ANTENNA SELECTION FOR THE FEMTOCELL COMMUNICATION SIGNAL FOR NETWORK CONNECTIVITY

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Abstract - The studies report on the selection of antenna for femtocell cellular base station application. We have categorized the influential signal lost factors into four core elements that were experiences by the users. We have conducted measurement on Received Signal Strength Indicator (RSSI) parameter in the campus environment and outline the steps and techniques of such research activity. Our studies show that certain type of antenna that have been use by provider at the base station to connect a single network connection might not be able to support for reliable Internet network connectivity for critical communication device.. Hence, the technique to select antenna type for the communication module could be an effective solution to combat the issue on signal lost for GSM, CDMA2000, TD-SCDMA, WiMAX and LTE solutions providers.

Keywords - Femtocell system; antenna; RSSI

I. INTRODUCTION

Femtocell is a low-power cellular base station, typically designed with small size for utilization in a building, home or small business. A popularexpression which is more pervasive in the industry is called small cell, with femtocell as a subset. It link up to the service provider's network via broadband (such as DSL or cable); latestmodel typically support 4 to 8 simultaneously active mobile phones in a residentiallocation depending on version number and femtocell hardware, and 8 to 16 mobile phones in enterprise settings [1]. A femtocell allows service providers to extend service coverage indoors or at the cell edge, especially where access would otherwise be limited or unavailable. Although much attention is focused on WCDMA, the concept is applicable to all standards, including GSM, CDMA2000, WiMAX and LTE solutions. The use of femtocells benefits both the mobile operator and the mobile user. For a mobile operator, the attractions of a femtocell are improvements to both coverage, especially indoors, and capacity. Coverage is improved because femtocells can fill in the gaps and eliminate loss of signal through buildings. Capacity is improved by a reduction in the number of phones attempting to use the main network cells and by the off-load of traffic through the user's network (via the internet) to the operator's infrastructure. Instead of using the operator's private network (microwave links, etc.), the internet is used [2]. Due to 3G networks congestion, offloading to femtocells extends a networks physical coverage distance from each tower. Users and small businesses benefit from greatly enhanced coverage and signal strength since they have a dedicated base station inside their premises. As a result of being relatively close to the femtocell, the mobile phone (user equipment) expends significantly less power for communication with it, thus increasing battery life[3]. They may also get better voice quality via (HD voice) depending on a number of factors such as operator/network support, customer contract/price plan, phone and operating system support. Some carriers may also offer more attractive tariffs, for example discounted calls from home. Femtocells are an option way to distribute the benefits of fixed–mobile convergence (FMC). The difference is that most FMC architectures require a new dual-mode mobile phones which works with existing unlicensed spectrum home/enterprise wireless access points, while a femtocell-based deployment will work with existing mobile phones but requires the installation of a new access point that uses licensed spectrum[4].Typically the range of a standard base station may be up to 35 kilometres (22 mi), a microcell is less than two kilometers wide, a picocell is 200 meters or less, and a femtocell is in the order of 10 meters. Figure 1 shows the femtocell base station.

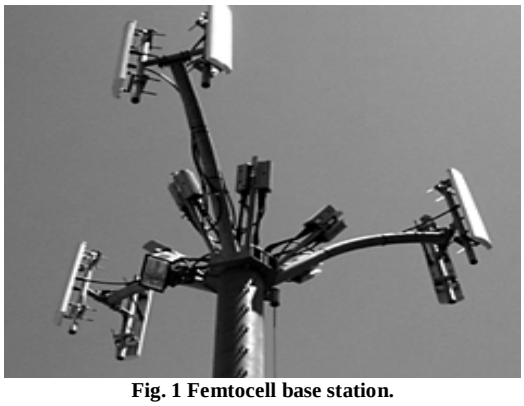


Fig. 1 Femtocell base station.

