

Study of WiMAX Site Diversity for WINDS Experiment in Indonesia

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This paper presents the scenario performance evaluation of MAN-based site diversity for Ka-band VSAT networks in urban areas using WiMAX links for mitigating the rain attenuation problems. Our simulation shows that linking VSAT in this way will enable substantially higher availability than one VSAT operates in isolation during rain periods.

Key Words: WINDS, WiMAX, Site Diversity

Nomenclature

RSL :received signal level
P :power
L :loss
G :gain
FSL :free space loss
FM :fading margin

Subscripts

o :output
c :cable
tx :transmitter
rx :receiver
a :antenna
d :diffraction

1. Introduction

The objective of WINDS development – which operates at Ka Band – is to demonstrate high data rate communication system. Indonesia that has high intense rain profiles will also covered by WINDS. It is well known that attenuation due to rain can be a major of signal loss over tropical regions, such as in Indonesia. In this case, site diversity is a well proven technique for mitigating the rain attenuation.

Major improvements in the quality of reception can be achieved if one exploits the fact that statistical properties of the received signal due to rain attenuation at two or more sites - sufficiently spaced apart – is not correlated. If one or more VSAT terminal in VSAT system cannot access satellite due to loss of signal from satellite, the others which are in operation may help to restore the whole VSAT system.

2. MAN-Based Site Diversity

Site diversity techniques involves the specification of means to bring signals from separate receiving terminals

to a common location, then to synchronize and combine them.

Applying site diversity techniques on VSAT network in metropolitan area will be economic by using WiMAX links of MAN to provide enhanced VSAT availability. The reason behind applying MAN-based site diversity techniques on VSAT networks in metropolitan area is the economical implementation of restoration technique by using WiMAX links of MAN, which inherently provide interactive network for users and also enable substantially higher availability than when one VSAT in single operation.

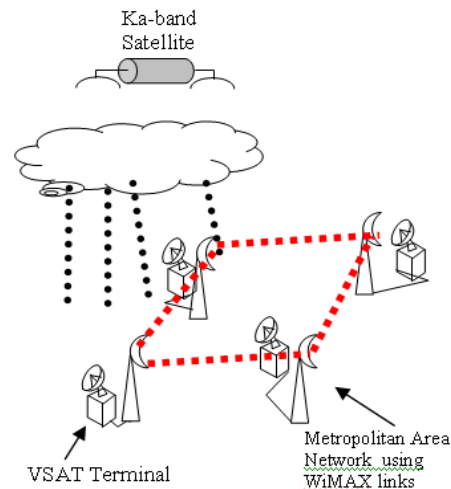


Fig. 1. MAN-based Site Diversity using WiMAX links

The MAN-base site diversity concept is shown as in figure 1 [1]. In this study we use the WiMAX links to connect ground station Bdg1 at ITB with second ground station at Bdg2 about 4 km distance from ITB as in figure 2. The important benefits of WiMAX are their fast deployment capability and operates at < 10 GHz band so it becomes robust from rain attenuation.

3. Rainfall Simulation

The performance of MAN-based site diversity during rain intense periods will be analyzed by using the spatial-temporal rain-fade model – adopted from rainfall characterization. The performance evaluation will be focused on overall links availability of MAN-based site diversity.

The models will be developed based on areas of relatively intense rainfall, called *rain cells*. Observational studies have shown that there is a tendency for new rain cells to form in the vicinity of existing cells, so that rain cells tend to cluster within larger scale structures [2]. This clustering structure makes use of cluster point processes a natural approach to modeling of rainfall data. For the purpose, it is desirable to use the generic terms *rain cell*, *storm* and *rain event* for three levels of rainfall element – rain cell clustering within storms, which cluster within rain events. The single site model is shown as in figure 2.

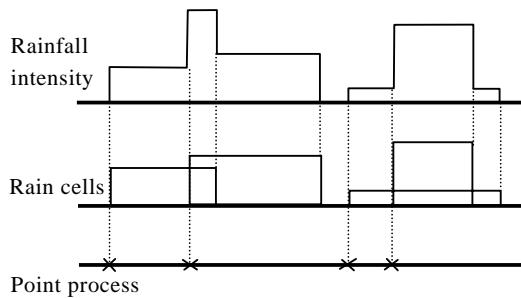


Fig. 2. Spatio Temporal Rainfall Model

4. WiMAX Link Design

WiMAX promises to bring high-speed data connectivity to a wide coverage area, opening up ubiquitous internet access without costly investment in wireline infrastructure. A lot of consideration has been given to the access portion of WiMAX networks: the fixed and mobile specifications 802.16-2004 and 802.16e-2005 respectively have both been ratified; the first WiMAX certified fixed products are available and mobile products are expected in late 2006.

The WiMAX Forum, an industry group of nearly 400 member companies, estimates that there are already more than 150 announced commercial trials and deployments of fixed WiMAX networks. Despite this, little attention has been devoted to WiMAX backhaul needs and evolution. With multi-sectored antennas likely and high data throughput possible, conventional point-to-point (PTP)

wireless transport solutions will quickly reach capacity. Recently released spectrum at 5.2 GHz is allowing a new generation of high speed radios to be realized. Data rates to gigabit-per-second and beyond are possible in cost effective radio architectures, opening up a host of new applications including economic altering WiMAX wireless backhaul networks.

