Serial-To-Ethernet Devices an Inexpensive Upgrade

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ABSTRACT

The communication section of MARTA's existing Synchronous Optical Networking (SONET) system was failing. The SONET system utilized a Plain Old Telephone Service (Modem/POTS/T1) to communicate Train Control, and Supervisory Control and Data Acquisition (SCADA) indications, and controls from the related field equipment to the Rail Service Control Center (RSCC). When the SONET failed RSCC would lose indications, and controls for large sections of the system, which caused large areas of the RSCC's graphic display to "go dark".

MARTA Systems Engineering received two directives from Management, to:

1. Stabilize the existing system.
2. Provide a back-up system at a remote location.

First, a theory was developed to tunnel serial protocols over Ethernet utilizing two Serial-to-Ethernet devices (Terminal Server) that would replace existing communications (Modem/POTS/T1).

Next, a Serial-to-Ethernet device had to be selected, and tested. The device had to be reliable, economical, and easily configured.

Conclusion, two different terminal servers were utilized; Train Control used a Lantronix UDS1100, and SCADA a Perle IOLAN DS1. Because the Train Control and SCADA communication is now on an Ethernet network, MARTA was able to build a Back-Up Control Center.

INTRODUCTION

The purpose of this paper is to present information that could benefit another Authority or Rail Road which may be experiencing similar technological failures.

BACKGROUND

In 1979 the Metropolitan Atlanta Rapid Transit Authority (MARTA) began rail operations with new train control and SCADA systems. Currently the MARTA system has thirty eight rail (38) stations and operates forty eight (48) route miles. MARTA's rail system operates four Lines; North-South, Northeast-South, East-West, and the Proctor Creek Line. MARTA also has three rail yards, one on the North Line, one on the South Line near the Airport, and one on the East line. Each rail station and yard has a Train Control Room (TCR). MARTA's train control and SCADA systems total fifty one (51) TCRs and fifty three (53) traction power sub-stations.

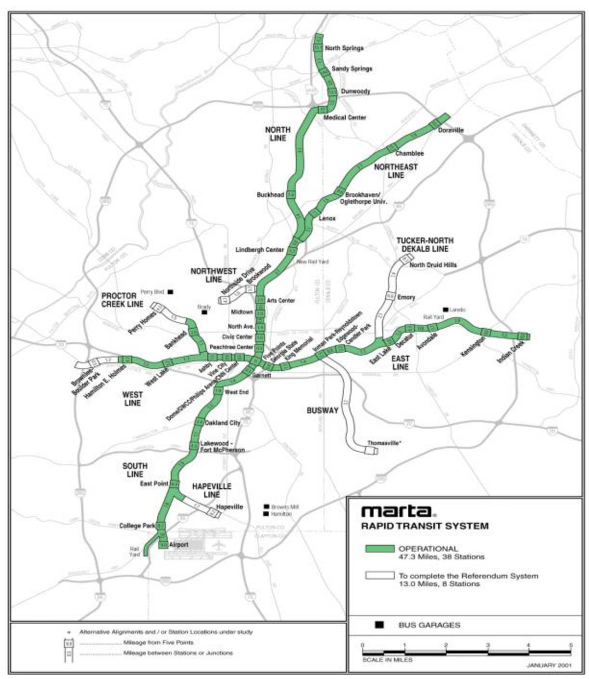


Figure 1. System Map

MARTA was designed with, and implemented at that time, the best technology available, which was deemed "state of the art" for communications from the RSCC to the field. That technology consisted of 1200 BAUD modems, POTS, Channel Banks, and T1 lines, to communicate data from the field equipment to the RSCC and vice-a-versa.

In the 1980's MARTA upgraded to an Alcatel SONET Multiplexer system utilizing fiber along the right of way (ROW). This system became the backbone for transporting the data to and from the field devices; however, the field devices were not replaced at the time. They were still serial, and connected to a 1200 BAUD modem at the field device and at RSCC.

