Radio Access Network (RAN) Standard for Potential Use in the Synthetic Training Environment (STE)

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ABSTRACT

TITENN Inc. and the University of Central Florida (UCF) Institute for Simulation and Training (IST) are currently working with the U. S. Army Combat Capability Development Command (CCDC), U.S. Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI), and the U.S. Army Training and Doctrine Command (TRADOC) to develop a new concept called the Synthetic Environment Radio Access Network (*SE RAN*) Standard for potential use in the U.S. Army's Synthetic Training Environment (STE). The SE RAN is an innovative methodology that differs from traditional simulation and training protocols such as DDS, DIS, TENA, HLA, and TSPI because it also incorporates compute, storage, latency, security, and other requirements as part of the methodology. In addition, the SE RAN Standard also differs from these legacy protocols because it includes the protocol and cloud microservice management to provide efficient, low-latency network and microservices management. This reduction in overhead and latency inherent in legacy protocols are required to meet the low latency requirements for Augmented Reality/Mixed Reality (AR/MR) operating in large-scale training events (e.g., Brigade-sized training events at the Combat Training Centers), and the increased network data/bandwidth requirements associated with the convergence of Synthetic and Live Training.

The paper will include an overview of the Modular Open System Approach (MOSA) used to develop the SE RAN Standard, an overview of the steps for transitioning the SE RAN Standard to the STE community. The paper will also include details on the current modeling efforts to validate the benefits of SE RAN Standard, including reductions in bandwidth and latency, improvements in security and how STE developers can build future training environment simulation solutions using the SE RAN Standard.

ABOUT THE AUTHORS

Nicholas Tenn is the President of TITENN Inc., in Orlando, FL. Mr. Tenn received his undergraduate degree in Electrical Engineering from the University of Central Florida (UCF) and an Executive MBA from UCF. Mr. Tenn worked for Northrop Grumman for 17 years, where he served as the Program Manager of the Combat Training Center Instrumentation System (CTC-IS) radio network currently in use at the National Training Center and Joint Readiness Training Center. This effort included building out an LTE wireless network, installing a secure cloud network, developing a new set of enterprise cloud software, and ultimately integrating these complex multi-level security and communication systems together. Mr. Tenn has over 20 years of engineering and program management experience leading several DoD contracts dealing with communication, Artificial Intelligence (A.I.), and Modeling and Simulation. In addition, he has more than three decades of software and hardware engineering and production experience.

Dr. Glenn Martin, Ph.D. is Research Associate Professor & Lab Director, leads the Interactive Realities Laboratory at the University of Central Florida's Institute for Simulation and Training (IST). He earned a Ph.D. in Modeling & Simulation in 2012 from the University of Central Florida, specializing in adaptive training through automated scenario generation. Dr. Martin pursues research in adaptive and intelligent training, game-based learning, multimodal simulation, cybersecurity, competitive learning, and interactive high-performance computing. Since joining the Institute in 1995, he has worked on (and directed) numerous projects including a testbed for evaluating virtual reality and video games for training uses, development of after-action review technologies, and adaptive automated scenario generation. Dr. Martin also is co-manager of the UCF Advanced Research Computing Center, providing computational resources and research within high-performance computing for faculty across the campus.

Brian J. Holmes is an Executive Director of Business Development for ManTech International, where he leverages his extensive experience in a wide range of disciplines to develop innovative solutions for both his military and commercial clients. Brian's experience includes working with entire departments, teams, small groups and individuals, at every level in an organization, from Boards of Directors and upper management to support staff. Brian has held positions as Project Engineer, Systems Engineer, Lead Engineer, Project/Program Manager, Capture Manager, Proposal Manager, Director of Operations and Vice President during his 33+ years in the Modeling, Simulation and Training (MS&T) Industry. Brian's journey in MS&T began at the University of Central Florida where he graduated with a Bachelor of Science degree in Electrical Engineering in 1988 and accepted a position with the Naval Training Systems Center (NTSC, now NAWCTSD). After 5 years at NTSC, Brian accepted a position as a Lead Systems Engineer at the former Simulation and Instrumentation Command (now the Program Executive Office for Simulation, Training and Instrumentation). During his time within the government acquisition commands, he also pursued and completed a Master of Science degree in Industrial Engineering from the University of Central Florida, with an emphasis in simulation and training. Brian has been an active participant on I/ITSEC Subcommittees since 2010, including Chairman of the Simulation Subcommittee in 2014, I/ITSEC 2017 Program Chair, and I/ITSEC 2019 Conference Chair.

