

Medium Resolution Communications Modeling in the OneSAF Objective System

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ABSTRACT: *The OneSAF Objective System (OOS) is being developed as the Army's next generation entity level simulation. When delivered in FY06 OOS will offer user-based composition of physical and behavioral components into interesting battlefield entities such as individual combatants, tanks, trucks, helicopters and a variety of other equipment for friendly, neutral, and opposing forces. The OOS physical model set supplies the physical characteristics of the entities and includes their mobility, vulnerability, acquisition, and communications capabilities among others. This paper looks at the characteristics of the medium level resolution communications model that will be delivered as part of the FY06 capability. To do this we will review the overarching conceptual model and the characteristics of the communications model, and describe how the communications model impacts the perceptions on the simulated battlefield.*

1 Introduction

The One Semi-Automated Forces (OneSAF) Objective System (OOS) is the U.S. Army's next generation, composable, entity based simulation system. It is being developed to provide an integral simulation service to the Advanced Concepts and Requirements (ACR), Training, Exercises, and Military Operations (TEMO), and Research, Development, and Acquisition (RDA) domains. With requirements ranging from closed-form analytical support to command level human-in-the-loop training, OneSAF will be a High Level Architecture (HLA)/Distributed Interaction Simulation (DIS) compliant, entity level simulation providing a common-based solution for a broad range of user requirements.

In today's dynamic warfighting environment communication plays a critical role in maintaining the friendly and disrupting the enemy's battle rhythm. Several real-world initiatives rely on robust dynamic communications to allow much greater information exchange from the foxhole to the commanding general. Initiatives such as Network Centric Warfare (NCW) and the Global Information Grid (GIG) signify the importance of achieving and retaining information dominance on the battlefield. For OneSAF to support exploration of the capabilities necessary for these

initiatives as well as the doctrine and tactics that will surround them OneSAF offers a comprehensive communications modeling concept, design, and implementation.

The following sections briefly explain OneSAF's communications conceptual model and the design for low and medium resolution communications.

2 The OOS Communications Conceptual Model

The OneSAF conceptual model presents an abstraction of the real-world warfighting environment capturing the fundamental elements and interactions to be represented within OneSAF. It explains what will be simulated within OneSAF without designing the implementation. The software developers use the conceptual model to understand the capabilities they must implement but not how to design their implementations.

The OneSAF conceptual model covers the Army's 7 Battlefield Operating Systems: Command and Control, Maneuver, Intelligence, Fire Support, Air Defense, Mobility/ Counter-mobility/ Survivability, and Combat Service Support. It further defines common aspects

across the BOSs such as combat, communication, environment, self-preservation, sensing and movement.

Before exploring the OneSAF communications conceptual model it is necessary to understand the color-coded UML-based Conceptual Modeling Language (CML). Please see [1] for a complete description of the OOS CML. The following color-coding scheme is used throughout the OOS CML.

- The things (nouns) of interest, both real and abstract, to OneSAF modeling are colored green and are called elements. In the communications conceptual model depicted in figure 1 the elements include the Sender, the Environment, the Receivers, and the specific communications Medium. Elements come in two flavors: Players and Markers. Players (e.g. Communicator) are explicit representations and Markers (e.g. Force and Medium) are implicit representations.
- Events, colored yellow, identify the element initiated interactions. Events trigger behaviors. Fig 1 shows Incoming and Outgoing Messages, Situational Awareness (SA) update requests, and the Tactical Picture Information Exchanges as the events triggering various interesting communications behaviors.
- Behaviors, colored blue, cause element state changes. Fig 1 shows Accept Message, Forward Message, Forward Situational Awareness and Accept Situational Awareness as the behaviors affecting the Elements.
- Red Modifiers, as shown in Figure 1, issued by Elements change behaviors' functions. For communications Jamming, Range, Line Of Sight (LOS), Frequency, and Modernity have the ability to modify the Forward Message behavior associated with a specific message.

