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Technical Report

Rapidly Deployable Radio Network Network Control of Sectorized Antenna Array

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ITTC-FY2000-TR-13380-010

September 2000

Defense Advanced Research Projects Agency/CSTO
ARPA Order No. 8195
Contract No. DAAB07-97-C-D263

Rapidly Deployable Radio Network
Network Control of Sectorized Antenna Array

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1. Introduction

The antenna system for the Rapidly Deployable Radio Network (RDRN) contains an electronically controlled sectorized antenna array and the corresponding control protocol and firmware. This document describes the control mechanism of the antenna array in the RDRN developed at the Information and Telecommunication Technology Center of the University of Kansas.

Two antenna control mechanisms will be discussed in this paper. The first mechanism is used in a wireless bridging mode – the wireless modem is directly connected to an end-user computer or to a local-area network (LAN). The second mechanism involves the use of a computer, which is referred in this document as the wireless link gateway, that is connected between the wireless modem and a LAN. In both modes, a user issues the control command through a graphical user interface (GUI). The command is transmitted to the wireless modem with a custom protocol through the ethernet network. The firmware on-board the wireless modem interprets the commands and generates the signals to drive the corresponding antenna sectors. The control protocol is flexible and expandable, and is envisioned to provide an interface for automated antenna sectorization control by an upper-level algorithm.

2. The Control Mechanism

The antenna control function is part of a GUI developed for the RDRN project, and is shown in Figure 1. The GUI provides the user with the ability to steer the antenna electronically by activating and deactivating the desired antenna sector. The user is also able to configure the antenna to have various transmit and receive patterns, as well as a single click to activate all sectors (omni-directional) or to disable transmission.

The wireless modem employed in the RDRN communicates to the wired network via ethernet. As a result, the control commands for the sectorized antenna array need to be incorporated into an ethernet packet in order to be received and processed by the on-board processor. A special protocol is utilized to allow the control packets to co-exist with regular ethernet traffic. Due to the difference in network structure, the control mechanism differs

