Ultra-Low Latency Messages over WAN for Training using Open Standards

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ABSTRACT

The need for Ultra-Low Latency (ULL) communication over a wide area network (WAN) is a challenge for military systems and certainly for the Modeling, Simulation, and Training (MS&T) community. The longing to provide multiple geographical area training has been desired by the warfighter and DoD entities. This messaging service would allow for collective training within live, virtual, and constructive (LVC) across geographic locations and centralize the distribution of the training effort.

The use of open standard communications is also a wanted ability within the MS&T community. It allows for the use of a standard so documentation can be easily found. It potentially provides a larger user and developer base that can be supported by industry and academics. The open standard is maintained by industry, hence reducing the cost for the government to manage. It also allows for industry outside of the MS&T to participate in supporting our warfighters to execute their primary objective.

The Synthetic Training Environment (STE) has been looking for a cost-effective, open standard communication to fill 'Point of Need' training. Utilizing ULL communication across a variety of networks, including WAN, tactical radio, satellite, WIFI, and (3G/4G/5G) cellular networks; along with non-IP and IP transports, provides more network availability which allows for the warfighter to train at home station, operation station, and other points of need.

This paper describes the open standard network communications, system architecture, security methods, and how all elements work together in all legacy, current, and future LVC training environments.

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INTRODUCTION

Ultra-low latency (ULL) communication over a wide area network (WAN) for modeling, simulation, and training (MS&T) systems is an important and much desired technology. MS&T is a very specialized industry that focuses on developing distributed simulation and training technologies to meet military training goals. Training systems have been developed in Live, Virtual, and Constructive (LVC) domains that allow the warfighter to maintain a high state of combat readiness. Legacy training systems have networks with high latency, and many are only capable of participating distributed exercises over Local Area Network (LAN). Research and Development (R&D) has offered guidance on how to incorporate building technologies to achieve true distributed simulation training over the WAN. The UK, Canada, and NATO are also moving toward using large scale, real-time simulations to train geographically dispersed, military personnel across multiple host computers using WAN.

The emphasis of ULL over WAN can be both a physical layer issue and a communication middleware layer (software) challenge. Since any delays seen in communications can be complicated by the senders, receivers, and the service providers supporting the WAN, ULL is a complex challenge. New systems, including driverless vehicles and unmanned air systems (UAS), remote medical procedures (surgeries), smart cities and factories, artificial intelligence (AI) decision systems, and real-time training systems are emerging and producing a revolution in technologies. These emerging technologies provide a hardware and software architecture will allow for innovations in services using Ultra Reliable Low Latency Communication (URLLC). The hardware includes 5G networks which have increased density (more devices per area) and 10x the speed in network traffic. The middleware (software) is data centric communication that provides real-time communication protocols. When training systems are at the point of need, it's important to have low-latency, high-performance, and highly secure networks.

URLLC is challenging when reliability is considered. The use of more resources for signaling, re-transmission, redundancy, and parity, will ultimately increase latency. In fact, many systems' sole purpose is to maximize throughput which makes it difficult to achieve high reliability and low latency, simultaneously. Ultra-reliability can be achieved with small packet sizes which causes a reduction in data rates or increases latency. Throughput, latency, and reliability requirements make physical layer design of URLLC more complicated. In the last decade, multi-force joint coalition exercises use advanced networking technologies. Computer hardware advancements are enabling geographically distributed simulation training exercises using web-based and cloud-enabled technologies. There are cutting-edge commercial technologies that enhance the interoperability for aviation, air traffic control, extended reality (XR), autonomous vehicles, medical training, etc., which can be applied to MS&T to produce cost-effective training systems.

This paper addresses the findings gained in our LVC lab in which ultra-low latency communication methods were developed using a commercial open standard. The goal was to test the validity of our proposed methods to achieve ULL WAN within our LVC environment. The metrics collected during the prototyping effort presented here will direct research paths within MS&T. We provide an overview on which WAN features are important and the results achieved in a distributed training exercise.

