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5 Modeling
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6 Opposing Forces
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Introduction to DIS Critical Review

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Distributed Interactive Simulation (DIS) is both a standard protocol for linking simulators and a philosophy for doing simulation. It is the purpose of the DIS standard to help achieve the DIS philosophy which is to link simulators of all kinds and types together to achieve flexible and effective training.

The papers presented as part of this Critical Review are for the most part by personnel at the University of Central Florida's Institute for Simulation and Training (IST). This is a natural outcome of the role that IST has come to play in distributed simulation. IST was founded a decade ago to support the burgeoning simulation industry concentrating around Orlando, Florida. IST became involved early in DIS and has come to be regarded as the "Underwriters Laboratory" of DIS; IST has taken a lead role in the IEEE DIS standard development process and developers involved in DIS come to IST to test their equipment for DIS compatibility.

The remainder of this introduction will give brief descriptions of each of the papers in the critical review and attempt to place them within the context of the DIS philosophy. In the interest of brevity note that a Protocol Data Unit (PDU) is the fundamental unit of information sent between simulators communicating according to DIS. Also, a computer generated force (CGF) is an un-manned simulator that through its software acts as if it were many manned simulators; that is the CGF generates a "force" comprised of many simulated simulators.

<u>Standards.</u> The first session deals with standards. Standard are the core of the power of DIS is in providing standards for networking simulators of all types. The paper, *Introduction to distributed interactive simulation* by Margaret Loper, discusses the DIS standards process.

In addition to network standard, human interface standards are important. As computational power grows, the concepts for direct voice and gesture inputs to DIS simulations are discussed in the paper, *Human Interface Development in DIS* by Scott Smith, will become particularly important.

To minimize network traffic in DIS, simulators must model other simulators, in a process called dead reckoning. Standards are crucial to maintaining the accuracy of this second order simulation process. In his paper, *Dead Reckoning and distributed* *interactive simulation*, Kurt C. Lin presents a detailed account of the mathematics and algorithms that underlay dead reckoning.

History. DIS is the outgrowth of several recent trends in simulation and computer technology; to fully appreciate DIS, the technological history leading to it should be understood. In *History of networked simulation* Brian Goldiez gives a comprehensive discussion of the history of simulator networking and the basic discoveries leading to DIS.

A more personal view is provided in *SIMNET: an insider's perspective (History of Simnet)* by N. Cosby, which contains an insightful discussion of where SIMNET has been, how it got to where and it, who helped along the way, and where it is now going under the banner of DIS.

DIS is a networking protocol and the *Relationship of DIS to other networking protocols* by Thomas L. Clarke discusses the DIS protocol in relation to the TCP/IP and OSI protocols. The application of various network topologies and hardware media to DIS are also discussed.

Interoperability. DIS is not just a protocol, it specifies the semantics of the information communicated between networked simulators. If the content of the PDUs is not consistent between the simulators then the networked simulation may fail despite apparently correct communication according to the DIS protocol. Guy Schiavone tackles this problem in his paper *Interoperability requirements for terrain databases in distributed interactive environments*. In particular, networked simulators must present compatible visual scenes to their operators. This paper discusses work aimed at providing measures that guarantee compatible views of the same simulated environment are generated by different simulators.

In the same vein *Testability and interoperability in DIS* by Amy Vanzant-Hodge presents procedures for testing simulators for compliance with the DIS standard for determining the ability to interoperate are discussed.

The problem of compatibility between images generated at different wavelengths is discussed in *Databases for infrared scene generation* by Eric Nold Problems of generating and validating data bases for infrared scene simulation are discussed in the context of network simulations.

Education. A properly designed protocol for networking simulators should be useful outside the domain of individual military training. The papers in this section discuss some of these applications. Ron Tarr, in *Command and Control in DIS*, provides insight into how DIS networked simulators are useful ,not only for training individuals, but also for giving commanders experience in command and control.

Collaborative learning: migration of distributed interactive simulation to educational applications by Michael Companion is a discussion of the applications of DIS to education. Particular attention is given to learning via networked computers. Particular attention is given to the Explorenet learning environment developed Moshell and Hughes at UCF.

An educational application of particular interest to SPIE is provided by Patsy Moskal in *Laser Safety Training*. Animated graphics of the propagation of lasers into the human eye and other tissues are used to give cognitively sound instruction in laser safety.

Modeling. All simulations are at root models of the physical world. If the simulators on which these simulations run are to be faithful to the physical world, then these models must be accurate. DIS's capabilities for networking many simulators may provide means to improve upon the simulation capabilities of single simulators. A class of simulations for which modeling limitations are particularly germane are those which involve propagation of radiation, sound, radar waves, laser energy, etc. In *Electronic warfare and DIS* by Doug Wood introduces DIS PDU's for electromagnetic emissions needed to simulate electronic warfare. Methods for processing these PDU's are discussed in the context of the IST CGF testbed.

Another difficult class of simulations are those involving behavior. Clark Karr discusses an approach to these problems in *Dynamic Obstacle avoidance*. This paper uses potential fields and grid based route planning in combination to yield more realistic obstacle avoidance in simulated entities.

Perhaps better understood, but more demanding of accuracy, are simulations aimed at virtually prototyping systems for purposes of making design and engineering decisions.

Interactive simulation-based optical system development by A. Ahmad, C. Feng and R. V. Sarepaka is pioneering work that shows how DIS can be applied to areas other than training simulation. DIS is used to network software and simulations of optical systems in order to virtually prototype optomechanical designs.

Opposing Forces. To realistically train at the reasonable cost, the opponents against which one trains should be simulated or computer generated. It is essential that these simulated CGF opponents behave in realistic fashion, but not take excessive computational resources. Achieving a practical CGF is a subject on on-going research as discussed by Mikel Petty in *Computer-generated forces in DIS*. In a very comprehensive article, he introduces the concepts underlying the development of CGF systems for DIS.

A particularly promising approach to reducing the computational needs of CGF is proposed in *Linking constructive and virtual simulation in DIS* by Mikel Petty and R. W. Franceschini. As noted, simulation of a battle at the level of individual combatants requires the CGF to handle enormous numbers on simulated entities. The computational burden can be reduced by using constructive techniques to simulate aggregations of these entities. Methods for linking constructive and fine-grained or virtual simulations are discussed.

The CGF can be too smart, can know too much. This potential problem is dealt with by Mikel Petty, S. Rajput and M. Craft in *Intervisibility heuristics for CGF.* Since the simulated entities in a CGF need to be able to see their opponent, but they must not be able to see too well; they can only be allowed to see what is visible through the terrain in a given simulation. Determining the intervisibility is a computationally intensive task that these authors deal with by providing heuristics to cut the Gordian knot.