component-based design paradigm and is clearly defined in the document. All major SEN2SOC components and associated functions are adequately specified. Our design also specifies an interface that constitutes the central point of interaction between the various SEN2SOC components: it primarily manages data communication among SEN2SOC components and offers them services to enable SEN2SOC functions.

SEN2SOC architecture follows a component-based design and it is depicted in Figure 2. It includes a stateless orchestrator component called Interface, which is accountable for service provision and data exchange among the SEN2SOC components. Sensor Data Monitoring constitutes the linking component between SEN2SOC and SmartSantander platforms, and its primary responsibility is to retrieve and store SmartSantander sensor data. In the following sections, we describe the basic components and data stores of SEN2SOC architecture

4.1 Basic Components

The basic components include :

Sensor Data Monitoring to carry out sensor data retrieval; sensor data aggregation based on geographic location of sensor nodes; sensor data analysis; along with alerts generation. The Sensor Data Monitoring component retrieves sensor data from SmartSantander platform and stores it in the respective data store (SmartSantander Sensor Data). This component is responsible for sensor data analysis and generates alerts whenever environmental sensor readings exceed certain predefined thresholds (i.e, detection of extreme or critical sensor measurements). Alerts are forwarded to both SEN2SOC Mobile Application (for display purposes) and Statistical Analysis component (for further analysis). However, Santander city is to be divided into a number of geographic areas (see Geographic Area Data below) to support and enable various SEN2SOC functions and services, such as: sensor data visualization, statistical analysis based on geographic areas, route recommendations to mobile application users, etc. For these reasons, the Sensor Data Monitoring component also performs aggregation of sensor data based on the geographic location of sensor nodes (either static or mobile ones, such as those installed on buses). For each geographic area and sensed environmental parameter an aggregated sensor value is calculated for a specific time point as the weighted mean of sensor measurements.

Social Data Observer to support geolocated data collection; and user-generated content mining. The Social Data Observer component collects geolocated data (within Santander) and supports UGC mining on various social media networks, such as Twitter, Flickr or Foursquare. Relevant information produced (i.e., geolocated information and the social media analysis results) is afterwards communicated to the SEN2SOC Mobile Application and Statistical Analysis components.

Mobile Application to offer user login through social media or SEN2SOC platform authentication process; display of alerts regarding extreme sensor measurements; alerts' sharing in social media; sensor measurement-based city map view; social media UGC-based city map view; route recommendations based on sensor measurement information; user feedback on recommended routes. The Mobile Application component, as the self-descriptive name implies, refers to the SEN2SOC application for mobile devices and addresses both Santander citizens and visitors. For the most part, the Mobile Application shows alerts on extreme environmental conditions, displays Santander city maps based on sensor information enriched with nearby POIs, as well as social media users' activity, and supports user navigation directions based on their preferences, current location and desired destination. Mobile Application records user feedback on: i) the sensed environmental conditions in their current area, and ii) their satisfaction with the provided recommendations

Statistical Analysis for statistical analysis of sensor data and of aggregated sensor data; sensor-user data co-analysis;analysis of social network user responses on alerts; sensor data anomaly detection. The Statistical Analysis component is a primary data processing component of SEN2SOC that correlates and analyzes data coming from various sources, such as: sensor measurements, user feedback data, and social media information. This component supports sensor data mining, performs statistical analysis, detects sensor data anomalies, and reports results to the SEN2SOC Web Application

