INITIAL INET TA NETWORK TESTING

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ABSTRACT

One of the core philosophies of the integrated Network Enhanced Telemetry (iNET) project is to leverage standard networking technologies whenever possible to reduce development cost and to allow standard networking applications to function. This also provides the best long-term scalability to new unforeseen applications much as the Internet has grown through its open standards. The Developmental Flight Test phase is currently under way to perform initial flight testing of the Test Article (TA) Network. This paper provides an overview of the planned TA Network Testing and the expected results. Current results from flight testing will be presented at the conference.

KEYWORDS

Telemetry Network System (TmNS), TA Network, Testing, iNET

INTRODUCTION

The integrated Network Enhanced Telemetry (iNET) project is an effort to enhance telemetry capabilities through the use of networks. Due to the ubiquitous nature of communication networks, particularly Internet Protocol (IP) networks, there are many well-defined and proven networking technologies that can be utilized within a network-based system. One of the core philosophies of the iNET project is to leverage standard networking technologies whenever possible, which will reduce development cost as well as allowing standard networking applications to function. This approach also provides long-term scalability to future applications.

The iNET project has defined a Telemetry Network System (TmNS). At the highest level, a TmNS is a network of networks. One of the networks in a TmNS is the vehicle network, or test article (TA) network. The TA network is an IP-based network that consists of various network components, some of which acquire data and generate network packets containing the data, and some of which record and/or process the acquired data after receiving it from the network [1]. Other IP-based networks are present on the ground and may consist of mission control rooms and other range infrastructure. The networks on the ground are connected to the TA network via the Radio Access Network (RAN) segment of the TmNS.

Spanning across all of the segments of the TmNS are the standardized system management interfaces and the common Metadata Description Language (MDL). A high-level view of the TmNS can be seen in Figure 1.

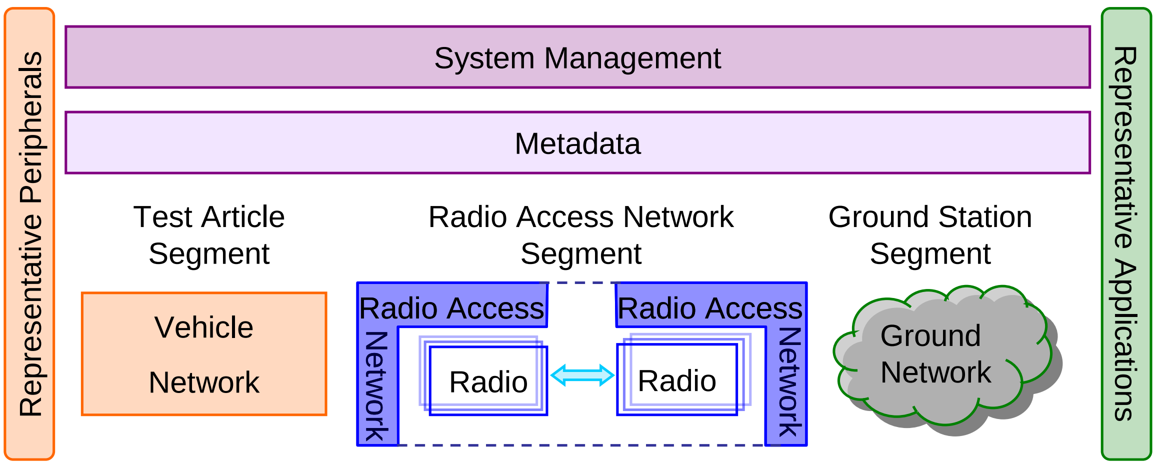

Figure 1. TmNS Networks

The iNET standards have matured to a level that can now be utilized to support flight test operations. Developmental Flight Testing (DFT) of a TmNS system is scheduled to occur in the last half of 2014 at Edwards Air Force Base. This paper focuses on the testing of the TA network.

INET TA NETWORK CAPABILITIES

The TA network consists of several different types of IP-based network devices. Network switches provide the backbone of the TA network. Data Acquisition Units (DAUs) acquire data from a variety of sources, be it analog signals, digital signals, avionics busses, etc. DAUs package the data it acquires into network IP packets for transport over the network. Recorder devices operate as network data sinks and record the data received over the network. Recorders also provide other network services, some of which allow for data mining and retrieval upon request.

All TA components implement several standard networking technologies, allowing standard off-the-shelf network applications to be used in conjunction with the system. Of particular interest is the implementation of the TMNS-MIB, a private Management Information Base (MIB) accessed through Simple Network Management Protocol (SNMP). The TMNS-MIB contains information common to all TmNS devices as well as information specific to certain types of devices. A network manager can utilize SNMP to command and control instrumentation over the network as well as retrieve on-demand health, status, and statistics from each device [2].