COMMUNICATION OVER WAN

WAN is a network that uses various links that include most of the internet traffic. This includes several hardware mediums but typically Multiprotocol Label Switching (MPLS) and wireless (cellular) to connect networks in diverse locations into a single, distributed network (Weinberg & Johnson). This sometimes includes connections a few miles apart or on the other side of the globe. In MS&T, the purpose of WAN allows connecting multiple training centers or even individual warfighters at the point of need to share training resources and communications.

Most training systems today use LANs to operate within a very small geospatial range. These LAN networks are private networks that connect smaller systems to specific endpoints that can be created with inexpensive equipment. The technologies and protocols that make LANs easy to set up don't scale beyond a certain limited distance or to high numbers of endpoints. When a vast distance is required or a high number of endpoints is needed, a WAN should be considered as it provides a means to connect several LANs across far distances.

WAN technologies aren't just limited to Earth. NASA and other space agencies are working to create a reliable "interplanetary internet," which aims to transmit test messages between the International Space Station (ISS) and ground stations. The Disruption Tolerant Networking (DTN) program is the first step in providing an Internet-like structure for communications between space-based devices, including communicating between the Earth and Moon, or other planets.

WAN Architecture

While LANs are usually maintained by DoD contractor's IT staff, WANs are provided by telecommunications carriers. Decisions on what kind of connections or communications protocols to use and how to deploy them will guide the creation of the WAN architecture, not typically controlled by DoD contractors. The MS&T industry is always looking for ways to reduce costs by utilizing Commercial-Off-The-Shelf COTS hardware and software. An internet provider's WAN such as (Bright House Networks) is considered a COTS network. Table 1 lists a sample of WAN protocols.

Table 1. Sample WAN Protocols

WAN Protocols		
Protocol	**Technology**	**Comment**
x.25	Uses packet-switching exchanges (PSE) for the hardware that drops traffic onto the wires connecting sites. The physical links include leased lines, dialup telephone services or Integrated Services Digital Network (ISDN) connections.	It's not used much anymore.
Frame Relay	Frame relay speed up the data rate compared to x.25 and relies less on dedicated connections to create meshed networks, meaning fewer physical circuits, hence saving companies money.	Frame relay, while once extremely popular, has become less so.
Asynchronous Transfer Mode (ATM)	Similar to frame relay with one big difference: data is broken into standard-sized packets called cells. Cells make it possible to blend different classes of traffic onto a single physical circuit and more readily guarantee qualities of service. ATM's overall use of bandwidth is less efficient than that of frame relay.	ATM also has fallen out of favor with business customers.
Multi-protocol Label Switching (MPLS)	An MPLS network provides segments called labels allow MPLS routers to decide quickly where to forward packets and to treat them with the class of service indicated by the labels. This makes it possible to run different protocols within MPLS packets.	Widely used today. Internet protocol (IP) is one protocol commonly carried within MPLS.

WAN Security

Traffic between WAN sites may be protected by virtual private networks (VPN) that overlay security on the underlying physical network, including authentication, encryption and confidentiality, and non-repudiation. In general, security is a crucial part of any WAN rollout. A WAN connection represents potential vulnerability that could be used to access the training network. For instance, a training facility without employing full-time cybersecurity practices could be a potential target; a hacker could breach the network and could then access the LAN that might expose assets that would have been otherwise impregnable.

Virtual Private Network (VPN) WAN Connections

WAN connections that operate over the internet or some other public network generally use a technique known as tunneling. By using a VPN connection, tunneling allows for a LAN private network to be created by encoding encrypting IP packets which are decoded onto another LAN at the receiving side. The packets behave as if they're travelling over a private WAN or inside the LAN. This keeps the data private as it travels over the public networks. VPNs allow remote operators to connect to secure training LANs. A VPN user's internet traffic is routed through the WAN network, which could give them an IP address that doesn't reflect their real physical location.

WAN Latency

WAN latency is based on several factors. The greater the distance a message must travel will increase the latency of the message delivery. Data transmission latency is reliant on the rules of physics, network congestion, and reliable network delivery. Ultra-fast processors and high-end graphics cards provide a major improvement in the latency of training systems by providing onboard circuit chips dedicated to rendering graphics. Other methods, such as applying optimization techniques include using compression algorithms and caching data, frequently used by end users, or data duplication where data *references* are sent instead of the actual data, etc. Application optimization adds another layer of efficiency by automating computer resources to respond on demand, in real-time.