Mr. Frank M. Tucker is the lead for the Army's Live Training System (LTS) and is a research and development project manager for the U. S. Army Combat Capability Development Command Soldier Center (CCDC SC). He has managed multiple research projects and teams for the Army and the Defense Advanced Research Projects Agency (DARPA) over the past twenty years. His technical leadership has been in support of technology development in the areas of photonics, navigation, wireless networking, and Artificial Intelligence/Machine Learning (AI/ML) based neural networks.

Mr. Brian E. Kemper is the Project Manager Soldier Training (PM ST) Chief Engineer for the United States Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI). Mr. Kemper received his undergraduate degree in Electrical Engineering from the University of Central Florida. Mr. Kemper has 35 years of systems engineering experience in both industry and civil service, supporting DoD military, Training and simulation, and NASA design and development initiatives.

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TODAY'S CHALLENGES

The Synthetic Training Environment (STE) is the future of Army training. Units from a squad through Army Service Component Command (ASCC) levels can train in the most appropriate domain - live, virtual, constructive, and gaming, or in all four simultaneously. STE will enable Army units and leaders to conduct realistic multi-echelon / multi-domain combined arms maneuver and mission command training, increasing proficiency through repetition. Units can then master collective training tasks in the live environment (CAC-T, 2018). For live training, this will require high-fidelity replication/representation of real combat to include direct and indirect fire weapons and non-lethal fires. Also, the STE will enable the Army to conduct live training in conjunction with immersive (live-mixed reality and constructive) training, enabling units worldwide, improving multi-echelon training exercises, and reducing costs. Most importantly, to be able to conduct tough, iterative, dynamic, and realistic multi-echelon combined arms maneuver and mission command training in support of Multi-Domain Operations (STE SoN, 2021).

Only half of the small arms and munitions currently issued to a Light Infantry Platoon can be accurately represented in today's Live Force on Force training (STE SoN, 2021). On a larger scale, 40% of Basic Combat Training platforms' weapons affect is not simulated in FoF live training events such as indirect fire weapons and area weapons (counter-defilade airburst grenades), and their effects. (STE LTE FoF SoN, 2019) To overcome these limitations, a low latency network that can route data more efficiently is required. The closest we have deployed today is Open Flow Software Defined Networks (SDN) doing network slicing with open standards as a messaging communication architecture. Some of the open standards include High Level Architecture (HLA), Distributed Interactive Simulation (DIS), Data Distribution Service (DDS), Live Training Transformation (LT2) - Time-Space-Position Information (TSPI), or Game Engine Protocols. Additionally, the Army is developing Augmented Reality (AR) high-fidelity capabilities to replicate/represent real combat for Brigade Combat training events. Using immersive live-mixed reality, such as AR Head-Mounted Displays (HMD) at the Point of Need, is essential to implementing the Army's vision (STE LTE FoF SoN, 2019). AR HMDs provides deployed soldiers with a more immersive training capability, such as realistic representations of real combat environments where soldiers can visualize direct and indirect fired weapons munitions, non-lethal fire effects, and much more. However, there are several challenges, such as bandwidth and latency, to implementing AR HMDs in Live Training immersive live-mixed reality environments across Home Stations (HSS), Combat Training Centers (CTCs), and deployed locations (Jeremiah Rozman, PhD, 2020).

