Wireless Connectivity Predicaments in GSM-based AMR System: An Empirical Research

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Abstract— ***The convergence of Global System for Mobile Communication (GSM) and Information Communication Technology (ICT) allows the mobile and wireless application to be implemented in Automatic Meter Reading (AMR) system. In addition to the advancement of cellular technology and spectrum refarming, GSM-based AMR system is continuously facing propagation challenges that affect the stability of wireless connectivity. A field study was conducted to investigate the real reasons for having predicaments in coverage behaviour introduced by GSM-based AMR system for three local Internet Service Providers (ISPs) in Malaysia. The main objective of this study is to verify signal coverage performance at identified AMR locations that were reported having signal lost. We have categorized the challenges and depicted the signal quality readings that show signal performances for different service providers. The outcomes form the basis for our future development of cognitive network selection prototype for utility (gas, electricity, water) companies wireless communication smart grid.***

Keywords: AMR, cognitive selection mechanism GSM modem, RSSI, signal quality

I. INTRODUCTION

AMR is a technology that automatically collects ener-gy consumption data from customer metering devices to a specific utility database for billing purposes. AMR trans-forms the conventional manual meter reading methods which suffer from a wide variety of disadvantages such as manpower and transportation cost [1]-[3] Obviously, AMR reduces human intervention in meter reading and manage-ment processes since the wireless modem is incorporated for transmitting data from meter to the billing department at a regular interval [4]. Figure 1 illustrates basic network architecture of a GSM-based AMR system.

GSM is a digital cellular technology used for trans-mitting mobile voice and data services. GSM-900 and GSM-1800 are used in most parts of the world with uplink and downlink values as described in Table 1 [5]. The amount of data that has to be sent is quite low, ranging from only several bytes to Kbytes depending on the time performing such data collection task, peak or non-peak. With demanding low bit rates [1]. AMR system utilizes low power radio frequency (RF) communication in GSM net-work, transmitting meter readings to a remote receiver [6].

Figure 1. AMR network architecture

Table 1: Uplink and Downlink for GSM

GSM (MHz)		Uplink (MHz)	Downlink (MHz)
900		890-915	935-960
1800		1710-1785	1805-1880

The rapid development of GSM technology has made wireless communication in AMR system more reliable and feasible [5]. However, a stable, reliable and less fluctuate wireless connection is crucial to ensure that all readings are successfully sent to the data center for billing department utilization. An often time, wireless connectivity in AMR is facing several challenges that affect such desirable features. Uncertainties in wireless connectivity can eventually lead to the loss and error of quality data while transmitting. The utility company may face a monetary lost if they are unable to charge customer accurately.

Having a communication device that is wirelessly con-nected are susceptible to the risks such as communication lost, call drop-outs and out-of-coverage signalling especial-ly on collecting real-time data in short period of an interval [7]. It is hard to confirm that the selected provider can sus-tain a good connectivity at all time. This is even more chal-lenging when the AMR device is relying on single network connectivity since should anything happen to this network the AMR meter will only resume operation once the only network is back to normal.

The new development area

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is a risk too. Business wise, telecommunication provider may refuse to install a new base

station in this location due to less population of poten-tial customers. It is difficult to justify for the return of in-vestment on the high infrastructure cost to provide good connectivity especially at very challenging geographical terrains such as the top of the hill, ravines, and archipelago of islands. In addition to this, an AMR location in a base-ment area is an issue too. Connection instability due to building penetration effects is one of the reasons for such predicament [8].

Rural areas and smaller cities may also encounter lim-ited telecommunications infrastructure especially those which are remote and isolated [9]. The key challenges for providing communication services in rural areas are driven by technological and economic consideration. High cost is needed to set up the communication infrastructure. Figure 2 summarizes these elements in AMR wireless connectivity that motivate our studies to further investigate these predic-aments through conducting preliminary coverage analysis activities at specific reported AMR locations.

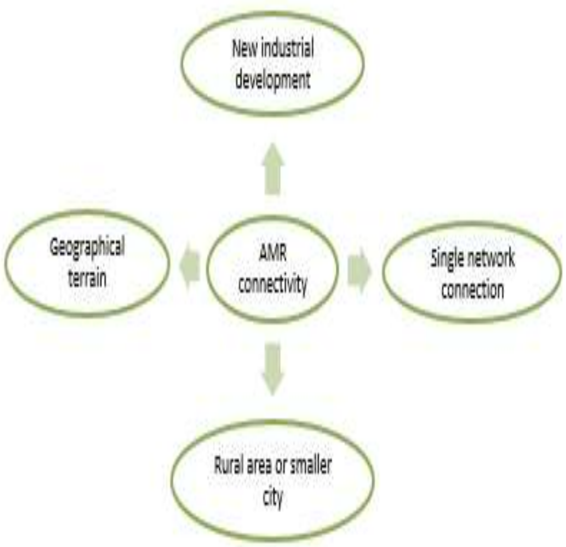

Figure 2: Challenges in AMR Wireless Connectivity

The coverage analysis activities were conducted at AMR location to identify the signal strength value (dBm) based on three local service providers in Malaysia such as Celcom, Maxis, and Digi. The reason for these selections is due to their wide coverage as compared to other local ISPs.