As hardware technologies advance, network latency has improved over the last three decades (Rumble, Ongaro & Stutsman). See Table 2.

Table 2. Factors that Affect Latency

A Look at the factor affecting latency over the last three decades

	1983	2011	Improved
CPU Speed	$1x10Mhz$	$4x3GHz$	$> 1000x$
Memory Size	$\leq 2MB$	$8GB$	$\geq 4000x$
Disk Capacity	$\leq 30MB$	$2TB$	$> 60000x$
Net Bandwidth	$3Mbps$	$10Gbps$	$> 3000x$
Round-trip Time (RTT)	$2.54ms$	$80\mu s$	$32x$

Source: It's Time for Low Latency, Stephen M. Rumble, Diego Ongaro, Ryan Stustsman, Mendel Rosenblum and John K. Ousterhout.
Stanford University 2011

Technologies Aiming to Improve WAN End-to-End Latency:

1. **High-Speed Interconnection (infrastructure):** By building networks that support high throughput, like a 10 gigabit ethernet, it can ensure data rates that support serialization delay and protect the network from microbursts of data. Short-term events that create network clogging congestion can be avoided by having a network that supports these challenges.

2. **Ultra-Low-Latency Switches:** Specialized switches provide capabilities specific to the network data being produced. These high-end switches reduce latencies on the switch to nanoseconds. Choosing switch manufacturers like Cisco or Brocade offer ultra-low-latency switches designed for high-performance training networks.

3. **Message Acceleration Systems:** If well-defined message structures are produced on the training network, there are reliable providers that offer message acceleration software. This can be found in several different middleware providers. It's also possible to find a new breed of purpose-built, hardware-based acceleration appliances that optimize message generation. Frequently, both ethernet and InfiniBand networking are supported.

4. **Next-Generation Security:** Special-purpose, low-latency, firewall hardware can supply multiple functions that reduce a unified threat network traffic challenge. This provides the ability to control specific applications and prioritize network traffic.

5. **Network Management Technologies:** These management technologies provide critical data to the network administrator to understand how the network is behaving and identify challenges in the network. Potential users can create loop-back challenges by plugging in appliances or simply by plugging in a wire incorrectly. It's also possible to have unauthorized software causing data congestion not recognized by an administrator until the network is diagnosed. Technologies have been developed to identify these challenges that troubleshoot the system.

6. **Low-Latency Storage:** Based on the type of systems on a network, it's possible that hard disk speed and size can contribute to low-latency and high-performance networking. Traditional disk storage can be restrictive due to access time, technology latency, and transfer rates. Using high fidelity, solid-state storage offers an efficient and cost-effective alternative that can significantly reduce latency. Enterprise solid state drives can offer a 475% improvement in Input/output Operations per Second (IOPS) over other enterprise hard drives. It is possible to configure a system that optimizes data on SSDs that are used most frequently and use lower cost storage for large amounts of archived data.

Highly Distributed Simulation and Training Exercises via WAN

The U.S. DoD has a goal to build highly distributed simulation and training capabilities with Computer Generated Forces (CGFs) that run with minimal human intervention using a shared WAN so joint exercises can utilize various training systems from multiple locations across the globe. The legacy MS&T training systems have long been relying on Hight Level Architecture (HLA) and Distributed Interactive Simulation (DIS) protocols and Virtual Private Network (VPN) to achieve interoperability. Due to this limitation, given the six (6) identified areas above, we observed that advancement in Message Acceleration Systems and Network Management Technologies have been utilized for ULL purposes. Earlier efforts showed that HLA had a slightly advantage over DIS because HLA was able to be routed across the WAN without creating WAN tunnels, which was found to be time consuming and difficult to maintain (Zalcman & Blacklock). Simulation Object Runtime Database (SORD) was developed for Army's One Semi-Automated Forces (OneSAF) to enable a geographically dispersed OneSAF cluster (Figaroa & Baker). More recently, responding to the STE requirements, Gateways, APIs, and toolsets have been developed by the MS&T industry to support joint geographically separated sites using Web technologies. Legion, SpatialOS, and Bifrost are a few that presented preliminary results with the ultimate MS&T interoperability goals in mind, which is low latency and high throughput for theater training. These developing technologies are parting ways from HLA and DIS because of their WAN limitations. Results from using these new technologies over WAN have yet to be analyzed by the MS&T community.

