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Improving The DIS Collision PDU: Final Report

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INSTITUTE FOR SIMULATION AND TRAINING

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1.0 Purpose

This report is a deliverable item (CDRL A00T) required in completion of subtask 3.3.1, "CLARIFY COLLISIONS", on STRICOM contract N61339-94-C-0024 entitled, "TRIDIS: A Testbed for Research in Distributed Interactive Simulation."

2.0 Task Description

In preparing for the first DIS Interoperability demonstration at the I/ITSEC conference in San Antonio in 1992 (IDEMO92), IST recognized that explanations of collision handling were vague and incomplete as written in the PDU standard. Issues relating to handling, elasticity, and bounding volumes were discovered. Two position papers were submitted to the DIS workshops on these issues. The first one was submitted by Brian Goldiez in September 1992 on bounding volumes and elasticity. It was never addressed by the Interface Time/Mission Critical (ITMC) working group. The second position paper was submitted by Margaret Loper at the March 1993 workshop. This paper discussed Collision handling, based on actual test data from IDEMO92. In November of 1993, when the TRIDIS proposal was written, IST believed that this issue had been corrected in version 2.0.3.

IST stated in the proposal that the issues on Collision elasticity and bounding volumes must be addressed by the standard if the PDU is to ever be robust and complete. In addition, other aspects of collision handling remained to be addressed by the standard including a precise and workable definition of exactly what constitutes the beginning and end of a single collision event and how to treat cases involving more than two entities.

The TRIDIS contract included task 3.3.1, entitled "CLARIFYING COLLISIONS" to investigate ways to address these issues and implement prototypes.

During year 1, TRIDIS efforts resulted in a position paper on handling collisions in DIS [IST1] which was addressed by the Protocols Working Group. As a result of this Joseph Brann, chair of the Protocols Working Group, asked Scott Smith to ensure that the recommendations made in this paper be submitted in response to the IEEE ballot. This was done and the recommendations were included in the final balloted version. The white paper is included in this report as appendix A. All of the sections of the balloted text which refer to collisions are extracted and included in appendix B. A description of the elements which were recommended (and subsequently included in the balloted version) follows in section 3. Those recommendations, however, were limited in scope, addressing only the protocol of notification and the definition of a collision. Issues related to handling the physics of collisions were not included in the paper or the comments to the ballot.

During summer of 1995 a number of discussions were held within IST concerning so-called "Physics PDUs" and the possibility of handling collisions as one aspect of more general physically modeled events rather than as a special case. Those discussions and the recommendations which followed are discussed in section 4.

3.0 Recommendations adopted in IEEE1278.1 Balloting

IST's recommendations concerning collisions which were incorporated into 1278.1 are listed in this section.

3.1 Definition of bounding volume

IST's recommended definition was adopted as proposed:

> "The six-sided, rectangular enclosing space whose width, length and height are aligned with those of the entity."

3.2 Definition of a collision event

IST's definition of a collision even was adopted as proposed:

> "A collision shall be defined as an event which occurs when all of the following conditions are true:
>
> a) The boundary volumes of two simulated entities intersect (one of which may be a terrain object).
>
> b) The distance between the origins of the two simulated entities is decreasing.
>
> c) At least one of the entities is moving at a speed greater than COLLISION_THRSH_DFLT."

3.3 Clarification of criteria for issuing Collision PDUs

Section 4.4.2.2.3, entitled "Issuance of the Collision PDU" now includes more explicit and complete language to specify exactly when an application can and must issue a Collision PDU and when a Collision PDU should not be issued. It also includes clarification that a simulation application shall always issue one and only one Collision PDU per collision event.

4.0 Treating collisions as physically modeled interactions

In order to model some kinds of behaviors in DIS it will be necessary to bring simulation entities into contact in the virtual world. Aircraft landing on the ground or on ships and infantry mounting troop carriers are two examples. When these entities make contact they do not normally "collide." The difference between a contact and a collision seems to be one of degree and probably depends largely on the characteristics of the entities involved. A jet, landing on a carrier deck, makes contact at a high velocity and with significant force (albeit at a glancing angle), but usually suffers little damage. Without information about the forces being exchanged between the interacting parties it is probably not possible to model these actions physically.

