REAL-TIME DISTRIBUTED MONITORING OF ELECTROMAGNETIC POLLUTION IN URBAN ENVIRONMENTS

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1. INTRODUCTION

In the last two decades, the wide diffusion of mobile phones and wireless technologies have brought many advantages in professional activities as well as in everyday life [1]-[3]. In general, mobile telecommunication networks are constituted by a limited number of base stations (BSs) to which mobile terminals connect for data exchange. In order to provide a suitable quality of service (QoS), BSs have to be properly located such that the network coverage is uniform in the area of interest. Towards this end, the position of BSs is usually determined by taking into account the complexity of the scenario at hand through theoretical or empirical models. Unfortunately, because of the costs and the complexity of urban areas, the location of the BSs cannot be chosen in an optimal fashion. As a consequence, the spatial distribution of the radiated field turns out to be non-uniform with variations both in time and space that can exceed the normative limits of electromagnetic emissions. In order to assess the compliance of the BS coverage to the normative limits, communications authorities usually release a test certificate after the installation. Unfortunately, because of the need of highly-trained staff and due to the cost of the hardware measurement instrumentation, the coverage variation as well as the radiation levels are not generally monitored.

In order to real-time and in a long term monitor the electromagnetic emissions, an innovative real-time and low cost solution based on a wireless sensor network (WSN) [4] is presented in this paper. A WSN is a network consisting of spatially distributed autonomous low-power and low-cost devices (called "nodes") wireless connected that use suitable sensor to cooperatively collect physical quantities of interest for monitoring and control purposes. The proposed solution considers the deployment of a set of WSN nodes, equipped with a broadband field probe, to monitor the level of the electromagnetic radiation in a distributed and real-time fashion.

2. ARCHITECTURE OF THE NETWORK

The system is composed by a set of N sensor nodes, each one equipped with a broadband field probe, and a gateway node connected to a PC via serial interface. According to the schema displayed in Fig. 1, the field values are measured by an isotropic antenna of three crossed dipoles. The voltage signal related to the field sample is acquired by means of the I/O interface and converted into a digital quantity with the analog-to-digital converter (ADC) of the central unit. Such a unit is provided with a microcontroller (μC), a memory, and a radio device (RF) to transmit data to the gateway. As regards to the measurement procedure, each node acts in three different states: (*a*) stand-by, (*b*) field measurement, and (*c*) data transmission. In the state (*a*), the idle configuration or sleep mode is activated and the power consumption is minimized. After a wake-up signal, the data collection is performed by means of the broadband field probe [state (*b*)]. In such a state, the radio of the sensor node is turned off in order to limit/avoid the interferences on the field measurements. After the field measurement and digital conversion, the field probe is switched off [state (*c*)] and data are transmitted to the gateway node through the radio interface. The gateway unit is connected to a server station and the informations concerned with the electromagnetic emissions are then published on a web page to allow a real-time consultation.

As regards to the WSN architecture, the nodes can be organized either according to a star topology or a mesh network. In the first case, the gateway node act as a master node and it receives the messages from the sensor nodes. Such an architecture is simple, robust, and does not need complex routing protocols. Moreover, star networks seem to be quite effective for BS monitoring applications, since the nodes can be deployed around the electromagnetic source. On the contrary, mesh topologies are suitable to monitor larger areas, where the location of the electromagnetic sources are unknown. However, a synchronization is necessary to avoid data transmissions during the measurement phases.

3. PRELIMINARY VALIDATION

In order to preliminary assess the effectiveness of the proposed solution, $N = 5$ sensor nodes have been deployed in a star topology around a GSM BS located in an urban environment. Figures 2 shows a prototype of the sensor node. The central unit consists of the TinyNode 584[1] unit operating at 866 *MHz* and the working frequency band of the field probe goes from 100 *MHz* up to 2 *GHz*. Such a probe is interrogated every $\Delta t = 10$ *min* by the central unit in order to read a voltage signal that is proportional to the root mean square (RMS) value of the electric field.

As regards to the main features of the system, the proposed implementation is effective in terms of power consumption [0.1 *mA* in the state (*a*), about 10 *mA* in the state (*b*) and 50 *mA* in the state (*c*), being 100 *ms* the average duration of the phases (*b*) and (*c*)]. Moreover, in addition to the informations concerned with the electromagnetic emissions, the web page also reports the status of the battery and the quality of the wireless link of each node (Fig. 3). In the preliminary validation, the system proved to be robust, easy to carry on and easy to install. However, a further analysis is certainly needed to thoroughly assess potentialities and limitations of the WSN-based measurement setup.

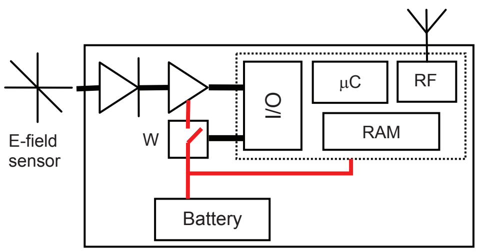

Figure 1 – Block diagram of a sensor node

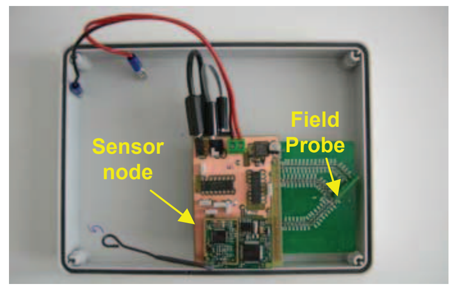

Figure 2 – Prototype of a sensor node

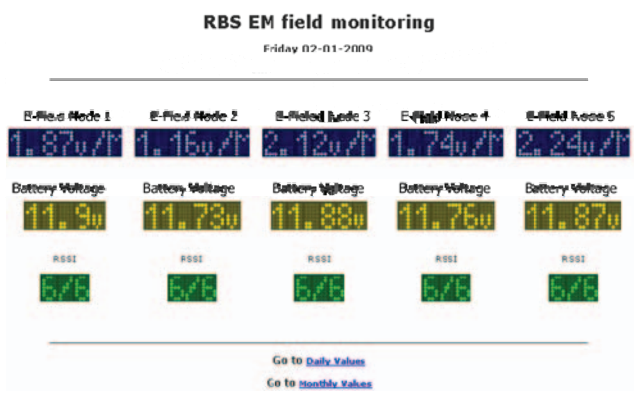

Figure 3 – Screenshot of the webpage reporting the informations about the electromagnetic emissions.

4. REFERENCES

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[1] http://www.tinynode.com/index.php?id=104