In today's business operations, reliable network connectivity is a must in order to continuously access corporate resources, business data, vendors' information and billing details all the times [5]. As an example, utility company with smart grid technology introduces a real competitive advantage whereby, connected devices can provide the company with up-to-date information about electric, gas and water consumption so that it helps to identify patterns and trends. The company can better manage their infrastructure, assets and operations with comprehensive data analysis. Bad connectivity can also influence customer satisfaction. A report by [6] highlighted several complaints from utility customers who were having lost connectivity on the meter and it took a month to solve the issue despite nationally, a network coverage test was conducted. According to researchers that the issue could be due to single network connectivity that the meter has andalso the location of the meter was down in the basement [7]. Another reason that has been highlighted in this paper is the unreliable antennathat has been useat the either in the indoor, basement area, hill side area or the limited frequency allocation by the antenna itself. It is important to realize that, Internet connection to these key devices in the utility network that capture such data should be 99.99% available all the times. Fig. 1 illustrates the system architecture of femtocells using cellular network. The femtocell equips with built-in communication module through GSM modem.

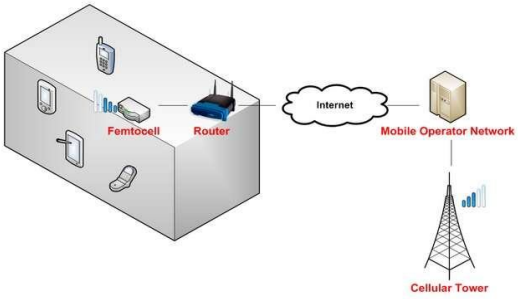


Fig. 1:Generic Femtocell Architecture

In this paper, we will describe the method on how to select high gain and high directivity antenna to overcome the issues of network connection signaling lost as experienced by femtocell station followed by our field measurement studies that provide evidences to these issues based on signal strength measurement performance. The results shows the method to identify the best antenna to be locate in the femtocell base station. Finally, summary of the studies as well as acknowledgement remark are highlighted towards the end of this paper.

II. NETWORK SIGNAL STRENGTH FIELD MEASUREMENT

The problem of missing data at the end user's broadband internet is identified and identifying the best antenna is proposed. The team have conducted a signal strength measurement to the identified femtocell locations that were reported having difficulties in obtaining data wirelessly. A handheld signal analyzer is used in the RSSI measurement. Signal Analyzer (SA) is a deviceto measure the relative quality of a received signal to a client from Keysight Technologies model N9340B that can be use within the frequency range from 100 kHz to 3 GHz. It needs 13W power consumption and the battery can last up to 4 hours. The antenna for the SA is an OmniLOG antenna model 90200 from Archonia is a highly omni directional isotropic antenna from 700MHz to 2.5GHz specially for GSM, 3G, LTE and 2,4GHz WLAN connected via SMA (male) connector. Figure 2 shows the handheld SA used during the campaign.



Fig. 2: Signal analyzer (Keysight N9340B) to measure the signal from fentocell

It was lodged that a few of the places in the study area do not have sufficient network coverage in turn decreasing quality of service, so further analysis and assessment need to be done. In order to measure basic network availability, a common parameter such as RSSI can be utilized for detecting network coverage. The primary goal of measuring RSSI parameter is basically to estimate distance which indirectly reflects the proximity range between two nodes. At a certain position, the value indicates whether the signal power is strong or weak. Strong signals usually shows the distance from the transmitter to the receiver, is within a short range and vice versa. This is depicted in Fig. 3.

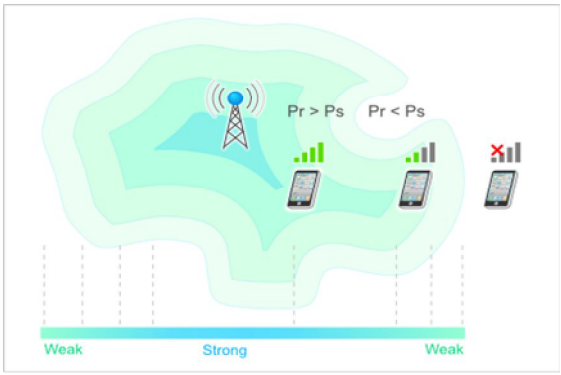


Fig. 3. Received signal strength from femtocell within 10 meters distance.

