Interconnection OTBSAF and NS-2

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Abstract

Computer Assisted Exercises are carried out at our Center of Simulation and Training Technologies using the tool for constructive simulation, which is called OneSAF Testbed Baseline Semi-Automated Forces (OTBSAF). Here, each exercise is realized using the model of real terrain and therefore the velocity of movement of units depends on their position and the supposed direction of movement. It can be stated that the movement of units in the simulation almost approaches the reality. But this is not true in the case of radio-communication. The transmission between particular units is accomplished via classic telephone sets which are placed at the workplaces of exercising persons and this arrangement does not reflect the position of units in the terrain at all. In contrast to the real situation, the communication in simulation is not influenced by terrain surface, weather etc.

This article provides new approaches to more realistic radio - communication in the frame of the constructive simulation OTBSAF realized namely by either the introduction of radio-visibility directly into the OTBSAF or by taking advantage of connection of an external system "The Network Simulator (NS-2)" using the communication protocol Distributed Interactive Simulation.

keywords: OTBSAF, DIS, Radio Propagation, Constructive simulation, NS-2

1 Introduction

The Czech Army simulation center located in Brno and Vyškov provides Computer Assisted eXercises (CAX) to Czech military forces and also cooperates with other NATO armies and civil authorities. We train soldiers in many kinds of combat situations or Operations Other Then War (OOTW).

During the operation soldiers need to communicate with each other. Also all sensors in Network Enabled Capability (NEC) environment need to send gathered information. These communications can be provided by voice or/and data.

For voice communication we use classic telephone sets and nowadays we also utilize the ASTi Digital Audio Communications System (DACS) system. This system transforms voice to data packets and sends these packets through the data network Distributed Interactive Simulation (DIS) [1, 2, 3, 4, 5]. This is useful for After Action Review (AAR) because it is possible to know the situation in the battle field and voice communication at the same time. So you can get information about orders/commands and you can see what happens in battle field simultaneously.

Data communication is realized by the system $C2I$ or by email messages. In real situation voice/data are propagated in the air while vehicles are moving. In real terrain the radio signal is fading because of obstacles or can be disturbed by jammers or other signals.

2 Radio propagation in OTBSAF

OneSAF Testbed Baseline Semi-Automated Forces (OTBSAF) [6, 7] is a large-scale constructive simulation system developed to portray elements down to the individual platform or entity level. Although it is a constructive simulation, it provides both logical and real-time clocks so it can be

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used for a real-time interactive simulation to portray additional elements in an exercise beyond those represented by manned simulators. For communication with manned simulators, it uses the DIS protocol. Each entity is simulated by instantiating the appropriate model for that entity. Initially, each entity has the default values for each of its parameters. These parameters can be modified by the Semi-Automated Forces (SAF) operator. Default values can be also changed by editing source code because Czech Army has these codes. OTBSAF consist of hundreds libraries. Some libraries are responsible for unit/vehicle tasks and the others for Graphical User Interface (GUI) etc.

To compute radio propagation parameters we need to know the following values:

1. Position of vehicles.
2. Parameters of radio equipment (antenna parameters, frequency, power, modulation type etc.).
3. Terrain profile between the vehicles, wheather conditions etc.
4. Other parameters that can influence radio propagation (depending on fidelity of the model).

2.1 Position information

OTBSAF uses terrain database in the format of the Compact Terrain Database (CTDB), which contains elevation data, soil types and other feature data. OTBSAF uses library *libctdb* [8] to load this database into memory, and then uses libctdb-functions to access the data therein.

There are two types of terrain databases currently used in Czech Army. Older ones are mostly gridded, where elevation posts are stored at regular distances and triangulated. These databases may have more details added using microterrain [1] triangles. The newer databases are generated completely from microterrain, in a Triangulated Irregular Network (TIN).

For getting position of the vehicle we can use function:

```
void ent_get_position_gcs(vehicle_id, position)
    int32   vehicle_id;
    float64 position[XYZC];
```

from library *libEntity*. This function returns three coordinates X,Y and Z. These coordinates origin in center of Earth and the WGS-84 referenced ellipsoidal is used here.

