INTERNET DRAFT   J.M.Pullen
                                             George Mason U.
                                           M.Myjak
                                             U.of Central Florida
                                           C.Bouwens
                                             SAIC, Inc.
                                           20 September 1996
                                           Expire in six months

        Limitations of Internet Protocol Suite for Distributed Simulation
                 in the Large Multicast Environment
                        <draft-pullen-lame-00.txt>

Status of this Memo

Abstract

    The characteristics of distributed simulation in the Large
    Multicast Environment are described. Mechanics and rates
    of data exchange are elaborated. Required network
    characteristics are described. Using this information,
    additional capabilities needed to use the Internet Protocol
    Suite for support of large-scale distributed simulation
    are enumerated.

1.   **The Large Multicast Environment**

    The Large Multicast User's Group (LAMUG) was formed to create a
    consensus-based requirement for Internet Protocols to support

Distributed Interactive Simulation (DIS), its successor the High
Level Architecture for simulation (HLA), and related applications.
The applications are characterized by the need to distribute a
real-time application over a shared wide-area network in a
scalable manner such that numbers of hosts from a few to tens of
thousands are able to interchange state data with sufficient
reliability and timeliness to sustain a three-dimensional virtual,
visual environment containing large numbers of moving objects.
Each such host may simulate a number of battlefield entities
that may be as few as one or an many as thousands. The network
supporting such a system necessarily will be capable of multicast.

Distributed Interactive Simulation is the name of a family of
protocols used to exchange information about a virtual
environment among hosts in a distributed system that are
simulating the behavior of objects in that environment. The
objects are capable of physical interactions and can sense each
other by visual and other means (infrared, etc.). DIS was
developed by the U.S. Department of Defense (DoD) to implement
system for military training, rehearsal, and other purposes.
DIS standards are used for the same purposes by defense and other
organizations in other countries as well. More information on DIS
can be found in the references.

The feature of DIS that drives network requirements is that it
is intended to work with output to and input from humans across
distributed simulators at both local and distant locations in real
time. This places tight limits on latency between hosts. It also
means that any practical network will require multicasting to
implement the required distribution of large amounts of data to all
participating simulators. Large DIS configurations are expected to
place hosts in multicast groups based on sharing the same sensor
inputs in the virtual environment. This can mean a need for
hundreds of multicast groups where objects may move between groups
in large numbers at high rates.

DIS real time flow consists of packets of length around 2000
bits at rates from .2 per second per simulator to 15 per second
per simulator. This information is intentionally redundant and
normally is transmitted with a best-effort transport protocol
(UDP), and in some cases also is compressed. Required accuracy
both of latency and of physical simulation varies with the
intended purpose but generally must be at least sufficient to
satisfy human perception, for example in tightly coupled

simulations such as high performance aircraft maximum acceptable
latency between applications end-to-end is 100 milliseconds between
any two hosts. At relatively rare intervals events (e.g.

collisions between battlefield entities) may occur which require
reliable transmission of some data on a unicast basis, to any other
host in the system. Other protocols supporting the DIS environment
(e.g. Network Time and Simulation Management) may require
information transport in addition to the flow of DIS entity-state
data.

DoD has a goal to build DIS systems with up to 100,000 simulated
objects, many of them computer-generated forces that run with
minimal human intervention, acting as opposing force or simulating
friendly forces that are not available to participate. DoD would
like to carry out such simulations using a shared WAN. Beyond
DoD many people see a likelihood that DIS-like capabilities may
be commercialized as entertainment. The scope of such an
entertainment system is hard to predict but conceivably could be
larger than the DoD goal of 100,000.

The High Level Architecture (HLA) is a development beyond DIS
that aims at bringing DIS and other forms of distributed
simulation into a unifying system paradigm. Thus HLA has
networking requirements at least as demanding as DIS. HLA is
still under development, therefore this document will focus on
the requirements of DIS.

2. **DIS network requirements.**

a. real-time packet delivery, with a small fraction (less than
two percent), of packets exceed an established latency, in no case
more than a few hundred milliseconds, in a shared network

b. multicasting with thousands of multicast groups that can
sustain join/leave in less than one second at rates of hundreds
of join/leaves per second

c. support for secure networking, needed for classified military
simulations

d. A high degree of flexibility in constructing networks depending
on the working environment, such as leased lines, ISDN, ATM, and/or
mobile links on instrumented ranges.

3. **Internet Protocol Suite facilities needed and not yet available for**
large-scale DIS in shared networks.

These derive from the need for real-time multicast with established
quality of service:

a. Requirement: resource reservation available in production systems. Work needed: RSVP seems to be on a path to achieving this, however a mechanism is needed to group streams such that multiple multicast groups can share the same network capacity. The RSVP Working Group recognizes a need for this and is planning to consider it after they complete a draft standard based on their current work (experimental RSVP version 12).

