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Comparison of Smart Antenna Technique Based on Adaptive Antenna Systems and Switched Beam Systems

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Abstract

The continuous increment of mobile communication subscribers, require a higher capacity and spectrum efficiency of the cellular system especially in an urban area where the traffic density is high. In order to accommodate the increasing number of subscribers, smart antenna technology is used to improve system's performance, which could increase the number of call and data transmission as well as simplifying the networking management. The basic principle of a smart antenna is to control and reduce the effect of interference to provide the user with the highest quality of uplink and downlink signal. This can be achieved by using narrow beams with signal processing capability at the base sites and to optimize its radiation pattern, which automatically updated according to MS movement or as signals conditions change. In this study, two types of smart antenna were considered, which are the switched beam systems and adaptive antenna systems. The significant difference between these two systems is from the beamforming point of view. The key part of this study is to develop a simulator for adaptive antenna systems (AAS) and switched beam systems (SBS) based on GSM 900 in order to determine the factors that could affect network's quality and capacity. Simulation results of different techniques are compared and the performance evaluations of C/I are discussed. Results show that the AAS gives a better performance compared to SBS, with average improvement of C/I around 5 to 10 dB.

Keywords: *smart antenna, adaptive, switched beam,C/I*

1. Introduction

New technologies are being introduced into the market with the evolution of the mobile communication system. Cellular phone companies are always trying to give the best services to the customers through high quality coverage with more capacity.

Smart antenna has become another alternative in order to increase the capacity and efficiency of the system. It offers various methods to improve the performance of the wireless system. In general, smart antenna has a potential to provide wider coverage area, increase the performance of the downlink and uplink while improving the system's capacity.

In this paper, research has been done based on two types of smart antenna, which are switched beam system (SBS) and adaptive antenna system (AAS) that are used in base stations. The comparisons of these two systems were done according to a few aspects such as system's quality performance and system's capacity. The significant difference between these two systems is from the beam forming point of view in order to serve MS. Figure 1(a) shows the radiation pattern of the switched beam system while Figure 1(b) shows the radiation pattern for adaptive antenna system. In Figure 1(b), the main lobe is always directed to the desired signal while at the same time it puts the null to the interference signal.

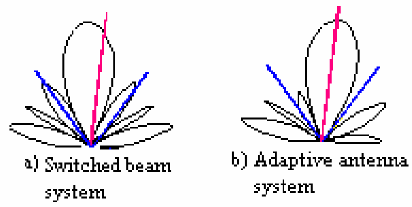


Figure 1. Radiation pattern that might be chose or transmitted to serve target MS (red) and co-channel interference signal (blue) by SBS and AAS.

2. Methodology

Simulation is a very cheap, efficient and practical method to be applied. Hence, a simulator has been developed in order to study the performance of the switched beam system and adaptive antenna system using Matlab 6.5 software. The objectives of the simulation are to study the factors that influence the performance and predict the performance of both antenna systems. Focus is given to the mean value of carrier to interference ratio (C/I) that can be achieved by both systems.

First, a few models were chosen for the simulation such as path loss model, base station antenna model, and beam forming algorithm. To estimate the power received by MS, log-distance path loss model was used. Figure 2 is the flow diagram that shows the simulation process that has been executed.

