

Installation for simulating the state of radio communications between entities engaged into an operation

The present invention relates to an installation for simulating the state of radio communications between entities engaged in a simulated operation of the type:

5 - a generator of entities allowing a set of entities engaged into the operation to be defined;

 - means for elaborating a scenario able to describe the sequence of actions to be carried out in the operation;

10 - a radio traffic generator able to simulate radio traffic between the different entities;

 - a module for simulating the operation able to execute the scenario and define the consequences of the actions provided by the scenario and integrating these consequences into the following of the course of the scenario; and

15 - a module for restoring the state during the period of radio communications between entities engaged into the simulated operation.

In order to evaluate the feasibility of certain civil or military operations, the use of simulation software packages is known, allowing, in addition to simulating the operations in the field, to reproduce by a simulation as accurately as possible the state of the communications between the entities during simulated achievement of the operations.
20 These software packages provide pieces of technical information on the state of the communications between the different engaged entities over time. In particular, they give pieces of information such as the existence or not of possible communications between the entities, the service quality available on each connection, the rate of use of each connection, the number of data not transmitted to their destination, etc...

25 These communications, which are carried out by radio means, may be of different natures. They are highly sensitive to the relative positions of the transceivers, to the geography of the field, and to the possible congestion of the band width during the operations.

30 These lacks of communications, or degraded communications may make the operations difficult, or even make them materially impossible, in reality.

 Thus, such simulation software packages are particularly useful upon defining means to be engaged into an operation, in the definition of the planning of this operation, or further in defining the technical communication means which should be used for achieving at best the projected operation.

35 These simulation software packages are also very useful upon specifying, designing and validating new pieces of communication equipment by industrial personnel.

They may define the desired behavior of the new pieces of equipment, check proper operation of them, extrapolate the overall system performances when they are applied in an operation. They also allow studying and ensuring interoperability and compatibility with the already deployed existing means.

5 In practice, the simulation software packages known today apply methods in which, for the whole simulation, traffic assumptions between the entities are defined according to independent statistical assumptions on the real development of the simulation, or by programmable automats generating periodic traffic.

10 The object of the invention is also to propose an installation for simulating the state of radio communications allowing better taking into account of the behaviors of the different entities during the simulation.

For this purpose, the object of the invention is a simulation installation of the aforementioned type, characterized in that it includes:

15 - a matrix of exchanges defining the policy and the exchange rules between the entities,

- means for assigning to each entity, processes grouped in jobs defining successive activities to be applied during the course of the scenario, each activity providing the application of specific communications, and

20 - means for simulating, for each activity, the specific communications for each entity during the course of the scenario.

According to particular embodiments, the installation includes one or several of the following features:

- the installation includes, for each activity, a description of the radio fluxes between the involved entities,

25 - the description of the radio fluxes comprises specifications on at least one of the methods for exchanging data or information from the exchange protocol, the degree of reliability of the exchanges, the degree of priority, the type of safety and encryption, and the expiry date of the exchange data,

30 - the installation includes, for each entity, a description of the radio means applied by the entity,

35 - the description of the radio means comprises specifications of at least one of the behavioral methods used by the radio means for transmitting electromagnetic data towards other radio means while minimizing natural opposing effects (attenuation due to the distance, electromagnetic noises, obstacles related to the topology or to the buildings, interferences due to other radio means operating in the same area), methods used by the radio means for allocating and optimizing the time slots and the fragments of the

electromagnetic spectrum required for any exchange of information, and methods used by the radio means for finding routes through which data and information may be exchanged with constraints on the amount, on the quality and integrity of the data,

- the installation includes modification means during the scenario, for the processes assigned to each entity in the means for assigning processes to each entity, and

- the installation includes modification means during a scenario, for the matrix of exchanges for modifying the policy and the rules for radio communication exchanges.

The invention will be better understood upon reading the description which follows, only given as an example and made with reference to the drawings, wherein:

- Fig. 1 is a schematic view of an installation according to the invention;
- Fig. 2 is a schematic view of the main functional modules of the installation of Fig.

1;

- Fig. 3 is a view of a display showing the engaged entities and the field over which the successive phases are illustrated;

- Fig. 4 is a view of a display showing processes associated with entities; and
- Fig. 5 is a view of a display showing procedures applied in the processes.

The installation 10 illustrated in Fig. 1 is intended for simulating the state of radio communications between entities during a simulation of an operation, for example a conflict opposing two groups of opposite entities such as two enemy armies.