The signal strength measurement was conducted using the following steps;

1. Identify spectrum arrangement plan as advertise by regulator. For our study we refer to Malaysian

Communication and Multimedia Commission (MCMC) frequency assignment to each operator. Fig. 4 shows the frequency arrangement for Malaysian operators classified into separate air interface technologies.

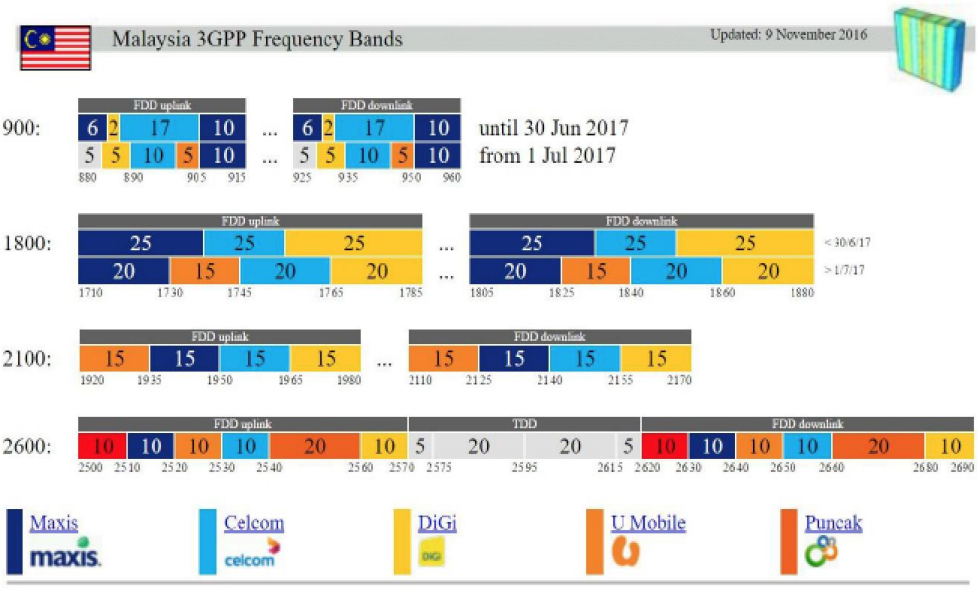


Fig. 4: Malaysian 3GPP Frequency Bands for local network operators

2. In this study we selectedthe 4G network provided from Celcom, Maxis and DiGi as the operators since they are the main cellular network operators in Malaysia that have wider network coverage nationwide.Starting with any operator (CELCOM, MAXIS, DIGI), we follow the frequency for LTE (4G) 2600 MHzallocation based on the spectrum plan in Fig 4. Since we are looking at the RSSI parameter, refer to the downlink frequency based on each air interface technology.

	Bands	Maxis	Celcom	DiGi
4G	2600	2630-2640	2650-2660	2680-2690

Table 1: Downlink frequencies arrangement

For downlink frequencies of reference, Table 1 lists the frequencies in details.

3. Tune the spectrum analyzer to the specified downlink frequency. The spectrum analyzer is calibrated to get an average maximum, minimum RSSI values. This step provides display averaging of the measurement results. Because measurements of noise or random signal characteristics may produce unsteady or highly variable results. The display averaging function can smooth the result and provide the mean value. The specific frequency range of interest for each operator will shows its RSSI as shown in figure 5.

