Smart Antenna Potential on Performance Improvement

for Mobile Communication Systems

Asst. Prof.Dr.Ismail M.Jabber

University of Madenat AL-Elam

Amin_ck87@yahoo.com

Asst.Lec.Ansam M. Abed

University of Madenat AL-Elam

ama_ansam@yahoo.com

Abstract

Smart antennas have numerous important benefits in mobile communication systems. Smart antennas can provide higher system capacities by directing narrow beams toward the users of interest, while nulling other users not of interest. This allows for higher signal-to-interference ratios, lower power levels, and permits greater frequency reuse within the same cell. This, in turn, increases the system capacity and the quality of services.

In this paper we analyze the effect of base-station sensitivity obtained by using smart antenna to increase capacity and reduced the mobile transmit power at different loads scenarios.

Key words: Smart antennas, communication systems, mobile.

ملخص البحث

للهوائيات الذكية إمكانيات مهمة في تحسين أداء شبكات الهاتف النقال. بإمكان الهوائيات الذكية أن تعطي منظومات اتصال بسعة عالية وذلك بتوجيه حزم ضيقة باتجاه المشترك المطلوب الاتصال به وتصفير اتجاه مصادر التداخل.

وهذا يؤدي لزيادة نسبة قدرة الإشارة إلى التداخل مما يسمح بإعادة استخدام الترددات بشكل اكبر وهذا بدوره يزيد من سعة المنظومة ونوعية الخدمات .

في هذا البحث قمنا بتحليل تأثير حساسية محطة القاعدة التي يمكن الحصول عليها باستخدام الهوائي الذكي لزيادة السعة وتقليل القدرة المرسلة بوحدة المشترك باستخدام سيناريوهات أحمال مختلفة للنظام .

1. Introduction

As the number of cellular subscribers continues to grow rapidly, service providers are forced to increase the capacity of their networks especially in populated areas. Increasing capacity is of prime importance to serve a large number of subscribers at the same time [1].

Mobile communication system capacity can be increased in several ways. These include enlarging the total bandwidth allocated to the system, reducing the channel bandwidth through efficient modulation, decreasing the number of cells in a cluster, and reducing the cell size through cell splitting or sectorization [2,3].

It is expensive for the service providers to get additional spectrum with high license fees that must be paid. Reducing the cell size means many new base stations have to be built, with additional costs and results in more numbers of handoff. Cell sectorization provides greater possibility of reusing a frequency channel by reducing interference across the original cell, but it results in more frequent handoffs, which requires greater system resources to support and coordinate [4].

One of the important strategies for increasing capacity are interference reduction on the downlink and interference rejection on the uplink. Interference can be rejected by focusing the transmitted energy along the direction of the intended users using directional beams or by forming nulls in the direction of interfering sources.

The use of high gain narrow beams antennas improve carrier to interference ratio (C/I) , thus reduces frequency reuse factor for the same quality of service. Lower frequency reuse factor means more channels per cell, i.e., higher capacity. This can be accomplished by using smart antennas at the base to direct the electromagnetic energy to the intended users [5].

This paper concentrates on techniques for increasing capacity using smart antennas.

2. Smart Antenna Theory

The smart antenna combines multiple antenna elements (antenna array) with an adaptive signal processing capability to optimize its radiation and/or reception pattern in response to the signal environment.

The idea of smart antennas is to direct a single beam to each user to optimize the radio performance as shown in Figure(1). Using smart antenna with M elements will increases the signal amplitude (M) times because the desired signal received at each antenna element is phase-shifted due to weight coefficient, and then the signal components from each element are positively combined [7] [6].

The gain provided by smart antennas can extend the range of a cell to cover a larger area and more users than would be possible with omnidirectional or sector antennas [1].
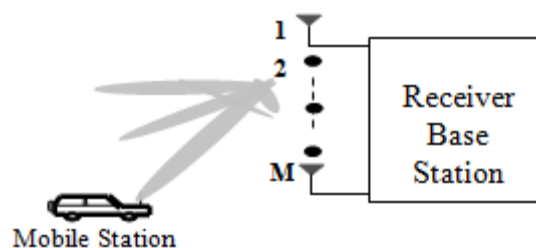
Figure 1. Smart Antenna Theory

Interference reduction can be implemented using high gain narrow beams to communicate with mobiles on the downlink, a base station is less likely to interfere with nearby co-channel base stations than if it used an omnidirectional antenna. Theoretically, the number of cells per cluster can be decreased, increasing spectral efficiency and capacity [2].