In the following, each entity formed for example with a vehicle equipped with a radio, with a soldier equipped with a radio or with any fixed or mobile piece of radio equipment, for example a relay, is designated per node.

The installation includes a central unit for processing information 12 able to apply a software package consisting of a set of suitable programs, a data base 14 for storing data and programs as well as at least two terminals 16A, 16B connected to the central unit for processing information 12.

These terminals 16A, 16B are able to configure the conditions of the simulation for each engaged party, for example an army. Each terminal is able to modify, during the simulation, the time-dependent change in the operation for the entities or nodes of the army which it is able to control. A terminal is also able to be used for directly ordering the operations for an army, the other army being only managed by an engine of the simulation.

As illustrated in Fig. 2, the software package includes a central simulation module 200 able to receive data stemming from the terminals 16A and 16B and to simulate, from a simulation engine, the course of the operations over time. It is in particular able to

simulate radio communications by evaluating the possibility that they are established or not and their quality. The central simulation module 200 will be described in more detail later on.

The simulation module includes a data base 202 notably containing a computer communication model, a model of the radio equipment of each node, and models for propagating radio communications depending on the conditions.

In order to allow simulation, each terminal 16A, 16B includes a generator of entities 220 giving the possibility of defining a set of entities engaged into the operation. This generator is in particular able to define the vehicles and the men engaged with their radio means, each forming an entity or node in the sense of the simulation. It gives the possibility of defining, for each entity, the equipment which is available to it and in particular the pieces of radio equipment which it has with their specific technical characteristics.

For this purpose, the module for generating entities 220 includes means for inputting and storing the whole of the engaged entities, with, for each of them, the radio communication means which they have.

For each communication means, a description of the radio means is stored in memory. This description comprises specifications of at least one of the behavioral methods from among the methods used by the radio means for transmitting electromagnetic data to other radio means by minimizing the natural opposing effects (attenuation due to the distance, electromagnetic noises, obstacles related to the topography or to the buildings, interferences due to other radio means operating in the same area), the methods used by the radio means for allocating and optimizing the time slots and the fragments of the electromagnetic spectrum required for any exchange of information, and methods used by the radio means for finding routes allowing exchange of data and of information with constraints on the amount, quality and integrity of the data.

The generator of entities 220 further defines the operations, the assigned military missions, the nature of the field, the engaged military platforms, the deployment method, the organization, the maneuvers, the engagement rules, the behaviors, the weather, the time of the day and optionally outer elements of the environment, such as the presence of isolated snipers.

These entities are stored in memory in a database 201 of the state of the entities controlled by the entity generation module 220 and the central simulation module 200. This database stores, during the simulation, the state of each entity.

Each terminal includes, under the control of the entity generator 220, means for displaying the entities for the associated army, characteristics and state of these entities as appearing in the base 201.

As an example, the constitutive engaged entities of an army are illustrated in Fig. 3 in an area 221 of the screen of a terminal 16A. These entities are each illustrated by a rectangle 222 associated with one or several ellipses 224 illustrating the communication means which the entity 222 has.

The entities are illustrated in an organizational way, for example a hierarchical way, for example over 4 levels. Each hierarchical level having prerogatives and particular needs, the entities are equipped with communication means which vary from one hierarchical level to the other.

The ellipses 224 are each provided with an inner frame representative of the technical characteristics of the communication equipment with which the entity is equipped. As all the telecommunication technologies are not compatible with each other, only the entities having ellipses of a same frame are assumed to be able to potentially communicate with each other.

Further, each terminal 16A, 16B includes means 240 for elaborating a scenario able to define the trajectories, kinematics, orientations, altitudes and attitudes of the entities over time. In particular, they are able to define the successive progression phases, the actions in the field, as well as conditional devices or not for triggering certain events.

For example, the scenario includes, for the successive phases, a phase I for having the engaged entities circulate as a convoy, and then an observation phase II and finally a combat phase III.

For the conditional triggering devices or not, the scenario elaborated from the means 240 defines a sensitive geometrical area defined on the mapping of the field and associates a conditioned triggering device. For example, this device is such that when one or several entities enter this sensitive area, an activity or a process is triggered, such as the destruction of the entity, the jamming of the radios and/or the attack of the convoy.

