International Journal Of Electrical And Electronics Engineers ISSN- 2321-2055 (E)
Http://Www.Arresearchpublication.Com IJEEE, Volume 07, Issue 01, Jan- June 2015

SMART ANTENNA ANALYSIS, ITS APPLICATION IN SATELLITE COMMUNICATION WITH SDMA

Mamta[1], Ilma[2]

[1,2]Electronics and Communication Engineering, I.E.T M.J.P Rohilkhand University, Bareilly, (India)

ABSTRACT

Smart Antenna is the most efficient leading innovation for maximum capacity and improved quality and coverage. Two different beam forming approaches in space division multiple access (SDMA) for mobile satellite communications: Switched beam antenna and adaptive antenna array systems are considered. The algorithm that meets the low computational complexity and high convergence requirements in the adaptive array antenna system of SDMA are developed.

In this paper we provide a brief overview of smart antenna, their benefits and how they actually works. A small model of smart antenna containing six elements is also discussed here.

Index Terms: SDMA, Switched Beam, Adaptive Array Antenna, SIR, RLS, RSSI

I. INTRODUCTION

The smart antenna technology is considered to be the last technology frontier in antennas that has the potential of leading to large increase in system performance. Smart antenna system comprises multiple antenna elements with digital signal processing to optimize the radiation pattern in response to the signal environment. Switched beam and adaptive array antenna system are used for this purpose. Such a configuration dramatically enhances the capacity of a wireless link through a combination of diversity gain, array gain, and interference suppression. Smart antennas are a specific type of directional antenna able to dynamically control the gain as a function of direction. This contrasts with more traditional directional antennas, where the dynamic ability is missing, and with omnidirectional antennas.

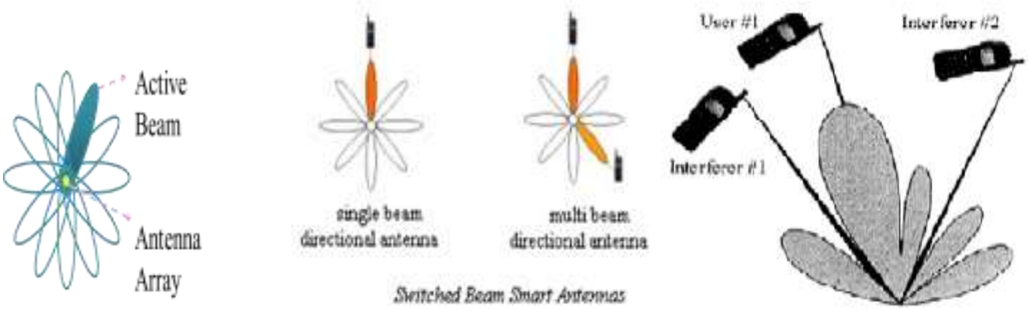
When applied to satellite communication the smart antenna can increase the coverage, improve link quality, lower power consumption, help with finding direction. In the satellite communication systems, as a rule, many users are active in the same time. Since resources of the systems are limited, it is advisable to use the channels to create the multiple access to channel. This generates a problem of summation and separation of signals in the transmission and reception parts respectively. The significant factor in the performance of multiple access in a satellite communications system is interference. It causes cross-talk, missed or dropped calls, and upsets customers. Most importantly, interference limits traffic-carrying capacity from the finite RF spectrum. Interference can come from another users, other cell sites operating on the same frequency, or out-of-band RF energy leaking into the allocated spectrum. The most usual types of interference are co-channel interference and adjacent channel interference.

Taking into account, what in the systems of satellite communications every user has own unique space position, this fact maybe used for the separation of channels in the space and as consequence to increase SIR ratio. Such method is named SDMA. There are two different beam-forming approaches in SDMA for satellite communications: one (Switched-Beam Antennas) is to track each subscriber of a given cell with an individual beam pattern as the target subscriber moves within the cell, and the other (Adaptive Array Antenna Systems) is to select one beam pattern for each subscriber out of a number of preset fixed beam patterns depending on the location of the subscriber.

