Pacific Ranges Interoperable Test & Evaluation Capabilities (PRITEC)

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ABSTRACT

The office of the Defense Test Resources Management Center (DTRMC) has developed two major programs to achieve Joint/Interoperable exercises between DoD test and training ranges. Joint Mission Environment Test Capability (JMETC) defines a LVC environment in which Joint operations take place, while the Test and Training Enabling Architecture (TENA) defines the communication within that environment. Putting these programs to everyday use has been a challenge for the ranges. The Pacific Missile Range Facility (PMRF) is executing the Central Test & Evaluation Investment Program (CTEIP) sponsored Pacific Ranges Interoperable Test & Evaluation Capabilities (PRITEC) project designed to develop a set of tools that will facilitate implementation of JMETC and TENA. This paper will discuss the PRITEC project in detail.

KEY WORDS

PRITEC, JEMETEC, TENA, TRMC, CTEIP

INTRODUCTION

The PRITEC project seeks to enhance interoperability between test and training assets in the Pacific and other DoD ranges and facilities. PRITEC will enable PMRF to integrate with other ranges and test facilities for effective testing of systems-of-systems within a realistic joint mission construct. In order to realize this vision, PRITEC will leverage capabilities and infrastructure developed by two programs managed by the Test Resource Management Center (TRMC). The first of these is the JMETC, which provides common infrastructure for joint, distributed testing within the DoD, enabling newly developing programs to test the Acquisition requirements of Joint Interoperability and Net Centricity. The second capability being leveraged by PRITEC is the TENA, which has been developed by the CTEIP to enhance reuse and interoperability among test and training ranges. In the past, operations that crossed from one range to another have been supported; however each instance typically resulted in a new and different connection method. TENA is a disruptive technology that has the power to change the way ranges conduct their operations by defining standard tool set and processes for connections and data transfers resulting in more efficient and cheaper ways of connecting ranges. This paper will describe how the PRITEC project is leveraging disruptive technologies such as TENA and creating disruptive technologies within PMRF, including a TENA-based telemetry decommutation system.

One of the key enabling technologies being used is TENA. PRITEC will enhance the PMRF infrastructure with insertion of TENA technology at the sensor and enable PMRF to interoperate with other DoD assets as part of a distributed T&E network. Key benefits of using TENA in the range environment include increased interoperability through the use of DoD standard interfaces and middleware, enhanced control of data flow during data processing through TENA's publish-subscribe mechanism, and reuse of TENA applications and tools between ranges.

Specifically, PRITEC will do the following to enhance the use of TENA at PMRF:

- Build a TENA-based network at PMRF
- Develop TENA interfaces to range instrumentation
- Develop a TENA-based decommutation system for telemetry

These activities are discussed in more detail below.

DEVELOPING A RANGE ARCHITECTURE WITH TENA

PRITEC will plan, design, and build an accredited network at PMRF that leverages TENA using a three phased approach.

In Phase 1, PRITEC will design, document, and build a TENA-based network (tNet) with security and information assurance (IA) requirements built into the tNet design. This network will be the backbone for TENA applications and sensor interfaces, such as telemetry, described in more detail later in this paper. Overall, the tNet will provide the network infrastructure between sensors and range applications, and the TENA Middleware will marshal the exchange of data and control messages across the tNet infrastructure.

In Phase 2, PRITEC will connect tNet to the JMETC network, providing external connectivity to DoD distributed test capability. By establishing a JMETC node at PMRF, remote users and test facilities can participate in live range test, execution and analysis. The JMETC Network Node builds on the tNet component to allow remote users to subscribe to the sensor object model. A conceptual diagram of the JMETC Network Node is shown in Figure 1.

