



8th Summer School on Applications of IoT and Wireless and Sensor Networks

Sensors talk and humans sense

Part II

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PRESENTATION OUTLINE

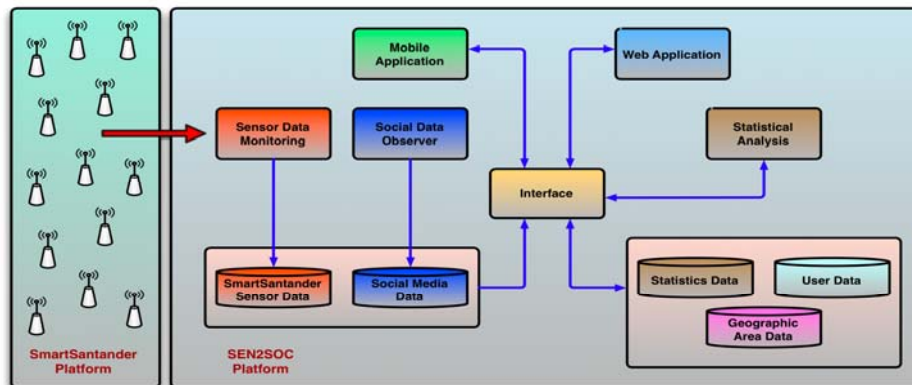
Part II

- SEN2SOC Architecture Specification and Components Design;
- SEN2SOC Data Stores;
- SEN2SOC experiment : setting the requirements;
- control flow diagram of SEN2SOC platform;
- required technologies

SEN2SOC architecture & components

SEN2SOC architecture is component-based with :

- 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.



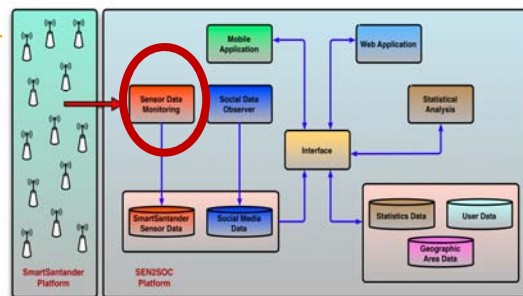
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SEN2SOC basic components (1 of 4)

Sensor Data Monitoring for :

- ✓ sensor data retrieval;
- ✓ sensor data aggregation based on geographic location of sensor nodes;
- ✓ sensor data analysis;
- ✓ alerts generation.

retrieves sensor data from SmartSantander platform and stores it in the respective datastore (SmartSantander Sensor Data).



responsible for generating 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).
- Santander city is divided into a number of geographic areas to support and enable various SEN2SOC functions and services, such as: sensor data visualization, statistical analysis based on geographic areas, route recommendations to mobile users, etc ..
- aggregation of sensor data based on the geographic location of sensor nodes having for each geographic area and sensed environmental parameter an *aggregated sensor value* calculated by the weighted mean of sensor measurements recorded inside this specific geographic area at the given time point.

SEN2SOC basic components (2 of 4)

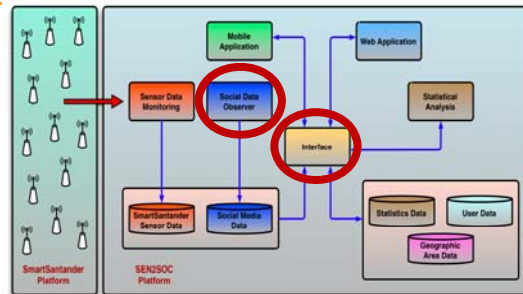
Social Data Observer:

- ✓ geolocated data collection;
- ✓ user-generated content mining.

collects geolocated data (within Santander) and supports UGC mining on various social media networks (Twitter, Flickr or Foursquare).

Relevant geolocated information social media analysis results

Is communicated to the SEN2SOC Mobile Application and Statistical Analysis components.



Interface:

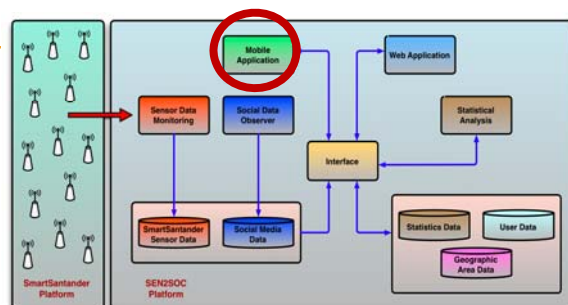
- ✓ service provision;
- ✓ data exchange.

It is the central point of interaction among various SEN2SOC components. It primarily manages data communication among SEN2SOC components and offers them services to enable SEN2SOC functions. Interface component implements software interfaces to communicate via an input/output manner and it reduces dependency on implementation specifics and makes SEN2SOC code more reusable.

