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Telemetry Network Standards Overview

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Abstract: In recent years, flight test systems have increasingly used network technologies to benefit from the capabilities that have driven the growth of the Internet and other industries. Seeing the power of network technologies, the Central Test and Evaluation Investment Program (CTEIP) established the integrated Network-Enhanced Telemetry (iNET) project to develop an interoperable air to ground network telemetry capability. The standards developed by the iNET project have recently been adopted as Chapters 21 through 28 of the Range Commanders' Council (RCC) IRIG-106 standards. This paper introduces the new IRIG Telemetry Network Standards and provides insight into the new capabilities that systems using these standards provide.

Keywords: TmNS, iNET, RCC, IRIG-106, Networking

1. Introduction

In 1948 a working group on telemetry was created such that "a large amount of development effort could be saved by standardization" [1]. In 1953, versions of the resulting standards began evolutionary sequencing that lead to (after approximately ten updates/revisions) active use by multiple ranges in 1969. Many decades later, both commercial and military telemetry communities reap the benefits of having invested in these standards. The Telemetry Network Standards (TmNS) pose a major enhancement to the sequence of evolving RCC standards.

The TmNS guide the development of network-based telemetry systems. They support leveraging network system design methodologies in order to enhance existing telemetry systems. The goal is to support development of telemetry systems that provide general-purpose networking capability meeting the majority of flight test needs of the United States Air Force, Army, and Navy, and that are interoperable among test ranges. Systems built in this fashion can efficiently support programs with both large and small numbers of measurands, including the Test Article (TA) components that provide the measurands. The philosophy can be used to specify systems that are small enough to be accommodated in fighter-sized aircraft.

The development of the architecture was a result of studies and workshops assessing the need for and implementation of network telemetry. The study team visited five Major Range and Test Facility Base (MRTFB) sites. The following capabilities were identified as being needed for networked aeronautical telemetry:

1. The need to dynamically share spectrum resources among many concurrent activities based on instantaneous demand for telemetry resources.
2. The need to manage this sharing appropriately through defined "quality of service" rules to ensure both defined priorities and fairness.
3. The need to provide real-time or near real-time access to all of the test article measurements either directly from the sensors or from data recorded and stored on the TA, significantly increasing the access to available information during a test compared to that available via the current legacy telemetry systems.
4. The need to command and control TA equipment, sensor parameters, legacy telemetry formats, and other functions from the test/training command and control center.
5. The need to provide effective over-the-horizon telemetry including access to test articles on a worldwide basis.
6. The need to provide additional telemetry communications to support systems-of-systems test and training involving large numbers of test articles (e.g., test article-to-test article communications, chase vehicle to test article).
7. The need to efficiently interconnect ground based systems with TA systems to support the use of simulation and stimulation.
8. The need to protect the integrity of all telemetry communications with the appropriate government approved information assurance technologies for classified information and/or commercially accepted technologies for company proprietary information.

Additionally, qualities that drove the philosophy of the TmNS standards include:

- Scalability
- Flexibility in operation
- User friendliness
- Complexity reduction concerning the networking concepts

The TmNS system architecture supported by the standards provides transformational interoperability enhancements for existing telemetry systems by leveraging networking technologies that can be used to increase test efficiencies. At its core, a TmNS-based system mimics general-purpose Internet protocol (IP) networks, but it also

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provides specialized protocols to support flight test capabilities. The technologies leveraged enable capability growth as the market place evolves.