Note: Some current DIS networks allow for quality of service in terms of reserved/prioritized bandwidth and/or minimal delay (ST-2 or RSVP) or private dial-up links with bandwidth on demand and compression (ISDN), but no commercial, production system using open standards is available to meet the performance requirements projected above.

b. Requirement: resource-sensitive routing to be used with the resource reservation mechanism. Work needed: a routing protocol for IP multicast, derived from the current versions (DVMRP or MOSPF) but sensitive to resource requirements. A new protocol called Quality of Service Open Shortest Path First (QOSPF) has been proposed and a working group is being formed to investigate its potential. QOSPF will work with RSVP. It is likely to require at least two years to develop such a protocol.

c. Requirement: IP multicast that is capable of taking advantage of link-layer multicast (such as ATM) for packet replication across multiple logical IP subnets (LIS). Work needed: Extend or replace the current standards-track IP multicast over ATM multicast, which uses a Multicast Address Resolution Server (MARS) to resolve the fact that ATM provides no mechanism to distribute IP multicast group information. It only works within an LIS and hence will not support high-performance, wide-area, shared-use IP/ATM networks in multicast mode. An approach to solving this problem has been developed in the DARPA Real time Information Transport Network (RITN) program and was briefed to the IETF in December, 1995 but no working group is pursuing it.

d. Requirement: a hybrid transport protocol that can support best-effort multicast of most data, lightweight reliable multicast of critical reference data, and reliable unicast of occasional data. Without such a protocol the application must become responsible for reliability of transport in the real time multicast environment. Work needed: A Selectively Reliable Transport Protocol (SRTP) has been proposed by the Distributed Interactive Simulation Communications and Security (DIS-CAS) working group. This work needs to be brought into the IETF and pursued there. A new IETF working group on multicast transport has been proposed. Such a group would provide a logical home for SRTP development.

e. Requirement: network management for DIS systems. Work needed:
   Create a DIS/HLA Management Information Base (MIB) for use with the
   Internet standard Simple Network Management Protocol (SNMP). This
   could be undertaken by the LAMUG.

   f. Requirement: a session protocol to start, pause, and stop a DIS
   exercise over an IP network. Work needed: a new subgroup of the
   Multiparty Multimedia Session Control working group to investigate
   use of that session protocol for DIS/HLA.

   g. Requirement: an integrated security architecture. Work needed:
   Investigate use of the IPv6 security architecture to meet this
   need.

4. References

   [1] Symington et. al, "Modeling and Simulation Requirements for IPng",
       RFC 1667, August 1994

   [2] DIS Steering Committee, "The DIS Vision", Institute for
       Simulation and Training, University of Central Florida, May 1994

   [3] IEEE 1278.1-1995, Standard for Distributed Interactive Simulation
       Application Protocols

   [4] IEEE 1278.2-1995, Standard for Distributed Interactive Simulation
       Communication services and Profiles

   [5] Deering, "Host Requirements for IP Multicasting", RFC 1112,
       August 1989

   [6] Case et. al., "Simple Network Management Protocol", RFC 1067,
       May 1990

   [7] Moy, "MOSPF: Analysis and Experience", RFC1585, March 1994

   [8] Estrin et. al., "Protocol Independent Multicast-Sparse Mode",
       work in progress (draft-ietf-idmr-pim-sm-spec-06), September 1996

   [9] Pusateri, "Distance Vector Multicast Routing Protocol",
       work in progress (draft-ietf-idmr-dvmrp-v3-03), September 1996

   [10] Atkinson, "IPv6 Security Architecture", work in progress
        (draft-ietf-ipngwg-sec-00), March 1996

   [11] Braden et. al., "Resource Reservation Protocol Version 1 Functional
        Specification", work in progress (draft-ietf-rsvp-policy-arch-12)

   [12] Zhang et. al., "Quality of Service Extensions to OSPF", work in

progress (Internet Draft) June, 1996

[13] Armitage, "Support for Multicast over UNI 3.0/3.1 based ATM
     Networks", work in progress (draft-ietf-ipatm-ipmc-12),
     February 1996

[14] Bormann et. al., "Simple Conference Control Protocol", work in
     progress (draft-ietf-mmusic-sccp-00), June 1996

[15] Pullen et. al. "Implementation of A Selectively Reliable Transport
     Protocol for DIS", Proceedings of the 14th Distributed Interactive
     Simulation Workshop, March 1996

5. Authors' Addresses

J. Mark Pullen
Computer Science/4A5
George Mason University
Fairfax, VA 22032
mpullen@gmu.edu

Michael Myjak
Institute for Simulation and Training
University of Central Florida
3800 Progress Drive
Orlando, FL 32826
mmyjak@ist.ucf.edu

Christina Bouwens
SAIC Inc.
Orlando FL
chris_bouwens@cpqm.saic.com