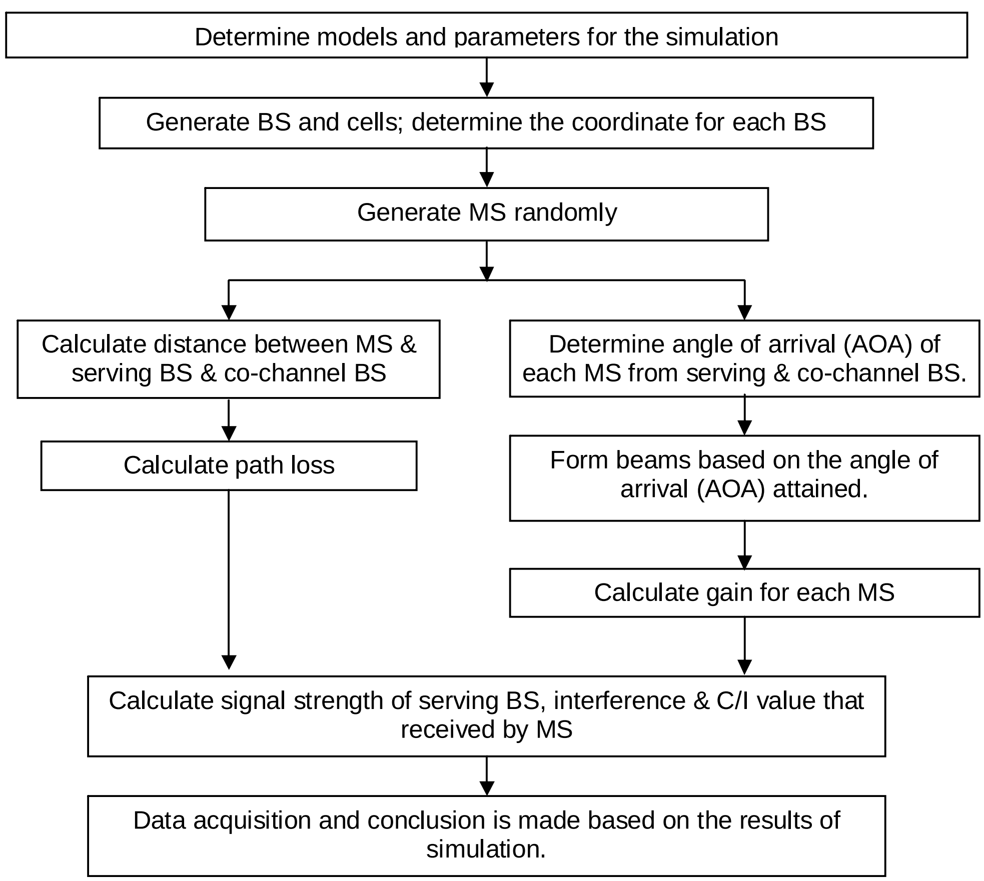


Figure 2. Flow diagram for the execution of the simulation process

3. Results and Discussion

Based on the results of the simulations, the adaptive antenna and switched beam system's performance were analyzed. The value of C/I depicts the signal quality in the cell, whereas the higher the C/I value, the quality of the signal received by MS is better. In the simulation, the evaluation of the system's performance was done by using C/I as the measuring standard. Factors that are studied are:

a. Minimum 3-dB beamwidth antenna factor, β.
   From Figure 3, the mean value of C/I for the switched beam system is much higher than the mean value of C/I for adaptive antenna system. This phenomenon occurs because the beams that are formed in the adaptive antenna system consist of various sizes, depending on the minimum separating angle between adjacent MS**.** For a beam with small β, the C/I achieved is high and for greater β, the value of C/I achieved is low. Thus, the mean value of C/I for switched beam system is much lower. In the switched beam system, MS receives the same signal strength because the entire beam has the same β size.

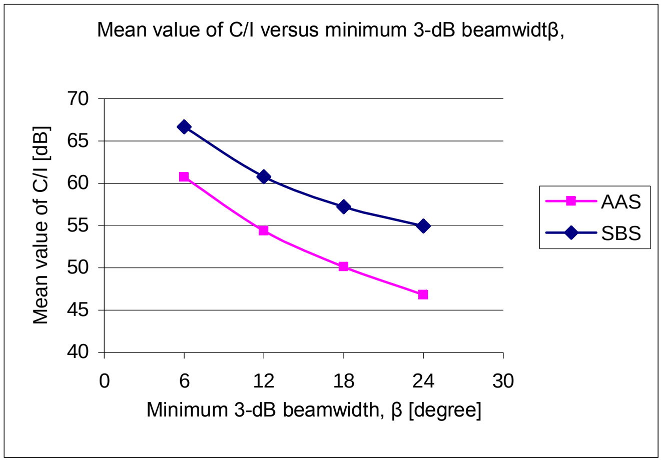


Figure 3. Mean value of *C/I* versus minimum 3-dB beamwidth, β

b. Co-channel interference that affects the MS in the serving BS.
   In figure 4, it is shown that when the interference increases, the value of C/I will decrease, but the quality of the signal received is still in good condition. This is due to the fact that a good quality cell for the GSM system has a mean value of C/I that exceeds the C/I threshold value, which is 12dB.

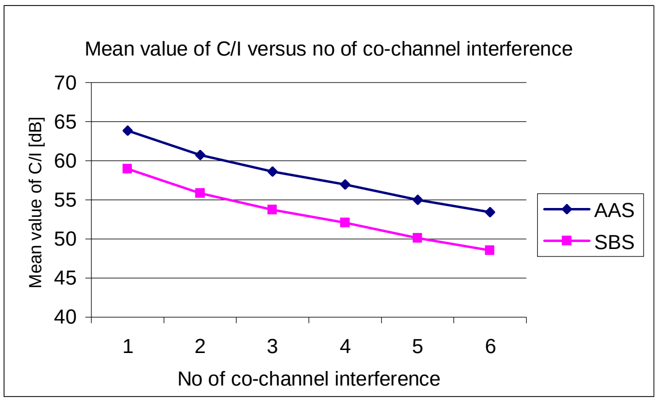


Figure 4. Mean value of *C/I* versus number of co-channel interference

c. Distance between MS and serving BS.