With that information in hand we can now dive into the communications conceptual model. The communications conceptual model is composed of four conceptual models: Explicit Communications, Implicit Communications, Indirect Communications, and Message Formats. The explicit communications conceptual model like the other conceptual models supports a variety of specific models. As a simple example we can generate the following list of specific communications models by the parameters they use to define successful communications:

- Perfect communications: An intended message between sender and receiver always succeeds. We will call this low resolution communications modeling.

- Line Of Sight (LOS) and range-based communications modeling. If the sender and receiver have LOS and their equipment characteristics can span the necessary range then the communications is successful. We will call this medium resolution communications modeling.
- Attenuation and propagation-based communications modeling where specific signal strength is degraded due to environmental and atmospheric interference. We will call this high resolution communications modeling.

If we now compare each of these to the conceptual model we see that they are all supported.

2.1 Low Resolution Support

Looking first at the low resolution case, in Figure 1 we see the path labeled 1a through 1f highlights the basic path from message sender to receiver along an explicit communications pathway. The sender initiates the flow by creating an OngoingMsg Event. The event triggers the ForwardMsg which in this low resolution perfect communications case is not impacted by any modifiers. The behavior modifies the Medium Element by updating variables associated with the messageQueue used for the transmission, senders and receivers, and other communications specific variables. Next the Medium Element creates the IncomingMsg event that triggers the AcceptMsg behavior associated with the receiver that then updates its understanding of the battlespace based on the contents of the message.

2.2 Medium Resolution Support

The same path is followed for the medium resolution case. Here, the ForwardMsg behavior is impacted by range and Line of Sight (LOS) as stated earlier within the medium resolution communications model. If the both constraints (the receiver is in range and there is LOS between sender and receiver) are satisfied then the ForwardMsg Behavior modifies the Medium Element and the message flow continues. If either of the constraints are not satisfied the ForwardMsg ends without modifying the Medium Element and the message is not sent to the receiver.

2.3 High Resolution Support

Finally, the high resolution case follows the low resolution case until the Medium Element's state is modified. At this time the specific voice, digital or landline environmental and/or atmospheric attenuation models are called. If the results completely degrade the signal the Medium Element will not create the IncomingMsg Event and the message will not be sent to the Receiver Element.