Discussions concerning force exchange PDUs led to generation of a white paper [IST2] which was submitted to STRICOM in fall of 1995. This paper discusses these issues in more depth. There are two general approaches to modeling the effect and magnitude of a collision or contact, these being either based on contact/collision forces or on momentum transfer.

In the first approach, messages (DIS PDUs) may be exchanged between the applications modeling the contacting bodies to express the magnitude and direction of the force each body exerts through the point of contact. For example, if two entities are dynamically connected during a DIS exercise, then a PDU will be required to initialize the event, provide a description of the type of mechanical connection (i.e. ball and socket joint, pin joint, friction contact, etc.) , and to indicate the magnitude and direction of the force vector. Such a PDU would be particularly useful for the implementation of ground vehicle towing or pushing in DIS. The PDU could be used to transmit connections and forces between the towing vehicle (tractor) and the vehicle being towed (trailer), allowing both the tractor and the trailer to use mobility models that incorporate towbar forces at the point of connection.

In the second approach the applications exchange information describing their momenta at the time of contact and the location of the point of contact on each. Each application will use an implementation of the same algorithm to determine transfer of momentum, resultant trajectory, and possible damage. This approach is appropriate for modeling the interactions usually considered to be "Collisions."

5.0 References

IST1 Smith, S. H., Williams, J. "Clarifying Collisions", *Proceedings of the Eleventh Workshop on Standards for the Interoperability of Distributed Simulations*, Orlando, FL, September 26-30, 1994, pp. 569-570.

IST2 Schiavone, G.A., Sureshchandran, S., Smith, S., *Generalized Time-Dependent Physical Description PDUs for DIS Synthetics Environment Representation,* White Paper submitted to STRICOM, 7 September, 1995.

6.0 Appendix - Extracted Sections of IEEE 1278.1 Relating to Collisions

This section includes all of the text relating to collisions which is present in the balloted version of the standard presented to the IEEE in August 1995.

Section 1.3.4.1 Current Capabilities

"... Throughout a simulation exercise, the state information associated with the interactions that take place between entities needs to be exchanged. Interactions that are currently supported include collisions. In the event that two entities collide, the simulations controlling the entities must be informed of the collision. A message about the collision is sent by each simulation application when it detects that its entity has collided with another entity. Each simulation application determines the damage to its own entity based on information in the collision message...."

Section 3.1.7 " bounding volume: The six-sided, rectangular enclosing space whose width, length and height are aligned with those of the entity. "

Section 4.4.2 Entity information/interaction

"... Information associated with collisions between entities shall be communicated in a DIS exercise through the use of the Collision PDU (see also 5.4.3.2)."

Section 4.4.2.2 Collision PDU

"The Collision PDU shall be used to communicate information about a collision between two simulated entities or between a simulated entity and another object in the simulated world (such as a cultural feature)."

Section 4.4.2.2.1 Collision Event

"A collision shall be defined as an event which occurs when all of the following conditions are true:

a) The boundary volumes of two simulated entities intersect (one of which may be a terrain object).

b) The distance between the origins of the two simulated entities is decreasing.

c) At least one of the entities is moving at a speed greater than COLLISION_THRSH_DFLT."

Section 4.4.2.2.2 Information contained in the Collision PDU

"The Collision PDU shall contain the following information:

a) The identification of the entity that issued the PDU.

b) The identification of the entity with which the issuing entity collided. If this ID number is unknown, the ID field shall contain ENTITY_ID_UNKNOWN.

c) The event identification of the specific event marked by the collision of the entities.

d) Information for damage determination. This information, when available, shall be used by each entity to determine the extent of damage received during the collision. This information includes:

1) The velocity vector of the issuing entity.

2) The mass of the issuing entity.

3) The location of impact in entity coordinates of the entity with which the issuing entity collided.

Any of these three fields may be set to zero if data required for that field cannot be determined by the issuing entity.

e) Information identifying whether the collision should be modeled as an elastic or in-elastic type collision."