For the 1996 Olympic Games MARTA installed a new Office System based on Ethernet communications. This upgrade replaced the train control servers, all work stations in the theatre, and replaced the control center's overview panel with a mosaic panel, for train control and SCADA indications.

In 2007 the components of the SONET system began to fail; this affected train monitoring and control, breaker status and control, and station alarms and control.

TECHNICAL OVERVIEW

MARTA's train control communication system began with a technology named Line Data Transmission System (LDTS) by General Railway Signal (GRS). When the North Line was built Alstom Signaling, formerly GRS, provided the train control system and installed their latest product named Vital Processor Interlocking (VPI), which MARTA used only in a non-vital application. The North Line was extended and US&S/Ansaldo Signaling installed their non-vital processor called GENISYS. MARTA added a new yard named Armour Yard, which included a TCR in the yard, and a TCR in the yard throat. Ansaldo was selected to provide the signaling equipment for Armour Yard and Yard Throat, and to upgrade the existing Avondale Yard, and Avondale Yard Throat. At these locations Ansaldo's MICROLOKII was installed for both vital and non-vital applications.

Due to the additions through the years MARTA utilizes three communication protocols to communicate train control indications and controls from the TCR to the office and vice-a-versa. They are: LDTS from the LDTS equipment, DT8 from the VPI, and GENISYS from the GENISYS, and MICROLOKII equipment.

MARTA's train control office is a Train Management System (TMS) by Alstom Signaling.

The SCADA system also consists of several different Remote Terminal Unit (RTU) brands and they are; BBCSI, GRS, TANO, TANONET, and IMPULSE. These systems all use the protocol BBCSI to communicate to the RSCC. The SCADA office is an Advanced Information Management (AIM) System by ARINC.

Alstom's TMS utilizes two Communication Processors (COMMs) to connect to the field devices via an Ethernet switch, and terminal server for the train control system. AIRINC's AIM utilizes two Front End Processors (FEPs) for the SCADA system, also via Ethernet switch and terminal server. The terminal servers are connected to the modems, thus back to 1200 BAUD POTS, and channel banks technology.

CONCEPT PHASE

MARTA's office equipment, train control's non-vital equipment including the TCR to office communication equipment, and SCADA's, Supervisory and Control (S&C) equipment, was approaching the end of its expectant life. Because of this, a project was being developed that would provide MARTA with an entirely new office, and replace all field processing, and communication equipment for the train control, and SCADA systems. The project is named Train Control & SCADA Upgrade (TCSU), but is not scheduled for completion for several years. Until the TCSU project could be completed, MARTA needed a team to stabilize the existing system until the new office, and associated field equipment would come online.

MARTA's Senior Management pulled together a team of experts to stabilize the existing system. The team was named "The RSCC Stabilization Team".

The RSCC Stabilization Team was given two main directives:

1. Stabilize the existing system.
2. Provide a solution that supported multiple operation centers; a Primary Control Center, and a Disaster Recovery Control Center, at a remote location.

The RSCC Stabilization Team began to put together various options and technologies that might negate the disruptions caused by the SONET failures.

The first system to be addressed was the train control system. The SONET system was losing communication with the office, which caused large display portions of the rail line to go dark, which resulted in the RSCC losing the train's occupancy in the affected area. The RSCC would also lose the ability to call or cancel routes or receive any alarms during the outage.

Victor Hernandez, Manager of System Engineering, came up with the concept of using a device that would convert the RS232 serial data to a data format that encapsulates serial data into packets for transmission over the Ethernet.

The search for a product began with cost, lead time, easily configured, reliable, and size of product in mind. The Lantronix UDS 1100 was selected to use as a pilot for the train control system.

Figure 2. Lantronix UDS 1100

IMPLEMENTATION PHASE

A plan had to be developed for implementing the UDS1100 during the pilot, and if successful in the pilot, to test, and install system wide.

