Development of web based Radar Control Software for future generation Active Phased Array Radars

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Abstract:

Radar Controller software has been realized in-house at NARL to acquaint better control over complex network of 1024 TR modules distributed over an array size of 130m x130m. Parameters like network throughput, different operational commands, delay required between two requests to maintain a good network stability, ping request timeouts, connection timeouts etc. are properly realized and implemented with 1024 modules.

Radar Controller software facilitates the user scientists to set the experimental operational parameters as well as allows to operate different modes of scientific experiments such as DBS, SA, VAD.

The detailed implementation methodologies, validation procedures, flexibility in operation and data archival of the monitoring parameters will be discussed in this paper.

Keywords: Radar Controller Software, Beam steering software, active phased array radar

1. Introduction

Active Phase array Radars are highly emerging and complex atmospheric probing instruments with a dedicated TR Modules (Transmit and Receive modules) for each radiating antenna element. These radars are adapted by many atmospheric researchers and scientists around for its ability to place radar beam in any desired direction, ability to conduct multi-channel experiments such as spaced antenna, Interferometry/imaging with flexible array configurations. The advantage of these radars are good spatial and temporal resolutions which help to observe atmosphere in small time etc.

The major subsystems of the Radar are Radar control software- which is usually termed as brain of the overall system, Transmit-receive modules, RF subsystems like exciter, RF distribution units, etc. Each TR module is equipped with a FPGA based TCSG digital card, which generates necessary control signals for the proper operation of the TR module, monitor health status of TR module. The proper radar operation requires the synchronization of the TR modules along with the other subsystems. Radar Controller software plays a major role in transferring the necessary experimental parameters and phase information for the required beam formation to each TCSG card. More scholarly approach is required in developing such software which controls and monitors such sophisticated probing instrument with huge number of TR modules located in wide antenna area, far away from the control room.

A brief discussion has been made on the implementation strategies of Active Array MST Radar (AAMSTR) in which the connectivity of 1024 TR Modules to a controlling PC through a multi-level hierarchical network topology and the methodology in employing the software paradigm for achieving successful data packet transfer through this complex network.

2. Functionality & Methodology

Before diving into the discussion regarding software design methodology, Acquaintance of some knowledge about *terminology* used throughout the paper to get an essence of this transcript is very vital. The Numerical figures in the below paragraph will give a better comprehension of how the number of processes required to execute a task (or job) are quantized for unexceptional data transfer.
P.S: All optical Ethernet switches specified in this transcript are Layer2 switches

2.1 AAMSTR Module Network:

Active Array MST Radar [1] at NARL, Gadanki consists of 1024 element array arranged in a 32x32 square grid in which Antenna array is segregated into a cluster of 16 Modules called as *Group*. 16 such cluster of modules jointly called as one *Quarter*. So in a bird-view, Whole 1024 array is divided into *4 Quarters* or *64 groups*, *16 modules in each group*. All the 16 TR modules in each group are connected to a Layer2 optical Ethernet switch forming a star network topology. Such 16 star topological groups are connected to another L2 switch via *optical fibre bus* through which data is transferred to a Quarter of 256 modules. Such four optical Ethernet switches are connected to the radar control PC through copper Ethernet switch as shown in figure-1.

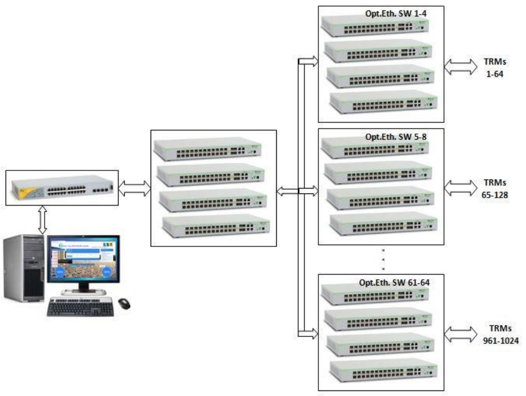

Fig-1: Ethernet connectivity of the L2 managed switches with Radar control PC.

Each TR Module is assigned with unique IP address with respect to its location in the antenna field. The RC PC communicates with each module using this IP address information during the operation. AAMSTR uses TCP/IP and ARP/ICMP protocols for data transfer and identification of connection status from RC PC to TR Modules. The data packet has to traverse through these three levels of optical Ethernet switches for successful data transfer.

2.2 Active Array Radar Controller Functionality

One of the salient features of Active Array radar is its ability to place the beam at any elevation and azimuthal angles with the help of inbuilt phase shifters placed in each module. With this electronic beam steering capability, beam can be switched in micro intervals of time.

For successful operation radar, Radar Controller Software has to send commands containing Beam Position information, experimental specification data or parameters i.e. Pulse Width, Inter Pulse Period, NFFT, NCI, NICI and other operation & control information to all TR modules. Beam information unlike other commands is different for each TR module having phase shifter information for each specified transmit and receive beams.

Radar Controller should be properly configured with the number of processes to be assigned for a particular task for a true worthy data transfer to all TR modules. Delays between consecutive requests should be properly estimated to avoid congestion of network and overflow of data packets. One of the Characteristics of a good software design is to make scalable software, providing ability to configure the processes to be forked to complete the job.

2.3 Methodology

The methodology which we are going to discuss is based on client-server model, where client sends requests to server regarding a resource from database or IO access.
Server depending on the request from client, responds by transferring data or queuing the process spawning message/data to the Message-Queuing back-end engine. A detailed picture of protocols employed in data transfer between different backend processes is shown in figure-2.

