

New Architecture Model for Measuring Dynamic Changes of EMF Strength Levels Using Smart Dust motes

First Kemal Hajdarevic, Second Colin Pattinson, and Third Jasmin Hadzigrabic

Abstract – Devices and appliances such as transformers, mobile phones and GSM antennas, or electro motors, produce, electromagnetic fields (EMF) around them during their operation. According to an International Commission on Non-Ionizing Radiation Protection (ICNIRP) levels above 2000 milligauss (mG) or 200 microtesla (μ T) for occupants in general premises are considered as dangerous for human health. While this is international standard, national standards have different acceptable value levels of EMF strengths around devices and antennas. Scientists from 1979 are trying to prove connection between serious health risk and EMF. The European Council and World Health Organization (WHO) in the May of 2011 changed their policies related to EMF and health risk. Before this policy change in May 2011, the WHO had assured public that no adverse health effects can be established with radio frequency electromagnetic fields. In this paper the health risk of EMF is not proven, and that was not an intention in this paper. Our concerns are EMF strength levels around devices and appliances and more specifically GSM antennas, and how strength levels can be monitored and controlled dynamically because of new knowledge by which EMF is connected to health risk. This paper presents new architecture model for collecting data about EMF strengths levels around devices and antennas which radiate EMF in dynamic manner using smart dust technology.

I. INTRODUCTION

ELECTROMAGNETIC field is the area around a magnetic body or a current-carrying body as defined in Webster's dictionary [1]. Concerns about EMF and potential health risk issue raised epidemiologist Dr Nancy Wertheimer and electrical engineer Ed Leeper in 1979 in their scientific paper [2]. This issue became more important in recent time because of huge number of mobile phone users and wide spread GSM mobile antennas which serves these mobile phone users and which radiate EMF [3], [4]. Other equipment such as wireless access points, electric cars [15], [18], [19] and general access points can saturate living and working environment [29] by EMF.

GSM antennas as a EMF radiation sources can be close to or installed on occupants buildings, close to schools, hotel premises (Figure 1. Antenna in the white circle) and even kindergartens in some countries. Number of subscribers of the mobile phone service is increasing and it is decided by The European Council not to wait for high levels of scientific and clinical proof because it can lead to very high health and economic costs what is one of conclusions in The European Council resolution from 6 May 2011 [28]. Title of announced European Council's resolution is "The potential dangers of

electromagnetic fields and their effect on the environment" [28].



Figure 1. GSM antenna installed on hotel premises

As another step to reduce human exposure to EMF from radio frequency World Health Organization (WHO) the same month (31st May 2011) announced [27] that they classified radio frequency electromagnetic fields as possible carcinogenic to humans.

Before this, WHO had assured that no adverse health effects can be established with radio frequency electromagnetic fields. To adequately tackle issue with EMF health risks our idea is to propose new architecture model for dynamic measuring EMF strength levels around EMF sources. These measurements will be performed by using Smart Dust motes equipped with EMF sensors. Smart Dust network is composed of tiny sensor called motes which are able to collect sensor data and to communicate with each other with a goal to transfer collected data.

II. RATIONALE FOR PROPOSING NEW ARCHITECTURE MODEL FOR MEASURING EMF STRENGTH LEVELS

In the reports [4], [5], and [6], it is claimed that there is a risk of EMF created by 50 / 60 Hz power usage and in reports by WHO [27] and European Council [28]. Specific surroundings can be already saturated by EMF as a result of close proximity GSM antennas or power stations and cables to homes, offices, and schools. Main goal for GSM operators is to provide reliable service to their users. To achieve this they are trying to place their antennas closer to the users of the GSM services. This is

usually close to living areas what became issue to consider in recent years because of potential lawsuits against GSM operators who placed they GSM antennas close to living areas. One case from France was subject of public court arbitration from 2009 [7].

Electromagnetic field (EMF) strength is measured in Tesla (T) or in gauss (G) [9]. Special publication edition of The International Commission on Non-Ionizing Radiation Protection (ICNIRP) with name: “Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields” [8] reveals that acceptable levels of EMF strength which does not impact human health is below 200 microtesla (μT) (2000 miligauss (mG)) limit for general, and 1000 μT (10000 mG) for occupational exposure. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) [10] proposed as safe level for general exposure is less than 1000 mG and less than 5000 mG for occupational exposure. Defined EMF safe levels according to ICNIRP and ARPANSA are presented in Figure 2. below.