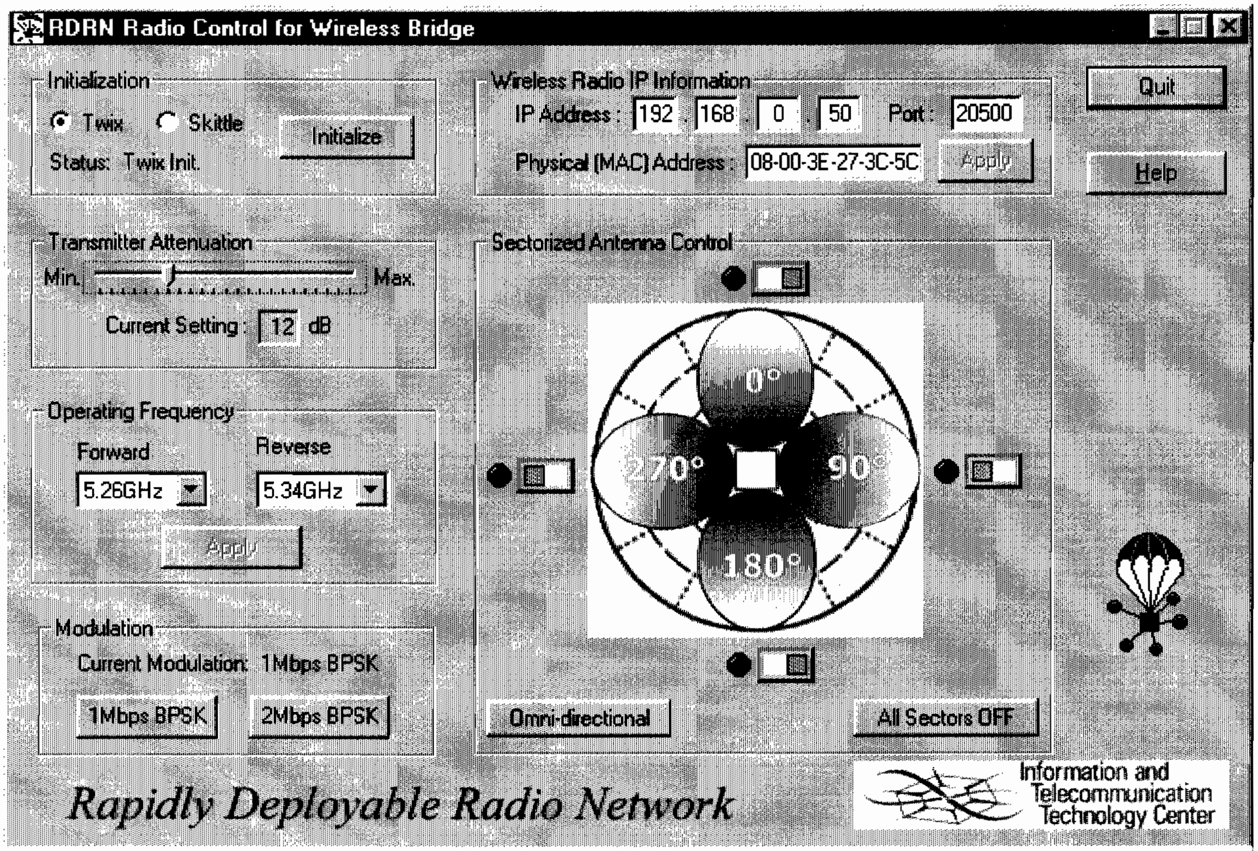

Figure 1 The RDRN Graphical User Interface with Directional Antenna Control

between the two operating modes discussed previously. In the following section, the mechanism for each mode of operation will be discussed in detail.

2.1 ANTENNA CONTROL IN WIRELESS BRIDGING MODE

In wireless bridging mode, the wireless modem is directly connected to the end-user computer or to a LAN. This is shown in Figure 2. Because the connection between the LAN and the modem is shared between normal and control traffic, standard internet protocol (IP) have to be utilized to transfer the antenna control commands via the ethernet network.

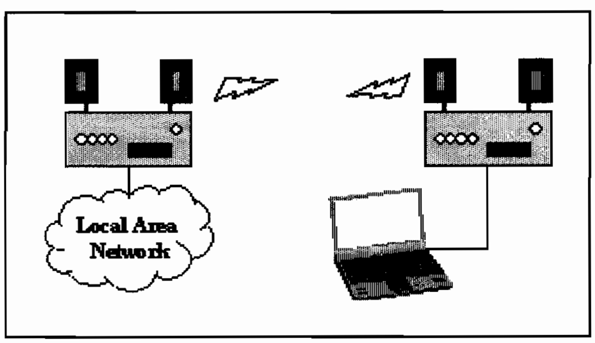

Figure 2 RDRN Wireless Bridge Architecture

Each wireless modem in the RDRN contains an ethernet interface which has its unique 6-byte media access control (MAC) address. An IP address is assigned to each modem so that the control packet can be routed by standard internet packet routing equipment.

In the example shown in Figure 1, the MAC address is 08-00-3E-27-3C-5C, and the IP address assigned is 192.168.0.50.

The firmware of the wireless modem is pre-programmed with the corresponding unique MAC address. When a control packet, which uses the User Datagram Protocol (UDP), is issued from the GUI, it is routed to the network segment to where the modem is connected. The modem's firmware checks the destination MAC address of every incoming IP packet for a match. A normal IP packet, which does not contain the modem's MAC address, is unmodified and forwarded to the other modem via the wireless link. When it is addressed by the special IP packet, the modem extracts and decodes the data payload. The decoded information is stored into a register. The register's content is used to control the input/output (I/O) pins which activate/deactivate the corresponding antenna sector(s).

2.2 ANTENNA CONTROL WITH A GATEWAY COMPUTER

When a wireless link gateway is placed between the wireless modem and the LAN, the wireless link is accessible to those that are programmed into the gateway. The link between the wireless modem and the gateway employs a special protocol layer called radio control adaptation (RCA) layer. As a result, any control command addressed to the modem has to go through the gateway and the IP control packet described in the previous section does not apply to this configuration. The addition of the RCA layer requires a new protocol to transmit control information from the GUI to the modem.