Section 4.4.2.2.3 Issuance of the Collision PDU

"The Collision PDU shall be issued by an entity when a collision is detected between the issuing entity and an object or some other entity taking part in the simulation exercise. If the collision involves two entities, both entities shall issue the Collision PDU even if only one of them detected the collision. An entity that receives a Collision PDU indicating another entity has collided with it without first detecting such a collision shall issue a Collision PDU naming the entity that issued the first Collision PDU, and should take steps to ensure that if and when it subsequently detects the same collision event it does not generate a Collision PDU to report it. When a simulation application receives a Collision PDU naming an entity it simulates as the other party involved in a collision after reporting the same collision event, it shall not send another Collision PDU in response. A simulation application shall always issue one and only one Collision PDU per collision event it detects or is informed about in which an entity it simulates is a participant even if that application does not perform collision detection tests.

The Collision PDU shall be issued by using a best effort multicast communication service."

Section 4.4.2.2.4 Receipt of the Collision PDU

"Upon receipt of the Collision PDU, the data contained therein shall be used to record the event and to determine the extent of the damage sustained in the collision."

Section 5.2.4 Symbolic Names

"The following symbolic names are used in this standard to represent the identified numeric

Symbolic Name	Numeric Value
...	
COLLISION_THRSH_DFLT	.1 meter/second"

Section 5.3.18 Event identifier record

"Event identification shall be specified by the Event Identifier Record. This record shall consist of a Simulation Address Record and a 16-bit unsigned integer specifying the event number. The latter is uniquely assigned within the host by the simulation application that initiates the sequence of events. The Event Number field of the Event Identifier Record shall be set to one for each exercise and incremented by one for each fire event, collision event, or electromagnetic mission event originated by the entity. In the case where all possible values are exhausted, the numbers may be reused beginning again at one. The format of the Event Identifier Record shall be as shown in Table 20."

Section 5.4.3.2 Collision PDU

"Collisions between entities shall be communicated by issuing a Collision PDU. The Collision PDU shall contain the following fields:

a) PDU Header - This field shall contain data common to all DIS PDUs. The PDU Header shall be represented by the PDU Header Record (see 5.3.24).

b) Issuing Entity Identification - This field shall identify the entity that is issuing the PDU. This field shall be represented by an Entity Identifier Record (see 5.3.14).

c) Colliding Entity Identification - This field shall identify the entity which has collided with the issuing entity. If the entity ID is unknown or the collision is with a terrain object, this field shall contain ENTITY_ID_UNKNOWN. This field shall be represented by an Entity Identifier Record (see 5.3.14).

d) Event Identification - This field shall contain an identification generated by the issuing simulation application to associate related collision events. This field shall be represented by an Event Identifier Record (see 5.3.18).

e) Collision type - This field shall identify the type of collision. This field shall be represented by an 8-bit record of enumerations (see Section 10 in EBV-DOC)

f) Velocity - This field shall contain the velocity (at the time the collision is detected) of the issuing entity. The velocity shall be represented in world coordinates. This field shall be represented by the Linear Velocity Vector Record (see 5.3.33.3).

g) Mass - This field shall contain the mass of the issuing entity. This field shall be represented by a 32-bit floating point number representing kilograms.

h) Location - This field shall specify the location of the collision with respect to the entity with which the issuing entity collided. This field shall be represented by an Entity Coordinate Vector Record (see 5.3.33.1).

The format of the Collision PDU shall be as shown in Table 33.

Table 33__Collision PDU

Field Size	Collision PDU Fields	
96	PDU Header	Protocol Version__8-bit enumeration
		Exercise ID__8-bit unsigned integer
		PDU Type__8-bit enumeration
		Protocol Family__8-bit enumeration
		Time Stamp__32-bit unsigned integer
		Length__16-bit unsigned integer
		Padding__16 bits unused
48	Issuing Entity ID	Site__16-bit unsigned integer
		Application__16-bit unsigned integer
		Entity__16-bit unsigned integer
48	Colliding Entity ID	Site__16-bit unsigned integer
		Application__16-bit unsigned integer
		Entity__16-bit unsigned integer
48	Event ID	Site__16-bit unsigned integer
		Application__16-bit unsigned integer
		Event Number__16-bit unsigned integer
8	Collision Type	8-bit record of enumeration
8	Padding	8 bits unused
96	Velocity	X-Component__32-bit floating point
		Y-Component__32-bit floating point
		Z-Component__32-bit floating point
32	Mass	32-bit floating point
96	Location (with respect to Entity)	x-Component__32-bit floating point
		y-Component__32-bit floating point
		z-Component__32-bit floating point
Total Collision PDU size = 480 bits		

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