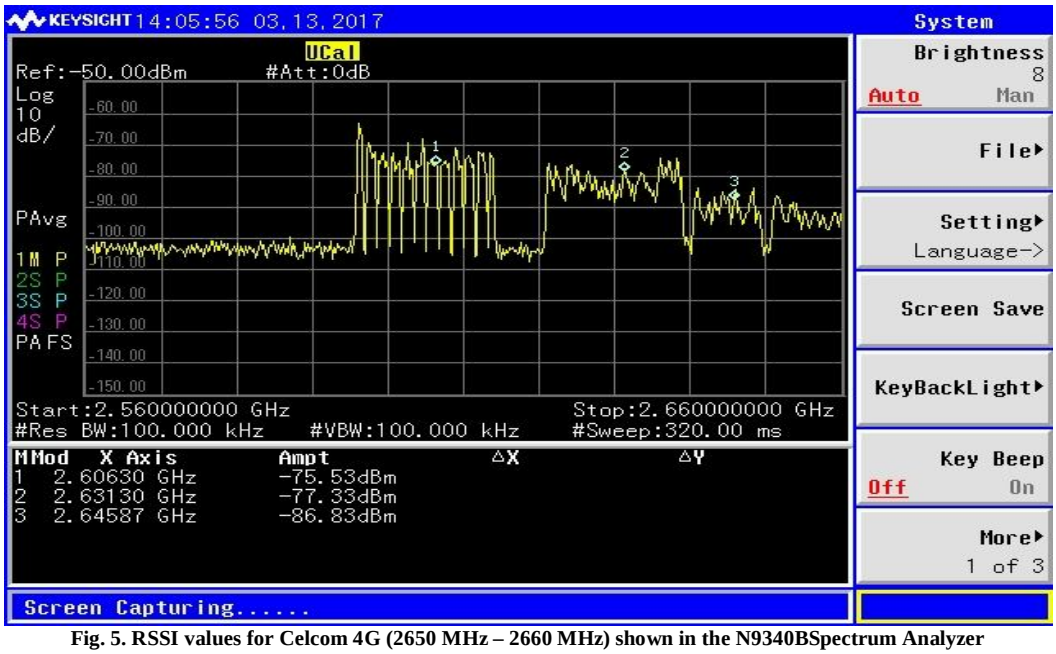


Fig. 5. RSSI values for Celcom 4G (2650 MHz – 2660 MHz) shown in the N9340BSpectrum Analyzer

4. Next, measure the signal strength in dBm as well as the spectrum power density and record the value as in table 2 for each operator. The results shows the comparison of each operator's signal strength in dBm.RSSI describes the total signal power received in miliwatts (mW) whereby the value is usually expressed in dBm (logarithmic scale) and typical values are -100dBm for a low signal level to -60dBm for a very strong signal level [8]. Selected locations are identified as follows based on their unique environment categories on the signal lost effects.
Remote area : Kg. Jenderam Hulu, Dengkil, Selangor.
Surrounding buildings:Shaftesbury Square, Cyberjaya
Hill side:Diplomatic Enclave, Putrajaya
Each location is measured and the position of the antenna is identified.

Location	CELCOM Available network (MHz)	Signal strength (dBm)		
		Avg	Max	Min
In door receiver	4G (2560 -2660)	-93.73	-86.35	-104.77

Location	DIGI Available network (MHz)	Signal strength (dBm)		
		Avg	Max	Min
In door receiver	4G (2560 -2660)	-104.06	-99.84	-109.02

Locatio n	MAXIS Available network (MHz)	Signal strength (dBm)		
		Avg	Max	Min
In door receiver	4G (2560 -2660)	-87.34	-76.52	-107.62

Table 2: RSSI results location of cyberjaya (13th March 2017)