II. SWITCHED-BEAM ANTENNA

It is possible, using array antennas, to create a group of overlapping beams that together result in omnidirectional coverage. It is the simplest technique, and comprises only a basic switching function between separate directive antennas or predefined beams of an array. Beam-switching algorithms and RF signal-processing software are incorporated in smart antenna designs. For each call, software algorithms determine the beams that maintain the highest quality signal and the system continuously updates beam selection, ensuring that customers get optimal quality for the duration of their call. One might design overlapping beam patterns pointing in slightly different directions similar to the ones shown in figure

Switched-beam antennas are normally used only for reception of signals since there can be ambiguity in the system's perception of the location of the received signal. Switched-beam antennas gives the best performance, usually in terms of received power, but also suppress interference arriving from directions away from the active beam's center, because of the higher directivity compared to a conventional antenna, some gain is achieved. In high-interference areas, switched-beam antennas are further limited since their pattern is fixed and they lack the ability to adaptively reject interference. Such an antenna will be easier to implement in existing cell structures than the more sophisticated adaptive arrays, but it gives a limited improvement.



III. ADAPTIVE ARRAY ANTENNA SYSTEMS

Adaptive array antenna systems continually monitor their coverage areas, attempting to adapt to their changing radio environment, which consists of (often mobile) users and interferers. In the simplest scenario - that of a single user and no interferers - the system adapts to the user's motion by providing an effective antenna pattern that follows the user, always providing maximum gain in the user's direction. The principle of SDMA with adaptive antenna application is quite different from the beam-forming approaches described above. The processing of events occurs in SDMA adaptive array antenna systems could be presented as following sequence:

"Snapshot", or sample, is taken of the signals coming from all of the antenna elements, converted into digital form, and stored in memory.

The SDMA digital processor analyzes the sample to estimate of the radio environment, identifying users and interferers and their locations.

The processor calculates the combining strategy for the antenna signals that optimally recovers the users signals. With this strategy, each user's signal is received with as much gain as possible and with the other users' and interferers' signals rejected as much as possible.

An analogous calculation is done to allow spatially selective transmission from the array. Each user's signal is now effectively delivered through a separate spatial communications channel.

The system now has the ability to both transmit and receive information on each of the spatial channels making them two-way channels.

As result, the SDMA adaptive array antenna system can create a number of two-way spatial channels on a single conventional channel, be it frequency, time, or code. Each of these spatial channels enjoys the full gain and interference rejection capabilities of the array. In theory, an array with m elements can support m spatial channels per conventional channel. In practice, the number is somewhat less because take place the received multipath signals which can be combined to direct received signals. In addition, by using special algorithms and space diversity techniques, the radiation pattern can be adapted to receive multipath signals which can be combined. These techniques will maximize the signal to interference ratio (SIR) (or signal to interference and noise).

The more detailed benefits of an SDMA system include the following:

The number of cells required to cover a given area can be substantially reduced.

Interference from other systems and from users in other cells is significantly reduced.

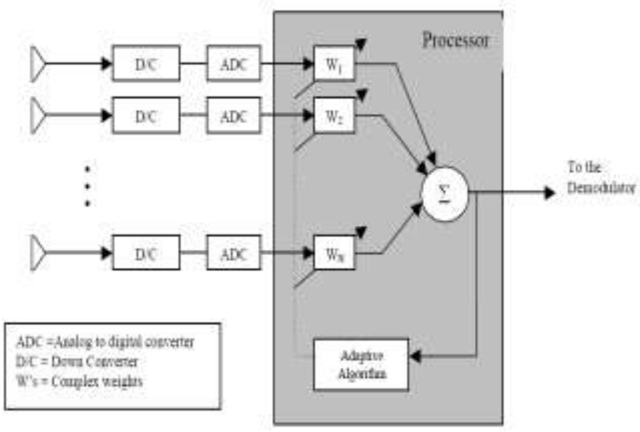
The destructive effects of multipath signals – copies of the desired signal that have arrived at the antenna after bouncing from objects between the signal source and the antenna — can often be mitigated.