USE DDS TO ACHIEVE FAST AND RELIABLE COMMUNICATION

Another observation from our survey research is that the mentioned new technologies are either proprietary or for DoD use only, which will not benefit the technology cross-over for both the commercial world and the MS&T industry. We believe that adopting commercial standards for interoperability and developing innovative ways to enhance highly distributed simulation and training exercises via WAN would contribute to the technology transfer.

Based on our survey research results, we chose to use Data Distribution Service (DDS) to achieve fast and reliable interoperability over WAN during a distributed simulation exercise. For real-time systems, DDS is an Object Management Group, machine-to-machine standard that aims to enable data exchange using a publish-subscribe (pub-sub) pattern. This commercial open standard has been used in applications like aerospace and defense, air-traffic control, autonomous vehicles, medical devices, robotics, power generation, simulation, smart grid management, transportation systems, and other applications that require real-time data exchange.

We decided to use RTI's Connext DDS professional version because it provided a robust toolset and a WAN Transport feature to monitor, debug, test, visualize and prototype real-time, distributed CGF systems. This DDS solution is used by the Large Distributed Control System at NASA to reduce complexity for NASA's Launch Control and Data Systems through a DDS data services. It also supports redundant networks and sensors without servers for the Ship-Wide Area Network (SWAN) on the U.S. Navy LPD-17.

Our initial WAN Transport evaluation indicates that UDP is used as the underlying IP transport layer together with other non-IP and IP (TCP, IPv4/IPv6) protocols to traverse Network Address Translation (NAT) routers. We are CGF developers, and we have an OneSAF Distribution Agreement in place with the U.S. Army Program Executive Office Simulation Training and Instrumentation (PEO STRI). In addition, we also added a copy of Integrated Sensor Architecture (ISA) on the network. ISA was developed by U.S. Army Night Vision and Electronic Sensors Directorate (NVESD). We have developed an ISA-DIS plugin that brings all DIS data to ISA and vice versa for another IRAD. Sample training scenarios were developed in OneSAF and ISA to collect metrics on bandwidth and latency as well as the robustness and reliability of the WAN.

Initial DDS over WAN Configuration

Three WAN Configurations

1. As Fast as Possible WAN: The simplest WAN configuration was to set up two separated LANs in our LVC lab and connected over a local master router. In this configuration, two workstations with different Operating Systems and Virtual Machines (VMs) are used to host two OneSAF systems, one runs Windows 10 with a VM, another runs Linux Redhat with a VM. There were two routers connected as two puppet routers, and each had a separate computer attached with their own internal IP address given, which connects to the master router. This as-fast-as-possible (AFAP) configuration simulated WAN did not travel over a wide area via Internet Service Providers (ISP), but it allowed us to do simple testing without worrying about latency, but it also gave us a baseline for the fastest possible scenario.

2. Regular WAN: This configuration utilizes WAN over two ISPs.

3. WAN over Google Cloud Platform (GCP): This configuration uses VM instances at different locations such as Moncks Corner, South Carolina & Los Angeles.

Routing Service Configuration

Environmental variables needed to be properly set according to the specific DDS requirements. Port forwarding rules needed to be defined and setup for each configuration. When a router's IP address was hit, the router would then forward all network traffic on the designated port to one of the computer's internal IP addresses. There were some Connext specific environment properties needed to be properly set too, which we foresee every available DDS solution would require. For example, Quality of Service (QoS) was set to "best effort". This initial routing service set up was successfully tested by sending simple DDS packets back and forth between the workstations in all configurations.