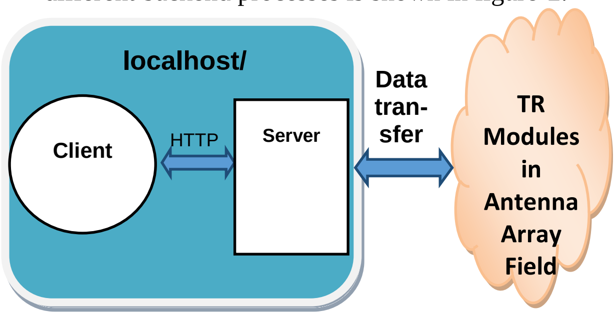

Fig 2: Block diagram of software design methodology

Client provides interface or API through which the operator interacts by sending requests to the server over a HTTP protocol.
Web Languages like HTML, CSS and JavaScript provide efficient functionality for event handling and better user experience. Hence, HTTP is the best suited protocol for data transfer between client and server, to develop rich user-interfaces for better usability of the software using Web technology.

Data exchange between client and server is done as JSON objects, which is a standard way of data representation that can be read through both JavaScript and any back-end languages.

3. Software features and Results

A Software has been designed and developed with the above mentioned functionality & features. Active Array MST Radar controller software can be scaled to 2^n number of parallel executing processes/workers for a task (provided supported by the machine). Many network parameters like consecutive requests time delays, network throughput between RC PC and a module are estimated and implemented. A browser is required to execute requests to the server.

Other features of Active Array MST Radar:

i. AAMSTR controller software includes all of the aspects of a good software like Scalability, usability, portability, performance, and maintainability.
ii. Flexibility in the selection of any sub-array for any specified experiment.
iii. Logs Health status of TR modules during every operation for future analysis
iv. Able to send control commands like interlock reset and toggling of 60V supply to any module in during operation.
v. Interactive polar plot displaying the experiment status and position of the beams.
vi. Better usage of pixels of the display viewport following the *simple is the best* policy.
vii. Completely isolating the view and controller processes to avoid *not responding* errors during operation.
viii. Completely developed from open source libraries which makes it a most efficient, cost-effective software. All software module using platform independent languages for portability between different platforms.

The following figures 3(a)&(b), 4 below shows the few screenshots of AAMSTR controller user-interface of standalone TR module testing with different status flags and interlocks and user-interface for whole Radar operation with 1024 TR modules. Main Radar controller interface, Analog and flag status display web page showing the health of a group, consisting of 16 TRMs.

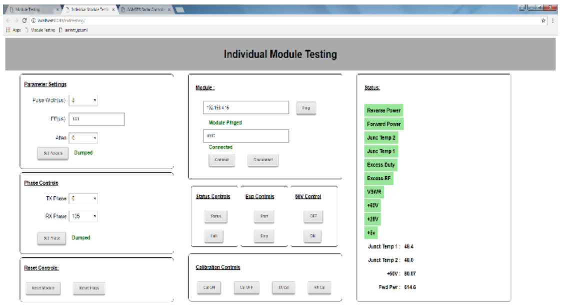

Fig 3(a): Standalone TRM Testing interface

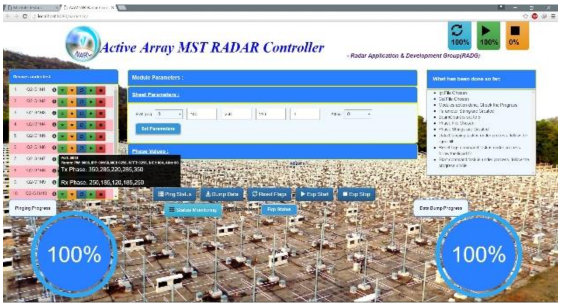

Fig 3(b): Radar Controller user interface

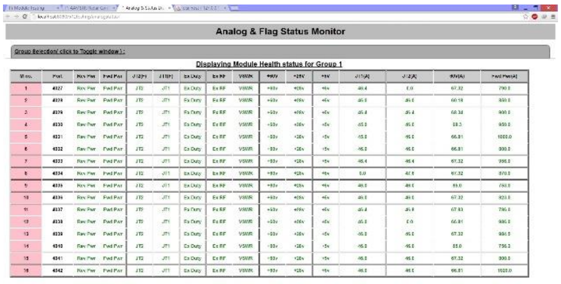

Fig 4: Health status display showing a group of 16 TRModules

4. Conclusion

Radar controller software has been successfully validated with Active Phased Array MST Radar, NARL which constitutes a complex network of 1024 TR Modules distributed over an area of 130mx130m. The AAMSTR system has been tested in DBS mode, VAD mode with 32 beams, the scientific results are very much encouraging.

Currently the system is supporting ISRO satellite launch missions from SDSC,SHAR by providing wind information during the launch campaigns.

REFERENCES

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[3] Official documentation of libraries and tools used in radar controller.

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Jeldi Kamal Kumar born in 1991 received B.Tech (Avionics) degree from IIST, Trivandrum. Joined Semi-Conductor Laboratory, Mohali on November, 2013 and at NARL, Tirupati on December, 2014. His areas of interest include development of Radar Controllers, Maintenance and Health Monitoring web applications, software tools for Active Array Radars.

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