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# Monitoring and Prevention the Smart Cities

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***Abstract*- Nowadays, the intensive use of Technology Information (TI) provide solutions to problems of the high population density, energy conservation and cities management. This produces a newest concept of the city, Smart City. But the inclusion of TI in the city brings associated new problems, specifically the generation of electromagnetic fields from the available and new technological infrastructures installed in the city that did not exist before. This new scenario produces a negative effect on a particular group of the society, as are the group of persons with electromagnetic hypersensitivity pathology. In this work we propose a system that would allow you to detect and prevent the continuous exposure to such electromagnetic fields, without the need to include more devices or infrastructure which would only worsen these effects. Through the use of the architecture itself and Smart City services, it is possible to infer the necessary knowledge to know the situation of the EMF radiation and thus allow users to avoid the areas of greatest conflict. This knowledge, not only allows us to get EMF current map of the city, but also allows you to generate predictions and detect future risk situations.**

***Index terms* - *Smart City, electromagnetic radiation (EMR), sensor system, electromagnetic hypersensitivity (EMS), electro-sensitivity (ES), monitoring, detection, risk, internet of things, human***

## I. Introduction

The Smart City concept has received multiple definitions and meanings throughout its existence, and based on the optics from which we analysed: economic, technological, social, or generalist. From the late 90's there have been proposals of all kinds, but always focused on taking advantage of the solutions it (Technology Information) for the benefit of the citizen, and therefore of the city, and its sustainability. Each community or city is unique and singular, establish the concept Smart at all levels is an extremely difficult task, because each of them has a depends on the policies, objectives, goals and funding, and applies not only to have the necessary resources, but also of the qualifications of the professionals and users and a complete synergy of all these elements to achieve the success of the 'smartification' called by [5, 6]. This is not a process limited in time, with a start and end date, but a constantly evolving sustainable over time, because Smart City is not an objective is a way of life, a means, a continuous improvement process is evolving constantly to improve the quality of life and social cohesion of the city in which to do this must take precedence over the commitment between the technology and the actors.

Speaking of systems developed in the Smart Cities under the range of TI in the present moment is not only talk about computers, mobile devices, sensors, interconnection networks, visors, etc… is to talk about new concepts and paradigms socio-technological as:

- Internet of Things (IOT)
- Cloud Computing
- M2M
- Big Data
- Home and building Automation
- Augmented reality and vision artificial
- Intelligent agents
- Semantic networks (Web 3.0)


Figure 1: influence IoT area for hypersensitive people

Nevertheless, the technology used (see Fig.1) is capable of generating a complex combination of weak electric and magnetic fields, also called electro pollution, that normally do not affect the majority of the population but there is a collective of people, according to studies by [7, 8, 17], which is affected by this exposure studied by [18, 19, 20], presenting symptoms such as headaches, memory loss, sleep disorder, blurred vision, nausea, or fatigue. It has been suggested that exposure to magnetic fields at power frequencies (50/60 Hz), that is to say, *extremely low frequency* (ELF), could lead to an increased incidence of cancer in children and other adverse health effects. The evidence comes mainly from epidemiological studies in residential areas. These studies suggest that there is a partnership between children's exposure to ELF magnetic fields and the increased risk of leukemia [9].

*Electromagnetic fields* (EMF) are characterized by its wavelength or frequency in a radio-active or two categories (Table 1 illustrates the features of each one of them):

- Non-ionizing: low level of radiation which generally sees the human being but without causing serious injuries.
- Ionizing: can alter the DNA due to their potency.

TABLE I
CLASSIFICATION OF ELECTROMAGNETIC FIELDS. (SOURCE [10])

| Definition | Forms of radiation | Examples |
|---|---|---|
| **Non-Ionizing** *Low to mid frequency, which is generally perceived as harmless due to its lack of potency* | Extremely Low Frequency (ELF) Radio Frequency(RF) Microwaves Visual Light | Extremely Low Frequency (ELF) Radio Frequency(RF) Microwaves Visual Light |
| **Ionizing** *Mid to high frequency radiation which can, under certain circumstances, lead to cellular and DNA damage with prolonged exposure* | Ultraviolet(UV) X-Rays Gamma | Ultraviolet Light X-ray range between 30 * 1016 * 30 Hz to 1019 Hz Some Gamma Rays |

The concept of Smart City allows us to have access to a large volume of data generated by the various types of technological resources in real time, processing them, and developing new analytical tools for a great value to help this group of persons hypersensitive.

To meet the new challenges in the Smart Cities arises the need for control panels or applications, through which users or citizens, with some type of hypersensitivity to this type of radiation, to have information in real time and deferred of the levels of EMF as the zone where people move, to try to avoid its prolonged exposure. There are proposals in which deals with the measurement of EMF for monitoring such as those of Urbinello [11] or Huss [12], but suffer from the fact that require the installation of new measurement devices or Smart Meters that further enhance the magnitude of the EMF radiation.