Channel reuse patterns of the systems can be significantly tighter because the average interference resulting from co-channel signals in other cells is markedly reduced.

Separate spatial channels can be created in each cell on the same conventional channel. In other words, intra-cell reuse of conventional channels is possible.

SDMA station radiates much less total power than a conventional station. One result is a reduction in network-wide RF pollution. Another is a reduction in power amplifier size.

The direction of each spatial channel is known and can be used to accurately establish the position of the signal source.



Block diagram of Adaptive array systems

3.1 Proposed Algorithm

Evidently that adaptive algorithm must be implemented with number of contradictory demands. This is, first of all, high convergence to optimum solution, since in low convergence will be seen the high level of interference at the beginning part of connection with subscriber. In the second place, the adaptive algorithm preferably must to have low hardware implementation, since adaptive processor have to put in satellite. The first demand dictates applying of the direct matrix inverse algorithms of adaptation, and second recursive implementation of such algorithms. We present recursive least square (RLS) vector operations efficient algorithms for real time weights optimizing and signal tracking that apply eq.(22) with computational complexity O(N). Applying of this algorithm for tracking allows decrease its complexity of hardware implementation.

For i = 1,2,...,k the output vector can be obtain as

$$Y_i = R_i^{-1}\alpha x_i = \frac{1}{1-\alpha}\left(R_{i-1}^{-1} - \frac{\alpha R_{i-1}^{-1} x_i x_i^{\sim} R_{i-1}^{-1}}{(1-\alpha)+\alpha x_i^{\sim} R_{i-1}^{-1} x_i} \right)\alpha x_i$$

where i = 1,2,...,k is output of channels in i-th moment of time .

making substitution , $z_i = R_{i-1}^{-1}\alpha x_i$,

$$Y_i = z_i - \frac{z_i z_i^{\sim} x_i}{(1-\alpha)+\alpha z_i^{\sim} x_i} = z_i - z_i d_i z_i^{\sim} x_i$$

Where $d_i = \dfrac{1}{(1-\alpha)+\alpha z_i^{\sim} x_i}$

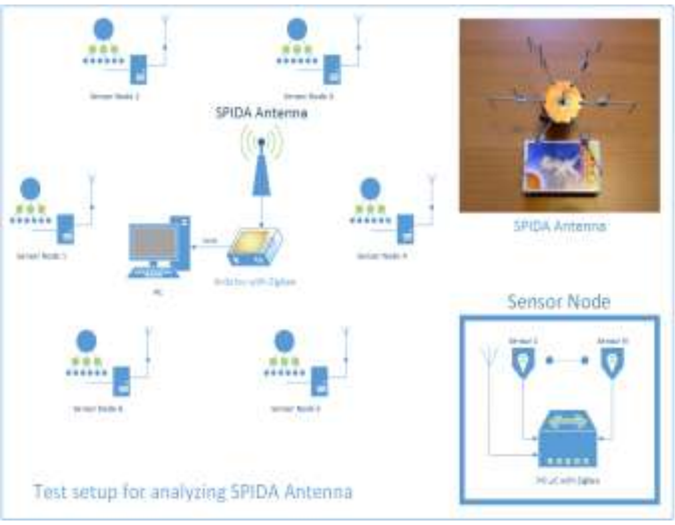
Then inverse of matrix is ,

$$R_{i-1}^{-1} = R_0 - \sum_{j=1}^{i-1} z_j d_j z_j^{\sim}$$

then result is ,

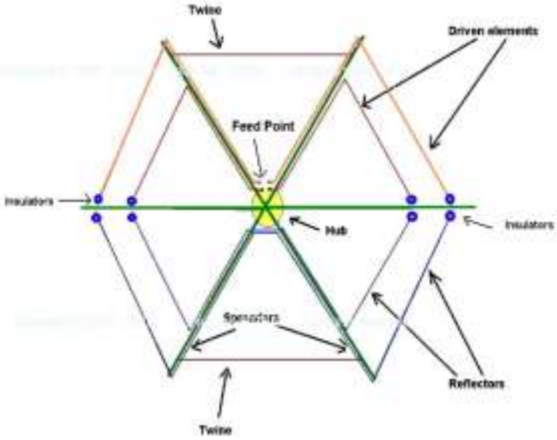
$$z_i = \alpha x_i - \alpha \sum_{j=1}^{i-1} z_j d_i z_j^{\sim} x_i$$

