Cooperative Smart Objects in IoT Infrastructures for Context-Aware applications

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Introduction

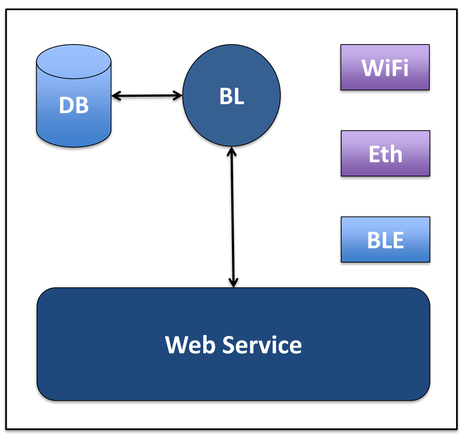
Over the last years, researchers have shown a great interest in Internet of Things (IoT). The work done during the last year focuses on cooperative smart objects in IoT infrastructures that exploit technologies such as Bluetooth Low Energy (BLE). BLE enriches smart objects with new interesting features, for example, can make them discoverable enabling users to exploit their presence through a simple smartphone. This process works also in the other way: each smartphone can act as BLE Advertiser, enabling other smart objects to discover it. Proposed approaches have been designed to be implemented on several fields such as those related to Smart Parking, Smart Home, and Smart City scenarios.

Proximity-based Smart Objects discovery

The proposed system implements a proximity-based discovery for smart objects. A user can discover the nearest smart objects located in the environment in which he is immersed. After the discovery phase, a peer to peer communication among smart objects and users is established. This process is not centralised: there is no need for an entity to manage smart objects since each of them holds the information about its features in a database.

Each smart object is visible within the environment through the BLE technology and it is organized as a RESTful Web Service that exposes methods to configure and exploit its functionalities. Smart objects provide a semantic description of their functionalities described in N3 language and a syntactic description in the Swagger format. When a user is surrounded by smart objects, he can select an action (e.g., increase the luminosity) by using a specific smartphone application. Smart objects nearby the user are discovered by using BLE technology and provide their functionality descriptions through a N3 file.

The Semantic Reasoner processes the N3 files and selects the smart objects able to accomplish the action required by the user. The application implements an automatic mechanism to choose a smart object among the ones selected by the Semantic Reasoner. However, the user can directly interact with available smart objects that provide a useful functionality to complete the required action. User preferences are stored to simplify the execution of future requests through the same smart objects. Each smart object needs some modules to interact with the smart environment. BLE module are required to interact with other IoT entities, while WiFi and/or Ethernet interfaces are required to connect the objects to the network.

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@prefix funcs: <http://example.org/funcs#>.
@prefix foaf: <http://xmlns.com/foaf/0.1/>.

obj:SmartObject obj:Provide funcs:open-window.
obj:SmartObject obj:Provide funcs:close-window.
obj:SmartObject obj:Provide funcs:on-lights.
obj:SmartObject obj:Provide funcs:off-lights.

data:@prefix obj: <http://example.org/objs#>.
@prefix funcs: <http://example.org/funcs#>.
@prefix foaf: <http://xmlns.com/foaf/0.1/>.
{
        ?someone foaf:knows obj:SmartObject.
}
=>
{
        ?someone obj:Provide funcs:open-window.
        ?someone obj:Provide funcs:close-window.
        ?someone obj:Provide funcs:on-lights.
        ?someone obj:Provide funcs:off-lights.
}.
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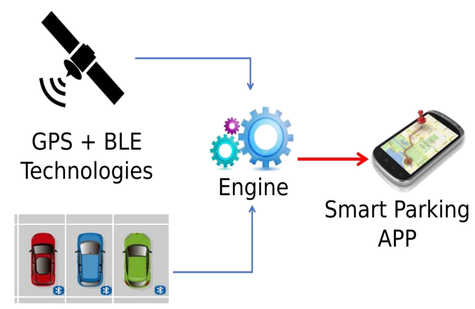
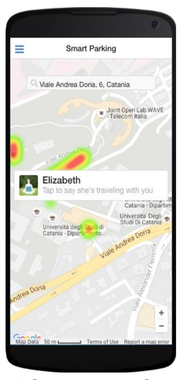
A Context-Aware Smart Parking System

This system helps users to reach a free parking slot, in a small area or a city, using context-aware information. The approach does not require an existing infrastructure of sensors spread in parking areas. A prototypical application to collect user contextual information and display mapped parking areas has been developed.





A mechanism based on BLE Advertising is adopted to detect passengers. Furthermore, once the user starts driving, the application starts retrieving GPS position at regular intervals sending them to a remote server which builds a path joining all user GPS points received from the application until the destination is reached. These paths are compared through an algorithm that checks their similarity in order to estimate the number of parking slots still available.

The application shows parking areas near the user's position or interesting and visited locations. The color of the area represents the probability to find a free slot parking. The green color indicates a large probability to find a free parking. The red color highlights a very busy parking area. The yellow and orange represent the middle way between a full and a free parking area.

Bus as a Sensor: a Mobile Sensor Nodes Network for the Air Quality Monitoring

The Bus as a Sensor (BaaS) project intends to support the Catania Municipality with a Multi-Sided solution that acts as a Decision Support System and instrument able to simplify the exploitation of services ensured by the city. Despite the traditional air quality monitoring system based on static stations, the BaaS exploits a network of sensor nodes fixed on public buses of Catania transport company. Thus, BaaS is able to provide information with a high temporal and spatial resolution map, while the coverage of the network dynamically changes over time, generating a solid snapshot of the air pollution current state at a specific time. The BaaS architecture is composed by four layers: the Sensor Node Layer, the Platform Layer, the Middleware Layer, and the Application Layer. This proposal was implemented at a first stage using simulated data. In addition a real trial on field within the University campus has been carried out. Next steps will include the deployment of this solution within Catania and to introduce new smart city services based on the actual acquired data