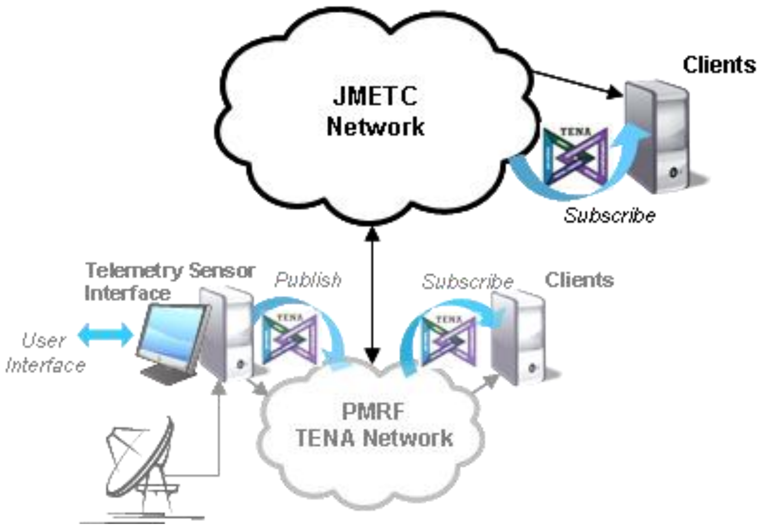

Figure 1. JMETC Network Node Conceptual Diagram

In Phase 3, PRITEC will connect the legacy PMRF instrumentation network (iNet) to the tNet and JMETC networks. Connectivity to iNet will provide access to all sensor data available at PMRF. At the end of the three phases, there will be end to end connectivity between PMRF instrumentation and the T&E assets on the JMETC network. This three phased approach was chosen in order to mitigate schedule risk associated with the certification and accreditation process. Over time, data processing applications and sensors will migrate from the legacy infrastructure to the TENA-based architecture. PRITEC is developing a migration strategy that will serve as a road map for this transition and provide a template for TENA implementation at other ranges. The iNet Connectivity component builds on previous work and is depicted in Figure 2

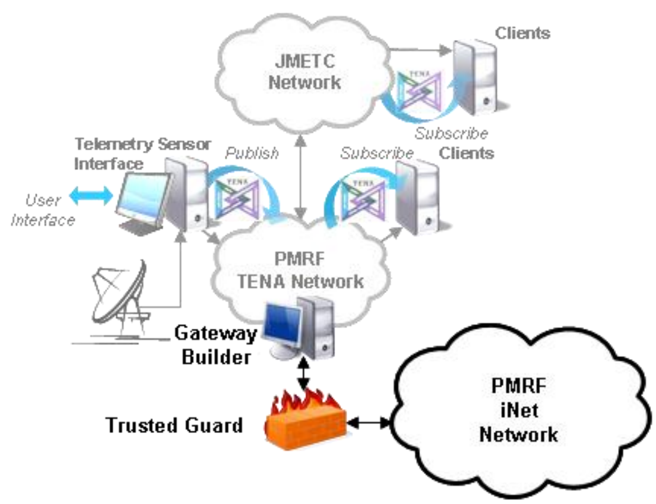

Figure 2. iNet Connectivity Conceptual Diagram

DEVELOPING TENA INTERFACES TO RANGE INTERFACES

The overall capabilities of TENA will promote interoperability and reusability among DoD ranges, facilities, and simulations. In order to take full advantage of TENA capabilities, the tNet architecture at PMRF supports TENA interfaces at range sensors. PRITEC is working to take TENA all the way to the sensor, thus reducing latency, eliminating "Stovepipe" handling of various instrumentation sources, and providing native interoperability with other TENA compliant resources. PRITEC is developing a road map to migrate all range applications and sensors to the tNet over time. As a starting point, PMRF formed a team comprising stakeholders of the major range systems whose task was to select a candidate sensor for TENA integration. Based on a comprehensive study of radar, optics, and other systems, telemetry was chosen for its high return on investment. For many tests conducted at PMRF, telemetry systems collect a great deal of data that is of interest to range users. Since one of the primary reasons for using TENA at the range is to facilitate data exchange, the project wanted to work with data that both internal and external users wanted to see. The selection of telemetry also minimized risk to ongoing operations at PMRF. The range has multiple telemetry receivers, and existing digital switches on range would make it easy to maintain range operations while concurrently sending a telemetry feed to tNet for the prototype effort.

Telemetry was chosen to be the first TENA enabled system to connect to the tNet. PRITEC would develop an interface to the telemetry receiver that would incorporate the TENA Middleware to publish data over the network.