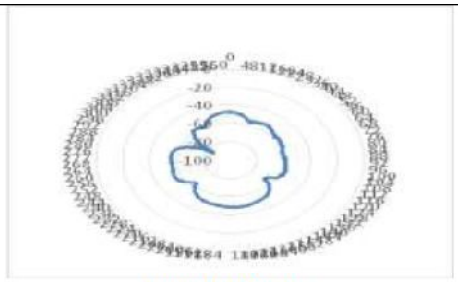
III. ANALYSIS ON THE ANTENNA TYPE

Considering different type of antenna that have been used at the femtocell location, the characterization of each antenna that has been utilized is investigated. There are 4 different types of antenna that is under investigation. The S11 return loss parameters and the bandwidth frequency are measured using the Vector Network Analyzer (VNA) at the Microwave lab of IIUM. Return loss is a measure of how well devices or transmission lines are matched. A match is good if the return loss is high. A high return loss is desirable and results in a lower insertion loss [9].While the radiation pattern of the antennas is measured at Universiti Teknikal Melaka Malaysia (UTEM)'s Anechoic Chamber. The radiation pattern will shows the directional or angle dependence of the strength of the radio waves from the antenna or other source.Table 3 shows the antenna type and model under studies. Table 4 and 5 show the results analysis of the S11 and the radiation pattern.

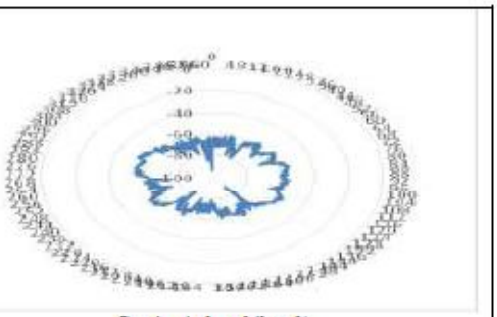
Dipole/ ETM8120-2	Semi spiral multiband/ ECD310
	

Patch/ FME_EMW100	Patch/ITRON
	

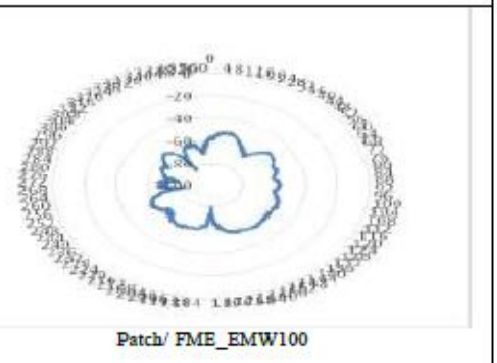
Table 3: Type of antenna / Model under studies



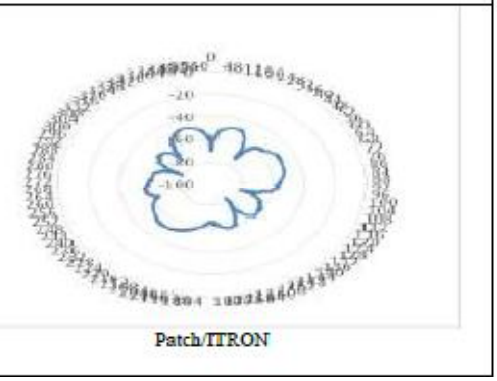
Dipole/ ETM8120-2



Semi spiral multiband/ ECD310



Patch/ FME_EMW100



Patch/ITRON

Table 4: Antenna Radiation pattern (From Anechoic Chamber Measurement)



