SURVEY ON WIRELESS CHANNEL PARAMETERS FOR SHORT RANGE COMMUNICATION

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Abstract: The wireless short range communication is important for today's world in the field of wireless sensor network, Internet of Things and on-chip or chip to chip communication. Path loss is considered to be a fundamental parameter in channel modeling, since it plays a key role in the link budget analysis. Also, it determines the robustness against interference and noise, which in turn influences the bit error rate behavior. This paper deals with the analysis of how signal get affected with various parameters and also give a view on channel models for short distance communication.

Index Terms **- channel modeling, short range communication.**

I. INTRODUCTION

With the rapid evolution of wireless technologies, ubiquitous and always-on wireless systems in homes and enterprises are expected to emerge in the near future, many improvements are rapidly under way to embedding short range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things themselves. From anytime, anyplace connectivity for anyone, we will now have connectivity to create an entirely new dynamic network of networks. The Internet of Things (IoT) constructs a network that covers everything in the world, and its development depends on dynamic technical innovation in a number of important fields, from wireless sensors to nanotechnology. The wireless sensor network is developed as a one of key technologies of internet of things, which the operating environment would be indoor.

Many parameters taken into account depending on the type channel, distance, frequency and also with signal propagation. Propagation models have traditionally focused on predicting the average received signal strength at a given distance from the proximity to a particular location. It is clear that in IoT, the bulk of traffic will come from technologies that communicate in the proximity of objects. Propagation models that predict the mean signal strength for an arbitrary transmitter-receiver separation distance are useful in estimating the radio coverage area of a transmitter and are called large-scale propagation models. Propagation models that characterize the rapid fluctuations of the received signal strength over very short travel distances (i.e., a few wavelengths) or short time durations (i.e., on the order of seconds) are called small-scale or fading models.

In any communication system, there is a need to determine the link budget, which refers to the difference between the transmitted signal power and the signal power at the receiver. It specifies how the power at the transmitter is allocated along the communication channel to the receiver. The reason for having a link budget is that the signal loses some of its power as it travels through the wireless channel due to undesirable environmental and signal propagation effects.

II. RELATED WORK

The short range wireless channel parameters analysis is done by many researchers for various channel parameters [1]. Many proposed channel models in the near field communication and analyzed performance of path loss models depending on the distance, alignment and frequency of transceiver and also compared existing path loss with modified models.

Link budget for the traditional Radio Frequency-based communication models deals with the Magnetic Induction Communication Systems (NFMIC). Although there are a number of studies on the EM-based communication link budget, but there are only few models applicable for the magnetic induction communication case. The authors in [2] proposes a channel model for NFMI communication called Agbinya - Masihpour NFMIC channel model. Another study on sensor networks and IOT applications, a line-of-sight (LOS) signal propagation experiment in frequency domain is performed, considering a signal of center frequency 5.8GHz for measurement. Based on measured datum, cumulative distribution of RMS delay spread is modeled as approximately normal distribution. Then, a multi-path fading channel model is proposed and compared with other models having specific statistical distributions. It is observed that the proposed model agrees quite well with the Nakagami channel model. The proposed model should be an effective, short range fading model for indoor wireless sensor networks and Internet of Things applications [3]. A Statistical Spatio-Temporal Radio Channel Model for Large Indoor Environments at 60 and 70 GHz is considered in [4]. A separate channel model for each frequencies has been done and observations recorded reveal that, only space-time parameters are same, remaining parameters like 70GHz frequency suffer higher losses both specular and diffuse components.

Millimeter wave propagation of 60 GHz frequency range and channel modeling for various indoor parameters for direction of arrival, continuous route measurement and also the statistical parameters of the propagation of channel such as RMS delay spread, path loss and shadowing is discussed[5]. The Poisson distribution is used for large path loss and lognormal distribution for RMS delay spread.

In Channel Measurements and Modeling for a 60 GHz Wireless Link within a Metal Cabinet [6], channel measurements using a lithographic metal box is done. This metal cabinet experiment is to move towards a reliable and fast wireless connection for industrial use, many efforts have been made to provide suitable channel models for the wireless harness applications. In very small-scale applications such as inter chip connections or board-to-board communications a noticeable difference, in terms of channel properties, has been reported in the literature compared with the typical indoor channels.