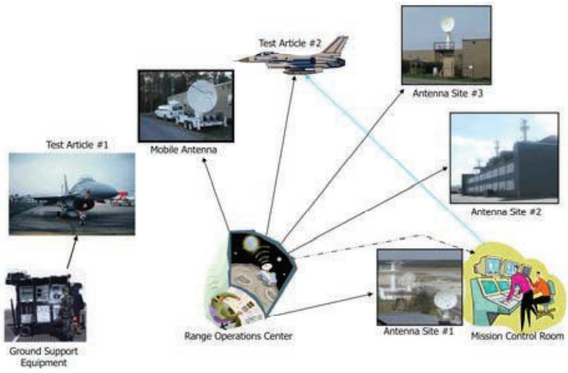

Figure 1: An example of typical TmNS subsystems

TmNS system architectures supports five major subsystems, the general functional areas (see figure 1 for an example). While the overall architecture does not mandate all five areas be utilized by every instance of a TmNS-based system, it is expected that typical system deployments will incorporate concepts from each of the subsystems. The five subsystems are described below.

1. TA Subsystem: The airborne TA provides functionality associated with network-based interfaces for transport, health and status information, configuration, and control of data sources, recording devices, and telemetry transmission devices. The TA also provides the means to interface into existing Pulse Code Modulation (PCM) systems.
2. Ground Antenna Sites Subsystem: A Ground Antenna Site supports the connecting of TAs with Range Operations. It provides a mechanism for routing data between a TA network and the range network. It relies on existing tracking mechanisms, such as a Serial Streaming Telemetry (SST) signal coming from a TA.
3. Range Operations Subsystem: The Range Operations functionality is focused on interfacing the RF-based components within antenna sites (e.g. radios) with the Range Operations Center (ROC). The Range Operations functionality provides the ability to remotely manage the resources within the Ground Antenna Sites (or Ground Stations) such as the tracking antennas, network devices (switches and routers) and the range network infrastructure, which provides the means to interconnect the range facilities.
4. Mission Control Subsystem: The Mission Control architecture concepts provide a means for interfacing into existing telemetry processing systems. The Mission Control consists of the resources necessary for processing TmNS data messages, communicating with the data side of the TA, and communicating with the telemetry processors.
5. Ground Support Subsystem: The Ground Support functionality supports various functions necessary to maintain the TmNS system's metadata, to perform maintenance and pre-flight checkout of the TA components, and to perform limited data reduction on the network data.

The bi-directional nature of the TmNS is fundamentally different from the historic approach. That is, devices on a TA may be accessed remotely during a test. When used in a typical military scenario, encryption-based separation of TA and mission control room portions of the network from the range and RF portions of the network is required. As such, there exists what we call a red side and a black side. We call the TA and Mission control room the red side.

2. IRIG 106 Chapters 21 through 28 Overview

The TmNS Standards comprise chapters 21 through 28 of IRIG-106. They are hosted for public download at www.wsmr.army.mil (see Figure 2).

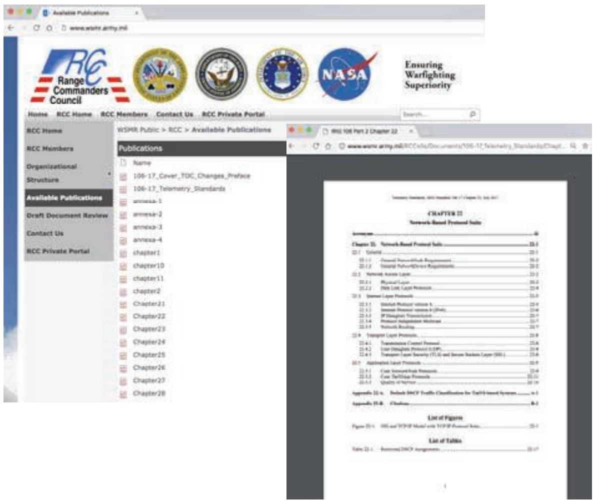

Figure 2: www.wsmr.army.mil is the official site hosting the TmNS Standards (chapter 22 is shown)

IRIG Chapter 21: Telemetry Network Standards Overview, introduces the overall concepts and introduces the remaining seven chapters. Abbreviated and slightly annotated versions of these descriptions is provided below [2].

IRIG 106 Chapter 22: Network-Based Protocol Suite. The TmNS approach leverages existing standardized Internet protocols to serve as the core set of communication. The TmNS's Network-based protocol suite and a large portion of the TCP/IP Protocol Suite (also known as the Internet Protocol Suite) along with other supporting technologies (e.g., underlying data link and physical layer technologies) are described in this chapter.