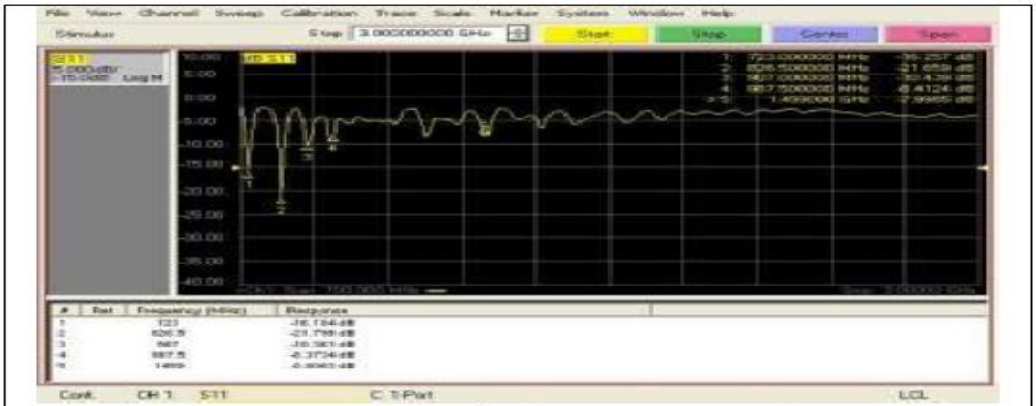
Antenna: Dipole/ ETM8120-2

Freq: 833.4 MHz (2G)
S11 = -8.2 dB



Semi spiral multiband/
FCD310

Freq1: 1.689 GIIz (2G), S11= -23.2 dB
Freq2: 1.9075 GIIz (2G), S11= -27.1 dB
Freq3: 2.172 GHz (2G), S11= 30.37 dB
Freq4: 2.505 GHz (3G), S11= -22.92 dB
Freq5: 2.77 GHz (2G), S11= -25.3 dB



Freq1: 723 MHz (2G), S11= -16.257 dB
Freq2: 826 MHz (2G), S11= -21.65 dB
Freq3: 907 MHz (2G), S11= -10 dB
Freq4: 1.45 GHz (2G), S11= -7.99 dB

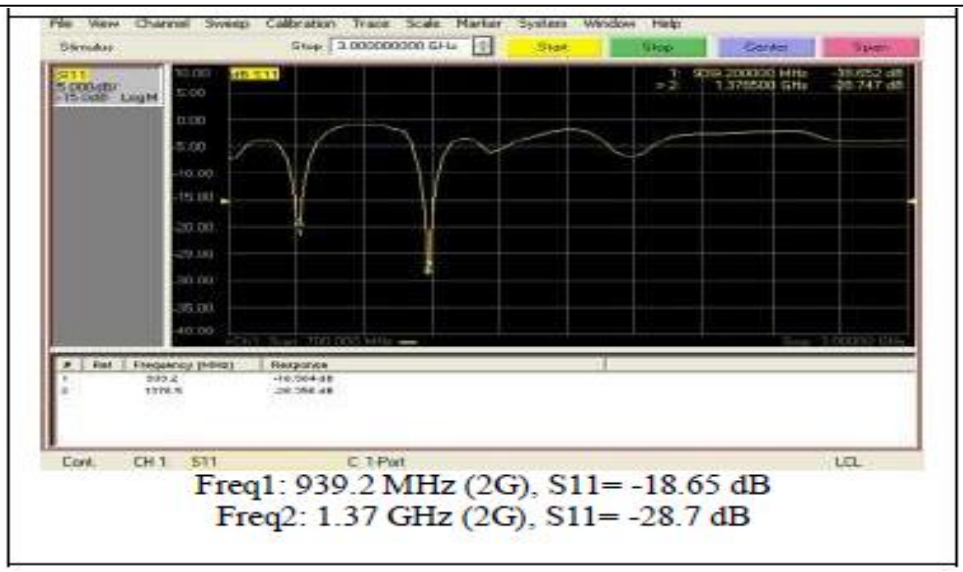


Table 5: Return loss measurement for the antenna

CONCLUSION

After thorough observation and analysis of the 4 types of antenna that frequently used by the femtocell, we conclude that the semi spiral antenna(ECD310) which is a multiband frequency antenna (up to 5 frequencies with high gain) is highly recommended due to the high return loss S11 values for each frequency and high bandwidth measured at 20 dB gain, compared to other antennas. The radiation pattern measurements for the semi spiral multiband ECD310 also show almost uniform spherical coordinates at all angles where high gain directivity can be achieved almost at all directions. The femtocell antenna is one of the reason for high quality of service of the signalling network.

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