3. Smart Antenna Potential in Improving Capacity

Smart antennas can be used to allow the subscriber and base station to operate at the same range as a conventional system, but a lower power. This permit channels frequency reuse more frequently than conventional systems using fixed antennas, since the carrier-to-interference ratio (C/I) is much greater when smart antennas are

used. Ability to tighten frequency reuse allocates many channels per base station, and long range associated by smart antennas due to high gain [7].

The minimum RF level at the receiver input is referred to as the receiver threshold sensitivity level. At this level, the signal is only just above noise-level and is not very intelligible. If the radio-base station sensitivity can be reduced, this would be translated into a capacity increase and reduced mobile transmitted power.

If P_c is the carrier power, N is the noise, and I be interference power, then the receivers sensitivity (S) , can be given by [7] :

$$S = \frac{P_c}{N+I} \qquad (1)$$

The cell load (α) can be shown to be

$$\alpha = \frac{I}{N+I} \qquad (2)$$

where I denotes the other-cell interference and the same-cell interference.

Reducing the load factor for a given number of users or sector throughput improves both coverage and capacity.

If the smart antenna lower the receiver's sensitivity requirement to S', a capacity increases of (β) and a power reduction of (δ) can be achieved, as follows [7]:

$$S' = \frac{P_c}{N+I'} = \frac{\delta P_c}{(1-\alpha)(N+I)+\beta\delta\alpha(N+I)} \qquad (3)$$

It follows that the capacity gain and the power reduction are given by :

$$\beta = \frac{\delta(S/S')+\alpha-1}{\delta\alpha} \qquad (4)$$

$$\delta = \frac{1-\alpha}{(S/S')-\beta\alpha} \qquad (5)$$

If the capacity   is increased ,the system load will also increase. When the transmitted power is reduced , the battery life of the mobile is extended. On other hand ,with the same mobile transmitted power, this could be translated into a range extension [6,7].

4. Smart Antenna Simulation Results and Discussion

4.1 Power Reduction Using Smart Antenna

In Figure (2), the power reduction (δ) is plotted as a function of the gain that can be achieved using smart antenna (10 Log M), for different load factors (25%, 60 %).

In 60% loaded system, a 5.0 dB in the receiver's sensitivity could lead to a 8.0 dB power reduction. The same receiver sensitivity could lead to a 5.9 dB in 25% loaded system.
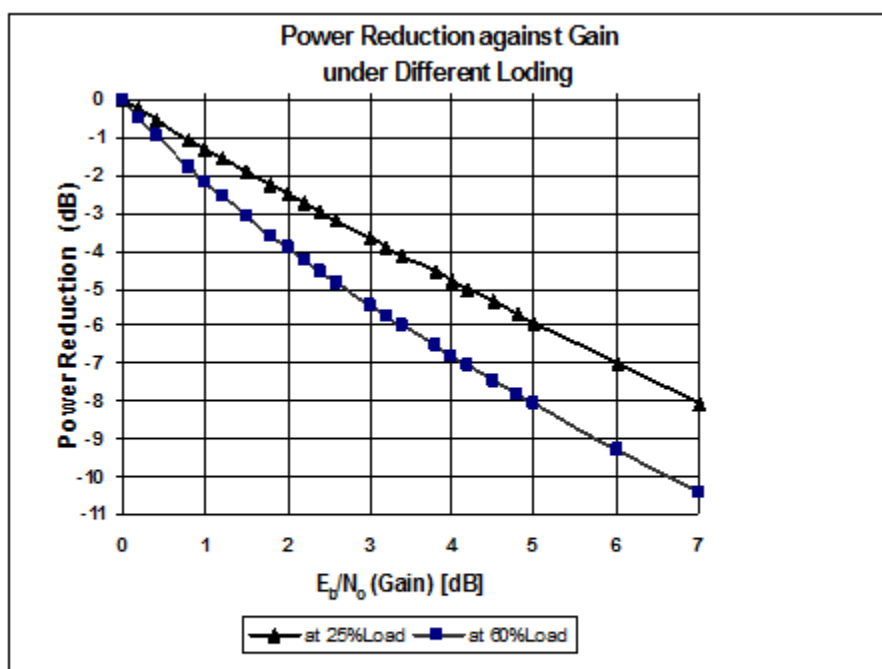

Figure (2) Power Reduction and Gain with Smart Antenna under Different Loading Scenarios

If smart antennas are used to allow subscribers to transmit less power for each link, then the Multiple Access Interference (MAI) is reduced, which increases the number of simultaneous subscribers that can be supported in each cell.

If the received power requirement at the mobile remains the same, with M-element array at the base station, the output power from amplifiers are reduced .Optimizing transmission toward the wanted user achieves lower

power consumption and amplifier costs, since the hardware components of the high-power amplifiers are expensive.