OVERVIEW OF SE RAN STANDARD

TITENN Inc. and the University of Central Florida (UCF) Institute for Simulation and Training (IST) worked with the U. S. Army Combat Capability Development Command (CCDC), U.S. Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI), and the U.S. Army Training and Doctrine Command (TRADOC). TITENN and UCF worked with the Army to research techniques and methodologies to reduce latency and increase the scalability of mobile networks to support bandwidth requirements for future live training systems and simulations. The result of that research is a proposed standard, which we describe in this paper.

One of the team's objectives was to research if a Modular Open System Approach (MOSA) Standard can support a brigade-sized Augmented Reality Live Training Environment Synthetic Training Environment (AR LTE STE) event. The AR LTE STE requirement is to have brigade training events with high-fidelity replication/representation of actual combat, including direct and indirect fire weapons and non-lethal fires. (STE SoN, 2019) This capability will require geo-paired engagements combined with augmented reality operating over a Radio Access Network (RAN) at Combat Training Centers (CTCs). A RAN is a network that connects individual devices to other parts of a network through radio connections. The Army’s biggest current challenge in supporting an AR LTE STE event is meeting the low latency requirements over a RAN, as low latency is required to ensure realism in the training environment.

The value to the future of STE using the SE RAN Standard is that the SE RAN abstracts away network, server, microservice, and security management from developers enforce a reduction in latency. The SE RAN Standard seeks to simplify how STE LTE AR simulation solutions are built while it lowers *deployment and operation cost* (which we will cover in more detail in this paper). Traditional M&S Standards (DIS, HLA, DDS, and Game Engine Protocols) focus on defining message formats or API interfaces to support simulations. What is exciting and different about this research was that it centered a MOSA-enabling standard to manage latency over a RAN to support AR LTE STE requirements. We called this new MOSA-Enabling Standard the "SE RAN Standard". For the SE RAN Standard to manage latency, the SE RAN Standard will have to control the network, server, and service management. The SE RAN Standard transfers system-level control to the SE RAN Standard defining the latency, server, service, radio, security, and messages. We then explored the latest research to validate if there was a network technology which could support the SE RAN Standard requirements and have concluded that cognitive networks will support the SE RAN Standard. More details on *SE RAN* and research used to validate that a cognitive network met the SE RAN Standard requirements are provided in the "Synthetic Environment Radio Access Network" section of this paper. This paper will refer to an instance of the Radio Access Network in italics (*SE RAN*), whereas the standard and standard components are not italicized (i.e., SE RAN Standard, SE RAN Standard Container, SE RAN Standard Components).

In the following sub-sections, we will discuss SE RAN Standard as a MOSA-Enabling standard which includes a breakout of the SE RAN Components and the benefits of the *SE RAN*. Then we will cover how the team is establishing the SE RAN Standard.

SE RAN STANDARD AS A MOSA-ENABLING STANDARD

The Department of Defense (DoD) Modular Open Systems Approach (MOSA) is intended to design systems with highly cohesive, loosely coupled, and severable modules that can be competed separately and acquired from independent vendors. This approach allows the Department to purchase warfighting capabilities, including systems, subsystems, software components, and services, with more flexibility and competition (STE SoN, 2021). The SE RAN Standard consists of two component types: microservices and IoT devices. The SE RAN Standard concept for developing simulation solutions is grouping SE RAN Standard microservices and SE RAN Standard IoT devices together. There are endless possibilities to what developers can build with the SE RAN Standard as long as the latency, compute, and storage requirements are physically possible. This section will explain how each of the SE RAN Standard Components (microservices and IoT Devices) supports DoD MOSA requirements, what information is required for each SE RAN Standard Component and provides an overview of constructing an SE RAN Standard simulation solution.

SE RAN Standard Microservices

SE RAN Standard microservice architecture is an approach to simulation development where discrete, modular M&S software is installed inside an SE RAN Container. A SE RAN Container is a lightweight, standalone, executable package of software that includes everything needed to run an M&S service except the Operating System (OS). SE RAN Containers run in isolated processes from one another, so several containers can run in the same host OS without conflicting with one another. SE RAN Standard microservice architecture promotes a loosely coupled and independently deployable architecture, creating a highly maintainable and testable system. SE RAN Containers support the Open Container Initiative recommended by the DoD’s *DevSecOps Fundamentals Playbook*. (Secretary DoD, 2021).

