THE MODULAR RANGE INTERFACE (MODRI) DATA ACQUISITION CAPABILITIES AND STRATEGIES

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ABSTRACT

The Modular Range Interface (ModRI) is a reliable networked data acquisition system used to acquire and disseminate dissimilar data. ModRI's purpose is to connect TSPI systems to a central computer network. The modular hardware design consists of an SBC, COTS network interfaces, and other COTS interfaces in a VME form factor. The modular software design uses C++ and OO patterns running under an RTOS. Current capabilities of ModRI include acquisition of Ethernet, PCM data, RS-422/232 serial data, and IRIG-B time. Future strategies might include stand-alone data acquisition, acquisition of digital video, and migration to other architectures and operating systems.

KEY WORDS

TSPI, test range, distributed computing, real-time, network, C++, VME

INTRODUCTION

One of the primary missions of Eglin AFB, Florida, is the testing of weapon systems for multi-service and international customers. Another is Eglin's support of training activities from various DOD organizations. To accomplish these missions, Eglin utilizes ranges instrumented with data acquisition systems that interface with centralized real-time computer networks. Traditional methods used over the last 25 years connected these range data systems to real-time computer networks. Since no interface standards existed, each equipment manufacturer developed proprietary input/output (I/O) interfaces, resulting in one-of-a-kind interface systems. The unique systems that evolved through the course of time are now difficult to use and expensive to maintain. In order to provide customers with competitive and flexible solutions in an ever-changing testing environment, the Freeman Computer Sciences Center (FCSC) located at Eglin AFB has upgraded these legacy systems to modern software and hardware technologies.

Customers can perform both mission control and real-time data analysis at FCSC during a test or training mission. FCSC also maintains the interface between the test range and real-time computer networks that support the customer. Previous legacy systems consist of 1970's minicomputers coded

in assembly language, using customized communication hardware and proprietary network protocols. As mentioned, these systems were both costly and difficult to maintain. Consequently, the FCSC developed a flexible, modular method to connect test range data systems to central real-time computer networks. The result was the Modular Range Interface (ModRI). The ModRI provides the FCSC with a reliable and easily configurable system to support connection of range data systems to centralized computers at any real-time test range. Currently ModRI provides the central real-time computer networks with Time-Space Position Information (TSPI), Global Positioning System (GPS), and FAA Airport Surveillance Radar (ASR) data. This paper describes the current and future capabilities of the ModRI along with an overview of the high-level hardware and software design.

CURRENT CAPABILITIES

ModRI is currently in production and used as the primary Standard Data Server (SDS) for all FCSC mission rooms. Updates to the user interface and real-time system additions continue to be performed, enhancing ModRI capabilities. Having utilized Commercial Off-The-Shelf (COTS) hardware, replacement of components and upgrades keep the cost and integration complexity to a minimum. In addition, FCSC built two more ModRIs to support Next Generation Mission Room development and range training activities.