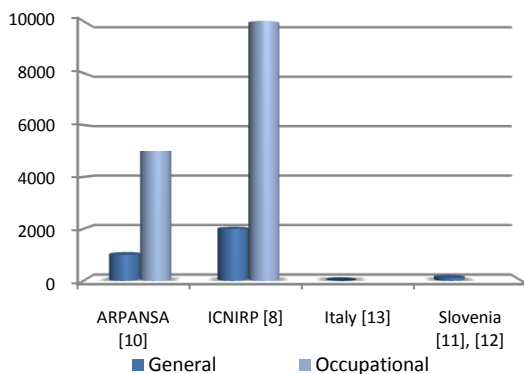


Figure 2. ICNIRP and ARPANSA EMF strength limits

Above defined safe levels by ICNIRP and ARPANSA presented in Figure 2 are not considered as general standard in all countries, because different countries have different acceptable strength levels of EMF. Different countries have their own regulative rules what is presented in report [8]. Unsafe EMF strength level in Slovenia is above 100 mG [11], [12] while in Switzerland is 1000 mG (operational premises) and 10 mG (children’s playgrounds) [11]. Legal binding in three regions in Italy is limited EMF exposure to 0,2 μT (2mG) [13].

As it is shown different countries have they own acceptable levels of EMF different for the one defined by ICNIRP and ARPANSA. As a result of constant scientists results reports WHO changed policy regarding EMF exposure. Research results reported by the National Cancer Institute [14] shows that EMF strength values above or 4 mG could increase risk for human health, more specifically risk for cancer [15]. In work reported by Adam et al. [15] a limit below 2 mG is taken as the threshold for safe exposure based on research results [13], [16]. ARPANSA [10] argued that it is not possible to be sure about risk of EMF and in the same report it is stated that cigarette smokers have 10 to 30 times the risk (relative risk) of contracting lung cancer as do non-smokers and not everyone who is exposed will get cancer. This ARPANSA report shows that the risk factor

for EMF exposure is 3 (where 5 represents high risk factor for cause of cancers) [11]. Because of increased number of mobile phone subscribers and new scientific results, IEEE in 2010 announced, a revision of the standard covering human exposure to electric, magnetic and electromagnetic fields of frequency between 3 kHz and 300 GHz [17]. This frequency range is in scientists focus because of the wide spread usage of mobile phone users and wide spread cell towers in urban surroundings.

In upcoming years protection against potential EMF health risk will become more important because of scientific reports and European Council and WHO reports referenced above too. Our living and working environments can be saturated by the EMF [29] and it can be concluded that monitoring of EMF with lower frequencies (50 / 60 Hz) will be in the focus [31]. Interest in healthier living becoming more important in other areas of living because of media reports [18] which reveals growing concerns for drivers of hybrid cars where batteries and power cables in hybrids are often placed close to the driver and passengers [15], [18], [19], [20] what can lead to health risks.

In official international organisations reports magnetic field density or EMF should not exceed a limit value of 1000 mG for general and limit of 5000 mG or 500 μT (for occupational areas [11], [21], [22], [23]. Research results show that the human body should not be exposed to this high levels of EMF [11], [14]. This is becoming important because in home and working environment there is real potential risk of creating points “hot spots” where EMF exceed acceptable level values [8], [11], [14]). Computer devices together with other electrical devices in close proximity together can produce greater values than stated above creating “host spots” [29]. One of the previous research task was to contribute and promote idea that GSM base station has to be mapped than their EMF has to be measure [29] using wikimapia category “base tranceiver / GSM station”. In January 2011 there were 23 mapped antennas and on 1st of July 2011 there were total 64 mapped GSM base station world wide – Figure 3.



Figure 3. GSM antenna locations

As it is explained, governmental organization such as Australian government agency ARPANSA [10] propose general exposure avoidance guidelines. Some

manufacturers of electrical devices state that their devices comply with all standards relating to EMF but almost all documentation lacks exact guidelines to avoid “hot spot” creation what we reported in previous research [29].