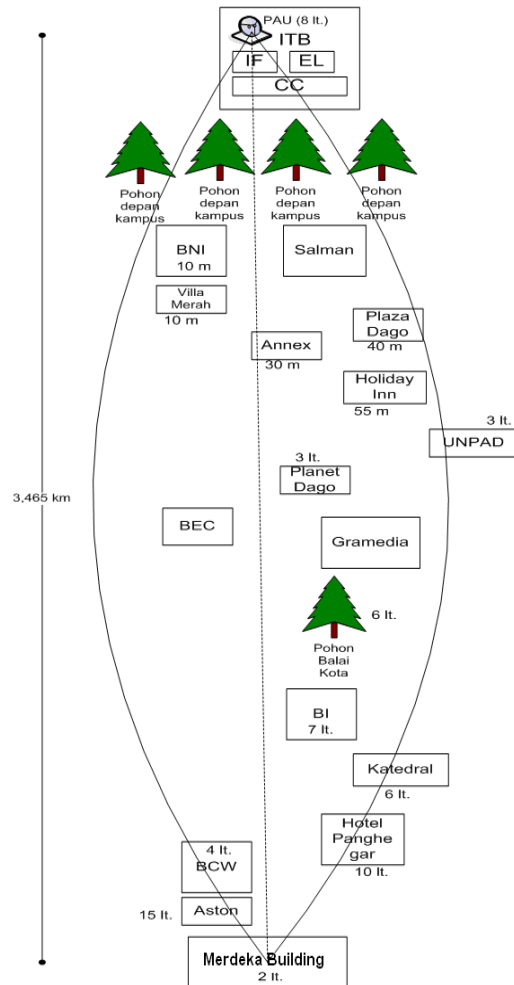


Fig. 3. WiMAX Links for connecting Bdg1 and Bdg2

In this study, we prepare the MAN-based Site Diversity by locating the VSAT terminals at ITB as Bdg1 and BRI Tower as Bdg2. These two ground station will be connected using WiMAX link as illustrated in figure 3. In this case, we use 5.2 GHz WiMAX system for point to point backhaul link. Our link budget and path analysis indicate that the WiMAX link design is appropriate enough for providing high data rate between ITB and BRI Tower sites. The path analysis is illustrated at figure 4.

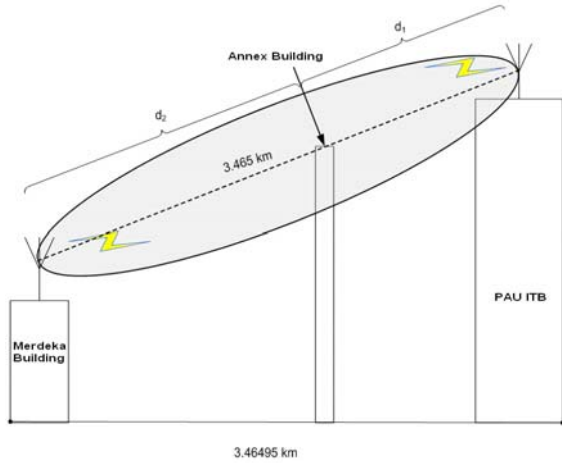


Fig. 4. Path Analysis of PAU ITB and Merdeka Building

$$\begin{aligned}
 & \text{Receive Signal Level (RSL)} \\
 RSL &= P_o - L_{cix} + G_{atx} - L_{crx} + G_{arx} - FSL \\
 & \quad + G_d + FM_{upfade} \\
 &= 10 \log 200 - 3 + 30 - 2 + 28 - \\
 & \quad 117.65 - 34.12 + 5.29 \\
 &= -70.47 \text{ dBm (more than the} \\
 & \quad \text{receiver sensitivity -83 dBm)}
 \end{aligned}$$

5. Performance Evaluation of WiMAX Site Diversity

For evaluating the MAN-based site diversity performance, we need to simulate the spatial distribution of rainfall and its variation over time. It is used to evaluate the performance of site diversity technique over the service areas during rain periods.

By modeling the spatial-temporal of rain fade on satellite link from spatial distribution of rainfall and its time variation, an accurate performance analysis can be achieved. We have performed the simulation of rain events on the service area with the two site locations, separated by the distances of 4 km as shown in figure 5, one site Bdg1 was ITB site, and Bdg2 as BRI Tower.

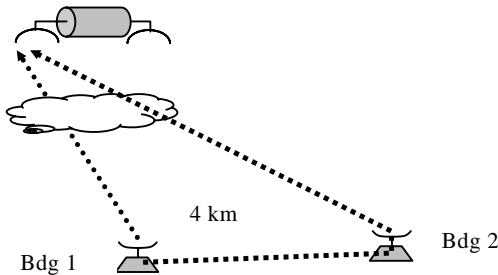


Fig. 5. Site Diversity Simulation

Most satellite rain fade studies have supplied CDF's of rainfall rate and or rain attenuation, but in this paper we use the signal level as a time function during rain period on the three site locations.

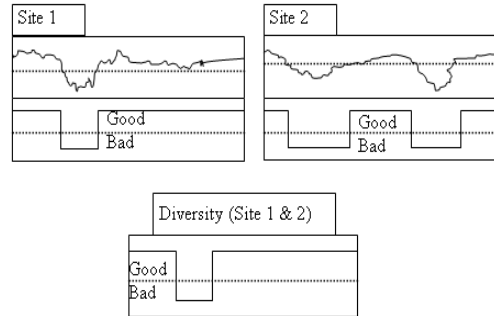


Fig. 6. Individual Site and Site Diversity Signal Level [1]

These figures show us the individual signal level and their state of each site. Diversity using two sites gives much better performance than single site as shown in figure 6.

6. Conclusion

From our simulation, we can show that the rain fade characteristics of urban area give us some opportunity to develop MAN-based diversity techniques to compensate the rainfall effect to our VSAT network. In this case, WiMAX link could reach a wider coverage and provide high data rate connection between Bdg1 and Bdg2 sites.

References

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- 2) Chandler, R. et. al, *Spatial-Temporal Rainfall Processes: Stochastic Models And Data Analysis*, University College London.