Python Application Programming Interface (API) Development

Connext DDS offers a simple Python API where we used as a baseline to develop a specific software layer to allow specific organization of data packets be packaged before sending over WAN. This is very important because DIS data packets can be big and most of the time there is no need to decompose the data before sending over to WAN. In this API, we created a data buffer with a MAX_PACKET_LENGTH of 10000 bytes to package DIS data packets into a DDS-DIS packet, then send to two abstract pipes Topic A and Topic B. Note the size of packets can be changed when necessary to scale the network traffic.

Topic A and Topic B were created to accommodate the fact that we were using two OneSAF on the network and they can send and receive data at any given time. Another reason for having two Topics was because DDS reuses Sender and Receiver without distinguishing which computer it's sending the data to. Both DISReader and DISWriter were set to keep a history of one packet. Figure 1 depicts how the simulated AFAP WAN is configured and the flow of data packets on the network was directed by extending the Python API.
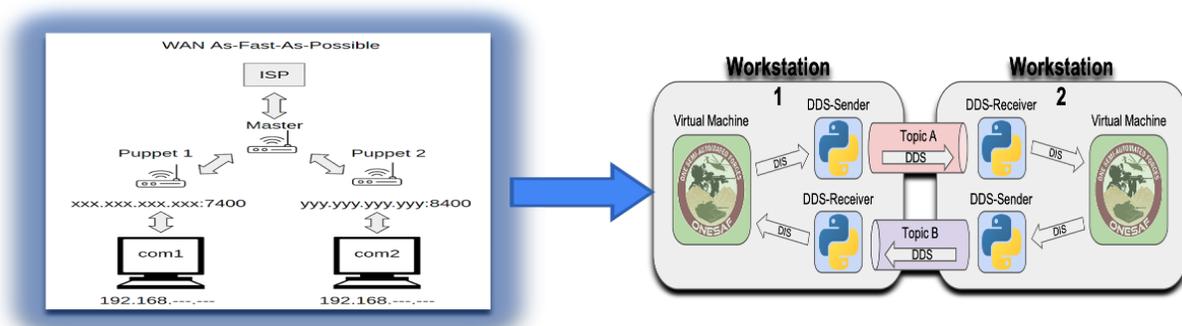

Figure 1 Simulated AFAP WAN

To test how the Routing Service works with the API extension, we created a couple of simple training scenarios in OneSAF where BLUEFOR and OPFOR tank companies performed in a distributed exercise with the two OneSAF ran on our simulated AFAP WAN. We observed that bi-directional traffic flow seamlessly with a perfect interoperability with almost no latency.

To further test the interoperability, we brough in ISA and the ISA-to-DIS plugin that was developed by another in-house IRAD project, into the scenario. This plugin was created to take live sensors and package their relevant information into an appropriate PDU. Since this work was done via DIS and over the network, it was trivial to integrate this technology into the scenario because they were already speaking the same protocol.

Dispersed Locations and Cloud WAN

In this configuration, we moved one workstation to a geographically different location. A LAN is set up at each location and connected via two different Internet Service Providers (ISP). GCP as utilized to achieve the dispersed location requirement. With the limitations in the DAs for OneSAF and ISA, we couldn't move these systems to another location. However, one of the greatest features of DIS is that it is a standardized protocol, and hence any simulation systems that are DIS compliant can be used in our experiment. Protocol Data Units (PDUs) are the data packets transmitted over the DIS network, therefore, if we can send emitted DIS PDU packets to WAN, the test will suffice (Figure 2.)

It is worth noting that setting up configurations of multiple locations can be easily done in DDS because most of the configuration files are in XML format. Adding a new location over WAN only requires updating the IP address and port. We ran the same scenarios created for the simulated AFAP WAN on the two additional configurations and achieved full interoperability with minimal effort.