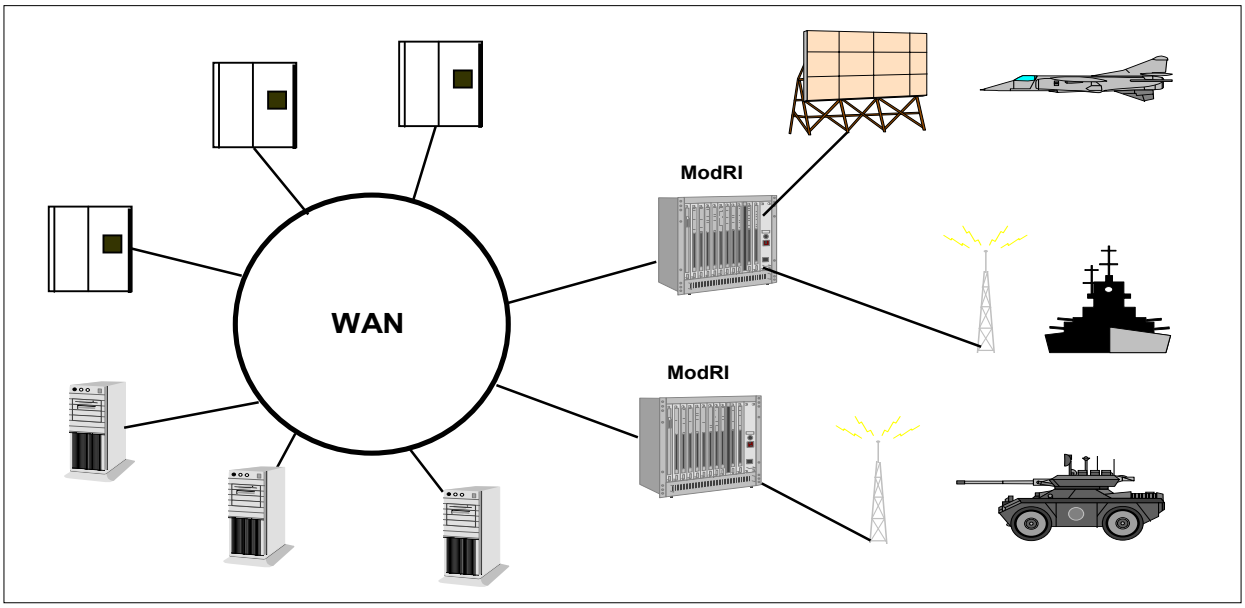

Figure 1. ModRI Range Connections

Figure 1 above depicts ModRI's interface with different range data systems. As the figure shows, data can be from phased-array radars tracking an aircraft; a GPS downlink system receiving position information from an aircraft, ship, or ground vehicle; or from a multi-positional system tracking ground vehicles. ModRI localizes these range-specific interface connections, receives and buffers incoming data, performs any needed data conversion or formatting, and sends the range data (in a standard format) to any real-time computer that requested the data. Current range connections allow transmission of tracking radar PCM data via an RS-422/232 serial protocol and other data via

Ethernet. Data is output to the range (via slaving, control, closed loop, etc.) by the reverse of this process. ModRI can also transfer real-time data between ranges using Ethernet via standard Internet Protocol (IP) over local area network (LAN) and wide area network (WAN) links. Ethernet transfer can be at the UDP or Data Link (MAC) level.

ModRI executes five real-time (RT) tasks that control all system operations. These tasks control RT data selection, receive RT data from the range data sources, send RT data to the range sites, send RT data to compute nodes, and provide a user interface. Each production ModRI receives RT selection, control, and status request via Ethernet/FDDI RT networks. ModRI's primary purpose is to send input data to any RT network application processor that has requested that data. Each ModRI task controls access to its associated resources via three run-time configuration files. These run-time files reduce the need for application program changes as range data systems are added or removed, as well as when real-time networks are upgraded or changed.

ModRI's modular approach to hardware and software component design has maximized system flexibility and portability. All of the hardware and software modules supporting a specific range data system are interchangeable between ModRI boxes and are COTS-based. Furthermore, customers can transport ModRI from one range to another and simply plug ModRI into a compatible network connection at the new location.

The maintenance cost associated with previous legacy systems has been dramatically reduced and overhead costs associated with those systems ($1,600/month) eliminated. In terms of reliability, ModRI has operated 24x7 since July 1, 2003 with no system failures. This reliability has directly contributed to FCSC having a very high rate for its Real-Time Mission Support performance indicators (On Time Mission Rate and Error-Free Mission Rate).

HIGH LEVEL DESIGN

The goal of this project was to design, develop, and operationally use ModRI for real-time mission support. ModRI accomplished this goal with modular hardware and software components, maximizing flexibility and portability while minimizing complexity and cost. The modular hardware design integrates modular hardware components into a COTS enclosure. Standard modular I/O hardware connects to the range data systems, and standard network interfaces connect to the real-time computer networks. A single board computer (SBC) controls all the modular hardware supporting daughter board add-ons. The modular software design uses object-oriented design techniques and implements it in an object-oriented language (C++). The software development environment consists of a standard real-time operating system (or RTOS, which assures deterministic behavior) adhering to POSIX standards (ensuring platform independence). ModRI takes advantage of many applicable interface standards. These standards facilitate asset sharing between test ranges, lower the cost of testing, increase dual-use potential, and allow easy integration of new range data systems in a cost-effective manner. ModRI successfully demonstrated its solid design robustness by achieving 100% reliability for all test and training missions supported in the FCSC during the past 10 months.

High Level Hardware Design: Technology has advanced to the point where it is possible to build a complete interface system entirely from modular COTS hardware components. Key technologies exploited by ModRI are VME enclosures with standard I/O hardware, fast SBCs, and standard network hardware. VME enclosures are very durable and reliable under extreme conditions, making them ideal for field use. As an industry standard for control and communications equipment, VME has over 5000 different interface cards supplied by more than 500 different manufacturers. Types of cards needed for connection to range data systems include Industry Packs for serial data (both asynchronous and synchronous) supporting various communication protocols (RS-232, RS-422, SDLC, BISYNC, and PCM); IRIG-B time code readers; precision interrupt timers; digital interfaces (PIO, DMA transfers), Ethernet (10/100/1000), and replicated shared memory. Figure 2 below is a representation of the VME chassis and card placement used by ModRI.