In Short-range Low-VHF Channel Characterization in Cluttered Environments [7], the indoor/outdoor near ground scenarios through experiments and electromagnetic wave propagation simulations is discussed. These include the effects of indoor penetration through walls and obstacles, as well as indoor/outdoor cases, for both line of sight (LoS) and non LoS (NLoS), at ranges up to 200 m. Based on statistical tests the measured channels have a nearly ideal scalar attenuation and delay transfer function, with minimal phase distortion, and little to no evidence of multipath propagation. Compared with higher VHF and above, the measured short-range VHF channels do not exhibit small-scale fading, which simplifies communications receiver signal processing, and enables phase-based geo-location techniques.

Path loss model for ultra-wideband signal propagation using two ray models is dealt in [9]. Considering the specific UWB application, the analysis is carried out over distance of up to 10 meters and in the operational frequency band of 3 GHz to 10 GHz. From this study, both the one- and two-slope analytical path loss models for short range, two-ray links with wide operational bandwidths are derived, which are considered to be good approximations for line-of-sight (LOS) UWB links operating in a relatively clutter-free environment.

Propagation model and performance analysis for short range microwave passive RFID systems, Site-specific model and statistical model are proposed for mean path loss in [10]. The key parameters affecting the performance are studied, including reader limitations, tag limitations, multi-path propagation environments, and antenna polarization.

This paper also deals with the exploration of antennas used for the short range communication. The designing and optimization of reliable antenna at ISM band is proposed in [11]. An interesting characteristic is its planar structure which allowing an easy fabrication with low cost. This antenna can be used for indoor or outdoor applications.

A simple micro strip patch antenna is designed for Wireless Local Area Network (WLAN) applications in IEEE 802.11b/g/n is presented in [12]. This patch antenna design covers 2.4GHz frequency range with the return loss of -39.008dB. The design of a compact integrated antenna-mixer using a micro strip circular patch resonator at 2.4 GHz is presented in [13]. The antenna parameters and surface current distribution are compared with patch antenna of 24 GHz frequency [14]. The compact 3D antenna is designed to radiate at 24 GHz and occupies less space compared to the space of planar patch antenna of similar frequency. The reduction in space offers wide advantages in designing on-chip RF systems. In [15], Parametrical variation and its effects on characteristics of Micro strip is presented and also represents a brief description about design of rectangular micro strip patch antenna and its parameter effects in size, efficiency and compactness and parametric analysis in terms of return loss, bandwidth, directivity and gain by using same and different dielectric substrate materials with same and different thickness of rectangular micro strip patch antenna. The proposed antenna is simulated using HFSS tool at resonance frequency of 4 GHz [15]. A wideband dual-polarized dipole antenna with four folded metallic plates is proposed and a prototype is fabricated and tested to verify the design [16]. A novel high-power axial-mode helical antenna has been discussed in [17]. The results centered at 12.5 GHz indicate that the gain is 8.6 dB and the axial ratio is 2.2 dB, and it could handle a pulse power of 44.6 MW under vacuum condition.

Design of a Small-Size, Low-Profile, and Low-Cost Normal-Mode Helical Antenna for UHF RFID Wrist bands, An NMHA design for passive UHF RFID wrist bands is discussed in [18].Experimental and Parametric Studies on Ultra-Wide Band and Low X-Pol Helical Antenna's design details, modeling in CST (Computer Simulation Technique), and fabrication of the antenna along with the comparison of simulated and measured parameters are presented in [19]. Miniaturized helix antennas are integrated with drug reservoirs to function as RFID wireless tag sensors for real-time drug dosage monitoring. The experiment on two prototypes of antenna sensor-drug reservoir assembly have shown the ability to monitor the drug dosage by tracking antenna resonant frequency shift from 2.4 to 2.5-GHz ISM band with realized sensitivity of 1.27 MHz for transdermal drug delivery monitoring and 2.76MHz sensitivity for implanted drug delivery monitoring [21].

III. CHANNEL AND PARAMETER ANALYSIS

Near field short range communication uses magnetic coils and for channel parameter analysis equivalent RLC and two port network circuit parameters are used. Here three path loss models are existed in which the first path loss model based on load matching condition, second path loss model on distance and third model based on coupling factor. NFMI communication is a non-contact wireless form of short range communications (up to 5m) that uses field magnetic flux to transmit the data. The link budget for this system is approached in two perspective, first they have used air core and ferrite core transmitting and receiving antennas for line of sight case and then ferrite core antennas are used to improve the link quality and range of communication [2].