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IRIG 106 Chapter 23: Metadata Configuration. This chapter describes system configuration data for TmNS based systems. It allows them to be described in a common fashion, and provides the means for describing the configuration of the components in a telemetry system, as well as their logical and physical interrelationships. This chapter defines a language, the Metadata Description Language (MDL). The MDL syntax defines vocabulary and sentence structure, while the MDL semantics provide meaning. MDL provides a common exchange language that facilitates the interchange of configuration information between telemetry system components.

IRIG 106 Chapter 24: Message Formats. The TmNS has defined several message structures unique for its use. This chapter describes the message formats of TmNS specific messages.

IRIG 106 Chapter 25: Management Resources. The TmNS defines Management Resources as resources that contain application-specific data accessible via an application layer protocol. Each TmNS Application defines a set of common resources and a set of application-specific resources. This chapter provides details concerning the standardized application resources.

IRIG 106 Chapter 26: TmNSDataMessage Transfer Protocol. The TmNS has defined several data transfer protocols unique for its use. This chapter defines how TmNS-specific messages (TmNSDataMessages) are transferred between TmNSApps.

IRIG 106 Chapter 27: RF Network Access Layer. This chapter defines the standard for managing the physical layer of RF links with the RF Network. The RF Network implements an Open Systems Interconnect (OSI) model approach to data transmission, where data moves through the OSI stack from the application layer to the physical layer, from physical layer to physical layer through some transmission medium, then back up the stack to another application on the receiving side.

IRIG 106 Chapter 28: RF Network Management. This chapter defines the standard for managing RF links within the RF Network.

3. TmNS Core Technologies

The TmNS utilizes an IP network, based on the success and description of the Internet Engineering Task Force (IETF) hourglass approach, which is shown in Figure 3. The IP layer is the basic interoperability between networked components. Figure 3 also shows a TmNS specialization of the classic IETF IP hourglass figure.

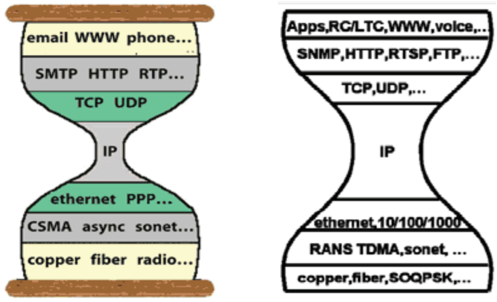

Figure 3: IETF vs. TmNS-Specific Hourglass

3.1 Network-Based Data Messages

Test data is delivered in TmNS Data Messages, which contains a header and a payload. Actual measurements are contained in the packages within a TmNS Data Message and the mapping of measurements in a TmNS Data Message is defined in a system configuration file, the MDL file. The MDL file describes the configuration for a particular device that is transmitting or consuming a given TmNS Data Message. Chapter 24 provides details concerning message shapes.

3.2 System Configuration and Management

System management within the TmNS is based upon the ISO Telecommunications Management Network model FCAPS, which stands for fault, configuration, accounting, performance, and security.

System Management is used across the TmNS to manage TmNS components, providing a view of fault, configuration, utilization, performance, and security configuration information on the network. Essentially, a TmNS system is composed of two types of components when it comes to management and configuration:

1. Managed devices: Any TmNS component that provides a management interface as defined by the System Management Standard and therefore can be managed.
2. TmNS Managers: An entity which manages TmNS Components. Managers implement the interfaces necessary to manage TmNS components in accordance with the System Management Standard.

All components within the TmNS are managed devices (including managers). As such, they can be managed by TmNS Manager(s). Figure 4 shows the building blocks of TmNS System Management. The core technologies used are Simple Network Management Protocol (SNMP) to pass management information through the system. SNMP Management Information Bases (MIBs) provide dictionaries for management information. Managed devices execute applications called agents which use the TmNS MIB to provide their internal status and accept controls and configuration. FTP, HTTP, and ICMP (ping)

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play supporting roles related to file transfer, discovery and configuration.

