MEASUREMENT OF SIGNAL POWER FOR THE PURPOSES OF LOCALIZATION

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ABSTRACT

The paper deals with the localization of wireless nodes based on measurement of power level of received signal. Despite this method is very popular for localization, the measurement suffers from several effects that negatively influence results and complicate the distance estimation between involved nodes. Thus, this paper presents the measurement performed to investigate signal propagation for purposes of localization. The measurements took place in both environments, indoor and outdoor in order to compare the results and possibility of localization.

1. INTRODUCTION

The necessity of localization in wireless sensor networks (WSN) arises from the possibility of nodes mobility during its activity. Not all WSN applications require a localization process but in some of them it is crucial to ensure the current position knowledge.

Several localization approaches and methods have been proposed [1]. Assuming triangulation method of localization in 2D, the distances from at least three nodes with known position have to be obtained. A few methods of distance estimation can be used, such as ones based on the time of light, angle of arrival or received signal strength. The method based on received signal strength (RSS) [2] seems to be cheap and appropriate method for usage in accuracy undemanding localization since it does not require any expensive additional components and description of RSS measurement capabilities is already included in the 802.15.4 standard which is commonly used in WSN.

The fundamental dependency of signal power on the distance is decreasing. However, there are several phenomenon that negatively affect the measurement. The most significant ones include multipath, shadowing, fading, scattering, RSS uncertainty and cause the inaccuracy in distance estimation. Therefore, the measured power is the sum of individual reflected signals at a receiver antenna. Apart from RSS uncertainty, their effect can be partly determined before measurements and its influence eliminated. The RSS uncertainty can be minimize only by multiple measurements [3].

2. MEASUREMENT TESTBED

The main aim of the measurement is dedicated to the investigation of received signal power and its change in dependency on the distance from signal source. The measurement concept was proposed with the intention of general and commercial product independent investigation of localization using signal propagation. Therefore measurement was not affected by transceiver characteristics of individual fabricated sensor node and can be repeated with any signal analyzing devices.

The measurement testbed consists of two basic parts: transmitter of radio signal and receiver of this signal. As the transmitter, generator ROHDE & SCHWARZ fsh3 was used, and signal was being received by the signal analyzer ROHDE & SCHWARZ FSP Spectrum analyzer. The generator transmitted the basic harmonic signal in ISM 2.4GHz band with zero SPAN at the power level -20dBm with monopole antenna. The last but not the least part of the scheme is PC running Matlab software. The spectrum analyzer and the PC with Matlab were interconnected using GPIB/USB cable to automate the measurement in order to make it faster and avoid human errors. The scheme of the measurement testbed can be seen in Fig. 1.

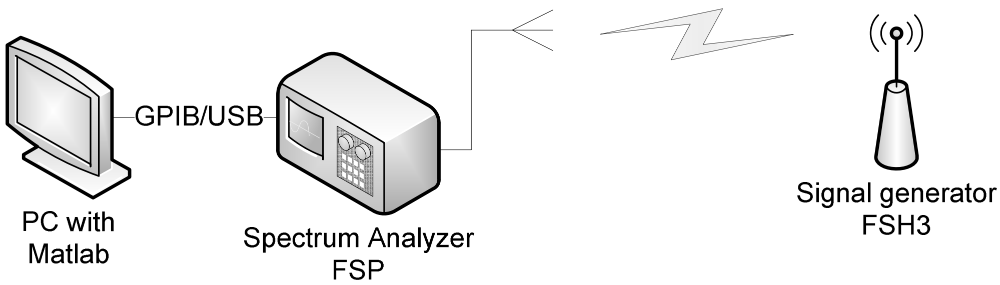

Fig. 1: The measurement testbed for received signal strength investigation

At the receiving side, with respect to common design of WSN nodes, the low noise amplifier was used to amplify the received signal before its processing. To power the amplifier, 12V power source and bias tee were used (see receiver scheme in Fig. 2).