One of the overall goals of the effort was to implement TENA as close to the receiver as possible. In the case of telemetry systems, the farthest upstream one can locate TENA is within the decommutation system itself. The input of the decommutator is typically pulse code modulated data containing multiplexed data from onboard sensors of the test article. The decommutator turns the serial stream into parallel words, at which time the data can be placed into a data structure for further processing and transmission. Within TENA, the structure for storing and transmitting data is called and Object Model (OM). There are standard OMs used by the community to define such measurands as position, velocity, and acceleration data. Users can also create their own OMs for special case applications and share them with others. It is the TENA Middleware that puts data within a TENA object model and then publishes this data to the network. The TENA Middleware on the receiving end subscribes to the types of object models that contain data of interest to the end user. The ideal technical approach for implementing a TENA interface to telemetry, then, is to implement the TENA Middleware within the decommutator itself and then exploit the powerful data processing capabilities of the Middleware to control information exchange over the tNet. As part of the TENA Sensor Interface development effort, PRITEC will also design and implement a TENA Measurand Object Model in which telemetry data will be published and disseminated. This object model will be shared with the TENA user community. Figure 3 illustrates the connection between the telemetry system and tNet along with the publication and subscription process employed by the TENA Middleware.

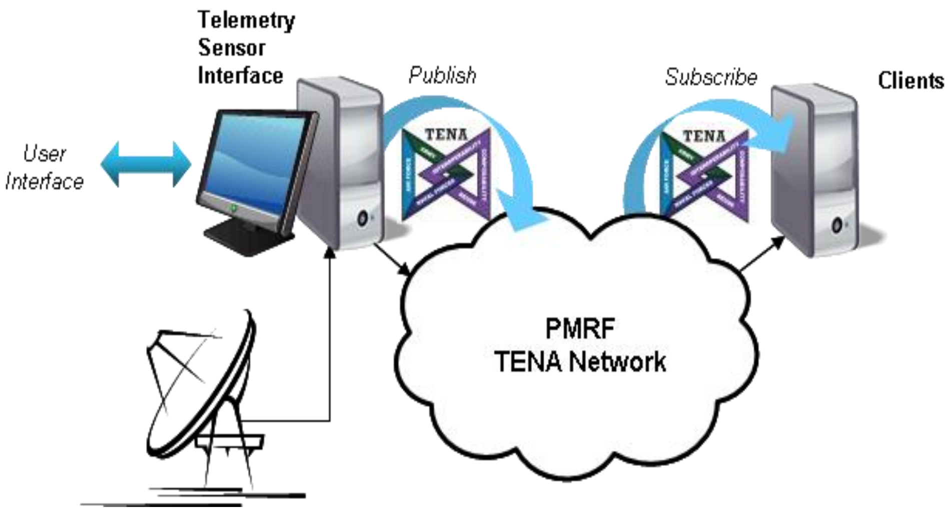

Figure 3. TENA Sensor Integration Conceptual Diagram

TENA SOFTWARE DECOMMUTATION SYSTEM (TSDS)

TENA is implemented within the telemetry decommutation system in order to bring TENA as close as possible to the sensor interface. Since the TENA Middleware runs within a software environment, it makes sense to implement the final portions of the decommutation process in software and feed the output of the decommutator directly to the TENA Middleware. PRITEC calls the final portion of the software decommutator, which publishes directly to TENA, the TENA Software Decommutation System (TSDS). Within the overall architecture, bit synchronization and frame synchronization are performed before data is sent to the TSDS, and the TSDS takes as an input a time tagged minor frame encapsulated within a packet. There are three attributes of the TSDS that make it of interest to CTEIP and the broader T&E community. First, the TSDS is a software based approach to telemetry stream decommutation implemented within Java. This offers technical advantages such as platform independence which will be discussed in more detail later in this paper. Second, the TSDS uses auto code generation technologies to further reduce the effort associated with updating decommutation systems to support new telemetry stream definitions. Users of the TSDS within the range are not required to have detailed knowledge of proprietary protocols, nor are they required to have an understanding of how to implement decommutation within software. The use of code generation in software decommutation offers potential cost savings throughout the entire T&E community. The third aspect of the TSDS that is of interest to CTEIP is that it offers a native TENA interface so that telemetry data can be published directly into TENA object models. Figure 4 shows how the TSDS is connected to the telemetry receiver and publishes TENA objects to the PMRF tNet and ultimately to users off range over the JMETC network.