In order to give a solution to this problem, this work provides a monitoring and in-formation system which allow us to measure the electromagnetic radiation level in buildings and cities, allowing its use in both real-time and deferred. This system will allow you to use a smartphone by way of such tool that allows us to define an alert level to inform users of the proximity of the antennas and the levels of radiation that can generate, advising as well to the users of the possibility of being affected by this radiation, this tool will serve as a basis for future lines of development which may be incorporated into the tool to other risk factors based on the monitored data and even the generation of predictive models based on the existing historical data.

## II. PROPOSAL: SMART SYSTEM SENTINEL EMF

The system that we present what we have called Smart Sentinel: monitoring of risks system in Smart Cities, and in particular we are going to focus on the Non-ionizing EMF fields generated by the different electrical and electronic devices existing anywhere.

We propose a system for process, analyze, monitor and generate scorecards in real time and deferred, in which the user may display the radiation levels caused by the non-ionizing EMF fields in any area where there is a smart infrastructure. With this approach the users will be able to avoid prolonged exposure in certain areas, as to day of today do not have that knowledge, and alleviate the symptoms produced by electromagnetic hypersensitivity.

To achieve the objective of our proposal we relied on Smart City generic architectural view defined by levels as proposed in [9].

Smart Sentinel System acts as a layer to cross all the levels defined in a Smart City architecture (see figure 2 and figure 3). This layer is fed by all the levels defined in it, from the level of monitoring in which you specify all the sensors and electronic devices and infrastructure, the level of business where we will store and we will process the data obtained in the previous level, the level of implementation where we will generate value-added resources such as web applications, standalone and mobile apps, and the level of communications which will allow you to get to know the infrastructure of internetworking, our aim is to be able to have all the necessary information about the technical characteristics of all the devices, the data recorded by each of them, the data and use of radiation emitted at each moment and the geographical positions, in order to process and analyze the information and offer services to users and systems or devices that can consume the type of information that we provide.

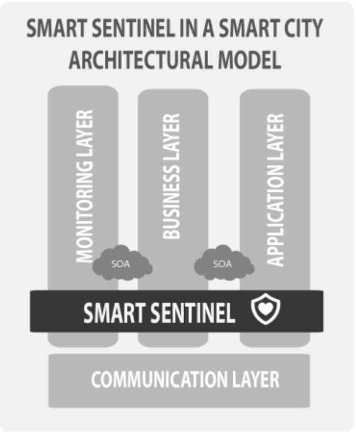


Figure 2. Smart System Sentinel on Smart City architecture

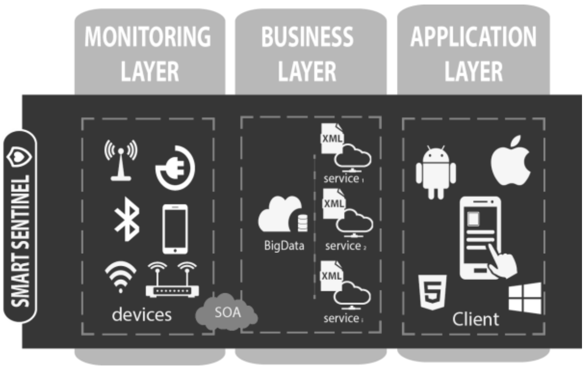


Figure 3. Smart System Sentinel internal level on Smart City architecture

At the internal level Smart Sentinel System makes use of all information generated by all levels of the Smart City architecture making intensive use of the level of business, this level will be responsible for generating the information in web services.

### A. Monitoring Level

In this level we use sensors, wireless systems, internetworking devices and electrical networks, which receive and transmit information and energy respectively for the environment in which have been integrated. The following devices are included in the list: smartphones, handhelds, and tablets that are connected via wifi and make use of the network. These two sets of devices provide us the information by which we are going to perform the implementation of our system.

The wireless systems employees are able to provide real time information about connections made and the level of data issued by each one of them, have a *Service-oriented architecture* (SOA) Services that feed information to business level for the subsequent analysis of the data proposed by [15]. By the electrical networks we know information on the purchases made in real time, the infrastructure deployed throughout the area and the power handling. As we have explained in section 1, which describes the state of the art, these technologies are basically M2M and services are available to interact with the business layer. As we have said before in the preceding section, we don't employ an external measurement devices such as Smart Meters, already they would add a higher rate of radiation in the Smart City and therefore harmful to the user.