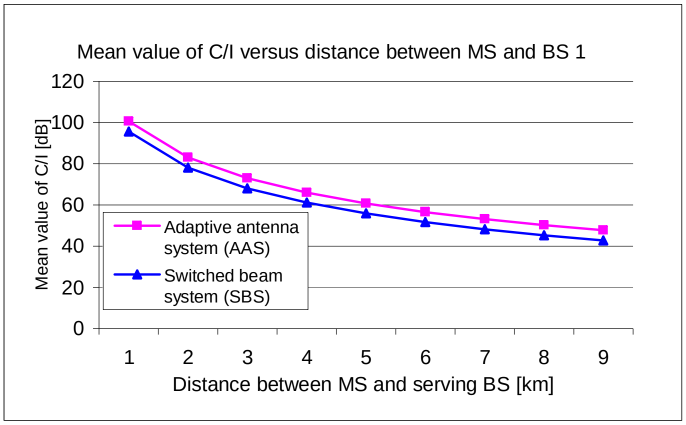


Figure 5. Mean value of *C/I* versus distance between MS and serving BS.

When MS is located further from the Serving BS, the strength of the signal received would decrease. As MS moves away from serving BS, it will come closer to the interferer BS, this will increase the interference thus degraded the mean value of C/I that can be achieved. Figure 5 depicts that performance of serving BS with adaptive antenna system always has a better performance than the switched beam system in term of efficiency of receiving the signal versus distance factor.

d. Number of MS in a cell.

Based on the graphs attained in Figure 6, it can be concluded that if there is a small number of MS in a cell, performance of adaptive antenna system is better compared to switched beam system. The performance degrades as the number of MS to be served increase.

Degradation of performance is due to the separating angle between adjacent MS. As the number of MS increase, the separating angle between adjacent MS will decrease and become smaller than the minimum separating angle that had been chosen**.** Hence, more MS will be served in the same beam and the size of 3-dB beamwidth will be wider. Therefore, radiated power from the serving BS cannot be focused to desired MS and the value of C/I will decrease.

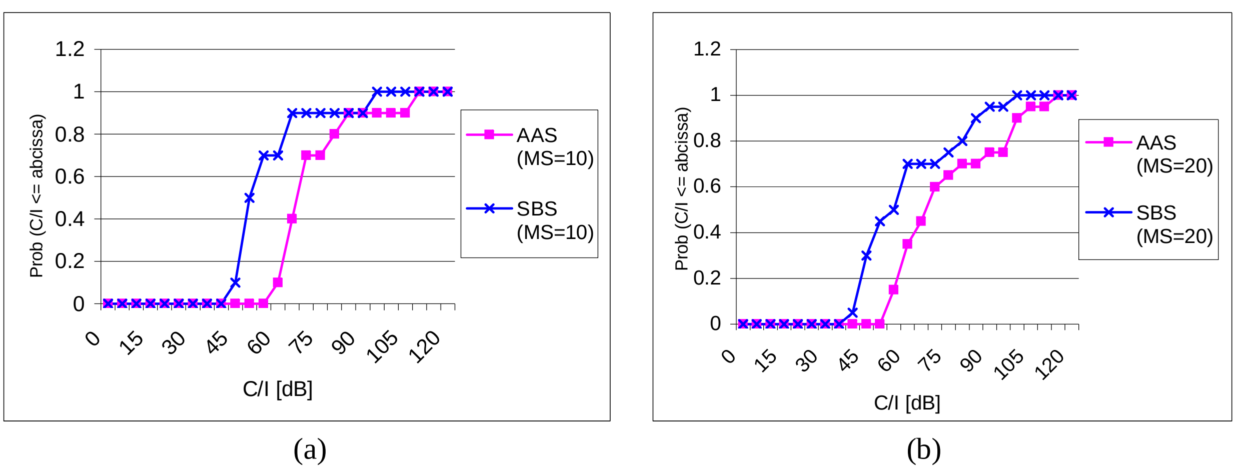
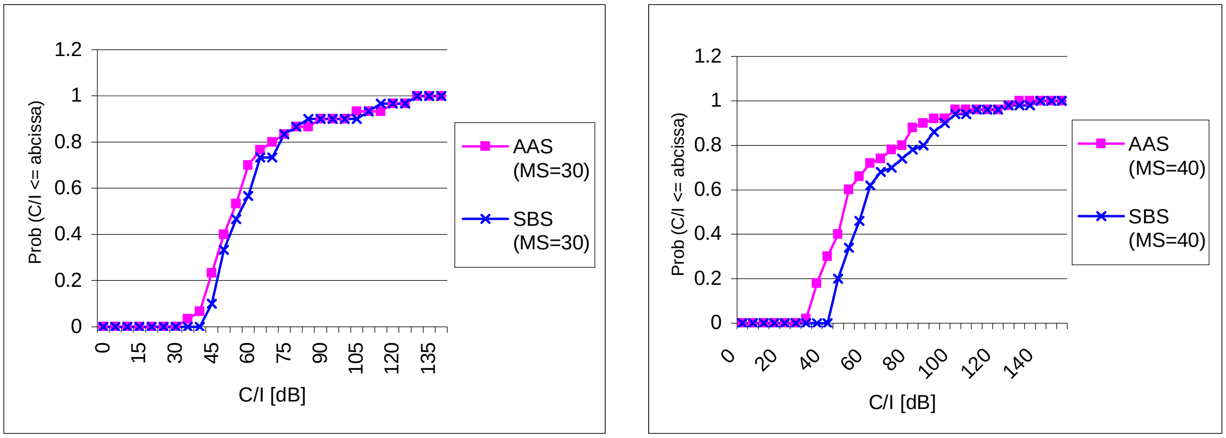