Once the full interoperability was achieved using DDS, another set of tests were performed to test the latency for all three configurations. A script was created using the rticonnextdds-connector-py API, similarly to how we created the Python API scripts, but instead of bi-directional communication being the goal, we had latency in mind. In one script we sent the DDS-DIS packet, and in the other we received this input and sent the information back. Using Python's built-in nanosecond timer, we measured how long it took from the time we packaged and sent the packet to the time that we read the packet back.
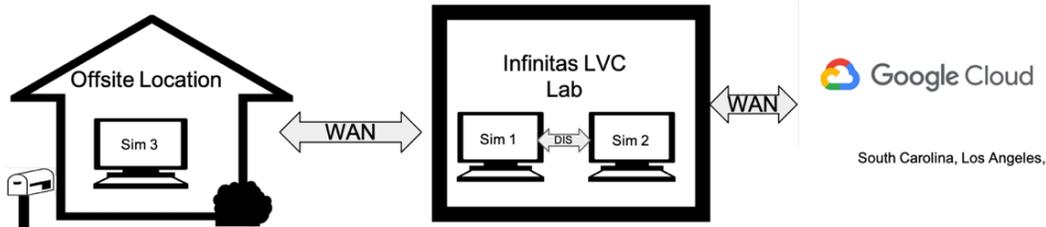

Figure 2 Dispersed Locations and Cloud WAN

With a DIS packet emitter running on Workstation 1 (EntityStatePDUs and TransmitterPDUs) we ran the sender script, and the corresponding receiver script on Workstation. This was done four separate times using all three configurations.

RESULTS

Network Configuration Evaluation

Setting up a simulated AFAP-WAN was a great first step taken for experiments like this. Because utilizing DDS over WAN for distributed simulation exercises using CGF systems to achieve ULL is a brand-new concept, innovative research and testing mechanisms were required at the beginning to ensure a successful experiment.

Secondly, Port Forwarding techniques were used after several tries of different methods while performing the initial shape test provided, and that once it was set up for the AFAP-WAN, it worked for all the configurations.

Thirdly, the RTI routing service was utilized, and environment variables were set on both computers accordingly. For example, PUBLIC_ADDRESS, BIND_PORT, REMOTE_RS_PEER, REMOTE_RS_PEER, etc. Once these environment variables were properly set (among a few others that are required to use Connext), the routing service enabled full interoperability for all configurations.

Distributed Training Scenario Evaluation

As CGF system builders, we are very familiar with building OneSAF training scenarios. All we needed was a training scenario at Company level where there is enough simulated entities and battlefield interactions that generate different types of DIS PDUs. Our training scenarios produced a steady supply of EntityState PDUs, Detonation PDUs, and Fire PDUs amongst all default simulation management PDUs on the network for our latency data collection. Because of our successful network setup for multiple configurations, it was very easy to choose a new location over WAN since it was as trivial as updating an IP address and port.

Latency Metric Evaluation

Latency metrics were collected running emitted DIS packets on all three configurations. Emitted PDUs were used because of the DA limitation imposed from OneSAF and ISA. Table 3 shows the latency test results. Note that round trip latencies are presented here.

Table 3 : Latency Data

WAN locations	Approx. Distance (mi)	Latency (milliseconds; N = 50)
As fast as possible	0	13 ± 5
Orlando to Orlando	10	28.3 ± 0.6
Orlando to Moncks Corner	400	26.2 ± 0.5
Orlando to Los Angeles	2500	77.8 ± 0.5

The approximate distances were gathered using google maps. It should be noted that this is a very rough estimate for two reasons: 1) the IP Address Google uses to find geolocation is not perfectly accurate 2) the geolocation is not indicative of the exact path that the fiber optic cable travels.

From this result, we observed that the distance is not necessarily the best measurement in terms of how latency can be extrapolated. It is obvious that GCP VM, being an enterprise grade ISP, provides the lowest latency because it might have the best technology in every of the six areas we have identified at the beginning of the paper. More tests are being conducted in the lab with increased DIS traffic as well as additional sites so we can perform a more complete analysis.

DISCUSSION AND DIRECTIONS FOR FUTURE RESEARCH

The result of the experiment indicated that, as expected, an open commercial standard such as DDS is able to provide full interoperability for highly distributed simulation training exercises over WAN. The collected metrics over multiple WAN configurations also indicated that network configurations, routing services, and API mechanisms are all factors that affect latency. DDS, with its commercial standard, has made ULL possible, and the fact that this standard network protocol has been used by many Defense and Aerospace organizations provides encouragement on technology cross-over between the MS&T domain and the commercial world. The MS&T industry will be able to fully utilize commercial open standards to bring other DDS compliant training systems and devices to the distributed simulation exercises in military synthetic training environment.