### B. Business Level

This level is responsible for collecting, standardizing, process, store, analyze isolated data and massive and transform them into useful information in addition under the paradigm of service, and provide services that provide interoperability, integration, expandability and compatibility between layers. A part of the data provided by sensors, wireless devices, and internetworking devices, this layer will have other detailed information such as: the technical sheets of all types of devices (density of emitted power, range expansion of the signal, channels, gain, sensitivity of the receptors, operating temperature, among others) and historical information about power consumed.

With all this information and storage systems and analysis can be employed as relational database management system (RDBMS), Data Mining, Data Warehouse, Big Data, we can generate information and offer it through the SOA paradigm to the clients or devices who want to make use of it.

For the distribution of data and services and applications, you can use the cloud as a common platform for data management and distribution as proposed by Armbrust in [13] or Buyya in [14].

Figure 4. Smart Meter

### C. Application Level

Through the development of applications for all types of devices such as smartphones, tablet, and desktop, the user will be able to dispose of information in real-time, historical or deferred about electromagnetic radiation and the areas with the greatest influx according to the need for it, because that will be able to make use of historical data for the generation of more reliable statistics and build predictive models.

The application layer will provide information about the status of a given area and, through a system of reminders, will offer the information to user if you are coming to the spaces with the highest rate of radiation. This application can work in online mode, but also in offline mode, for those users who are unable to make use of the data connection at all times because of their hypersensitivity, down-loading all the data needed to display the maps EMF.

This layer combines information from different sources to provide a greater level of detail, such as:

- Network Connections of networking devices
- Sheet of technical characteristics of each device
- Network Connections for smartphones, tablets and pc
- Electrical Connections in different locations
- Historical connections and electrical consumption

- Drivers of consumption of the devices themselves

For the distribution of data and services and applications, you can use the cloud as a common platform for data management and distribution.

### *D. Communications Level*

As mentioned above, the support of this level to our proposal is crucial, as it will sup-port services transactions that are generated by the services layer. At this level makes use of interconnect systems equipment and internetworking.

## III. PROTOTYPE

In order to test our system we have developed an application for Android devices. This application makes use of the service in real-time geolocation of the mobile de-vice, or in offline mode if you want to, and the Google API to provide information about the index of radiation to which you are subject, both inside and outside of the area. In this case a simulation has been made in the facilities of the General Library of the University of Alicante, which has a large amount of wireless devices, servers, routers, and electrical panels in certain areas of the same.

### *A. Characteristics of the information*

To provide actual data to users, we have used the information provided by each of the devices on which we rely to generate our maps of EMF radiation in our proto-type. We can distinguish two different types of sources of information:

**Data streaming**

- *Wireless access points*: for these types of devices we get existing connections in every instant in the wireless nodes, MAC, IP, or the name of the connected device. These data are obtained by the level of business and, after its convenient processing, services are offered through the level of application
- *Processing devices*: the services of business level are responsible for monitoring devices that are active on our system, such as routers, application servers, storage servers, information panels and in general all those devices that are part of the infrastructure to provide an estimate of areas with EMF radiation due to consumption of these devices.

**Stored Data**

- *Technical Information*: in the level of business will incorporate the technical information on the infrastructure and devices that are part of the facilities to be monitored, as can be routers, antennas, electrical panels, lighting, electrical lines, network wiring and in general any other electronic device.
- *Consumption data*: by the providers of services are obtained information concerning the global electrical consumption, peaks of electrical consumption, consumption by building and consumption of telecommunications network.

It should be noted that the devices connected to the data network can be monitored from the level of business, at least to know if it is active or not. This we know, for example, how many of the computers inventoried in the field of control (for ex-ample the University of Alicante) are consuming resources and issuing EMF radiation

### *B. Viewing the information*

The application is composed of two display modes of the commented previously information. A spatial mode in which we can combine all the information on the different types of data to give a vision to the user of the space that surrounds him and the EMF influence in your environment, and other display in meter mode that provides a simplified view of the EMF level of the current geographic location.

In the spatial mode of display we inform the user of the areas of radiation in the location in which it is situated. Shown here is a map, using the Google API, which highlights the user's current location and placed various elements that produce influence EMF in addition to various levels. One of the most important elements are the nodes of wireless access, in figure 5 we can see the representation of the wireless access points around the user that is currently in the general library of the UA campus.


Figure 5. Spatial Mode

Each of these nodes is represented by an area of influence that takes a color more or less intense depending on the signal from the antenna, the number of Wi-Fi connections that are enduring that node and the activity of the device itself.

On this map are formed by juxtaposing the different elements that produce the risk that we are being monitored, in addition to nodes of Wi-Fi access, also shows the electrical devices, areas of transformers, electrical consumption of a building, and the processing devices such as routers and servers. In figure 6a we can see a complete representation of all the elements of influence EMF that the application collects, along with the current position of the user, in this way through the greater or lesser intensity of the color that represents the EMF radiation a user can have an idea of which areas are potentially dangerous for and therefore should be avoided, also this figure represents the streaming mode of the application, which displays the data in real time.