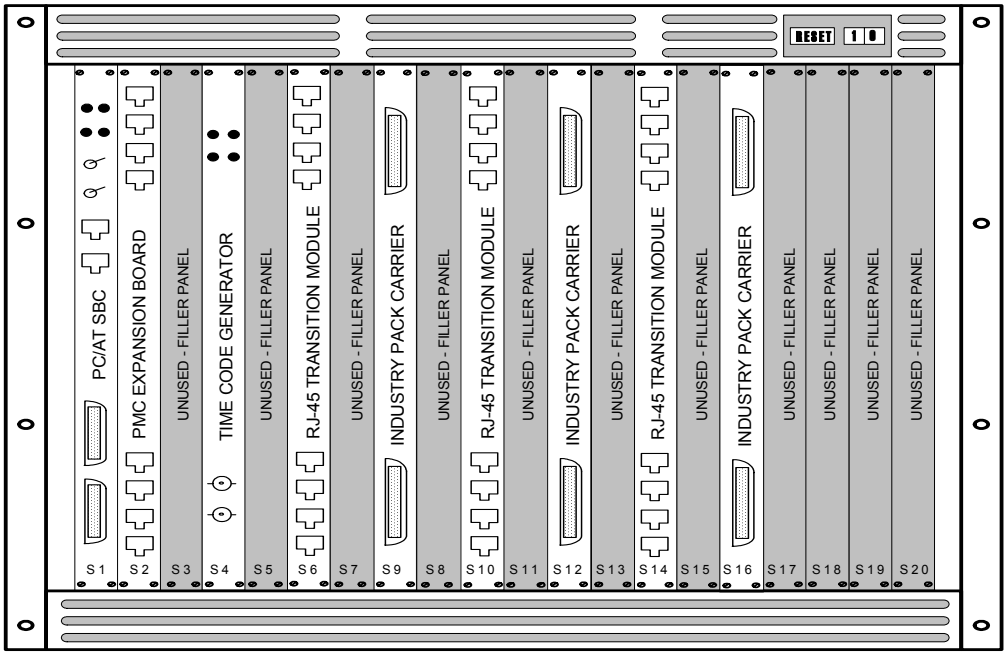

Figure 2. ModRI VME Chassis

ModRI uses extremely fast 32-bit SBCs using Intel Pentium III chip technology. These SBCs plug into VME bus backplanes (ANSI/IEEE 1014-1987), support VME 64-bit data transfers, contain up to 256 MB of memory, have built-in Ethernet (IEEE 802.3) interfaces, and include a PCI bus (132 MB/sec). The onboard PCI bus accepts a PCI mezzanine card (PMC, IEEE P1386.1) that can support FDDI interfaces, ATM interfaces, or a bridge to a PMC expansion module. SBCs implement various timers and include a SCSI-2 bus for data storage devices.

High Level Software Design: To complement the modular hardware design, ModRI has a modular software architecture that adheres to software engineering standards. Additionally, the architecture called for concurrent software tasks running at different rates and priorities. To accomplish this, ModRI utilizes software technologies that include a POSIX-compliant RTOS, standard networking protocols, and an object-oriented design methodology and programming language. A widely used operating system for developing real-time applications is VxWorks software from Wind River Systems, Inc. VxWorks features a priority-based, preemptive multitasking microkernel executive

suitable for applications requiring high-rate performance and deterministic behavior. VxWorks supports key industry standards including real-time POSIX (IEEE 1003.1), C/C++, and TCP/IP, and includes a feature-rich Integrated Development Environment (IDE). Figure 3 below shows all the real-time tasks executed during run-time operation of ModRI.