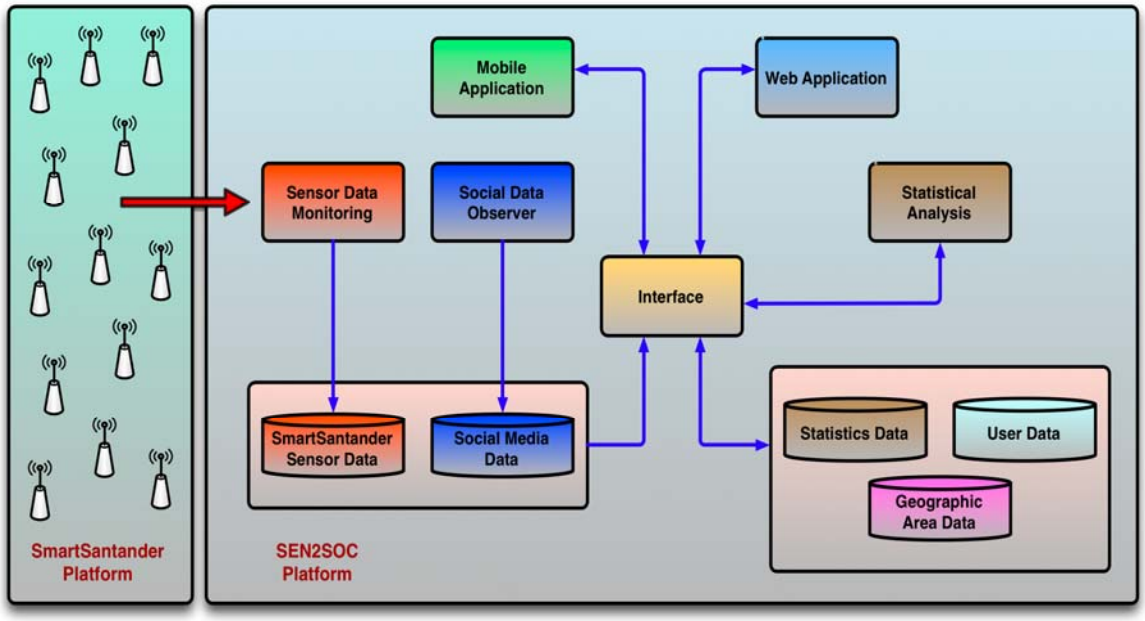

Figure 2. The SEN2SOC Architecture overview

Web Application: for user login; visualization of sensor data and aggregated sensor data; sensor-user data co-analysis results; display of alerts; sensor data anomalies reporting. The Web Application component is the web tool provided to Santander city authorities. It captures various aspects of the envisioned SEN2SOC functionality and visualizes useful information mined out of the analyzed data, such as: sensor data graphs, statistics, alerts and sensor data anomalies, sensor-user data co-analysis results, etc.

The Interface component to form the central point of interaction between the various components of the SEN2SOC architecture. It primarily manages data communication among SEN2SOC components and offers them services to enable SEN2SOC functions. The Interface component implements software interfaces to communicate with other components via an input/output system. Thus, it reduces dependency on implementation specifics and makes SEN2SOC code more reusable.

4.2 SEN2SOC DataStores

SEN2SOC architecture is based on a set of data stores which will be deployed in the SEN2SOC platform along with the information stored therein.

Based on the experiment's needs and tasks there is a need to support the following data stores along with their attributes :

SmartSantander Sensor Data:

• sensor data;

• aggregated sensor data based on geographic areas;

• human "acceptable" environmental condition range;

• alert messages.

User Data:

• user profiles;

• users' authentication data;

• users' approval/disapproval information regarding aggregated sensor measurements;

• information on users' sharing of alerts in social media;

• users' feedback on recommendations.

Social Media Data prioritizes the most city relevant social media and it involves :

• Twitter posts' content;

• Flickr images and related metadata;

• Foursquare POIs and users' visiting information;

• trending topics/places;

• items' (i.e. posts, images) clustering information.

Statistics Data:

• statistical analysis results of sensor and area level measurements;

• sensor data anomalies.

Geographic Area Data:

• boundaries of Santander geographic areas;

• statically and dynamically allocated sensors enclosed in geographic areas (static and mobile sensor nodes)