2.2 Terrain profile

Some radio propagation models consider terrain profile. Here we can use these functions:

```
float64 ctdb_lookup_elevation(ctdb, x, y)
    CTDB   *ctdb;
    float64 x;
    float64 y;

float64 ctdb_lookup_max_elevation(ctdb, x, y, check_canopies)
    CTDB    *ctdb;
    float64  x;
    float64  y;
    int32    check_canopies;
```

from the library *libCTDB*. Function *ctdb_lookup_max_elevation* finds the elevation at the specified point in the terrain database depending on the terrain surface, water, buildings, and tree canopies.

If we need information about soil type at the specified point we can use the function

[1] Microterrain is a collection of quadrilaterals and triangles which cover a portion of a patch.

```
int32 ctdb_lookup_soil(ctdb, x, y)
    CTDB   *ctdb;
    float64 x;
    float64 y;
```

So, if you have two positions of vehicles, you can get the terrain profile between them (Figure 1).

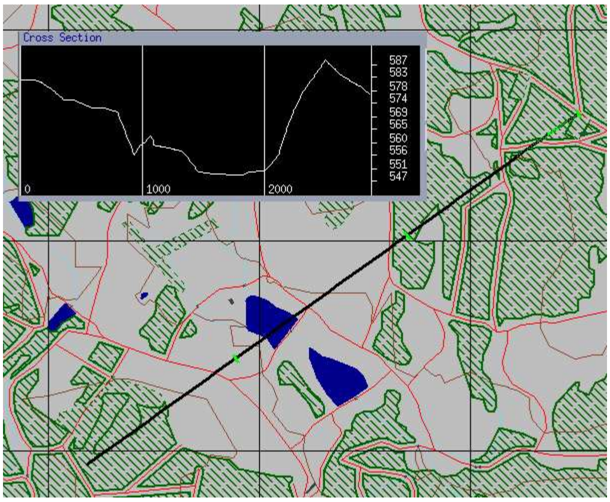

Figure 1: Terrain profile

3 Distributed Interactive Simulation

In a DIS exercise, each participating simulator broadcasts information about its simulated entities over a network via Protocol Data Units (PDUs). Each exercise is specified by unique excercise ID.

Connecting special application gateway to DIS network (Figure 2) [9], you can get information about location of the specific vehicle or unit (Entity State PDU) and also about radio equipments in vehicle for example whether the radio is transmitting or receiving (Transmitter, Receiver and Signal PDU). These PDUs contain only information about position of the vehicles, speed etc. but no information about terrain, weather is included at all. You can use the same terrain database CTDB like OTBSAF or specific terrain database with important parameters for experiments with radio propagation.

3.1 Entity state PDU

Entity State PDU [2] contains information about a particular entity state. The following fields are important for radio propagation:

- PDU Header - contains mainly *exercise ID* which represents specific exercise.
- Entity Identification - identifies the entity issuing the PDU. *Entity Identity Field* is the most important field because it contains unique ID of vehicle.
- Force Identification - identifies the force which the issuing entity belongs to (Red/Blue or Green forces).
- Entity Type.

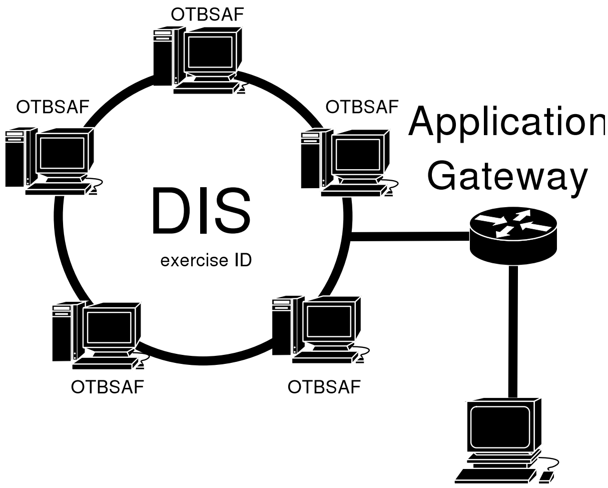

Figure 2: Connection of Application Gateway to DIS network

- Entity Linear Velocity.
- Entity Location - specifies an physical location of entity in the simulated world. The location of the origin of the coordinate system is specified by a set of three coordinates: X, Y, and Z. The shape of the earth is specified using WGS-84.
- Entity Orientation.
- Entity Marking - identifies unique label on an entity. The label is represented by an 11 element character string.