Figure (3) shows that as the distance increases, the received signal becomes weaker. When a subscriber unit transmits 0.6 watt (27.78 dBm), the power received at a base station located 2 km a way from the mobile unit will receive (-78.638 dBm), when using omnidirectional   antenna , while it will be (-69.608 dBm), when array of eight elements is used at the base station. The difference is due to the gain obtained by using the array (10 Log 8 = 9.03 dB).
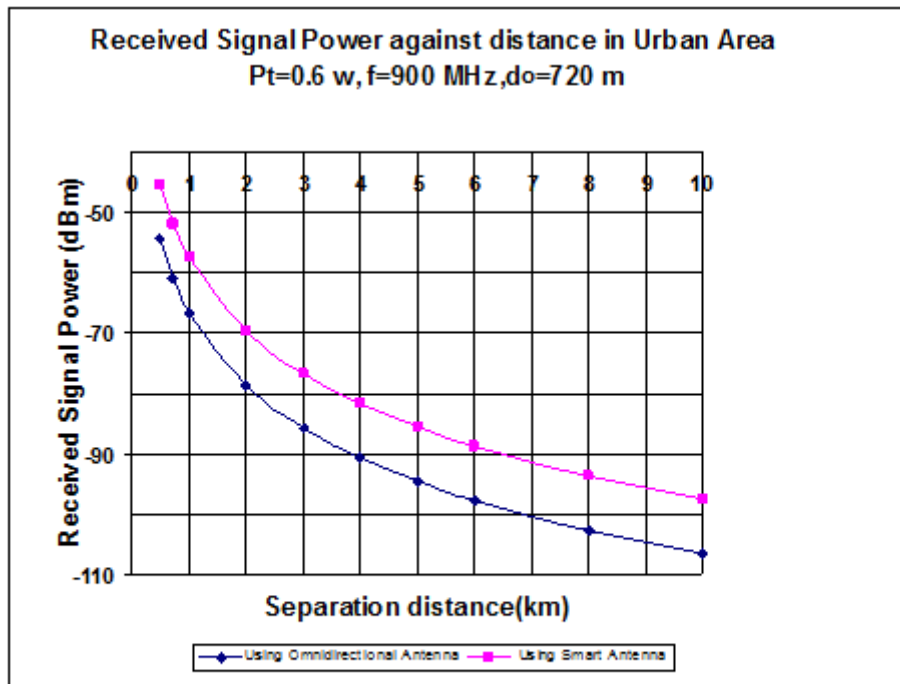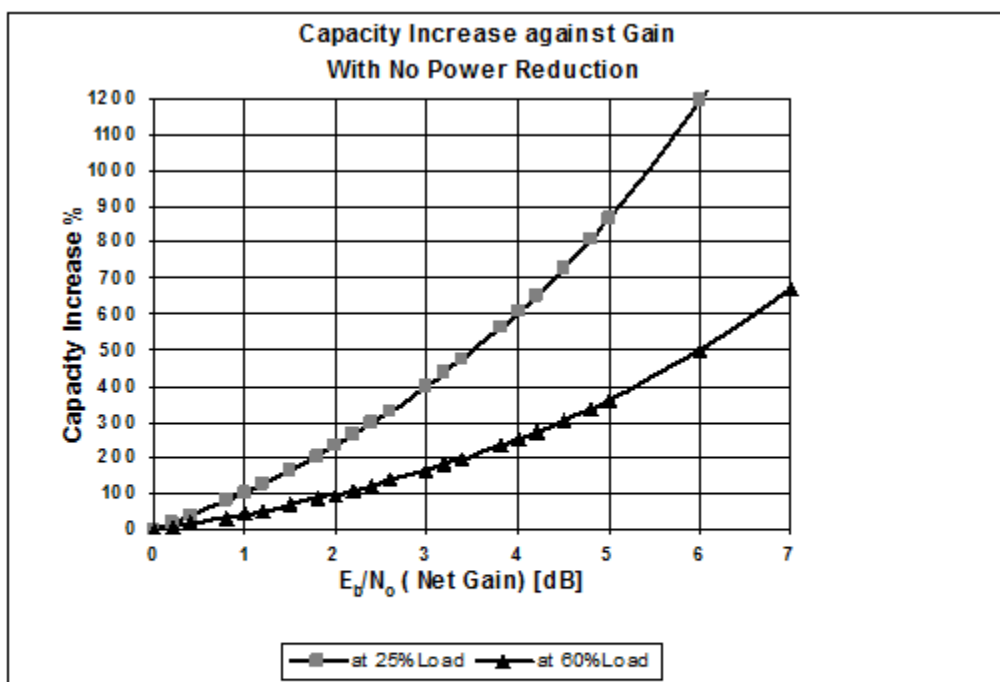

Figure (3) The Received Signal Power against Distance Using Omnidirectional and Smart Antenna

4.2 Increasing of Capacity

Figure (4) shows the expected capacity increase that can be achieved with no power reduction.