Figure 6. Distribution of C/I values for adaptive antenna system and switched beam system for (a) No. of MS=10, (b) No. of MS=20.



(c) (d)

Figure 6. Distribution of C/I values for adaptive antenna system and switched beam system for (c) No. of MS=30 and (d) No. of MS=40.

4. Conclusion

As a conclusion, the objectives of this study were accomplished and results attained from the simulation are the same as theoretically predicted. Generally, the conclusion that can be made from the simulation is that the BS with adaptive antenna system has a better performance compared to switched beam system. However, performance of adaptive antenna decreases as the number of MS in a cell increase. Although performance of switched beam system also decreases, but because of the constant size of beamwidth and lack of influence from environmental parameters, the degradation of performance seems not apparent until at one point, where performance of switched beam system is better than adaptive antenna system. From the point of view of the efficiency of receiving the signal, adaptive antenna system has a better performance compared to switched beam system in term of the mean value of C/I versus distance factor and number of co-channel interference.

References

Array Comm. 2000. Smart Antenna Systems. (online) http://www.iec.org/online/tutorials/smart_ant/index.html (5 Julai 2003).

Azlin bt Abdul Aziz. 2000. Pembentukan Alur Pengsektoran Sistem Sel Dinamik. Tesis Sarjana Muda, Jabatan Kejuruteraan Elektrik, Elektronik dan Sistem. Universiti Kebangsaan Malaysia.

Ben Strange. 2001. What is a Smart Antenna? (online) http://murray.newcastle.edu.au/users/students/2001/c9708212/smart_antenna.html (26 Ogos 2003).

Henrik Dam et.al., Performance Evaluation of Adaptive Antenna Base Stations in Commercial GSM Network. VTC, 1999.

Lehne, P.H. & Pettersen, M. 1999. An Overview of Smart Antenna Technology for Mobile Communications Systems. *IEEE Communications Survey, Fouth Quarter.*

Mahamod Ismail 1995. Cellular topologies for Personal Communications Systems. Disertasi Ph.D. University of Bradford, UK.

Mahamod Ismail, Doumi, T.L. & Gardiner, J.G 1999. Performance Enhancement of Cellular Topologies Employing Dynamic Cell Sectoring and Base Station Antenna Beam Steering using TDMA. *Jurnal Kejuruteraan* **11**(1), 1999: 21-34.

Rappaport, T.S. 2002. *Wireless Communications Principles and Practice*. Upper Saddle River, NJ.: Prentice Hall PTR.

Rappaport, T.S. & Liberti, J.C. 1999. *Smart Antennas for Wireless Communication – IS-95 and Third Generation CDMA Applications*. Englewood Cliffs, NJ.: Prentice Hall PTR.

S. Choi, D. Shim & Tapan K.Sarkar. 1999. A Comparison of Tracking Beam Arrays and Switched Beam Arrays operating in a CDMA Mobile Communication Channel. *IEEE Antennas and Propagation Magazine* **41**(6), December 1999: 10-22.

Yacoub, M.D. 1999. *Cell Design Principles*. Boca Raton: CRC Press.

Zeti Akma Rhazali 2003. Peningkatan Kapasiti Rangkaian GSM Menggunakan Teknik Antena Pintar. Tesis Sarjana, Jabatan Kejuruteraan Elektrik, Elektronik dan Sistem. Universiti Kebangsaan Malaysia.