In channel path loss models, near filed communication (NFC) path loss increases with the number of turns of the transmitting coil contrarily to the other models. For a different transmitting coil radius the same model-1 and model-2 give negative path loss values while the modified-Model gives more accurate path loss values. Similar observations are made concerning the variations in path loss with receiving coil radius and number of turns. According to Model-3, the path loss increases with the number of turns in the transmitter or the receiver. The same behavior as model-2 in the variation of the path loss as a function of the number of turns in the receiving coil [1].The path loss in modified model is given by

$$\mathrm{PL} = \frac{\mathrm{pr}}{Pt(d)} = \frac{\mathrm{RL}l^2M^2}{\mathrm{Rt}(\mathrm{RL}+\mathrm{Rr})^2+\mathrm{Rt}(\mathrm{XL}+\omega\mathrm{Lr})^2+\omega^2M^2(\mathrm{RL}+\mathrm{Rr})} \qquad (1)$$

Where transmitting coil is fed by a signal of angular frequency ω rad s^{-1}, Magnetic coupling (M) between the coils [1]. Link budget equation for air core antennas are expressed as

$$\frac{P+Q+\eta+20.\log\pi+30\log(r_T\, r_R)}{60} \tag{2}$$

Where p is power of transmitter and receiver, Q is quality factor, η is effeciencies and r_T, r_R are stands for transmitter and receiver coil radii, 60 is inductive power decays to the sixth power of distance [2].
Link budget equation for ferrite core antennas is expressed as

$$\frac{P+Q+\eta+\mu+30\log(r_T\, r_R)+20.\log\pi-30\log\left[1+\frac{r_T^2}{d^2}\right]}{60} \tag{3}$$

Where d is distance, μ is permeability [2].
The large-scale channel model, specifically the path loss model, is essential for any wireless system design to calculate its link budget. For a conventional channel path loss model suggests that the average received power decreases exponentially with increasing distance between the transmitter and receiver [2]. This is generally expressed in logarithmic scale as

$$\text{PL (d) dB} = \text{PL }(d_0)\text{ dB} + 10\,\alpha\, log_{10}\left(\frac{d}{d_0}\right) + X_\sigma \tag{4}$$

where PL(d) dB is the signal power loss at a distance d (m) relative to an arbitrary reference distance d0 (m), α represents the path loss exponent, and Xσ is a zero-mean Gaussian random variable with standard deviation σ reflecting the attenuation (in dB) caused by shadowing.The RDS is obtained by first estimating the individual path parameters {(a^2, n,t_n)} for each observation, and then computing

$$t_{rms} = \sqrt{t^2 - (t)^2} \tag{5}$$

Where t, t2, are the first, second and moment of the delay spread, respectively.
The channel path-loss (in dB) is computed using PL=$P_t - P_{uncalr} + G_t + G_r + G_{sys}$ (6)
Where P_t and P_{uncalr} are transmit and receive powers in dBm, G_t and G_r are the gains of the Transmitter and Receiver antennas, and G_{sys} is the sum of all other system gains and losses including amplifier gain, filter loss, and cable losses. G_{sys} Also includes a calibration factor for the USRP to map I and Q values to true power levels [3].
Correlation Analysis of Indoor Channels it is found that the large-scale fading, Ricean K-factor, and delay spread can be described by log-normal distributions [6], [7]. Furthermore, both autocorrelation and cross correlation properties of the above parameters are analyzed and modeled. These parameters characterize fading and delay behaviors as well as their mutual dependency and can be used as empirical values for future wireless system design and simulation in 15GHz short-range indoor channels. The Ricean K-factor can be estimated by a moment-based method proposed in which is given by

$$K = \frac{\sqrt{1-\text{Var [P (d)] / (E [P (d)])}^2}}{1-\sqrt{1-\text{Var [P (d)] / (E [P (d)])}^2}}, \tag{7}$$

Where [·], Var [·] denote the expected value and variance of [·], respectively. The estimation of K factor is also extracted from the data after application of the sliding window W mentioned before to observe the variation of the Ricean K- factor against distance. The cross correlation coefficient, ρ, is defined as the Pearson product moment correlation coefficient:

$$\rho = \frac{n\Sigma xi\ yi - \Sigma xi\ \Sigma yi}{\sqrt{n\Sigma x2^2-(\Sigma x2)^2}\ \sqrt{n\Sigma yi^2-(\Sigma y2)^2}} \tag{8}$$

where x, y represent any two parameters of the set {LSF, Ricean K-factor, and RMS delay spread} and n is the number of samples, that is, the number of locations. Cross correlation coefficients of these parameters [9].