This experiment only used two types of simulation systems in addition to emitted DIS: PDUs for Dispersed Location WAN and Cloud WAN configuration. The testbed can be easily expanded to include multiple CGF systems, virtual simulators, live sensors, and UAV systems, as long as they are either DDS or DIS compliant. The capability provided here broadens DoD training by including many commercially developed technologies currently not utilized. It is evident that our ability to provide interoperability for distributed training exercises with incredible speed allows us to create an infrastructure far beyond what we once believed was possible.

As we move forward with expanding our testbed and creating new technologies to increase the reliability of DDS over WAN, we also identified several areas that need our immediate attention for research and development.

DDS-DIS Translator

First is the usage of a DDS-DIS translator. Although Connext comes with such a translator, our preliminary analyses of the tool indicated that an increase of latency and lower throughput would occur due to the process of composing and decomposing the packets. A more in-depth study on how and when to deal with the translation is needed.

Tactical Priority Consideration

Another area of research and development is how to make a good use of well-defined, tactical priorities which is a very common in military training. For example, some network communications can be given priority over others that are time sensitive, such as Command and Control (C2) messages would be given a higher priority as opposed to email traffic that can be delayed without many effects. We need to determine how to insert such domain specific knowledge into the design of network configuration, routing services, and API development.

Use of Commercial Cloud Platforms

Third, our metrics showed that latency was greatly decreased due to the use of an enterprise grade ISP such as GCP. Commercial product such as GCP spends a great deal of R&D to improve every aspect of network services and management. There is great innovation in the commercial world that the MS&T industry can benefit from. We propose to bring cutting edge technologies from the commercial world to enhance our industry-specific R&D effort for greater results.

Information Assurance (IA) and ULL

An additional area of research will be learning how to use additional DDS capabilities in IA and performance optimization. The DoD encourages the use of COTS and Government-On-the-Shelf (GOTS) products. The DDS world is constantly enhancing their products just like the MS&T community. We will continue to explore and develop technologies to enhance WAN security and performance optimization that can protect and defend valuable military assets.

Large Scale Testbed Development

Finally, a larger scale of exercises is needed to be performed to collect metrics not only on latency but also on reliability and scalability. This is because soon, a synthetic LVC training exercise will include many simulated entities in largely dispersed locations. Not many large CGF systems like OneSAF are being used in a WAN configuration at this time, so it is important to include many types of legacy, currently developing, and future systems in large scale exercises. We will be able to collect latency metrics that reflect rules of physics, network congestion, API delays, IA delays, and even special configuration delays when secured VPNs are required to protect classified military assets.

URLLC in 5G

With training systems coming online that use fiber optic and 5G end-to-end latency in the network continue to improve. A 5G network can support one million connections per .38 miles at a speed of over 100Mbps. Testing multiple configurations using large scale testbeds for military distributed simulation exercises on 5G networks must be done.

CONCLUSION

Today, it is possible to provide highly robust, highly secure, real-time communication over commercial WAN systems. These systems can employ cutting-edge technologies including 5G network systems and ultra-fast network infrastructure. Although the overall throughput of such systems is highly reliant on the internet provider, ULL communication over WAN can be accomplished at a relatively low cost and with the expected quality of service.

Our research and development effort in finding ULL for distributed simulation exercises using data-centric connectivity has led us to discover an innovative approach on achieving full interoperability with DDS. Understanding that low latency and high reliability is a very challenging goal to achieve, with limited networking technologies being developed for the MS&T domain, we proposed to utilize the commercial standard DDS and its broad range of tools to enhance network performance, especially over WAN. The OMG DDS is the commercial connectivity standard for the Industrial Internet of Things (IoT). It provides a middleware protocol and efficient APIs, network configurations services, and data centric peer to peer communications. DDS is a part of the IoT digital transformation that is changing the way we live. We believe this ULL over WAN technology is set to bring every DDS or DIS compliant training device or system to the future synthetic training environment and will pave the way to utilize open standard communication for military training systems.

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