SEN2SOC basic components (3 of 4)

Mobile Application:

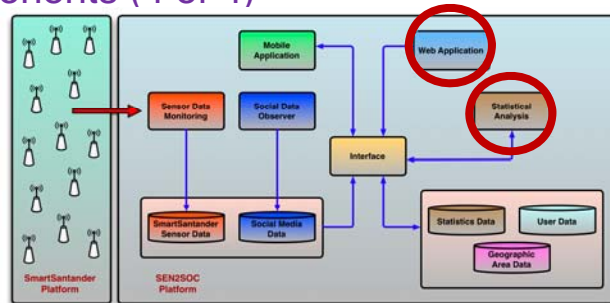
- ✓ user login through social media or SEN2SOC platform authentication;
- ✓ display of alerts regarding extreme sensor measurements;
- ✓ alerts' sharing in social media;
- ✓ sensor measurement-based city map view;
- ✓ social media UGC-based city map view;
- ✓ route recommendations based on sensor measurement information;
- ✓ place recommendations based on social media information;
- ✓ suggestion of areas and POIs to city visitors;
- ✓ cross-parameter navigation directions based on user preferences and profile;
- ✓ user feedback on recommended routes



SEN2SOC basic components (4 of 4)

Statistical Analysis:

- ✓ statistical analysis of sensor data;
- ✓ statistical analysis of aggregated sensor data;
- ✓ sensor-user data co-analysis;
- ✓ analysis of social network user responses on alerts;
- ✓ sensor data anomaly detection.



data processing component to correlate and analyze data coming from various sources, such as: sensor measurements, user feedback data, and social media information. It supports sensor data mining, performs statistical analysis, detects sensor data anomalies, and reports results to the SEN2SOC Web Application.

Web Application:

- ✓ user login;
- ✓ visualization of sensor data and aggregated sensor data;
- ✓ sensor-user data co-analysis results;
- ✓ display of alerts;
- ✓ sensor data anomalies reporting.

web tool provided to Santander city authorities which captures various aspects of the SEN2SOC functionality and visualizes useful information

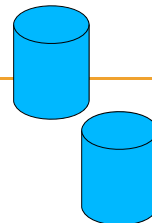
SEN2SOC Data Stores (1 of 2)

SmartSantander Sensor Data:

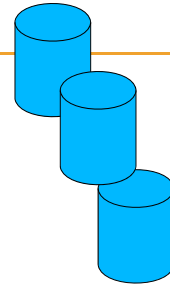
- ✓ sensor data;
- ✓ aggregated sensor data based on geographic areas;
- ✓ human “acceptable” environmental condition range;
- ✓ alert messages.

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.



SEN2SOC Data Stores (2 of 2)



Social Media Data:

- ✓ 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).

SEN2SOC : setting experiment requirements

SEN2SOC experiment requirements are distinguished into functional and non-functional.


For each requirement we identify :


- ✓ its indicative priority;
- ✓ relevant description;
- ✓ comments;
- ✓ list components involved.


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

Requirements topics abbreviation

SEN2SOC requirements prioritization

 **mandatory:** 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:** 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:** 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 requirements examples (1 of 5)

Sensor Data (DAT)

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 applications. Geographic areas will be represented as polygons specified by the geographic coordinates (latitude and longitude) of their vertices.
Indicative Priority:	Mandatory.
Components Involved:	Sensor Data Monitoring.

SEN2SOC requirements examples (2 of 5)

User Recommendations (REC)

Requirement No.:	REC-1
Name:	Route recommendations based on sensor measurement information.
Description:	SEN2SOC mobile application should provide users with route recommendations based on sensor measurement information.
Reason/Comments:	SEN2SOC mobile application will provide navigation directions to users within Santander by suggesting a route from current user location to their target destination via geographic areas with favorable environmental condition(s).
Indicative Priority:	Mandatory.
Components Involved:	Mobile Application.

Requirement No.:	REC-3
Name:	Suggestion of areas and POIs to city visitors.
Description:	SEN2SOC mobile application should suggest areas and POIs to city visitors.
Reason/Comments:	City visitors will be recommended with nearby areas based on the number and/or popularity of the enclosed POIs and current environmental conditions of the respective areas. Suggestion of areas will be accompanied by a summary of the enclosed POIs (e.g., museums, monuments, etc.). This requirement is considered to be desirable and not mandatory, and will address real-time needs of city visitors.
Indicative Priority:	Desirable.
Components Involved:	Mobile Application.

SEN2SOC requirements examples (3 of 5)

Web Application (WEB)

Requirement No.:	WEB-1
Name:	Web application contents.
Description:	SEN2SOC web application should present valuable information to city authorities, such as: sensor data information (current or past), sensor data statistical analysis results, generated alerts, etc.
Reason/Comments:	The web application constitutes required functionality of SEN2SOC platform. It essentially forms a user-friendly web tool that displays present/past SmartSantander sensor and area level measurements and shows relevant statistical analysis information using presentable charts.
Indicative Priority:	Mandatory.
Components Involved:	Web Application, Statistical Analysis, Sensor Data Monitoring.

Users as Sensors (USR)

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. Each qualitative scale will be mapped to the actual range of the given environmental parameter.
Reason/Comments:	This feature is mandatory in order for the SEN2SOC platform to be able 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 and for each environmental parameter type.
Indicative Priority:	Mandatory.
Components Involved:	Mobile Application.