2. RECEIVED SIGNAL STRENGTH INDICATOR (RSSI)

RSSI is a basic parameter to measure the signal strength of a communication signal. The value of RSSI varies due to terrain and cultural (building) obstruction or impairments to signal propagation as well as to the distance between the radio telephone and the base station or cell site [10]. Table 2 represents the RSSI value vs. signal quality. The higher the RSSI number, the stronger the signal. Thus, when the RSSI value is nearing zero, the better the signal, however, this is unachievable.

Table 2: RSSI Table

RSSI (dBm)	Signal Strength
> -70	Excellent
-70 to -85	Good
-86 to -100	Fair
< -100	Poor
-110	No signal

2.1 Field Measurement

Signal analyzer (Keysight NB3408) with Omni-LOG90200 antenna was used to measure the signal level for three main service providers as shown in Figure 3. Table 3, on the other hand represents spectrum arrangement for service providers retrieved from Malaysia Communications and Multimedia Commission (MCMC) website .The objectives of the site measurement are to verify signal cov-erage and to analyze signal performance for telecommuni-cation main service providers. The measurement was con-ducted by the following procedures.

a.The scanned data is saved for record and further analysis.

b.The availability of other services signal (Maxis and DiGi) is measured.

c.The scanned data is saved for comparison purposes.

d.Step a,b and c are repeated for UMTS (3G) and LTE (4G) coverage.

e.The results are analyzed and compared to find the signal strength performance.

The availability of Celcom GSM-900 and GSM-1800 signal coverage is verified by using spectrum analyzer at the site location. Figure 4 illustrates the process flow.

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Figure 3: Portable spectrum analyzer

Figure 4: Signal strength measurement procedure

Table 3: Malaysia downlink spectrum arrangement

Tech.	Celcom	Maxis	DiGi
GSM	933-950	925-931	931-933
	1830-1855	1805-1830	1855-1880
UMTS	2140- 2155	21252140	2155-2170
LTE	2560 –2660	1630-2640	2680-2690

Figure 5, shows three different sites locations under study that can be classified as the rural area, geographical terrain, and new industrial development.

Figure5(a) Rural area

Figure 5(b) Geographical Terrain

Figure 5(c) New industrial development

III. RESULTS AND DISCUSSION

Table 4 represents the value of signal strength acquired from the signal analyzer for the three main service provid-ers at AMR location under study. The value is represented in the graph as shown in Figure 6 (a). Based on the graph, it can be concluded that Maxis offers reliable signal strength with more than 19.54 dBm higher than other service pro-viders for the 2G network at 900 MHz frequency range. For 1800 MHz, DiGi offers more prominent signal strength with more than 18.13 dBm higher than the rest of the two. For the 3G network, Celcom offers reliable signal strength with just above 0.06 dBm higher than other service providers. While for the 4G network, Celcom offers reliable signal strength with more than 2.6 dBm higher than other service providers.

Table 4: Signal strength measurement (Semenyih – new development area)

	GSM-900 (dBm)	GSM-1800 (dBm)	UMTS (dBm)	LTE (dBm)
Celcom	-74.77	-100.78	-54.44	-94.13
Maxis	-55.23	-72.74	-63.63	-97.03
Digi	-98.51	-54.61	-54.50	-98.69

Table 5: Signal strength measurement results (Shrimp har-vester - rural)

	GSM-900(dBm)	GSM-1800(dBm)	UMTS(dBm)	LTE(dBm)
Celcom	-66.09	-71.12	-77.41	-81.71
Maxis	-68.99	-68.85	-62.78	-81.86
Digi	-85.57	-69.47	N/A	-98.69

Following the comparison of Figure 6 (b), we can ob-serve the average performance of Celcom is ranging above -80dBm to -60 dBm for 2G, 3G, and 4G respectively. The measurement for DiGi shows a poor performance in con-trast to Maxis.

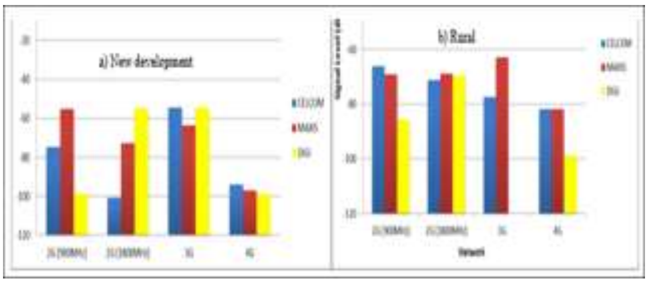

Figure 6: Signal strength comparison between new development and rural area

IV. CONCLUSION

We have conducted coverage analysis studies at specific AMR locations to verify signal coverage performance of an ISP. From the outcome, having more than one telecommunication providers could be a better solution to encounter instability in wireless connection. In the future 3G and 4G connection can be used to carry information with more speed as compared to other GSM modules.

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