(a) (b)

Figure. 6. (a) Streaming Mode (b) Offline Mode

In figure 7 we can visualize the configuration screen of the application, which allows us to mark items we want to represent on the map.

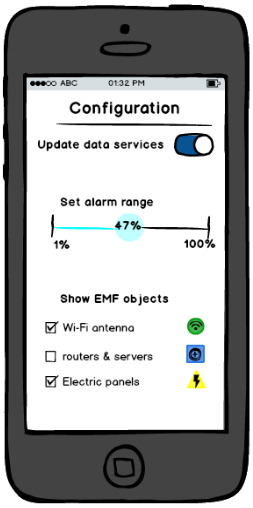


Figure. 7. Setup Mode

The application enables us to operate in offline mode or deferred (see figure 6b). This mode does not perform any data update and does not receive data from the streaming services, i.e. does not display data of incidence EMF in real time. When the application is in this mode, the map does not update the elements whose information depend on this service of streaming data, such as the signal strength of the wireless access nodes, or just stop render if we have no information about them. Only shows the data received in your last connection and static data tab as technical and historical data of the devices that emit EMF. In the lower left area of the screen we can see the map legend of EMF radiation, which has a scale of colors ranging from the 1, minor radiation index, to 100, area of greatest impact (see figure 8).


Figure. 8. Legend and radiation index scale

In the lower area of the screen we can see the position of the user in coordinates along with the value of EMF radiation in that position, which has a scale of values ranging from 1 (min), less radiation index, to 100 (max), area of greatest impact (see figure 8).

In **Meter mode** the application Smart Sentinel will allow us to inform the user of the index of EMF radiation in its current location. It has an alert mode, see left side of figure 9a, which prompts you through a red button (see figure 9b), if you have exceeded the limits indicated in the configuration of smart alarms Sentinel.

(a) (b)

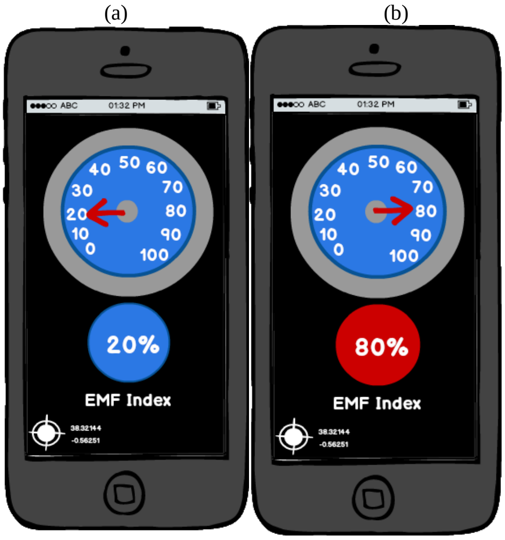


Figure 9. (a) Meter Mode without alarm.
(b) Meter Mode with alarm

The alert level is customizable via the configuration screen that has been seen in figure 8, thereby the user to set the maximum level of radiation in which he wants to be contacted depending on your tolerance. In addition to the two display modes shown, there is also an area of customization and configuration as we have seen in the figure 7, and information display (figure 10) where are identified the items represented in the application.

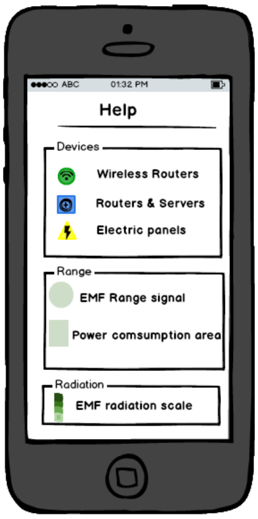


Figure. 10. Help Screen

## IV.CONCLUSION AND FUTURE WORK

The proposed system has a principal characteristic monitoring and reporting the index of electromagnetic radiation in the Smart Cities in real or offline time, that's originates by the intensive use of networking TI devices that affect a set of citizens that suffer from the symptoms of hypersensitivity.

This system complements to those defined by Urbinello [9] or Huss [10] with the economic characteristic main that do not require the Smart Meters installation for your condition, which increases the amount of EMF registered in electromagnetic space.

The system is capable of adding new elements of risk for the population, such as indices could be pollution, pollen, noise or environmental factors that affect a particular society as a whole.

We are currently working on the prototyping of systems using all the information stored to generate predictive models (for example as do meteorological models), to facilitate not only monitoring but also being able to predict the occurrence of these risk factors in the areas of interest to users, thus generating future preventive tools.

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