Figure 1 lists the key attributes to building an SE RAN Standard microservice. The concept is that a content creator loads their software into an SE RAN Container, identifying the maximum SE RAN Container compute requirements for their software, the type of processor (GPU /CPU), and the maximum storage requirement. Next, the content creator documents all outgoing messages in Google Protobuf format. Each outgoing message must identify its destination, such as a specific microservice or an IoT Device. Once all the outgoing messages are defined, a content creator must consolidate the destinations into a single list. For each destination, a creator must identify the maximum acceptable latency. For example, if the content creator had an SE RAN microservice with messages going to two services and one IoT Device, the consolidated list would be three destinations. Then for each destination, the content creator would have to identify their maximum acceptable latency requirement. The *SE RAN* then maintains that latency requirement for all the messages to that destination.

- Microservices
  - Operates in a SE RAN Container
  - Define container compute, storage
  - Messages
    - Define message content (Protobuf)
    - Identify message destination (Microservice or IoT device)
  - Define latency for microservice or IoT device

Figure 1. Microservice Attributes

The SE RAN Containers shut down all external communication functions; external Ethernet protocol communications will not work. What is provided in the SE RAN Container is an SE RAN Standard Network interface. This network interface only supports transmitting outgoing messages identified in that microservice SE Standard message list. This provides an innovative approach to achieving advanced level of security without the traditional overhead. The concept is currently being explored with government cybersecurity teams to develop an approach where developers who build to the SE RAN Standard would inherit the cybersecurity certification of the *SE RAN*.

Another feature of the SE RAN Standard is the protection of Intellectual Property (IP). Source code is not exposed since the software is delivered via the SE RAN Container protecting IP. In the "Simulation Construction with SE RAN Standard" section, we will cover in more detail how SE RAN Containers can be integrated while protecting a creator's IP.

SE RAN Standard IoT Devices

Internet of Things (IoT) is physical objects—a.k.a. "things"—that are wireless devices embedded with sensors, battery, software, and other embedded technologies to provide training mission capabilities. SE RAN Standard IoT Devices are IoT devices that support SE RAN Standard requirements. SE RAN Standard IoT Devices range from simple sensors to complex devices with real-time analytics, machine learning, complex sensors, and embedded systems. Some examples of SE RAN Standard IoT devices include direct and indirect weapons, cameras, radios on soldiers, joysticks, geo-pairing engagement devices, and other TADSS (Training Aids, Devices, Simulators, and Simulations).

Figure 2 lists the key attributes/requirements to build an SE RAN Standard IoT Device. Some of these requirements are similar to SE RAN Standard microservices. The concept requires a working device that operates on at least one of the SE RAN wireless network frequencies. The SE RAN supports different types of radios; at a minimum, SE RAN Standard IoT devices should support 5G and 4G/LTE networks. For example, if several wireless networks cover a player, the *SE RAN* will help maintain an optimal signal by switching between other wireless technologies. Creators must identify the radio types on the device and the MAC_ID of the device. Similar to the SE RAN Standard microservice, a content creator must document all outgoing messages in Google Protobuf format. Each outgoing message must identify its destination, such as a specific microservice or an IoT Device. Once all the outgoing messages are defined, a content creator then must consolidate the destination into a single list. For each destination, the creator must also identify the maximum acceptable latency.

- IoT Devices
  - Provide Radio Type (LTE, WIFI, 5G)
  - MACID
  - Messages
    - Define message content (Protobuf)
    - Identify message destination (Microservice or IoT device)
  - Define latency for microservice or IoT device

Figure 2 – IoT Device Attributes

A key feature of the *SE RAN* is its ability to maintain the latency requirements defined in the SE RAN Standard. This feature allows IoT devices to offload computationally expensive processing into the cloud. A significant challenge to live training is battery life and weight, and as the Army transitions to geo-pairing engagements, this challenge is amplified. In a geo-paired AR engagement where processing can be offloaded into the cloud, creators have more design options to make their TADDS more cost-effective, lighter weight, and energy-efficient.