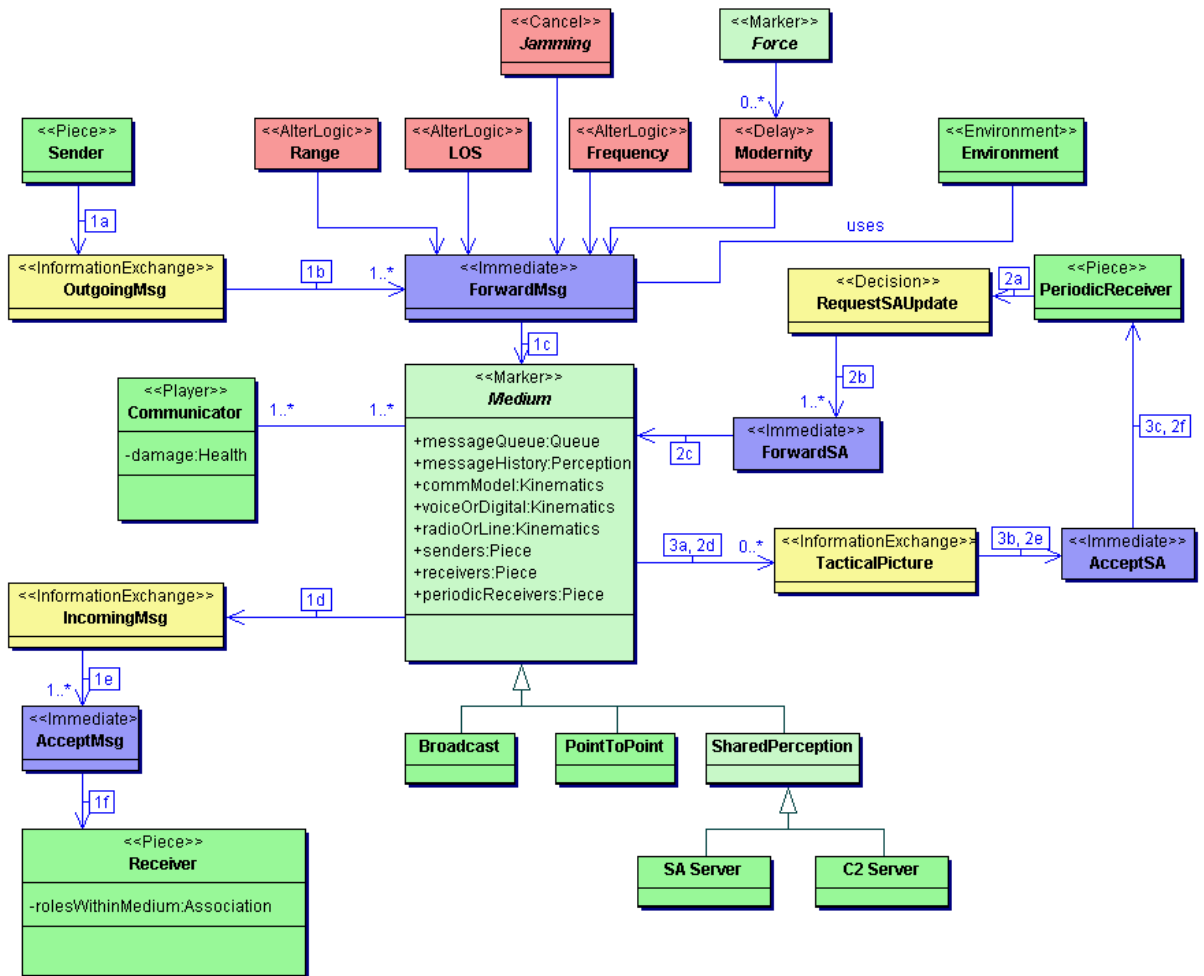


Figure 1: OneSAF Explicit Communications Conceptual Model

3 Medium Resolution Communications Model

Although the OneSAF conceptual model and implementation allow for multiple resolutions of explicit communications models the OOS FOC delivery plans include only low and medium implementations due to, program level funding and time limitations. As mentioned earlier the explicitly modeled low resolution capability reflects a perfect communications situation and is relatively uninteresting. It is envisioned that if high resolution communications models are required, such as those based on the Terrain Integrated Rough Earth Model (TIREM), for analysis or training they can be federated with OneSAF using an HLA-based

federation technique. Of most interest to the OneSAF implementation is the medium level resolution communications model.

The medium resolution communications model described below has been validated and approved by the Army Materiel Systems Analysis Activity (AMSAA).

3.1 Medium Resolution Communications

OneSAF has operational requirements to model the transmission, reception, and behavioral effects resulting from the use and/or disruption of voice and digital communications systems.[2] Each entity's communication model determines if its equipment receives each message. Once received, an entity acts on, forwards, and/or incorporates into its situational awareness the information received. The

communications model uses the health of the entity carrying the communication equipment as a precondition to triggering the communications algorithm. Once triggered the algorithm uses the range, power, frequency compatibility and line of sight to determine if the transmission traveled between the sender and receiver. The jamming model also uses these variables to determine if a transmission is jammed between a transmitter and its potential receivers. [3]

3.2 Process Steps

The determination of success or failure of receipt is based on a logical progress using the input variables mentioned above. This logical progression is described below.[3]

3.2.1 Determine Successful Reception Stations

- a) Poll vehicles within the transmitter’s maximum range.
- b) Transmission ranges for each radio type are stored in a database table. A maximum range value is associated with each power level specified for a given radio type.
- c) The separation between the transmitter and each potential receiver radio (i.e., each radio currently tuned to the transmitter's channel) is calculated when a propagation occurs. If the receiver is out of the transmitter's current range, then the message is not propagated.
- d) If the receiver is in the sender's range, then line of sight calculations are made based on terrain and location of each radio. Because of antenna heights, the LOS calculation should be based on a height above ground of 5 meters for both transmitter and receiver. If the radios have line of sight, the transmission is completed. If they do not, the message is not received.

3.2.2 Determine If a Transmission Is Jammed (Optional)

Jamming determination is performed after the preceding reception determination has been made.