SEN2SOC requirements examples (4 of 5)

Social Media Analysis (SOC)

Requirement No.:	SOC-1
Name:	Social media data collection.
Description:	SEN2SOC platform should collect recent User-Generated Content (UGC) from social media, which will be geolocated within the Santander region.
Reason/Comments:	The collection of social media content is necessary in order to perform analysis and identify popular areas and topics of interest. To support this requirement, focused data collection services will be developed that will leverage the APIs of the corresponding social media applications. The use of the APIs will conform to each application's Terms of Service.
Indicative Priority:	Mandatory.
Components Involved:	Social Data Observer.

Requirement No.:	SOC-2
Name:	Social media analysis.
Description:	SEN2SOC platform should analyze UGC from miscellaneous social networking services. Examples include: recognition of the most popular topics discussed by Santander citizens (Twitter, Flickr); recognition of the most popular areas in Santander (Foursquare, Flickr); detection of clusters of related images or posts (Flickr, Twitter). Since social media content will be analyzed in an aggregated manner, no user privacy concerns will be raised.
Reason/Comments:	SEN2SOC social media analysis will be affected by the available UGC in popular social networks, which will be geolocated within Santander. In other words, social media analysis results are inevitably restricted based on the availability of relevant content.
Indicative Priority:	Mandatory.
Components Involved:	Social Data Observer.

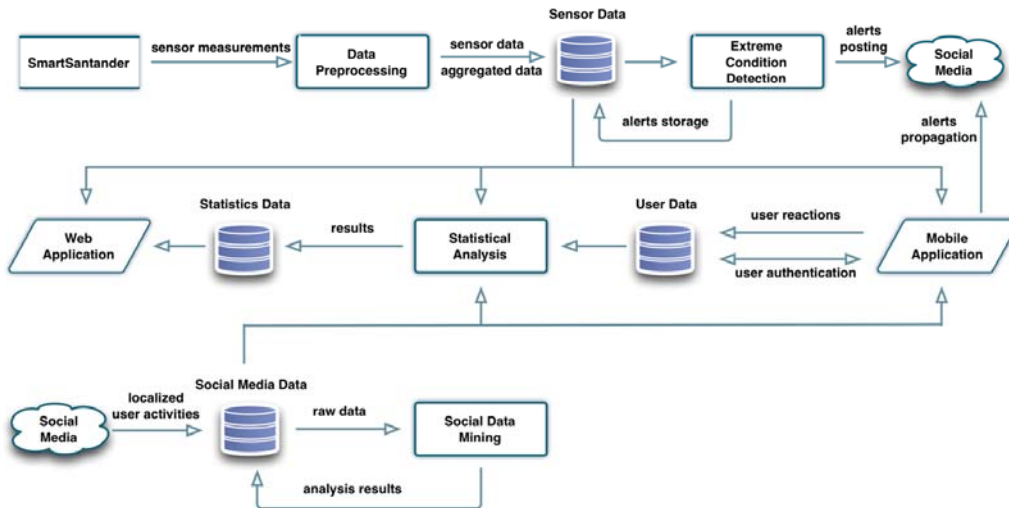
SEN2SOC requirements examples (5 of 5)

Experimentation (EXP)

Requirement No.:	EXP-1
Name:	Evaluation of user satisfaction on recommendations.
Description:	SEN2SOC experiment should estimate user satisfaction on recommendations based on social media and mobile application mechanisms.
Reason/Comments:	User satisfaction on place recommendations could be inferred via suitable social media mechanisms, such as the "Like" button in Facebook and the "Retweet" mechanism in Twitter. User satisfaction on route recommendations could be estimated via a satisfaction scale mechanism embedded in the mobile application.
Indicative Priority:	Mandatory.
Components Involved:	Mobile Application, User Data.

Requirement No.:	EXP-4
Name:	Estimation of user trust.
Description:	Estimation of user trust towards SEN2SOC platform through social media activity.
Reason/Comments:	Whenever extreme environmental conditions are identified by SEN2SOC platform, alert messages will be synthesized and posted to social media. Thus, the trust of users towards SEN2SOC platform could be estimated by measuring the number of alerts broadcasted to social media via the "Retweet" mechanism in Twitter and the "Share" function in Facebook.
Indicative Priority:	Desirable.
Components Involved:	Social Data Observer.

SEN2SOC experiment control flow



SEN2SOC required technologies

Technology	Usage
PostgreSQL	Sensor data storage, aggregated sensor data storage, spatial queries.
MySQL	Statistical analysis results storage.
MongoDB	Social media analytics repository.
Slim Framework	PHP micro framework for the SEN2SOC interface component.
Apache HTTP Server	SEN2SOC interface component, web application.
PHP	Service provision and data exchange.
Java	Social media data collection and analysis.
Python	Social media data collection and analysis.
JSON	Data interchange.
PhoneGap	Cross-platform mobile development framework for the mobile application.
HTML5, CSS3, JavaScript, jQuery Mobile	Web application, mobile application.
R programming language	Statistical analysis and visualization.
Third-party APIs	Social media APIs (e.g., Twitter, Facebook, Foursquare, Flickr) and Google Maps API for the connectivity with social media applications, and the presentation of information on the mobile and web applications.