Simulation Construction with SE RAN Standard

SE RAN Standard simplifies how simulation solutions are built because developers do not have to deal with network management, microservice management, server management, and security. All a developer has to do is build to the SE RAN Standard. The information in each of the SE RAN Standard Components (IoT devices and microservices) provides the information the network needs to connect the services while maintaining latency requirements. In the following example, we will walk through an example of building a simulation system using the SE RAN Standard, how enhancements could be made, and how a creator's IP is protected.

Figure 3 shows a simple example of building simulation capabilities. The green boxes represent microservices, the blue boxes represent IoT Devices, the purple disk is the *SE RAN*, and the purple lines show the *SE RAN* connecting microservices and IoT devices. Content creators build these individual SE RAN Components and provide the linkage and latency information as part of the SE RAN Standard. The *SE RAN* links SE RAN Components based on the information provided.

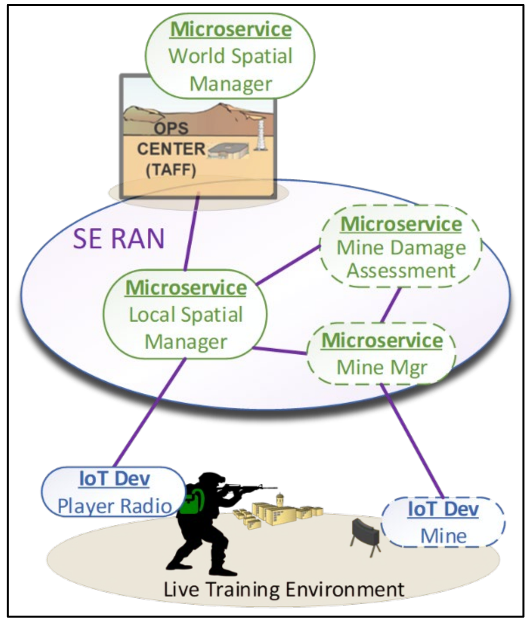


Figure 3 – Simulation Service Example

For example, a vendor builds a mine solution to operate on the *SE RAN*, which includes: 1) An IoT mine device; 2) A microservice that collects information from that IoT mine device (Mine Mgr); and 3) A microservice to perform damage assessment if the mine is detonated (Mine Damage Assessment) shown as components with dotted lines in Figure 3. When a mine device is powered on, the *SE RAN* uses the information defined for each SE RAN Standard component (IoT Mine Device) to start their supporting microservices. This process is done with each component until all supporting services are running. The *SE RAN* then connects these microservices and IoT devices together, resulting in an operating live training capability. This example highlights how the SE RAN Standard dictates how the *SE RAN* manages networking, server, service, and security management.

A third-party vendor with a more cost-efficient mine or better damage assessment microservice can replace the existing SE RAN Standard components with their own and reuse the current supporting services. The SE RAN Standard is highly cohesive, loosely coupled, and consists of severable modules. Third-party vendors reuse already develop capabilities by interfacing with their containers via the messages defined in each SE RAN Standard components definition. The ability to replace a single component and then group components together as containers to create a training capability without worrying about latency, networking, security, and service management simplifies development and reduces development time.

Creator's IP is protected because third-party vendors do not have access to the software inside the SE RAN Containers. Instead, content creators interface with existing SE RAN Standard microservices using the SE RAN Standard component defined messages. There will be a testbed where third-party vendors can test interfaces with other vendors' microservices without access to the container itself. The SE RAN Standard offers a new method to construct large-scale simulations by abstracting away network, microservice, and server management from simulation developers.

The SE RAN Standard is different from traditional standards because SE RAN Standard controls network, server, service and security management automating route planning, network configuration, microservice instantiation, server management, and more.