An Implementation Plan was developed and covered the following:

- Test Bench
- Maintenance Training
- Pilot Test
- Thirty (30) Day Confidence Test
- Production

A Test Bench was set up at the RSCC Computer Room to prove the concept. Initially, the Test used two UDS 1100's. One was used to represent the field device, and the other one represented the unit for the Office. The UDS for the office was configured as the Master and the one for the field was configured as the Slave unit. James Jenkins, Senior Systems Engineer created the test bench and configured the UDS 1100 for the Master and Slave configurations to represent the Office and Field environments.

Conversation began with our two suppliers to modify their software on the TMS and AIM servers. The software change would have the COMM/FEP servers communicate directly to the terminal servers (UDS 1100) in the field. This would eliminate the need of using a terminal server in the office. Until this software change was accomplished the project planned to move forward utilizing two UDS 1100's.

A Thirty-day test was planned for a TCR that is easily accessible and small in size, i.e. no interlocking and few track circuits. That location was the Five Points East/West TCR.

The test would monitor all indications from this TCR to the RSCC. The test included a Recovery Plan in case the UDS 1100 devices stop communicating. The test would also have a daily log to document the number of errors during the thirty days. This required daily checking for system delays and adding them in the log.

The Test plan also had a section on disconnecting the modem and connecting the UDS 1100 in the field and at the office. The Test began February 2010 and ran for thirty consecutive days. The test was a success with very few errors to record during the thirty day test. The Figure 3 above shows a field connection of the Lantronix UDS 1100

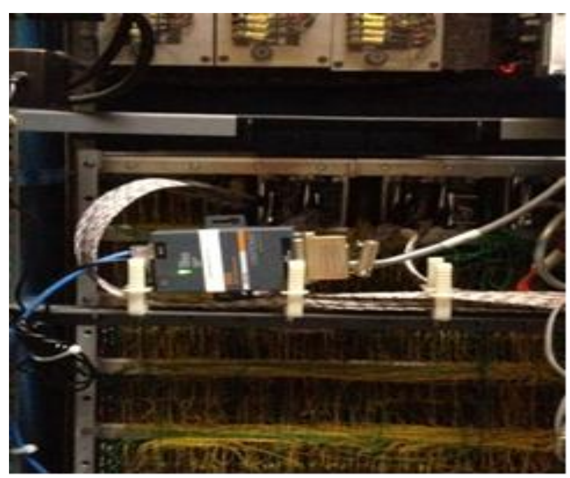


Figure 3 Lantronix UDS 1100

Training material and a course plan were concurrently developed for training the maintenance personnel. This training included course work and hands on training.

When the training course was completed, the training was scheduled, and conducted to the appropriate maintenance personnel. Once everyone had completed their training, production began for rolling out the Lantronix UDS 1100.

Alstom approved the usage of the UDS 1100, but ARINC requested that we use a device named Perle IOLAN DS1- with the SCADA system modification. ARINC had worked with the Perle on another project and was familiar with its characteristics. Please see figure 5 below.

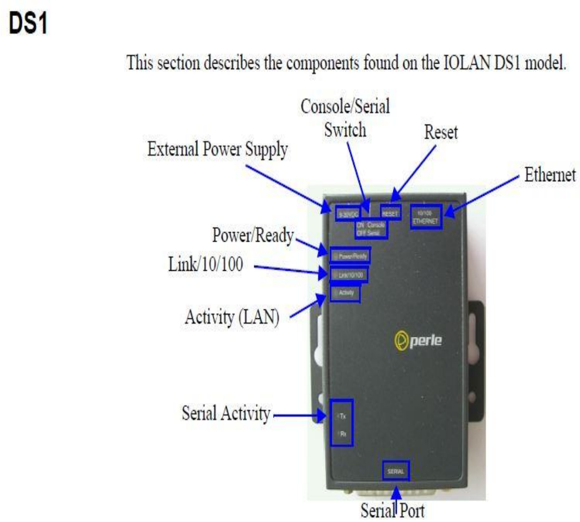


Figure 5 PERLE-IOLAN DS1

A similar Test Bench that was used for the UDS1100 was created for the Perle device. Formal tests were conducted, and performance evaluations were documented.