The MDL is defined by the Metadata Standard and is understood by all TmNS components. The MDL is used to construct configuration files that can configure all TmNS components in a test. There are a number of benefits to having this information contained within a single MDL file. For one, it means that a single application can be used to generate a file that contains all the configuration information for all devices. It also ensures that the packaging definitions used by the DAUs to package measurement data are the same packaging definitions that a recorder or other data mining application can use to unpack the messages received from the DAUs over the network [3].

As has been stated, the TmNS is a network of networks. The wireless Radio Frequency (RF) network also plays an important role in enhancing the capabilities of the telemetry system as a whole. Part of the RF network segment is a two-way network telemetry link. This new bi-directional link allows assets on the ground inside the Mission Control Room (MCR) to communicate with the instrumentation onboard the airborne TA. This new capability gives rises to new concepts of operations for telemetry systems.

PLANNED TA NETWORK TESTING

The initial DFT is on the horizon for the iNET project. The TmNS system to be used during DFT will consist of a small number of TA components, radios, and supporting ground components and applications. Though there will be TmNS switches, DAUs, and recorders on the TA network, the set of components will not produce enough representative data to exercise all of the functionality of the radios and the RF link. As such, there will also be supporting equipment on the TA to increase the network load to a more reasonable level.

The traffic generator system onboard the TA network is capable of producing various streams of network data. This system will be used to provide the data flows that are representative of a larger TA network. The traffic generator will be able to establish connectivity with a companion traffic generator inside the MCR network. The anticipated packet sizes and frequency of packets per data flow will be used to build a representative traffic load between the TA and MCR networks. These data flows will each carry their respective Differentiated Services Code Point (DSCP) within their IP packets, thus exercising the Quality of Service (QoS) capabilities of the iNET radios.

There will also be an active phone call using standard Voice over IP (VoIP) protocols. The end points of the call will be a phone connected to the TA network and a phone connected to the ground MCR network. There is one soft phone running on the TA network that has a microphone and headset attached, allowing someone on the TA to converse with someone inside the MCR.

There is another soft phone running on the TA network that is running in a loopback mode, allowing a ground phone user to speak and listen for the return echo, giving an indication of the round trip latency of the audio channel through the iNET radio link. The loopback phone is available in case there is no other person to talk to on the TA. Either way, a voice call will be active during DFT operation.

Upholding multiple levels of service for different data flows is nothing new in the world of networking, but it is somewhat new territory in the world of telemetry systems. Classical one-way telemetry links contain a fixed transmission schedule for the Time Division Multiple Access (TDMA) link of Pulse-Code Modulation (PCM) data. Due to the static nature of those links, there was no link contention or spikes in bandwidth requirements. However, flexibility and dynamic nature of IP networks can result in periods where there are multiple streams of data to be delivered over the link. To handle these periods of network contention, the iNET radios implement a series of rules to follow in order to guarantee a certain quality of service for each service class. The devices on the TA network are configured to include the proper DSCP marking in their data flows in order to receive the proper quality of service. For DFT, the traffic generator system can create the network contention, thus affecting the latency and throughput of delivered packets from the TA network to the MCR network and vice versa. The voice data from the VoIP phone call will utilize the low-latency service class of “Expedited Forwarding”.

Inside the MCR network will be an instance of the Ground TA Manager (GTAM), a software application that is capable of discovering devices on the TA network and managing those components as well. The GTAM can issue commands in order to control the instrumentation on the TA network. It can also retrieve the health and status of those devices along with any other statistics made available through the SNMP interface. Being able to control the airborne instrumentation from the MCR during flight is a new capability that may result in bandwidth efficiency gains over one-way static PCM links.

Another new capability within the TmNS is the ability to perform a PCM backfill function when the PCM data stream has momentary dropouts on the link. The TA network contains a PCM gateway device that acquires the same PCM data that is being sent over the Serial Streaming Telemetry (SST) link, packages the PCM data into TmNS Data Messages (TDMs), and then delivers those TDMs to the onboard TA recorder. When a dropout occurs on the SST link, there are one or more gaps in the data. When a gap is detected, the TmNS Data Server (TDS) issues a request to the onboard TA recorder for the missing data. The TA recorder responds by sending down the requested data stream over the two-way network link. Once the data is received by the TDS, the data can then be written to the data displays to fill in the gaps. This capability will be exercised during DFT.

DFT is the first step in exercising the functionality of the TmNS in an operational environment outside of the lab. Advanced Flight Test (AFT) is planned to follow some time after DFT in order to test the more advanced concepts of the TmNS.

EXPECTED RESULTS OF TA NETWORK TESTING

Many of the new concepts and capabilities that will be exercised during DFT have undergone some level of lab testing. This gives a level of confidence that the general functions and capabilities to be tested during DFT will be successful. It is expected that the GTAM software application will be able to configure the onboard instrumentation during preflight activities. During flight, the GTAM should be able to control and manage the onboard instrumentation. This includes enabling and disabling the data transmission capability of DAUs as well as modifying the recording state of the recorder. Also, the GTAM will be able to retrieve device statistics on demand from the TA instrumentation.