If you know *exercise ID* and you have a list of interesting vehicles, you can get their location.

For the following three (Receiver,Transmitter and Signal) PDUs are important these two fields: *Entity ID* and *Radio ID*. *Entity ID* identifies the entity that controlls the radio communication and *Radio ID* identifies the particular radio within the given entity.

3.2 Receiver PDU

The Receiver PDU [2] contains information which entity transmits data and which radio equipment receives some communication.

3.3 Transmitter PDU

Detail information about a radio transmitter is communicated by issuing a Transmitter PDU [2]. The Transmitter PDU contains the following fields:

- Input Source - specifies who (pilot, co-pilot, first officer, gunnery officer, etc.) or which data port in the entity is utilizing the radio.
- Antenna parameters such as Location, Pattern type and other specific antenna parameters.
- Frequency - specifies the center frequency used by the radio for transmission.
- Transmit Frequency Bandwidth - identifies the bandpass of the radio.
- Power - specifies the average power being transmitted.
- Modulation Type - specifies the type of modulation used for radio transmission.

3.4 Signal PDU

The actual transmission of voice, audio or other data is communicated by issuing a Signal PDU.

4 Network simulator NS-2

Ns-2 [10] is a discrete event simulator targeted at networking research. Ns provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks.

Ns began as a variant of the REAL network simulator in 1989 and has evolved substantially over the past few years. In 1995 ns development was supported by DARPA through the VINT project at LBL, Xerox PARC, UCB, and USC/ISI. Currently ns development is supported through DARPA with SAMAN and through NSF with CONSER, both in collaboration with other researchers including ACIRI. Ns has always included substantial contributions from other researchers, including wireless code from the UCB Daedelus and CMU Monarch projects and Sun Microsystems.

5 Putting all together

If you are able to catch all PDUs, you have sufficient information about entity location and also radio equipment status. Using these values, as an input for radio propagation model, you can get information whether some entity is able to communicate with other vehicle or not and also you can get special radio parameters (Power, Losses, etc.). (Figure 3).

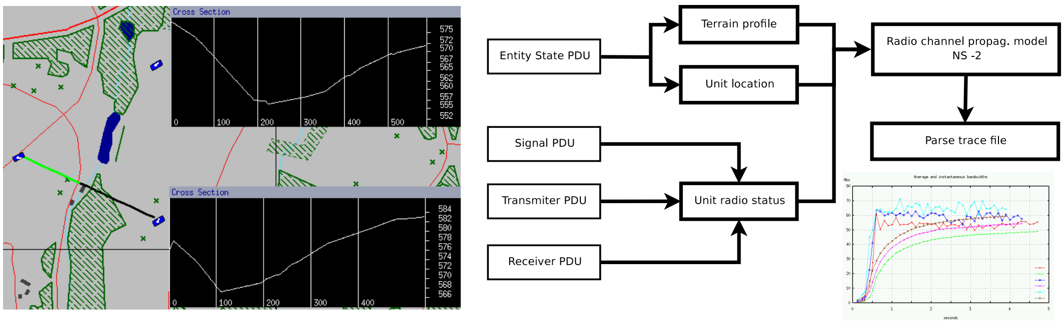

Figure 3: Putting all together

6 Conclusion

Modelling of radio propagation depends on fidelity of the propagation model. High fidelity models require more computing performance, terrain database with high resolution[2] and also high fidelity weather model or other models that can influence radio propagation. Implementing radio models to the simulation you can train as you fight and it brings new features to training. Simulation becomes more realistic and also you can test new devices in "real" situations before you buy these equipments (acquisition support).

[2]OTBSAF or newer version OOS support Multi Elevation Structure (MES) buildings, tunnels and so on.

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