It can be noticed that a 3 dB gain with 60% loaded system corresponds to 166% capacity increase.

Figure (4) Capacity Increase as a Function of the Gain with Smart Antenna under Different Loading Scenarios without Power Reduction

In Figure (5), we have plotted capacity increase in 50% loaded system, for 50%, and 0% power-reduction factors. It can be seen that for a 3 dB gain, power can be reduced by 50% and capacity will increase by 33 %. A capacity improvement of 110 % could be obtained with a 4 dB gain at the same scenario. From the figure it can be seen how capacity and power reduction can be traded off.
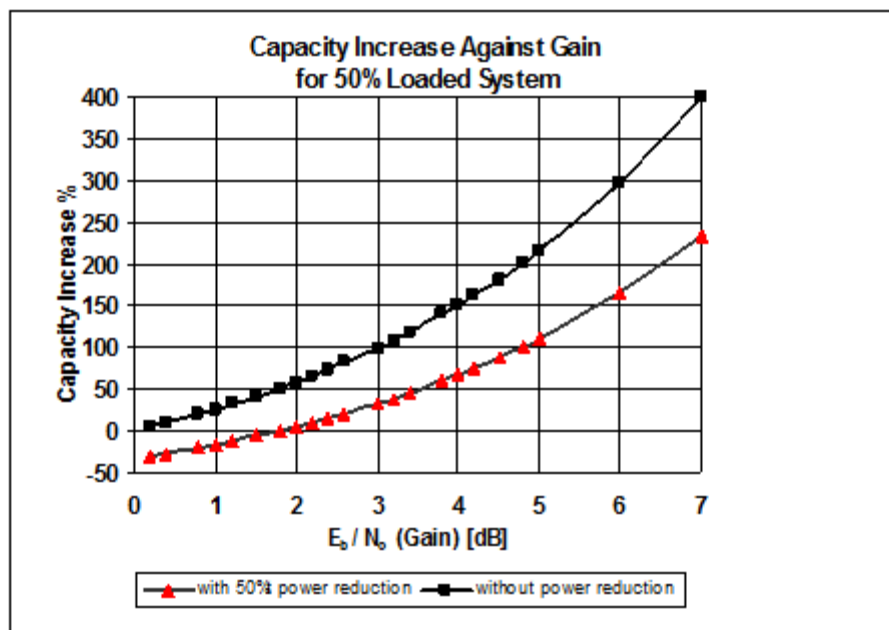
Figure (5) Capacity Increase as a function of the Gain with Smart Antenna of 50% Loading System, with 50%Power Reduction

5. Conclusion

The potential of smart antenna in improving mobile communication performance in terms of range and capacity is studied. The results obtained has been shown that reduction base station sensitivity requirement would be translated to a capacity increase and/or reduced mobile transmit power.

Concluded that with smart antennas at the base station, we can increase the uplink capacity by raising the uplink target load factor without sacrificing coverage because the reduction in array gain can limit the interference level and improve coverage.

References

1- **Sallomi**, Adheed Hasan. (2007) Smart Antenna Performance Analysis for Mobile Communications in Urban Environments. a thesis presented to the university of technology, Baghdad.

2- **Rappaport** ,S. (1997) Theodore and Blankship, Keith. Propagation and Radio System Design Issues in Mobile Radio Systems, Virginia polytechnic Institute.

3- **Sallomi**, Adheed H, and Salim, Sana R. (2009) Range –Coverage Extension Using Smart Antennas in Mobile Communication Systems. Iraqi Journal of Applied Physics, Vol. 5, No.2, PP25-28.

4- **Krzysztof**, Wesolowski. (2002) Mobile Communication Systems, Jhone Willy and Sons Ltd, First Edition.

5- **Bailey**, David. (2003) Practical Radio Engineering and Telemetry for Industry Gross", First Edition, Linacre House, Oxford.

6- **Balanis** C.A. (1997) Antenna Theory: Analysis and Design, 2nd Edition, John Wiley and Sons, New York.

7- Zooghby, A. H. (2001) Potentials of Smart Antennas in CDMA Systems and Uplink Improvements," IEEE Antennas and Propagation Magazine, Vol. 43, No. 5, pp. 172–177.