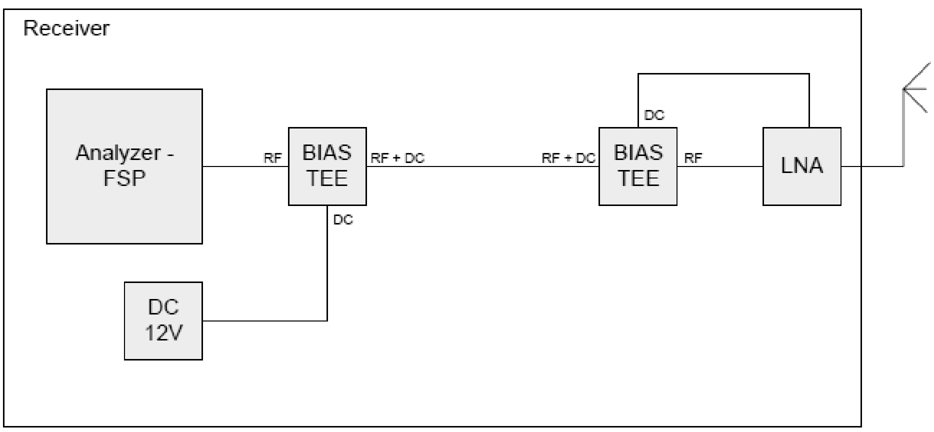

Fig. 2: The detailed scheme of receiving part of the measurement testbed

As commented in previous part of the paper, RSS measurement is significantly affected by uncertainty in radio channel. Thus, measurement of received signal power has to be performed several times at one place in order to obtain value of power level from which the distance can be estimated. As a consequence, the measurement process is significantly demanding. To shorten the time of measurement and to ease the whole process, automation of signal analysis was proposed. Using GPIB interface, IEEE 488.2 / IEC 60625.2 standard on the analyzer part and Matlab GPIB libraries, the procedure of measurement was written to the source code. The algorithm covers the analyzer setting, finding the frequency peak, capturing the power level and its storing. The one-place measurement consists of 10 individual measurements in a loop with total duration up to 1s.

3. MEASUREMENTS AND RESULTS

Both indoor and outdoor measurements were carried out for the investigation purposes. The indoor measurement took place in a large room with concrete walls, tile flooring and plasterboard ceiling. Also one of the room walls was formed by an iron structure and glass filling. All these factors have an impact on multipath effect and interference of reflected signals.

The basic measurement scheme consisted of measuring of signal power level in 0.13 m steps up to 7 m. Fig. 3 presents the results from the measurement. As commented before, at each point, ten individual measurements were performed. The minimum, maximum and average value can be seen in the figure. The considerable ripple along the distance is caused by fading effect and multipath signal propagation.

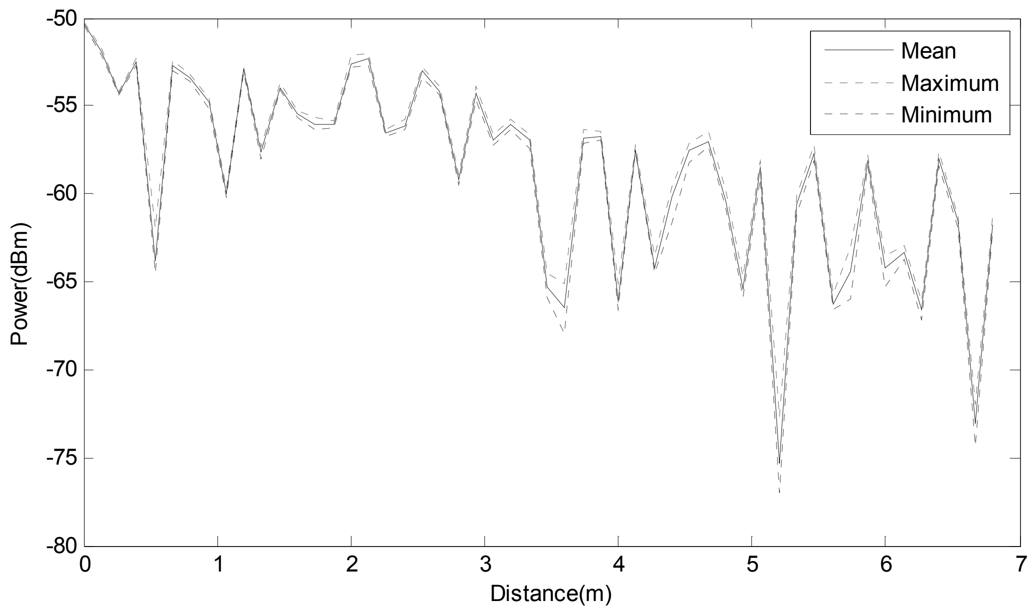

Fig. 3: The power levels of received signal measured indoor at different distances. The minimum, maximum and average value of each one-place measurement is depicted.