The same Implementation Plan that was used for the train control system was also utilized for the SCADA system; test bench setup, training, pilot test, thirty day test, and production.

The SCADA field system consists of two RTU systems. One is for station alarms and controls, located in the TCR at the rail stations. The other RTUs are for traction power, and they are located at the traction power substations.

The SCADA RTUs at the stations are called Auxiliary RTUs. There are forty one (41) Auxiliary RTU locations, and each location has access to the network. The designs for these locations are very similar to the UDS 1100 design for the Train Control system. Both units are in the TCR, and both connect to the same Ethernet switch.

The SCADA RTUs in the traction power substations are called TPSS RTUs. There are fifty three (53) traction power substations. The traction power RTU design would not be the same as the above designs. None of the traction power substations have Ethernet connectivity. In order to connect the traction power locations to the Ethernet a device by Cisco called Long Range Ethernet (LRE) was used.

Figure 6 LRE

A Thirty Day Test was completed for the Auxiliary and TPSS RTU's. The test was a success and thus completed the Implementation Phase of this effort.

PRODUCTION

With testing and training complete the team received the green light to proceed with installation of the UDS 1100, Perle and LREs.

The Stabilization Team worked with the various maintenance groups during the installation, and assisted with the scheduling, testing and commissioning of the systems.

The Technology group provided support with assigning IP addresses, and utilizing the Tunneling Technology through the MARTA Enterprise Network (MEN) for office to field communication. See Appendix A Figures 1, 1A and 2A, for layouts showing the migration of the project.

As stated earlier the installation originally used two UDS 1100 or Perle units. One was in the field and the other one was in the office communication rack. Figure 7 below shows the rear view of a modem rack with one UDS 1100 connected into the system. If the office software was not changed, this rack would be full of the UDS 1100's.

Figure 7 UDS 1100 connected into network

The picture below is the front view of the modem rack at the office. This rack is decommissioned with the completion of this project.

Figure 8 Front View of Modem Communication Rack

MARTA continued to work with Alstom and ARINC to develop their office software to communicate directly from the FEP or COMM Processors to the field.

Alstom completed the necessary program changes for their system and tested first. A Test Lab was setup utilizing the Standby COMM Server at the RSCC, and another work station was programmed to run the simulation software. The Test included the ability for the COMM servers to talk to the locations that had been modified, and also continue to talk to the locations that had not been modified with the UDS 1100. This was needed to facilitate the timeline that it would take to complete the conversion. The process to install the field equipment and test would take several months.

Another major concern was that after the software change, that the system would maintain the desired failover capabilities, so that if a failover occurs the current commands and indications would be transferred to the online server.

The Test Lab was completed and the COMM Servers worked as designed with the software change installed. The new software communicates to a specific IP address that is assigned for each location and programed into the UDS 1100 via its own setup software. See below for a sample page.

Figure 9 UDS 1100 Network Settings Page

AIRINC completed their changes to their software, and a similar Test Lab was setup for validating their software change. Once testing was completed the Perle equipment installation was similar to the UDS 1100. The main difference was the installation of the LRE for the traction power substations.

The LRE proved to be the weak link of the project. Some of the locations using the LRE never stabilized. Fortunately, the TCSU project was scheduled to pull fiber to each of the traction power locations, and they were able to modify their schedule to address some of the worst offenders.

All locations are now converted and are connected to the RSCC via the MARTA Enterprise Network. Because the field devices are communicating to the office, utilizing TCP\IP technology, if an emergency arises the data can be redirected to a Backup Control Center.

MARTA has designed and built a Disaster Recovery\Backup Control Center. See Figure 10.