ESTABLISH SE RAN STANDARD

We have covered details of concepts, data formats, and techniques of using the SE RAN Standard. TITENN and UCF IST are leading the effort to make the SE RAN Standard an open standard managed by the community. As part of the effort, we will be publishing the standard on the SE RAN website, and are executing a pilot program. We have a few early participants to test the standard and provide feedback, and we welcome others to join if interested.

The SE RAN Standard website is at www.SERAN.org. The SE RAN Standard website will be the initial portal for SE RAN Standard information. The website will continue to evolve as we receive feedback from the M&S community.

We will be running a pilot program where several third-party vendors will port their STE Live Training components into the SE RAN Standard. Other vendors may be added based on the interest we receive. Each vendor will follow the process from the SE RAN Standard website to develop SE RAN Standard components. TITENN and UCF IST will capture feedback from vendors throughout their SE RAN Standard conversion effort with informal meetings and questions. At the end of their final run, TITENN and UCF IST will do an exit interview. We will use this development cycle with third-party vendors to capture feedback in order to improve the SE RAN Standard. TITENN and UCF IST will also examine how the standard supports the mission and impacts development costs. The output of the pilot program will be an altered standard that will form the basis to work with the greater community possibly through an organization such as SISO.

SYNTHETIC ENVIRONMENT RADIO ACCESS NETWORK (SE RAN)

The SE RAN Standard offers network vendors a set of parameters to develop their own version of an *SE RAN*. Network vendors can find new ways to optimize performance and create cost differentiation or different value propositions for their network. The requirement for a vendor to build an *SE RAN* is that their network must support the SE RAN Standard, which mainly consists of maintaining network and latency requirements between many SE RAN Standard microservices and SE RAN Standard IoT devices. We envision many different network vendors creating their own *SE RAN*, making the *SE RAN* a commodity for DoD. Vendors can tailor their solution for specific use cases based on a given mission. More importantly, any simulation solutions built to the SE RAN Standard will operate on any compliant *SE RAN*. This approach provides a standard MOSA product line approach for the network and the simulation solutions. In the next section, we will provide details of the research that led us to cognitive networks. Then we will discuss the model we used to validate that a cognitive network would be able to support the SE RAN Standard and provide the model results.

SE RAN Research

Once the team had identified the SE RAN Standard, the team had to validate if a network could support the *SE RAN* requirements. We investigated alternative approaches to reduce network latency, which favored new, agile, and open paradigms for network deployment, control, and management. The team researched revolutionary and innovative networking solutions based upon programmability, openness, resource sharing, and edge computing around wired and wireless networks (Haavisto and Arif, 2019), (Berde and Gerola, 2014). The team researched new networking principles such as SDN (McKeown and Anderson, 2008), network virtualization (Chowdhur and Boutaba, 2010), and Multi-access Edge Computing (MEC) (Mao and You, 2017). We gained an understanding that these technologies demonstrate dynamic network control and agile management features (e.g., frequency planning, user scheduling, mobility management, among others). Our research concluded that these new technologies could be combined to maintain network latency Quality of Service (QoS) necessary to support Augmented Reality/Mixed Reality (AR/MR) large-scale training events at a CTC. Current-day networking technologies limit a network's ability to adapt, often resulting in sub-optimal performance. Limited in the state, scope, and response mechanisms, the network elements (consisting of nodes, protocol layers, policies, and behaviors) cannot make intelligent adaptations. Communication of network state information is stifled by the layered protocol architecture, making individual elements unaware of the network status experienced by other elements. Any response an element may make to network stimuli can only be made inside its limited scope. The adaptations performed are typically reactive, taking place after a problem has occurred. By combining these technologies, we can advance the idea of *cognitive networks*, which have the promise to remove these limitations by allowing networks to observe, act, learn and optimize their performance to maintain the latency requirements for AR/MR large scale training events. (Thomas and DaSilva, 2007).