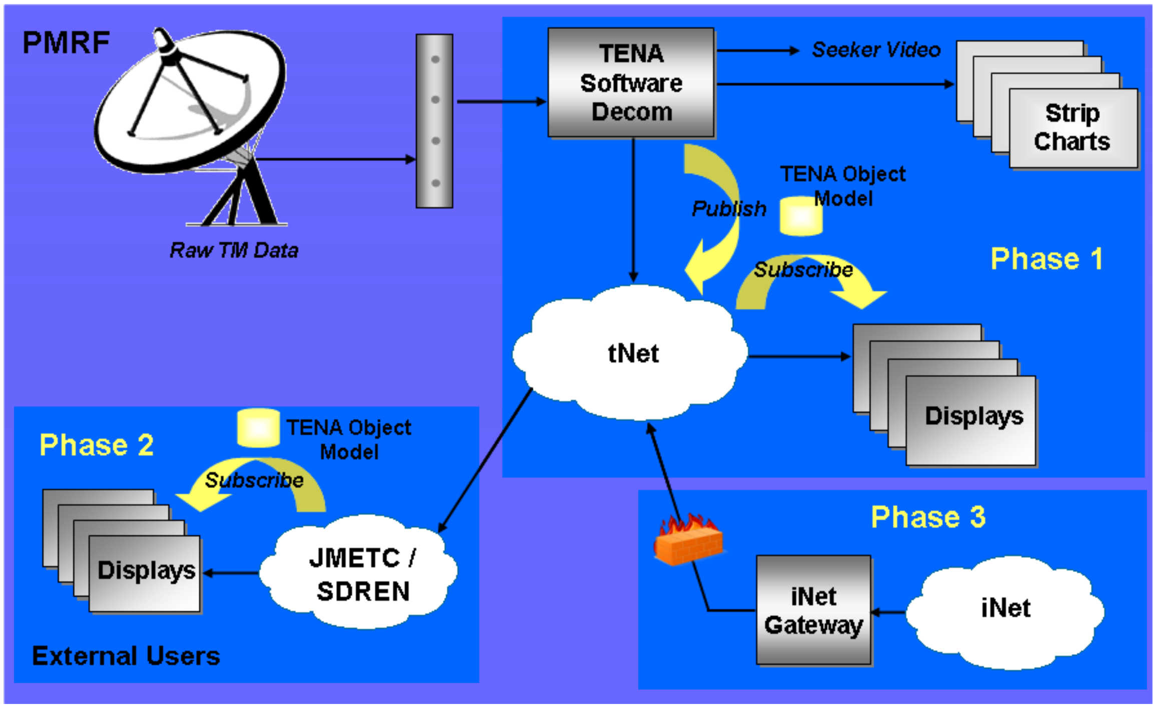

Figure 4. TSDS implementation within PMRF and JMETC network infrastructure

In order to provide the flexibility required to handle a variety of telemetry streams, TSDS is implemented with a modular architecture comprising 4 major components. This modularity offers the following advantages:

- Takes advantage of modern multi-processor and multi-core computers, thus maximizing the supported flow of telemetry data.
- Facilitates support for a variety of ways by which the raw telemetry data frames are collected
- Allows publication of selected telemetry data to TENA
- Simplifies the porting to different platforms.
- Facilitates the automatic generation of the component themselves.

Figure 5 highlights the functionality of each of the four components of the TSDS.