IV. SMART ANTENNA MODEL CONSISTING OF SIX ELEMENTS



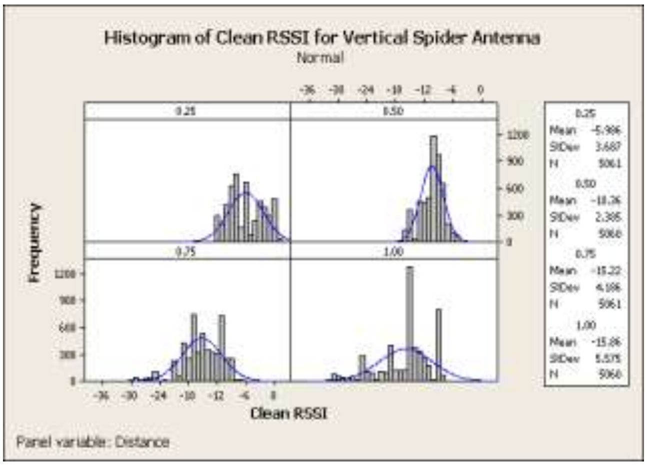
The SPIDA1 smart antenna operates in the 2.4 GHz ISM band aboard a TMote Sky device, using a CC2420 radio. The current prototype is shown in Figure 1, attached to the sensor node through a standard SMA connector. We describe next the hardware/software characteristics, along with preliminary results on the antenna behavior (Hardware/Software). The SPIDA is a switched parasitic antenna, i.e., it consists of a central active element surrounded by "parasitic" elements, which can be switched between ground and isolation.

When grounded, they work as reflectors of radiated power, and when isolated they work as directors of radiated power. The central monopole is a conventional quarter- wavelength whip antenna. As shown in Figure 1, the SPIDA is equipped with six parasitic elements, yielding six possible "switches" to control the direction of transmission. A distinguishing feature is the SPIDA's smoothly varying radiation pattern. The antenna gain is designed to vary as an offset circle from approximately 7 dB to -4 dB in the horizontal plane, without any significant side lobes even when using simplistic on-off control. The antenna is straight- forward to manufacture, and its most expensive part is the SMA connector costing about 5 ECU in single quantities. We design the control circuitry with a major aim of reducing interference and suppress noise from the sensor node digital circuitry. . We use the available lines on the TMote Sky to control the six parasitic elements, using two LC filters for each I/O line to prevent noise from entering the RF section. Each parasitic element is controlled by an ADG902 SPST RF solid state switch. The control circuit is soldered ontoastripboardwithanattached10-pinIDCconnectorthat fits directly onto the TMote Sky expansion pins. At software level, a simple AP I targeting the Contiki operating system is used. The first two functions serve to isolate or ground specific parasitic elements on the SPIDA, thus enabling individual fine-grained control. Nevertheless, we expect the common use of the SP- IDA to involve only one isolated element at a time, to direct the transmission in one specific direction. The last function configures all parasitic elements at once to enable transmission in one of the six possible directions. Giving 0 as input makes the SPIDA isolate all parasitic elements, leading to omnidirectional behavior. For instance, this may be useful for neighbor discovery. 2.2 Preliminary Results. To check the correct functioning of our prototype, we use the proper setup . The node in the middle is equipped with the SPIDA and generates periodic broadcast transmissions. Six nodes around the SPIDA, along the six possible directions of transmission are deployed. These nodes act as "probes" by logging the broadcast transmissions they hear, using standard omnidirectional antennas. Every 10000 transmissions, the control software on the SPIDA node dynamically changes the direction of transmission. The Received Signal Strength Indicator (RSSI) returned by the radio chip reaches a maximum when the direction of transmission aligns with the corresponding probe node. This reflects in better link quality and thus higher packet delivery. In contrast, the RSSI reading tends to be minimum when the direction of transmission is opposite to a given probe node. This shows that the prototype is able to direct the transmitted power in given directions while not involving other nodes.