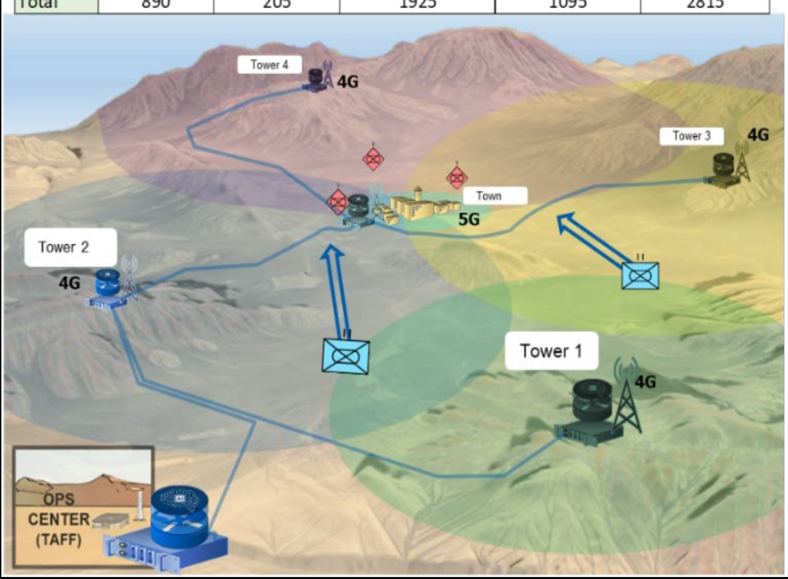
Our research concluded that *cognitive networks* can meet AR STE LTE requirements and support the SE RAN Standard requirements. Network management and server management are abstracted from traditional simulation environments by leveraging these innovations, allowing simulation developers to focus on building simulation solutions rather than worry about latency or deployment. As we continued developing the concept of the *SE RAN*, we also realized cybersecurity became an inherent function of the system. *SE RAN* will only allow messages define by the SE RAN Standard components to be transmitted on the network. With this level of security, we are working with government cybersecurity teams to develop an approach where developers who build to the SE RAN Standard would inherit the cybersecurity certification of the *SE RAN*.

SE RAN Model

The team then had to assess the feasibility of the *SE RAN* to support an AR STE LTE event and the SE RAN Standard. We created a maximum capacity use case that captured high-engagement AR LTE STE event at a CTC. We worked with stakeholders and collected their inputs to understand all the new SE LTE requirements. We built a complete list of all the engagements, SE RAN Standard Components (IoT Devices and microservices) needed to be modeled and created a High-Level Operational Concept Graphic (OV1) diagram shown in Figure 4. The OV1 shows: 1) the 4G/5G wireless network coverage for each tower and town represented in different colors; 2) the fiberoptic network shown in blue lines; 3) The battalion training forces (blue squares) and the opposing forces (red triangles); 4) The soldiers and vehicles distribution over the coverage area; 5) The location of where the server computing is located; and 6) The wireless connections between vehicles, soldiers, and towers.

	# Players on each tower	# Vehicles on each tower	# Players on vehicle network	# Connections to each tower	Total # Players on each tower
Tower 1	175	40	440	215	615
Tower 2	225	45	495	270	720
Tower 3	200	50	550	250	750
Tower 4	150	40	440	190	590
Town	140	30		170	140
Total	890	205	1925	1095	2815

- **Private Standalone Network**
- **Wireless Connections between**:
  - Warfighter to tower (4G)
  - Warfighter to vehicle (5G)
  - Vehicle to tower (4G)
  - Town (5G)
- **Server Compute Areas**
  - On Soldier
  - Radios at towers and town
  - On vehicles
  - At Ops Center
  - On Soldier
- **Towers & TAFF**
  - Towers within 60 miles of each other
  - TAFF is 120 miles from towers 2
  - Added in repeaters delays
- **Video Streaming**
  - Max 4 Live Streams per LTE radio
- **Other Devices**
  - 100 Mines, Sound, Smell and Smoke makers