The voice call from the ground within the MCR network to the TA network will be established. The expected bandwidth requirement for the two-way voice conversation is approximately 110 kbps in each direction. All data packets associated with the VoIP phone call will utilize the "Expedited Forwarding" class for QoS, allowing the voice call to receive transmission preference through the iNET radios in order to meet the low latency requirements of voice data. Even when the link is congested due to other flows of lower priority data, it is expected that the voice call should maintain good performance throughout the test, as long as the bandwidth allocations for the "Expedited Forwarding" class are not exceeded. The expected end-to-end latency of voice data is expected to be less than 200 ms.

Lastly, it is expected that the PCM backfill capability will be able to be demonstrated successfully. Modifications have already been made to the PCM decommutator and the display system that will be used during DFT. The display system will continue to generate real-time plots of the PCM data received. However, when a PCM dropout is detected, the TDS will automatically request the missing data from the TA recorder. When the data is received by the TDS, it will be provided to the display system. The display system can then fill in the missing data gaps in the display. Figure 2 provides an illustration of the PCM backfill operation [4]. The original PCM data is plotted in real time at a constant data rate, and it is subject to data loss due to data dropouts over the SST link. The pristine data arrives over the two-way iNET link upon request from the TDS. The pristine data may be characterized by some latency and bursty data, but it will be lossless.

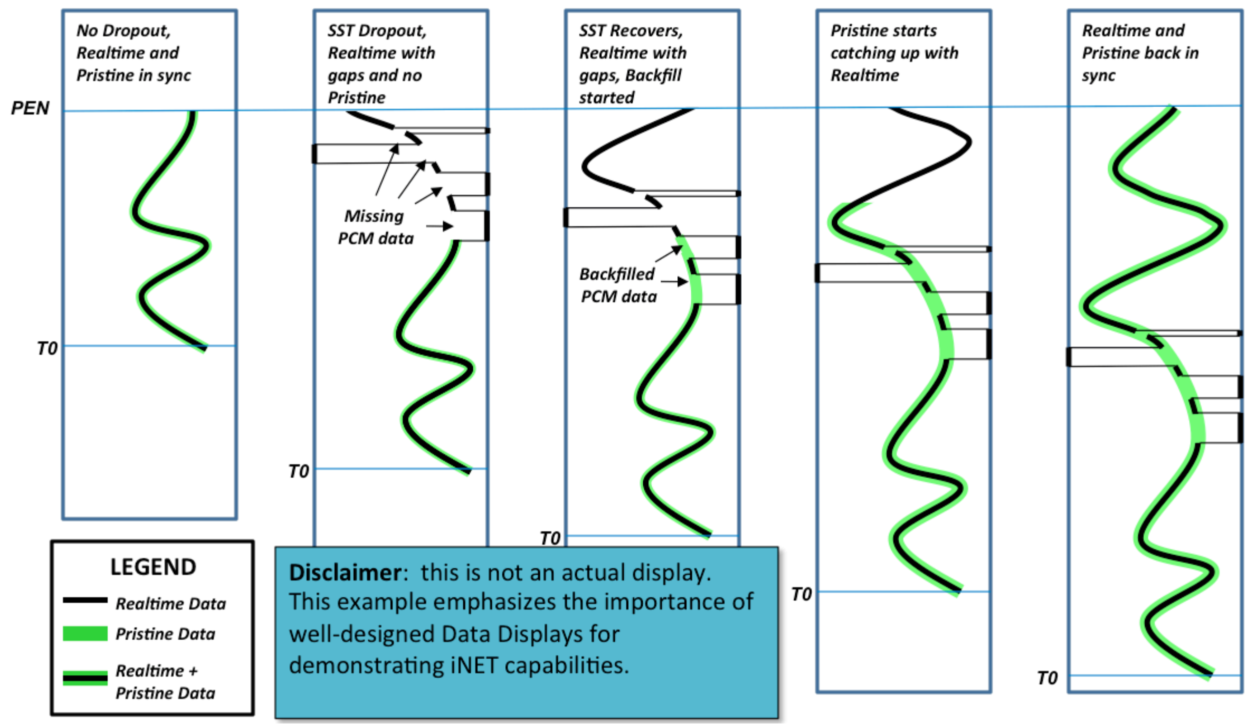

Figure 2. Example Stripchart Data Demonstrating PCM Backfill Capability

CONCLUSION

The iNET program's TmNS is poised to be a game changer for telemetry-based systems. By moving the instrumentation to a network-based architecture, the door is opened to leverage the wide array of proven networking technologies and tools in order to accomplish the testing goals. With the introduction of a new two-way telemetry link comes a whole new set of enhanced capabilities and concepts of operations for how the onboard TA instrumentation system can be used. Many of the new capabilities have been conducted in the lab environment with success. The upcoming DFT activities will yield actual results outside of the lab. Available results will be presented at the conference.

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REFERENCES

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