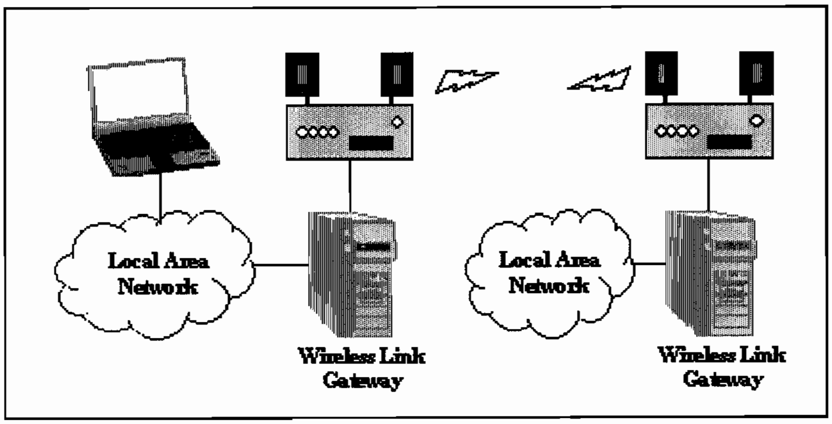

Figure 3 RDRN Wireless Link Gateway Network Architecture

The GUI addresses the wireless modem by sending a Transmission Control Protocol (TCP) packet with a pre-determined TCP port number to the wireless link gateway. The antenna control commands are embedded into the packet's data payload. A daemon service module residing in the gateway is activated when it receives this particular kind of IP packet. The daemon is responsible for interpreting the commands sent from the GUI and generating the corresponding information in the RCA layer. A flag in the RCA layer informs the wireless modem's firmware that this is an antenna control packet. The firmware reads the content of the packet, decodes it, and stores it into a register. The content of the register is then used to drive I/O pins to activate/deactivate the corresponding antenna sectors.

3. TESTING AND EVALUATION

The testing procedure for the two modes of operation is divided into three sections. These sections involve the verifications of:

1) control commands embedded into the IP packet's data payload;
2) electronic signals generated to drive the antenna sectors;
3) antenna transmission activity.

3.1 TESTING OF THE CONTROL COMMANDS

The first step in testing the antenna control was to confirm that the GUI was sending the correct commands. An ethernet traffic-monitoring program captured the control packet, and the data payload was compared against the user input. For example, if the 0° and 180° sectors are to be activated, the data payload should display a command pattern of "ON OFF ON OFF", or "0 1 0 1" in binary. Furthermore, the destination IP and MAC addresses were compared against the GUI settings. This comparison is very important as correct IP and MAC addresses ensure that the packet can reach the wireless modem.

3.2 TESTING OF THE CONTROL SIGNALS

Each sector of the directional antenna is equipped with a light emitting diode (LED), as shown in Figure 4. It is lit when the corresponding sector is activated. As a result, this portion of the evaluation visually confirmed that the desired antenna sector(s) was/were activated and that the pattern matched the one on the GUI.

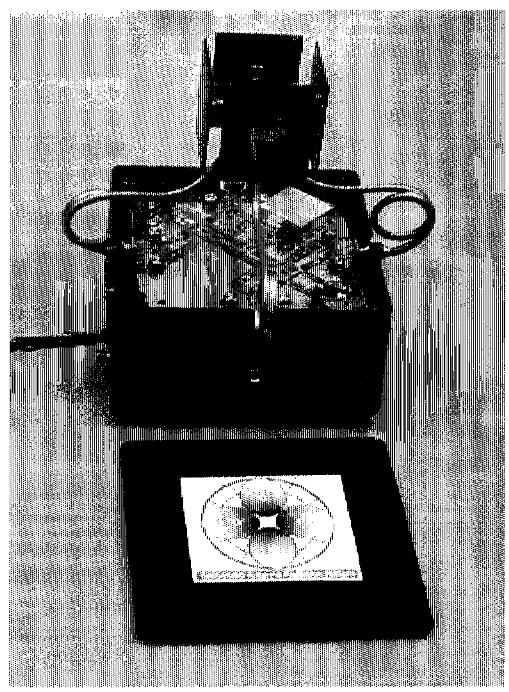

Figure 4 RDRN Sectorized Antenna

3.3 TESTING OF THE ANTENNA TRANSMISSION ACTIVITY

The transmission on each antenna sector was verified with the use of a spectrum analyzer. The spectrum analyzer was connected to each antenna sector one at a time, and that sector was activated and deactivated several times. The control command from the GUI should activate the sector's LED and a transmission signal should be detected by the spectrum analyzer.

4. Conclusion

The RDRN antenna system contains a sectorized antenna array which is electronically controllable by software. A control mechanism was developed to provide a convenient way for the operator to control the transmission direction. Furthermore, intelligent software control can be built on top of the mechanism to automatically activate/deactivate each antenna sector according to environmental or network topology changes. This flexibility allows the operator to efficiently allocate spectrum resource, resulting in higher throughput and increased capacity.