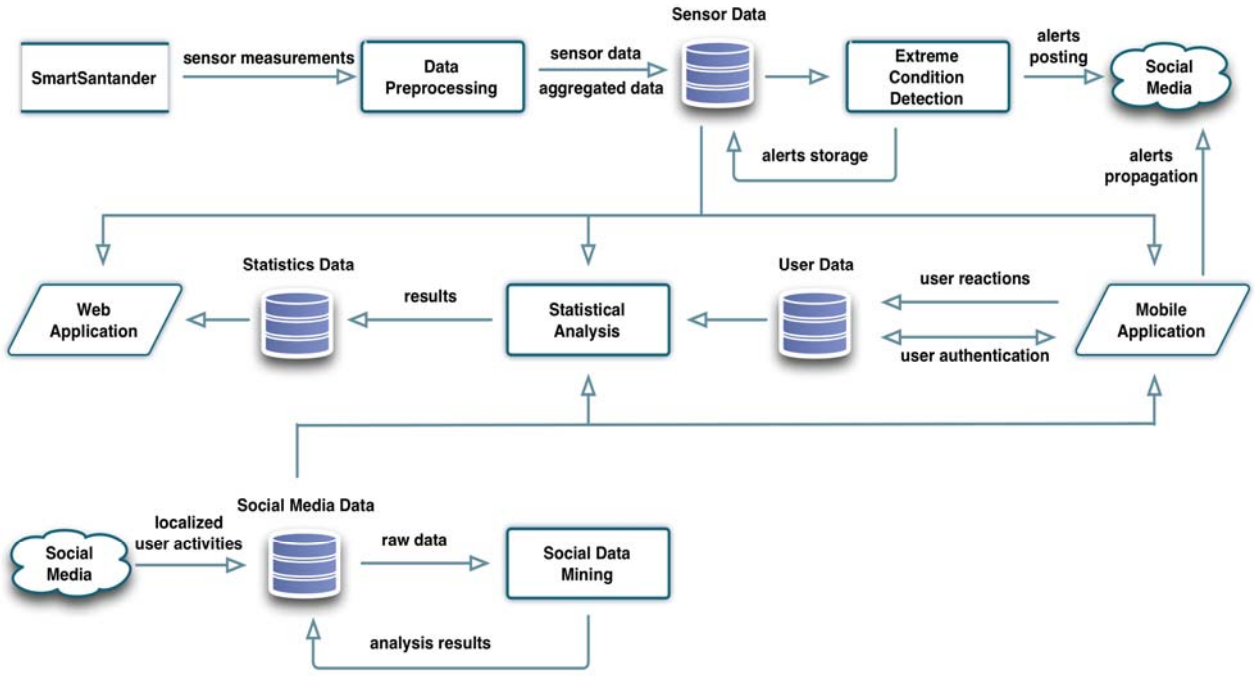

Figure 3. SEN2SOC Control Flow summary

Such a components and data stores selection permits an effective control flow and activities realization as illustrated in Figure 3. This is evident in accordance to the indicative scenarios outlined in Section 3.1 since for each scenario the next proposed components and flows will be followed :

City authorities scenario: utilize the Extreme condition detection along with the Web application components and flows to discover city conditions along with human sensing reporting. To avoid any crowd originated conflicts the social media alert and mining will also offer its analysis results in order to guarantee the Spanish minister's environmental safe route and interactions..

Citizens scenario: utilize the sensor data alerts and the Extreme condition detection to get summaries of sensors' measurements in relevance to humidity, temperature and CO level, and compare this with user reactions in the mobile application setting.

5. SEN2SOC Impact and future adoption

Follow-up activities include the development of a prototype of the SEN2SOC platform. This prototype will test the functionality of the intended SEN2SOC platform design, will support the major functions of SEN2SOC applications, and will serve as the basis for further improvements

SEN2SOC will define new ways of capturing city data from sensors and utilizing collective activities by: i) making recommendations to users, in order to improve their navigation within the urban environment, ii) allowing city authorities to have access to patterns and knowledge mined from city data through user friendly visualization interfaces. SEN2SOC will increase collective awareness for seamlessly communicating sensor data to services oriented to citizens such that city administration and e-governance is improved. SEN2SOC will provide new technology for city authorities for understanding of issues citizens encounter in their real life and of sensor data and comments that citizens provide to initiate handling of these issues. SEN2SOC will provide new technology for coupling such contextualization of issue reporting with data coming from multi-sensors, to draw policies and plans aiming at giving citizen a better understanding of governmental actions and governmental actors increased insight via citizens' collective intelligence.

The SEN2SOC techniques will ensure increased levels of environmental and mobility awareness for decision makers (i.e. city authorities) and shorter feedback cycles among citizens and authorities. Via a web-based application the city authorities will have access to data from sensors and users acting as "sensors" showing the current state in each area of the city with respect to environmental, mobility and users parameters (e.g. user likes and comments). Apart from raw data, city authorities will also have access to historical data and to data mining applications that allow them to analyze data from different perspectives and summarize it into useful information (e.g. mobility problems that persist in specific areas versus those occurring episodically, maybe due to an event). This will result in appropriate policy planning which considers all the location dependent variables (such as noise, temperature and CO levels) and aims to improve living conditions in areas detected as "problematic" which both exhibit over-threshold sensor measurements and constant citizens reports

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