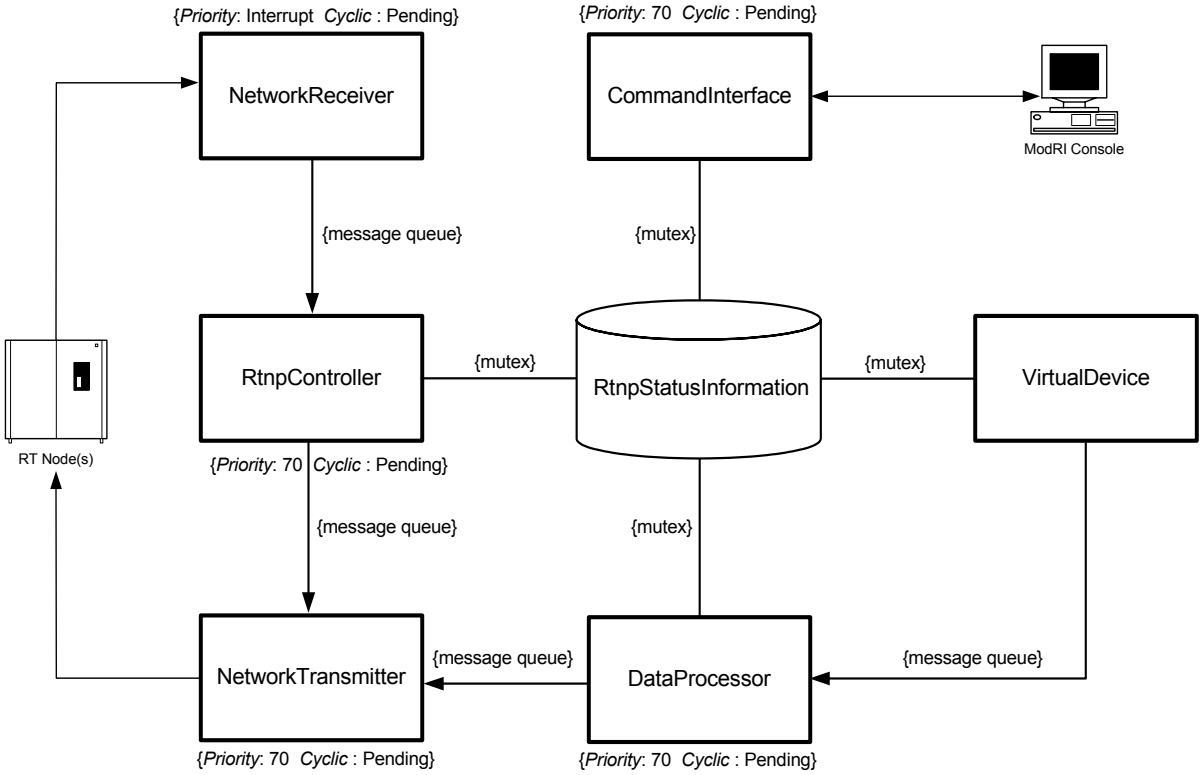

Figure 3. Real-Time Software Tasks

FUTURE STRATEGIES

Further improvements of ModRI are being planned. Future strategies include portability for stand-alone data acquisition, acquisition of digital video, acquisition of telemetry data, and migration to other architectures and operating systems. One strategy is the development of a portable stand-alone ModRI. This would allow the collection of range data and the storage of that data (i.e. on a removable onboard hard-drive). This precludes having a network involved, as is required in the current configuration. In remote situations or high-risk environments, ModRI could be a cost-effective way of obtaining data from dissimilar sources. Another future strategy is the use of ModRI for acquisition of digital video. With the capacity to expand Ethernet connectivity with PMC cards, ModRI could handle multiple sources of digital video and provide users with the flexibility to view, process, distribute, or store that video with ease.

In addition to the strategies mentioned above, ModRI could also be used to process and disseminate raw telemetry data alongside TSPI data. With ModRI's flexibility, commercial bit synchronization cards added to ModRI could provide PCM data to existing serial Industry Packs for decommutation.

Once ModRI acquires the raw telemetry data, compute nodes would receive the data via the existing real-time network. Software applications would then use the raw data for processing and display. Besides using current ModRI hardware, ModRI could process raw telemetry data from acquisition buses such as MIL-STD-1553 and ARINC-429. ModRI can easily accept commercial boards for these buses and their associated software drivers. With the addition of the telemetry hardware and software discussed, ModRI could achieve telemetry acquisition rates (30-40 Mbps) similar to systems specifically designed for telemetry acquisition.

A final strategy would be the migration of ModRI to other hardware architectures and operating systems, such as CompactPCI and Linux. CompactPCI is the latest architecture to be used for applied computing projects. Its strengths include a smaller form factor, compatibility with Intel products, and a wide complement of available vendor products. The use of Linux, or more likely Real-Time Linux, would have two things in its favor. One is the access to the source code that would allow customization of the operating system to adapt to different environments and requirements. Another is the decrease in target license cost associated with a proprietary commercial RTOS. The use of a Real-Time Linux can cut the target license for each production ModRI dramatically. This cost saving certainly would be significant for users of multiple ModRIs.

CONCLUSION

The primary purpose of ModRI is to support real-time range data transfers for all test and training activities at Eglin AFB, Florida. This is accomplished with a modular hardware and software design that results in the quick implementation of new range data systems, provides configuration flexibility as systems change, and replaces legacy equipment that is expensive or impossible to maintain. Additionally, the use of a modular hardware and software design provides portability—any networked range with existing data sources can use ModRI. As discussed, standardization keeps the cost and complexity low. Accordingly, ModRI utilizes a variety of VME COTS hardware, standard network protocols, and an OO paradigm. Current capabilities of ModRI include acquisition of Ethernet UDP packets, PCM data, RS-422/232 serial data, and IRIG-B time. Future strategies of ModRI might include portability for stand-alone data acquisition, acquisition of digital video, acquisition of telemetry data, and migration to other architectures and operating systems.

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