Figure 10 Backup Control Center

This is a tremendous asset to our system, and has been used once since its implementation.

SUMMARY

The title of this paper is Serial to Ethernet an Inexpensive Upgrade. For what you can achieve by switching to a device such as the UDS 1100 or the Perle, is well worth the money and effort. The UDS 1100 and Perle IOLAN DS1 cost roughly the same around $150.00 and the Cisco LRE runs about $50.00. So without a large financial investment your field devices could be connected into the network, thus bypassing a lot of equipment that could cause problems. Please see Figure 11 channel bank racks, and Figure 12 modem racks that are no longer required for communication from the office to the field and vice-a-versa.

Figure 11 Channel Bank

Figure 12 Train Control & S&C Modem Racks

ACKNOWLEDGEMENTS

We would first like to recognize the Computer, and Telephone Shops, for their efforts in installing and assisting with the testing at all locations. We also wish to recognize the efforts from the Technology group for their support with the tunneling and assigning the IP addresses for each location.

This project could not have been accomplished without the leadership, direction and financial support of MARTA's Senior Management Team.

Finally we would like to acknowledge the support from MATC, Systems Engineering and The RSCC Stabilization Team.

Because of everyone's efforts the Train Control and SCADA systems are stable and MARTA has a Disaster Recovery\Backup Control Center.

We would like to thank the following companies for their support and products:

ALSTOM TRANSPORTATION - HTTP://WWW.ALSTOM.COM/TRANSPORT/

AIRINC TRANSPORTATION - HTTP://WWW.ARINC.COM/SECTORS/TRANSPORTATION/TRANSIT/INTEL_TRANS.HTML

LANTRONIX –HTTP://WWW.LANTRONIX.COM/DEVICE-NETWORKING/EXTERNAL-DEVICE-SERVERS/UDS1100.HTML

PERLE –HTTP://WWW.PERLE.COM/PRODUCTS/IOLAN-DS-TERMINAL-SERVER.SHTML

CISCO – HTTP://WWW.CISCO.COM/EN/US/PRODUCTS/HW/SWITCHES/PS4916/INDEX.HTML

NOTE: LRE and Catalyst 2950 are at End of Life.