In the next scenario, four signal generators placed in the corners of the room were included and receiver was sensing the signal strength from each individual source. For easier implementation in source code of automation, the different frequencies of signal transmitters were used (2.478 GHz, 2.480 GHz, 2.482 GHz, 2.484 GHz). The receiver was being moved along the determined line among the generators (see Fig. 4)

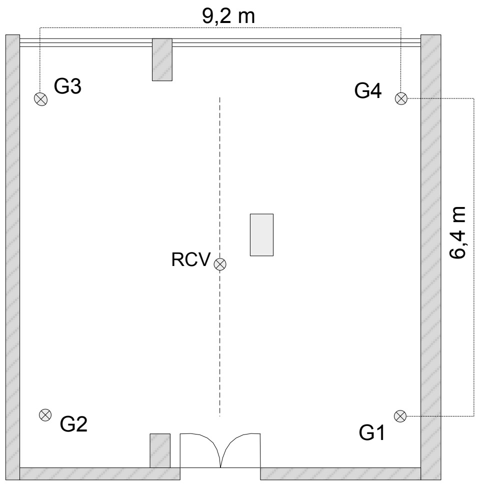

Fig. 4: The scene of indoor measurement including four signal generators

The obtained results, in spite of that the measurement was repeated several times, suffer from strong effect of multipath and for localization in one room of presented size are not useful (see Fig. 5). It is not possible to determine any tendency which could be used to create propagation model and to estimate the distance. In other words, assuming one level of signal strength, it is not possible to estimate in which distance the signal was measured.

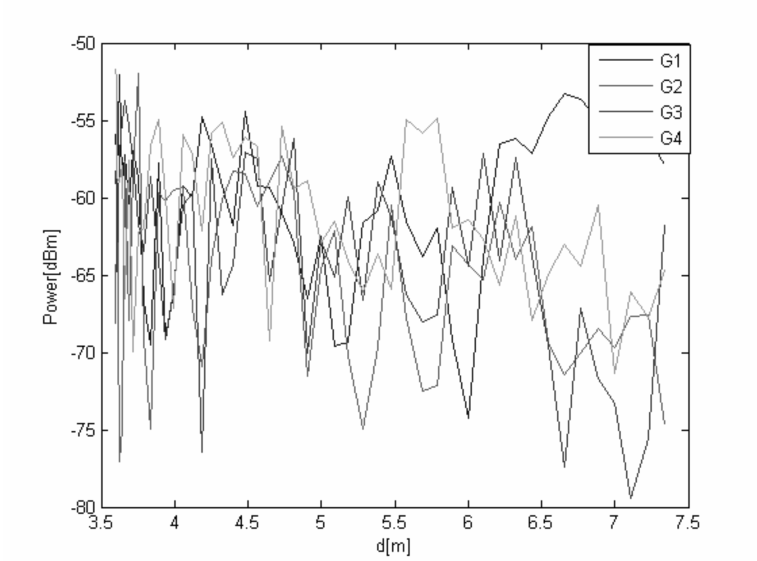

Fig. 5: The result of measurement of signal power from four sources in the second scenario

The second part of measurements was carried out outdoor at the place surrounded by buildings but sufficiently faraway from their walls to avoid the significant reflections. The surface was covered with small granite stones. The schema of measurement was analogical to the previous one. The decreasing tendency of received power is noticeable in Fig. 6. The ripple of the power is not so significant, like in indoor measurement, and the fitting exponential function can be calculated. If we can derive propagation model and its parameters from previous measurement, we are able to estimate the distance between the signal receiver and signal source from measured value of signal power. This is the basic prerequisite for the next step in localization which is lateration.

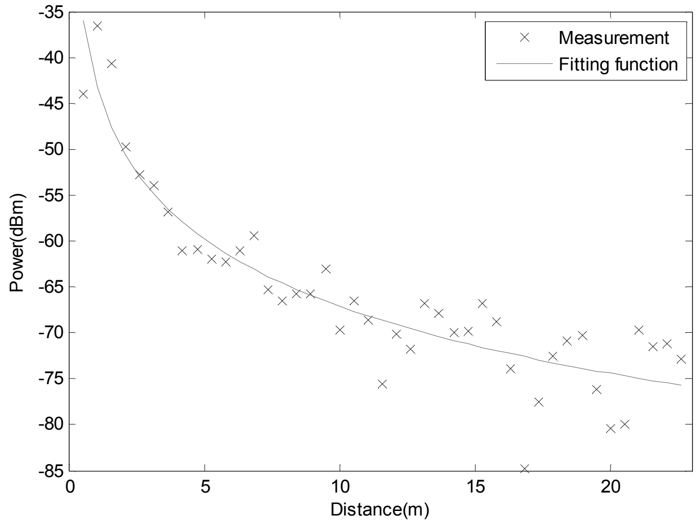

Fig. 6: The received power in outdoor scenario.

4. CONCLUSION

This paper treats the measurement of received signal strength for the purposes of localization in wireless networks. There were performed measurements in both indoor and outdoor environments in order to find if it is possible to use this method. Indoor environment suffers from big impact of multipath effect and subsequent interference of reflected signals. Moreover, distances considered indoor are shorter then outdoor and the fading effect is more significant.

As confirmed during outdoor scenario, parameters of propagation model can be derived and then distance estimated using this model. Due to the fading effect, RSS uncertainty and interference, the ripple of received signal power is not negligible but the RSS value can be used for localization.

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