The means 240 for elaborating a scenario are able to allow the input of the actions to be carried out and of the areas of the field in which these actions have to be carried out and to illustrate them on the relevant terminal.

A data base 241 of the state of the scenario groups the characteristics data of the scenario at each instant of the simulation. This base is read and powered by the central simulation module 220 and the scenario generator 240.

In Fig. 3, appears, in an area 242 of the screen, a map of the region of the operations which is divided in several areas 244A, 244B and 244C, each being associated with one phase of the operation.

For each of these phases, particular processes specific to each engaged entity are defined.

A process is an organized system of activities (for example an observation process in the military domain) which uses resources either co-localized or not, (personnel, equipment, hardware and information) for transforming incoming elements (for example observations) into outgoing elements for which the expected final result is a service or a product (for example a report summarizing the observations made on an area). The process has an owner who guarantees proper completion and proper operation of the latter.

The scenario defines the processes which have to be applied in the simulation. These processes are conditioned depending on the course of the simulation and may therefore be modified, either automatically by the engine of the simulation, or by an operator from the terminal 16A.

The processes are defined by the means 240 for elaborating the scenario.

The simulation module 200 is associated with a data base in which is stored a job reference system 300. This reference system comprises a set of processes. Each process groups activities and may be applied by the different engaged entities.

The processes are grouped within jobs, the whole of the jobs forming the job reference system 300.

Thus, a military reference system groups different 'jobs' to which may contribute entities. The jobs, 14 in number in the relevant example, are illustrated by visible blocks for the entities 302A, 302B, 302C in Fig. 4 showing an exemplary screen of a terminal 16A, 16B.

For example, protection, observation, combat are jobs of the military reference system.

Each job groups a set of procedures which may be applied depending on the cases with which the entity is confronted.

The processes of a job which contain the elementary activities applied by the job are multi-level processes. Processes therefore have different activities per level. For example, the 'protection' job in the military domain has a level H for protecting the global force, a level H-1 for protecting a portion of the organization, and a level H-2 for individual protection of 'its' platform.

The elementary activities per job and per level require pieces of input information which are subject to processing operations applied by the activity and producing output information and data.

Each process comprises one or several activities selected from a set of predefined activities for the relevant entity or the relevant entities.

Examples of processes distributed over several entities located on entities of different hierarchical levels 302A (level H), 302B (level H-1), 302C (level H-2), are shown in Fig. 4. In this figure are illustrated, for each typical entity of each hierarchical level, the jobs applied for each entity, as well as the ordering of the data flows between these entities.

Each entity applies processes only participating in certain jobs. Thus, for a given entity to which the processes are assigned, only the jobs indicated in a bright color are affected to it and thus, only the processes contained in these jobs may be applied by it.

For example the entity 302A, executes in the simulation, the jobs of planning, observing, informing on technical situations, of transferring back on the positions, tactical coordination, logistics and coordination of the supporting functions. On the other hand, it does not have any combat or protection job to be executed.

As illustrated, the jobs of the entities 302B, 302C are different, although these entities are involved in a same scenario.

Each of the processes is programmed by an operator and stored in memory in the job reference system 300 from the scenario generator 240. The ordering, the synchronization, orchestration of the processes is the means for conducting the operations.

When a process applies activities localized on different entities, distributed over a theatre of operations, pieces of information (data, orders, validations, authorizations, signatures) are exchanged, processing operations are applied on the data before executing the next activity of the process. The process may include iterative, procedural, conditional phases. The whole of the exchange needs between entities, required for the proper course of the processes during the execution of the operation form 'the communications needs'.

Each activity of process, as well as the actual process, is executed under well specified conditions. In particular, the incoming pieces of information have to meet certain criteria, first a quantitative criterion: the information required for the activity all have to be available on the node which will execute the processing operations related to the activity, and then a quality criterion: the input data have to be recent when they are tested

according to an expiry date or constraints on forwarding periods and then an integrity criterion: the input data should neither be corrupted, lost or denied.

The malfunctions of the system or of the communication means such as radio communication impossibility or difficulties in these radio communications may have a strong impact on the execution of the operation by perturbing the information flow between activities of the processes. For example this may be congestion, starvation, isolation, blocking, degraded modes, etc.

The central simulation module 200 is able to examine these criteria, on the whole of the entities applied in the operation. It gives the possibility of evaluating the efficiency, the performances, the cost effectiveness of the system and of the radio communication equipment. It is able to bring back these evaluations to the terminals 16A or 16B for making available evaluations to a user.