Without obtaining dynamic information about EMF levels radiated around specific EMF source it is not possible to make right decision if a specific source create higher levels than expected. It is not possible to collect relevant and data from different spots if only one or two sensor are used since EMF radiation can be emitted in all direction and not placing enough sensors to collect right information, valuable information could go missing. This new proposed model explained below uses different approach for measurement as the one presented in report [31]. Sensors becoming smaller and cheaper because of that they will be in wider usage in the future.

III. ARCHITECTURE MODEL

Smart Dust with motes is promising technology and as reported by CNN [33] HP is working on system "Central Nervous System for the Earth" where Smart Dust will be used to faster predict earthquakes, check ecosystem health, or to monitor energy use. Smart dust motes placed around device or antenna which emits EMF can collect and record exact data and dynamic changes in EMF strength levels around targeted object. Smart Dust sensors components are ideal for this type of usage because they can communicate with each other and record only EMF strength levels changes when strength levels gradually change their values. This behaviour would save electricity by not communicating all the time with each other but only when is needed when EMF strength levels are changed – Figure 4. One direction of future work can be simulating by using simulation tools to simulate Smart Dust environment. One approach for Smart Dust simulation is proposed in report [30] or other reports such as [34], and [35].

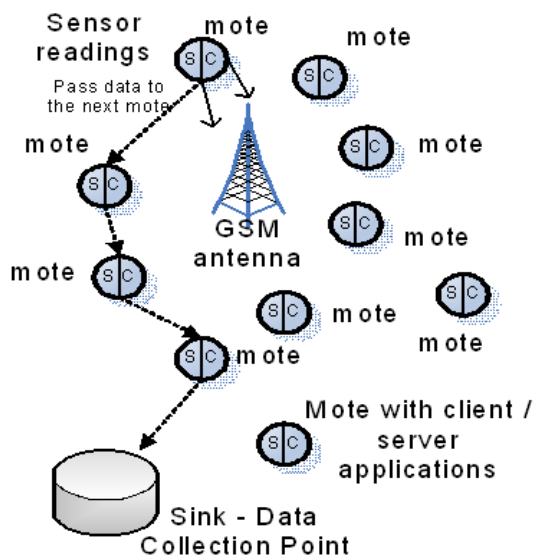


Figure 4. Architecture model for collecting dynamic EMF data changes

IV. SUMMARY

Recent reports about EMF from WHO [29], European Council [28], strict legal bindings in specific countries such as Italy [13], court cases [7] are giving answer to the question: is there need for something that can be done to warn general public if EMF strength levels are high what can be connected to health risks? The idea of having system which dynamically monitors EMF strength levels can help to control EMF radiation which might be harmful to human health. This system can be similar to systems which monitors CO2 or other pollution sources. Workers or occupants in buildings which are saturated by EMF should have information about EMF strength levels and Smart Dust motes can be able to collect relevant data and send collected data to monitoring station. Future work would involve study cases, continues measurement from previous work [29] and mappings of GSM antenna locations. More scientific research results and reports, service providers will decrease their own risk to have problems related to cases such the one reported in [7]. More important measured EMF levels would be transparent for all involved parties.

V. CONCLUSION

Referenced public court report Versailles Court of Appeal [7] it can be concluded that concerns about EMF which specific devices and antennas emits are becoming important. To support this claim recent reports from European Council and WHO reveals that something has to be done to control potential health risks which coming form EMF exposure. While presented data in this paper did not prove the health risk of EMF, presented approach might help to monitor and control EMF outdoor and indoor “hotspots” and even in home and office surroundings where occupants can be exposed to EMF for several hours. Proposed idea in this paper was not performed to prove possible health risks, but to report status of research activities in this area, and possible approach to monitor and control potential EMF hotspots. Other possible cases in the future might change scientific and public opinion about EMF concerns as in cases with European Council and WHO reports. This paper presents recent research activities in the area of EMF impact on human health, different international and national standards. New approach for dynamic monitoring and control of EMF is presented and it can help in raising additional awareness in this area, and possible solutions for EMF health risks. Authors are not aware that similar approach for dynamic monitoring of EMF strength levels by using Smart Dust components is proposed elsewhere.

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