- a) Poll operating jammers for any that are jamming on the same frequency as the message.
- b) Jamming ranges for each jammer type are stored in a database table. A maximum range value is associated with each power level specified for a given jammer type.
- c) If any jammer matches frequency with the message, check range from the jammer to each potential

recipient and the transmitter from part A above. The separation between the jammer and each potential receiver radio (i.e., each radio currently tuned to the transmitter's channel) is calculated when a propagation occurs. If the receiver is outside of the jammer's current range, then the message receipt is successful.

- d) If the receiver is within the jammer's range, then line of sight calculations are made based on terrain and location of the receiver and jammer. If they have line of sight, the transmission is prevented. If they do not, the message is successfully received.

Table 1, shows the possible combinations and their results

Jammer to Receiver LOS	In Range	Result
Yes	Yes	Jammed
Yes	No	Received
No	Yes	Received
No	No	Received

Table 1: Jamming Table

4 Impact on Entity and Unit Situational Awareness

Situational Awareness (SA) is the information an entity/unit or entity collects about itself and its surroundings. This information may include: the entity/units current state, its mission, other entities/units and their states that are directly perceived through an entity’s sensors or reported by other entities, the environmental conditions, and environmental objects. [4] OOS provides an explicit representation of entity and unit SA through its perception model. As with the physical models the OneSAF perception model will be delivered supporting two levels of resolution: low and medium.

4.1 Low Resolution Perception Model

At low resolution each entity uses its sensors to identify and maintain a list of units in its area of interest. This perception information coupled with the low resolution perfect communications model allows instantaneous access to each entity’s information by all of the entities on the posting entity’s side. This simplistic representation the low resolution implementation supports high entity counts, but is relatively uninteresting for how perception and communications models interact.

4.2 Medium Resolution Perception Model

The medium level perception model is more interesting and requires explicit sending of informational and order type messages and information before the information is shared between entities and units.

The medium level communications and perception model naturally fits with the medium level resolution entities within OneSAF. In general, some of these entities, individual combatants, vehicles, and both rotary wing and fixed wing aircraft have radio-based communication equipment. This enables them to subscribe and publish messages on the specific communications networks represented within OOS. Command and control, fire support, logistics nets are a few of the communications networks supported within OOS. Once an entity is assigned a communication-based role, the communications device is used to send and receive messages on the appropriate network.

4.2.1 Information Exchange from the Unit to the Entity

Once enabled the messages representing the real-world situation reports (sitreps), orders and fragmentary orders (fragos), and fire support type messages begin to flow across the different communications channels. This triggers various SA entities to receive the messages and populate their SA data. As mentioned earlier SA data includes information obtained through an entities individual sensors and through messages received through communication enabled entities. In the medium resolution perception model, once an entity receives a message the owning entity's unit (the other entities associated with the unit) can take advantage of the new information.[4]

Orders and fragos directed to the unit also pass through the communications models and can be jammed and impacted by destroying the appropriate communications equipped entities. Once orders are obtained by subordinates the entity with the leader role derives and sends orders to each of his subordinates. The final stage in this decomposition (verbal or hand-based communications) from platoon or squad leader to individual unit members is implicitly modeled and these orders cannot be jammed or intercepted. [4]

4.2.2 Jamming and Its Impact

The OneSAF medium resolution communications model and resulting medium resolution entities allow communications to be played and impacted during scenario execution. The impacts vary from degraded to delayed communications based on jamming, range, power, and frequency mismatches. An entity cannot act

on or update its situational awareness from a message it does not receive due to a communications failure, an entity's death, or jamming. This not only affects information to a specific entity, but if the entity is the last communications link within a unit, the entire unit will be cut off from external communications impacting its ability to send and receive orders and reports.

5 Summary

OneSAF as the Army's next generation entity level simulation, models the capabilities and impacts of communications on the battlefield. The communication and perception models, like other OneSAF physical and behavior models, comes in different resolutions that can be selected and tuned by the user depending on the specific use of the simulation. This paper gives a brief explanation of the power of the OneSAF communications and perception models by describing the communication conceptual model, the medium level resolution communications, and the interplay between the communications and perception models.

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7 References

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