Examples of procedures are described in Fig. 5.

Each process 301 includes a flow chart with sequenced activities optionally with tests between the activities conditioning the activities.

Certain activities apply communications with other entities according to particular predefined communication modes, with particular rates and during predetermined periods. In particular, the activities define the communications which should take place between the entities of an upper, identical and lower hierarchical level. The activities only foresee the addressees of the communications without defining the contents thereof, the coding method, the rate, the volume, which are defined by a policy and exchange rules defined elsewhere.

Thus, for example, an activity defines the addressees for the communication.

Each of these activities is inputted by an operator and is stored in the memory in the reference system 300 from the means for elaborating a scenario 210.

The processes provide the activities applied in the case of a difficulty or of degraded communication performances during an activity, for example in the form of alternative branches, of degraded modes, of change in configurations or organizational modifications.

Thus, for example, a process provides that in the case of non-communication, the consequence is an activity of displacement of the entity towards another point in the field, or on the contrary, an activity for stopping the latter or further an activity for increasing the transmission power of the radio means associated with the entity.

The simulator includes a data base 310 comprising at each instant the state of the activities and of the processes of each entity.

The simulator also includes a traffic generator 260 able to simulate radio traffic between the different entities depending on the activities of each entity at the given instant as provided by the processes applied in the scenario.

Each entity is capable of participating in certain processes of certain jobs (not all of them) by contributing via activities. The capabilities of the entities in terms of activity, process, job are defined by general policies – for example, per hierarchical level - (programmed by means of the 'traffic generator' module 260). These general policies may be substituted with particular policies, or even individual processes if need be.

This traffic generator is associated with a matrix of exchanges 280, i.e. a set of data defining the policy and the rules for exchanging information between the entities. For example, this policy defines that, each entity should report to the hierarchically superior entity on a determined radio frequency with a pre-established periodicity. Also, this entity should disseminate at the entities of a lower hierarchical level, a set of orders over a determined frequency with a periodicity defined according to the phase of the operations.

For example, a report must be made to the hierarchical superior entity every 10 minutes, on a given frequency with a given coding by transmitting images and text for a data volume comprised between predefined ranges.

The traffic generator 260 simulates the communications as defined in each activity, and by applying the policy and the rules of exchange of the exchange matrix. In particular it determines whether the communication may take place, taking into account other current communications, on the state and on the position of the entities, and if this communication cannot take place correctly, it simulates the degraded state or the absent state of this communication.

To do this, the traffic generator 260 takes into account, for each activity, a description of the radio fluxes between involved entities.

The description of the radio flux stored in memory for each entity comprises specifications on at least one of the methods for exchanging data or information from among the exchange protocol, the reliability degree of the exchanges, the degree of priority, the type of safety and encryption, and the expiry date of the exchange data.

The generator 260 also takes into account the description of the radio means applied for each entity.

A data base 281 comprises at each instant the current state of the communications as provided by the traffic generator 260. The contents of the base 281 is used by the central simulation module for applying the simulation while taking into account the current communication state of each entity.

The simulation software package includes first 420 and second 440 modification means respectively of the entities, and notably of the mobility, of the behaviour, of the engagement rules, or even of the organization) and/or means for elaborating the scenario depending on the actual time dependent change in the operation simulated by the central simulation module 200 and on the state of the communications.

In Fig. 2, these first modification means of the entities 240 are illustrated by feedback loops 420 acting on the base of the state of communications 281 towards the base of state of the entities 201.

For example, an external event, an alert, triggers stopping of a portion of the organization and is followed by landing of soldiers also equipped themselves with communication means, which will have a specific activity.

Also, the simulation software package includes a second modification means 440 able to ensure modification of the scenario and then acting on the base of states of the scenario 241, via an additional feedback loop 440, in order to take into account difficulties, and more generally states of the communications, this depending on the consequences defined in each of the procedures appearing in the processes from the reference system 300.

For example, the destruction of a portion of the organization requires reconfiguration of the maneuver, of the activities and of the communications.

Finally, the installation includes a restoration module 520 giving the possibility through terminals 16A, 16B of making information available on:

- the technical condition, over time, of the radio communications between entities engaged into the simulated operation. This restoration is for example made in the form of numerical matrices, of performance indicators, of a diagram illustrating the number and the type of communications having failed, as well as the transmission rate over a network.