Table1: Various channel models used in short range communication.

Name	Freq-uency	Distance	Models	Transceiver	Parameter analysis
MM wave propagation channel chars for short range communication[6]	60 GHz	Large indoor	Empirical model	Tx-antenna: Omni directional biconical horn Rx-antenna: Directive horn antenna	RMS delay spread, path loss and shadowing
wireless link within a metal cabinet[5]	60 GHz	Few meters (wireless harness)	Standard log normal and Saleh Valenzuela models	Small antennas in a lithography system	Path loss models. RMS delay spread
Low VHF channel characterization in clustered environments[7]	40 MHz	200 meter	Statistical tests	Dipole antennas	LOS and non-line of sight

Experimental study on indoor channel model for WSN and IOT[3]	5.8 GHz	10cm to 9m	statistical channel model and Nakagami model	Sequence of small antennas and sensors	RMS delay spread, power delay profile and multi path power
Channel model on NFC[1]	13.56 MHz	10cm	Modified model	Magnetic coils	Path loss models 1, 2 ,3
NFMIC Link budget[2]	13.56 MHz	10cm to few meters	Agbinya masihpour model	Magnetic coils	Free space models
Path Loss Model for UWB signal propagation [8]	5GHz	1.2m to 10 m	One slope, two slope model	Ideal	LOS
Experimental characterization analysis of Indoor channels at 15ghz [9]	15 GHz	Upto 20m	Log-normal variables.	HORN antenna	Standard deviation, Ricean *K*-factor, RMS and delay dispersion
Characterization of channel and Path Loss Modeling in Indoor Environment at 4.5,28,and 38GHz for 5G Cellular Networks [10]	4.5, 28, 38 Ghz	Upto 24m	Single and multi-frequency models with path loss exponent	Horn antenna	LOS and NLOS

Table: 2 various antennas and its parameters used in short range application.

Antenna	Freq-quency in GHz	Tools/ Substrate/ W,L in mm	Return Loss in dB	Gain In dB/ Input Impedance in ohm	Relative Permi-Ttivity	Application
Dipole antenna [11]	2.4	HFSS /FR-4/ 20.3, 36	-14.70	6.28/50	3.38	Indoor and outdoor, (WSN)
Rectangular Microstrip patch [12]	2.4	ADS / FR-4/ 29,25.3	-39.008	6.9/210	4.4	WLAN short range communication
Microstrip Circular patch [13]	2.4	HFSS /FR-4/ 29.062, 25.383	-10.00	2.1/50	3.2	Microwave communication
Microstrip circular [14]	24	HFSS /Die-electric	< -10	2.2/40.6	-	Automobiles
Dipole [15]	2.2	HFSS/Parasitic	-10	-	4.4	Mobile communication
High power dual branch helical antenna [16]	12.5	HFSS /parasitic 20.3,36	-32.00	3.38	8.6/50	Military applications
Normal mode helical antenna [17]	865-868MHz	HFSS /PET and FR4 material	-16	3.38	-	Health monitoring
Low Polarized helical antenna [18]	2.1 to 3.7	CST	-10	-	7.35/50	Mobile communication
Normal axis helical [19]	1.9	HFSS /FR4	-12	-	8.6/50	Mobile communication
RFID Tag helix [20]	2.4 to 2.5	HFSS /PDMS/ 22.3, 26	-18	4.5	8.5/50	Drug delivery monitoring

IV. CONCLUSION

Analysis and performance evaluation of wireless channel behaviour helps in calculating link budget at wireless short range communication applications. In this paper, survey of short range communication is done considering various frequency ranges, effects on various parameters and different antennas used. The effect on parameters like RMS delay spread, path loss shadowing, LOS and NLOS and free space models are modelled by standard log normal, SV models, statistical tests, Nagakami and also by modified models.

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