The Metadata Description Language (MDL) is used for describing system configuration (Metadata) in a common fashion. The eXtensible Markup Language (XML) schema defined for the TmNS provides the means for describing the configuration of the components in the TmNS as well as their logical and physical interrelationships. MDL is expressive enough to describe a wide variety of systems: large and small, simple and complex, from the low-level transducer-to-measurement association for an acquisition card on a Data Acquisition Unit (DAU) up to network topology of multiple test mission networks.

By using the system management capabilities, TmNS components can be configured, reconfigured, controlled and statused in an interoperable way. Chapter 25 provides details on system management.

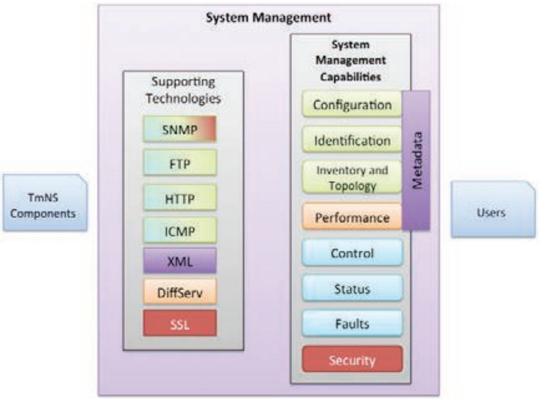

Figure 4: System Management Technologies

3.3 Time

Time within an entire TmNS based system is distributed using IEEE 1588-2008, also known as Precision Time Protocol (PTP) Version 2. Time within the TmNS is delivered without the addition of any wires. Chapter 22 provides details on 1588 time.

3.4 Quality of Service (QoS)

The TmNS annotates a typical Differentiated Services (DiffServ) architecture, a standard IP Quality of Service (QoS) mechanism for coordination of the delivery of competing data and command and control network traffic. Chapter 22 provides details on QoS functionality.

3.5 Routing

Routing is the process of selecting best paths in a network. The TmNS annotates IETF standards concerning a typical routed IP network. Using the classic routed IP architecture enables a variety of advanced capabilities, including relay, and other capabilities that have not yet been explored. Chapter 22 provides details on routing technologies.

3.6 Source Selection

When RF propagation from one TmNS transmitting radio source arrives at two or more TmNS receiving radios, it is possible using routing and source selection to choose any one of the network packets. This support is provided through TmNS interfaces, data message formats, and management concepts. Collectively, the portions of the standard that describe these concepts are called the TmNS Source Selector portion of the standard. Chapter 28 provides details on source selection technologies.

4. Conclusion

The TmNS architecture is, by design, a communications and data delivery system that is partitioned into abstraction layers. As in the Open Systems Interconnection (OSI) model, a layer serves the layer above it and is served by the layer below it. The layers are in general independent, so that a layer can be changed with little to no impact to the other layers. This layered architecture in turn allows different technologies to be used in each layer.

6. Acknowledgements

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6. References

[1] Reynolds, R. Stanton, "IRIG Telemetry Standards 1969," *Proceedings of the International Telemetering Conference*, Volume 5, 1969.

[2] IRIG 106 Chapters 21 through 28 found at www.wsmr.army.mil

7. Glossary

CTEIP: Central Test and Evaluation Investment Program

DoD: Department of Defense

IETF: Internet Engineering Task Force

iNET: integrated Network-Enhanced Telemetry

IP: Internet protocol

IRIG: Inter-range instrumentation group

MDL: Metadata Description Language

OSI: Open Systems Interconnection

QoS: Quality of Service

RCC: Range Commanders' Council

RF: Radio Frequency

SwRI: Southwest Research Institute

TA: Test Article

TmNS: Telemetry Network Standard

XML: eXtensible Markup Language