- the 'Quality of operational Services' (QoS) made available to the entities. This restoration is for example made in the form of numerical matrices, performance indicators, of a diagram indicating the service quality as well as the capability of holding phone conferences, of sending order messaging, of broadcasting video fluxes, of knowing the position of friendly forces.

- the 'Service Contracts' (SLA) which are commitments between customers (the entities or categories of entities) and providers (communication services and means). They evaluate their terms of execution (a single phone conference at a time at the lower levels), guarantees on the level of service (for example 95% availability of the phone conference service for 85% of the entities over a mission with a period of 4h).

The simulation software package also includes two additional correction loops 560 and 580 able to act, either on the basis of state of the activities 310, or on the traffic generator 260 and/or on the associated exchange matrix 280.

Thus, the loop 560 is able to act on the basis of state of the activities 310 in order to adapt certain procedures and activities to the state of the communications (and/or QoS, and/or SLA), or for generating an operational margin following unexpected events for example an attack or an accident. These modifications are made by an operator or automatically from the restoration means 520 in order for example to promote a category of entities to the detriment of other entities when the state of the communications is measured as degraded.

For example, depending on the context of execution of the scenario, certain services may be preferred to the detriment of other services: the voice service is maintained, even if it means degradation of certain 'data' services for example.

According to another example, depending on the context of execution of the scenario, the quality of the voice services at the combatants is promoted, and the operational messaging services are preferred for the commanding levels.

Further, the loop 580 is able to act on the traffic generator 260 and the associated exchange matrix 280 in order to adapt the traffic to the state of the communications (and/or QoS, and/or SLA), and/or for generating an operational margin following unexpected events for example an attack or an accident. These modifications are for example made by changes in the traffic policy for certain categories of entities.

For example, the following steps are taken for reducing traffic:

- the entities of low hierarchical levels send their observation reports twice less often for relieving the communication routes; and/or
- image and photograph transfers are forbidden.

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CLAIMS

1.- An installation for simulating the state of radio communications between entities engaged in a simulated operation of the type including:

5 - a generator of entities (220) allowing definition of a set of entities engaged into the operation;

 - means (240) for elaborating a scenario able to describe the sequencing of actions to be carried out in the operation;

10 - a radio traffic generator (260) able to simulate radio traffic between the different entities;

 - a module (200) for simulating the operation able to execute the scenario and to define the consequences of the actions provided by the scenario and to integrate these consequences into the subsequent course of the scenario; and

15 - a module (520) for restoring the state during the period for radio communications between entities engaged into the simulated operation, characterized in that it includes

 - a matrix of exchanges (280) defining the policy and the rules of exchanges between the entities;

20 - means (240, 300, 310) for assigning to each entity (302A, 302B, 302C), processes grouped in jobs defining successive activities to be applied during the course of the scenario, each activity providing the application of specific communications,

 - means (260) for simulating, for each activity, the specific communications for each entity during the course of the scenario.

25 2.- The simulation installation according to claim 1, characterized in that it includes for each activity, a description of the radio fluxes between involved entities.

30 3.- The simulation installation according to claim 2, characterized in that the description of the radio fluxes comprises specifications on at least one of the modes for exchanging data or information from among the exchange protocol, the reliability degree of the exchanges, the degree of priority, the type of safety and encryption, and the expiry date of the exchange data.

4.- The installation according to any of the preceding claims, characterized in that it includes, for each entity, a description of the radio means applied by the entity.

35 5.- The installation according to claim 4, characterized in that the description of the radio means comprises specifications of at least one of the behavioral methods used by the radio means for transmitting electromagnetic data towards other radio means while minimizing natural opposing effects (attenuation due to the distance, electromagnetic

noises, obstacles related to the topology or to the buildings, interferences due to other radio means operating in the same area), methods used by the radio means for allocating and optimizing the time slots and the fragments of the electromagnetic spectrum required for any exchange of information, and methods used by the radio means for finding routes
5 allowing exchange of data and information with constraints on amount, quality and integrity of the data.

6.- The installation according to any of the preceding claims, characterized in that it includes means (520, 560) for modifying during the scenario, the processes assigned to each entity in the means (240, 300, 310) for assigning the processes to each entity.

10 7.- The installation according to any of the preceding claims, characterized in that it includes means (520, 580) for modifying, during a scenario, the matrix of exchanges (280) for modifying the policy and the rules of exchanges through radio communication.