APPENDIX A

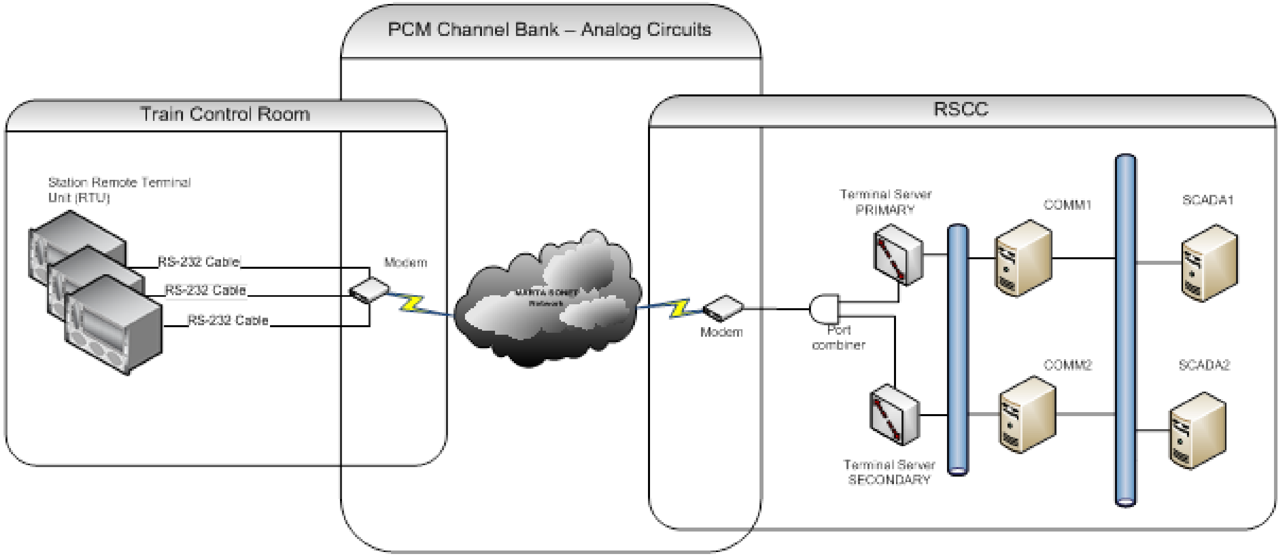
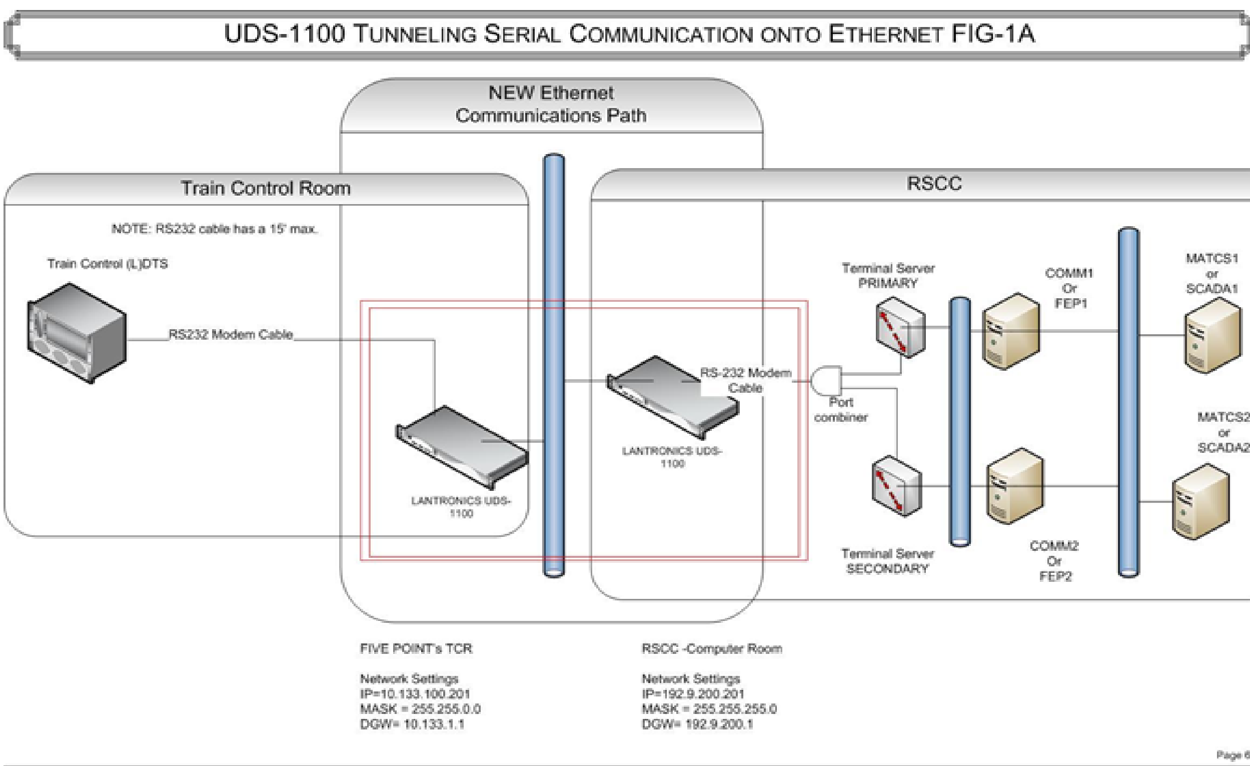


FIGURE 1



APPENDIX A CONTINUED