4.1 Demonstration Highlights

To demonstrate the operation of the SPIDA , a supporting base plate equipped with six super-bright LEDs is developed. The LEDs are controlled using dedicated circuitry inter- posed between the sensor node and the antenna. We turn an LED on when the corresponding SPIDA parasitic element is isolated, providing a visual indication of the current SPIDA configuration.



A setup connecting all nodes to a laptop for easier inspection of their internal states and visualization of the network topology. By controlling the radio output power, the setup can be demonstration on a 4 x 4 m table and still obtain a multi-hop scenario. However, a 10x10m space would allow more realistic setting. Using multiple experiment setups using the advantage of the antenna's:

- The increased packet delivery ratio in 1-hop unicast transmissions is obtained by directing the trans- mission towards the target device. We compare this to using the omnidirectional mode on the SPIDA, which emulates a traditional antenna.
- Still using unicast transmissions, the antenna's ability to change the direction of transmission by quickly alternating between the six probe nodes as target is shown. This demonstrates the SPIDA's dynamic abilities.
- The impact of using the SPIDA with a traditional tree-based collection protocol. One of the probe nodes as sink, and let the protocol build a tree among the nodes. The SPIDA alternates between omnidirectional mode for reception and neighbor discovery, and directional mode for transmissions to the parent in the tree2. We also plan to further involve the public by showing the various (disassembled) hardware components necessary for a SPIDA antenna, providing further insights into its construction process.

V. SUMMARY

The smart antenna works as follows. Each antenna element "sees" each propagation path differently, enabling the collection of elements to distinguish individual paths to within a certain resolution. As a consequence, smart antenna transmitters can encode independent streams of data onto different paths or linear combinations of paths, thereby increasing the data rate, or they can encode data redundantly onto paths that fade independently to protect the receiver from catastrophic signal fades, thereby providing diversity gain. A smart antenna receiver can decode the data from a smart antenna transmitter this is the highest-performing configuration or it can simply provide array gain or diversity gain to the desired signals transmitted from conventional transmitters and suppress the interference .Two approaches for SDMA satellite communication systems are presented: switch beam and adaptive technique and the algorithm of RLS is discussed.

REFERENCES

[1] MonzingoR.A., Miller W. Introduction to Adaptive Arrays. - John Wiley & Sons Inc, New York, 1980.

[2] Sklar B. Digital Communications: Fundamentals and Applications.- Prentice Hall, New Jersey, 1988.

[3] Liberti J.C., Rappaport T.S., Smart Antennas for Wireless Communications: IS-95 and Third-Generation CDMA Applications. Prentice Hall, NJ, 1999.

[4] Ohira, T. and J Chang 2004, analog smart antenna, adaptive antenna array, Berlin Springer pp 184-204

[5] M. Nilsson, “Directional antennas for wireless sensor networks,” in Proc. of the 9th Scandinavian Workshop on Wireless Adhoc Networks (Adhoc), 2009.

[6] J. Dunlop and J. Cortes, “Impact of directional antennas in wireless sensor networks,” in Proc. of the the 4th Int. Conf. on Mobile Ad-Hoc and Sensor Systems (MASS), 2007.

[7] D. Thiel and S. Smith, Switched parasitic antennas for cellular communications. Artec House, London, 2002.

[8] A. Dunkels, B. Grönvall, and T. Voigt, “Contiki - A lightweight and flexible operating system for tiny networked sensors,” in Proc. of 1st Wkshp. on Embedded Networked Sensors, 2004