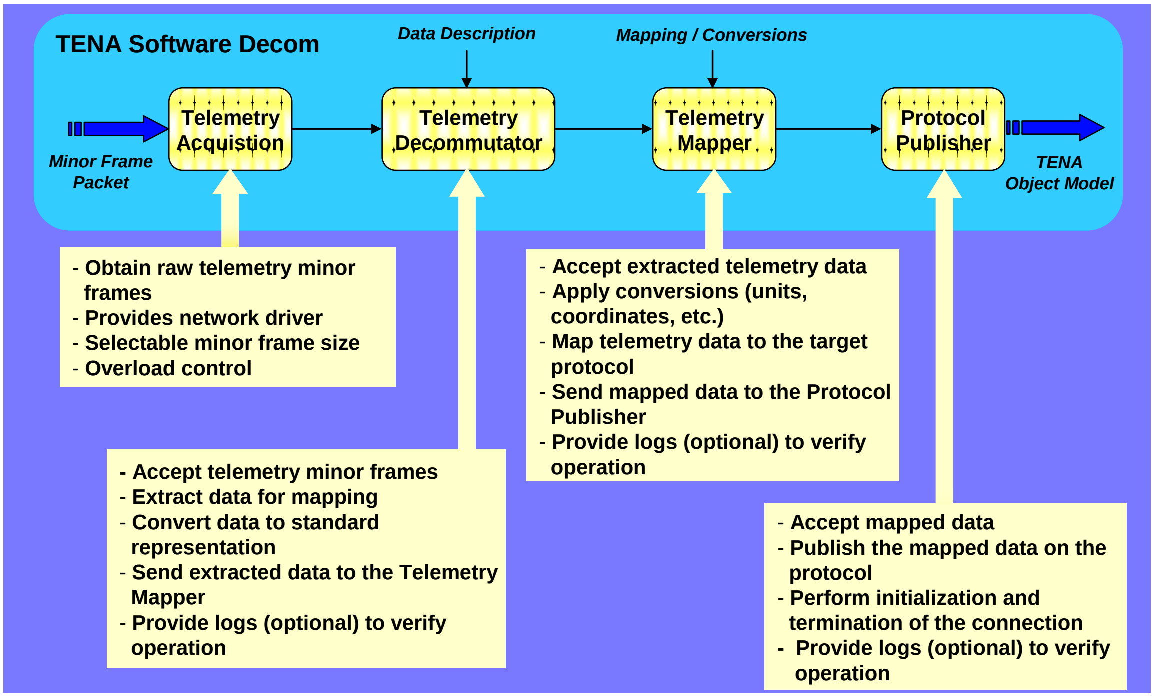

Figure 5. TSDS Architecture

TSDS DESIGN GOALS

In addition to modularity, other major design goals of the TSDS include:

- **Platform Independence**: The various elements of the decommutator system must be available for multiple platforms. Where possible these modules must be platform independent.
- **Ease of Use**: The TSDS should be implemented in such a way that a telemetry systems engineer can reconfigure the decommutator. No software development expertise should be required to implement changes in the telemetry stream definition or in the display or publication of data. The TSDS should have a user friendly GUI to allow the user to configure the decommutator.
- **Performance**: TSDS must support complex telemetry streams, including both synchronous and asynchronous data, as well as video. Latency must be monitored and minimized. The TSDS architecture should be multithreaded to take advantage of multiple cores and processors.
- **Multiple Input Standards**: The TSDS should accept multiple definitions for the incoming telemetry stream including TMATS and other ad-hoc representations such as XML or Excel spreadsheets

- **Remote Performance Monitoring**: The TSDS should include a display for remote performance monitoring and control of multiple instances of decommutators in the network.

TSDS Key Performance Parameters (KPPs)

The PRITEC project has identified the following KPP thresholds and objectives for the TSDS:

- **User Interface:** As a threshold, the TSDS shall provide a GUI for system configuration. This would include ad-hoc representations of the incoming telemetry streams, and parameter selections for TENA object output. The objective for this KPP is a fully functional GUI to include TMATS representation of the telemetry stream, and full TENA Measurand Object Model output.
- **Data Type:** The TSDS shall support both Synchronous and Asynchronous data types as input. This is both the threshold, and objective.
- **Data Rate:** As a threshold, the TSDS shall support data rates of 14 Mega bits per second (Mbps). The objective is 32 Mbps.
- **System Latency:** The threshold for system latency is 250 milliseconds, and the objective is 100 milliseconds. System latency is described as the time between the reception of the last bit of the incoming frame, and the transmission of the first bit of the TENA output object.
- **Output Parameter Selection:** The Threshold for this performance parameter is that the TSDS shall be able to extract parameters from the incoming stream to include TSPI, Range Safety, and Display Objects. The objective for this parameter is that the TSDS will have the capability to select data from the entire stream, including asynchronous video.

SUMMARY

Initial tests of the TSDS prototype indicate that the system is capable of meeting the design goals. The performance of the software based decommutation and publication to TENA object models has met most KPP thresholds, and many objectives. The KPP thresholds and objectives that have been met include: An initial GUI; Can handle both synchronous and asynchronous input data; Data rates of 15Mbps; and System Latencies below 100 milliseconds. Not all components of the TSDS are fully developed, and further testing will occur in the coming months.