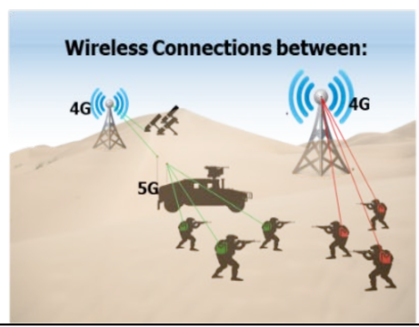


Figure 4 – High-Level Operational Concept Graphic (OV1) Diagram used for Modeling Simulation

The purpose of the *maximum capacity use case* was to create a scenario to be used as input to network performance models which simulated performance and network loading. We modeled the *maximum capacity use case* against two network architectures operating on a standalone private network. The first network architecture was an *SE RAN* approach that utilized the components of a cognitive network. We considered different pairing of networking and server management technologies as part of this research to determine the best fit. The second network architecture was a traditional Data Center approach where microservices are located at a centralized location (Ops Center in Figure 4). We modeled the engagements between two Battalion-sized units versus three company-sized units with 2815 players and 205 vehicles. The engagement is supported by a 5G network on vehicles, a 5G network in a town, and 4 LTE towers providing larger coverage areas.

We then ran the models to assess the two network architectures. The team used three criteria to evaluate the network: 1) Could the network deliver 60 updates per second to all the players wearing an AR HMD supporting frame rates over 240hz? 2) Could the network manage the network load to support all the engagements outlined in the *maximum capacity use case*? and 3) Could the network meet the latency requirements for all the SE RAN Standard Components defined in the *maximum capacity use case*?

SE RAN Model Results

For *SE RAN*, we found that tailoring the 3rd Generation Partnership Project (3GPP) Use Cases for the SE RAN Standard by incorporating cognitive network, network convergence, and optimizing the network traffic routing with intelligent switching technologies offered the best results. We used this approach when running the network performance model.

Our model results validated that during a *maximum capacity use case,* the *SE RAN* can deliver 60 updates per second to all the players wearing an AR HMD supporting frame rates of over 240hz, but the traditional data center approach cannot provide adequate time for microservice processing. In addition, our *SE RAN* model showed up to 20X times decrease in latency and up to 486X times increase in scalability for mobile networks to support bandwidth in backhaul network capacity compared to a "Traditional Data Center Architecture". For the *SE RAN* model, the average time to send a packet from a player and back was 5ms, leaving ~10ms for a microservice to perform its function, which met our SE RAN Standard components requirement defined in the maximum capacity use case. The results validated the feasibility of our hypothesis, these new technologies can be combined to support large-scale AR/MR training events at a CTC.

The next step is to validate the model predictions within a lab/hardware environment. As part of the pilot program, we will build out the *SE RAN* and develop a set of SE Standard components to validate the model predictions. We will instrument the environment to capture latency and bandwidth measurements. We will analyze the measured results compared to the modeled predictions. We will post the summary of the results on www.SERAN.org to share them with STE and M&S community. If we receive the performance/latency enhancements the model is projecting, the next step will be to deploy SE RAN to a home station.

CONCLUSION

The objective of the SE RAN Standard is to be an open standard owned, managed, and funded by the Modeling and Simulation (M&S) community. This paper aims to introduce the SE RAN Standard to the M&S community and to get feedback as the SE RAN Standard is developed. We hope to work with members of the M&S community to transition the SE RAN Standard to a working group that operates in a similar fashion to how the Distributed Interactive Simulation (DIS) Standard is managed today. If readers are interested in being an early tester, or contributor, please visit the SE RAN website at www.SERAN.org.

The emergence of technologies being built to support 3GPP and advancements in cognitive networks provides a foundation for changing how simulation solutions are built. The SE RAN Standard offers a simplified method to construct large-scale simulations by abstracting away network, microservice, security, and server management from simulation developers. The SE RAN Standard reduces cost with an open product line approach for both the network and simulation solutions. There are several key benefits to the SE RAN Standard, which are: 1) Reuse of components for a product line approach (Lanman, et al, 2011); 2) Lower cost to develop simulation solutions; and 3) inherited AI certifications. These benefits reduce the cost of development for industry, academia, and DoD and allow creators to protect their IP.

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