Accredited Standards Committee
X3, INFORMATION PROCESSING SYSTEMS

X3S3.3/92-174R
1 June, 1992

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To: X3S3.3

From: D. Marlow (NSWC)

Re: Proposed contribution describing the U.S. High Speed Protocols requirement identification and analysis effort.

NSWC has prepared this draft of a report to describe to the ISO SC6 community the work effort that was undertaken by the U.S. in its project 753, Study on the Requirements for High Speed Protocols. This contribution is proposed for "hand-carrying" to the July SC6 meeting for discussion under project JTC1.06.36, Enhanced Communication Functions and Facilities for OSI Lower Layers (formerly Enhanced Transport Mechanism Guidelines).

The SC6 Interim Meeting on Enhanced Transport Mechanism Guidelines (Paris, 10-13 February 1992) identified in an output document (Paris 26) that a requirement analysis needs to be performed prior to submitting NWIs in this area. Thus the intent of this report is to progress the work in project JTC1.06.36 and to enable the U.S. to submit NWIs in areas where the requirement analysis has been performed.

U.S. discussion on this input is planned for the ANSI X3S3.3 committee's June 1992 meeting in Raleigh, N.C.

Preface

The U.S. has had an on-going effort to study the requirements that pertain to the SC6 JTC1.06.36 project on Enhanced Communication Functions and Facilities for OSI Lower Layers. The U.S. completed, on April 19,1991, one phase of this effort where significant requirements were identified and the OSI protocols were analyzed in light of these requirements. This contribution provides information on the first phase of this activity as well as a description of current U.S. efforts to address these significant requirements. As technology is rapidly developing in this area, new requirements are emerging. The U.S. is continuing its requirements discussions and in the future may provide additional contributions in this area.

The U.S. is providing this contribution with the intention of supporting the progress of the JTC1.06.36 Guidelines Report and to support U.S. NWI proposals in this area in line with this project's program of work. The primary topics provided are: observations on the U.S. requirements effort, the identification of requirements, the identification of significant requirements which will drive standardization efforts, modification of OSI protocols and services to meet the significant requirements and the identification of major new standardization efforts. In addition, Annex A is provided which discusses the procedure followed for identifying the significant requirements.

Date: 1992-05-29

1 Introduction

The U.S. has been performing a study to ensure the viability of OSI Network and Transport protocols in the very high speed networking environment. This report describes the U.S. effort in identifying the requirements as seen by transport protocol users. An identification of the requirements which go beyond the present OSI service and protocol standards is provided. The results from U.S. discussions on the potential for modification or as a last resort, new services or protocols is provided. The applications considered came from application areas that represented the use of new data communication services and functions. The areas selected included the Use of Technical Workstations, Process Control, Real-time Military Systems and Scientific Supercomputing. Emphasis was directed towards identifying the requirements which go beyond the capabilities of existing standards (i.e. TP4 and ISO Connectionless Transport).

The U.S. has undertaken this work utilizing the approach called out by the program of work for the SC6 JTC1.06.36 project on Enhanced Communication Functions and Facilities for OSI Lower Layers which will include:

1) The identification of application requirements that have implications for OSI lower layer services and protocols.

2) The examination of existing OSI lower layer services and protocols to determine if the requirements identified in (1) can be met by existing or pending OSI standards.

3) In those cases in which requirements cannot be met by existing or pending OSI standards, the consideration of proposals for modification/extension of existing OSI services and/or protocols.

4) In those cases in which neither of the approaches outlined in (2) and (3) is sufficient to satisfy identified requirements, the consideration of proposals for new services and/or protocols.

The U.S. efforts have clearly addressed (1) and (2) above with the resulting conclusion that there are significant requirements which exceed present services/protocols and which will require both extensions to existing services/protocols and new services/protocols. In fact, the U.S. has concluded that there is a need for major new Transport efforts to meet the significant new requirements. The U.S. is currently working to develop extensions to the Network and Transport Layer protocols which support multipeer data transmission. In addition, because of the significant new requirements identified in the study efforts, the U.S. is working on new Transport Layer Services/Protocols which address the fundamental distributed computing paradigm shift and the requirements for more efficient data transfer protocols.

2 Scope and field of application

This paper describes U.S. work to analyze transport protocol requirements collected from various sources which go beyond the capabilities of present standards. Requirements considered are those of the “Transport Service User” avoiding any direct use of the services provided by existing or developing transport protocols. Significant requirements were identified and the capabilities for the current OSI protocols and services of the Transport layer were analyzed to meet these requirements. Modifications to the current protocols (or potentially new standards) are needed to meet these significant requirements. Areas where major changes (or new services and protocols) are needed are identified. Discussion is provided on the impact at the Network Layer. There is no information provided at this time on the impact at the Data Link Layer.

3 References

4 Definitions

5 Abbreviations

6 Observations from the U.S. Discussions

This sections provides summary points on requirements for transport protocols that have been brought out by U.S. discussions.

6.1 Paradigm Shift

The paradigm assumed for computer communications has undergone major changes in the last few years. In the past the paradigm involved large centralized computers working at a site interconnecting with other sites separated by long distances communicating with noisy 56KBit/second lines. The environments considered by all of the applications discussed in this paper involve many computational elements (i.e. workstations) located in close physical proximity. The availability of inexpensive microprocessors has revolutionized the computing industry over the last ten years and now the new computing environment is changing the nature of data communications. While today clusters of these processors are located within a floor or throughout a building, in the near future it is expected that such clusters may be spread across a metropolitan region and will soon span large distances. Thus while today LANs are typically used within such applications soon both metropolitan area networks and wide area networks will need to support these applications.

The paradigm shift encompasses all of the OSI Basic Reference Model layers from the Transport Layer down. At the Data Link Layer the use of very high speed LANs (Local Area Networks, i.e. ISO FDDI) as well as developing MANs (Metropolitan Area Networks, i.e. IEEE 802.6) and ATM are providing new capabilities. At the Network Layer interconnection of multiple high speed LANs, MANs and WANs will be required with performance that matches that achieved by these Data Link networks.

6.2 Bandwidth Metric

Initial discussions within the U.S. focused on bandwidth capabilities of the existing TP4 protocol. With relatively minor modifications (i.e. moving the checksum to the end of packets and utilizing one set of options) TP4 has been run at very high speed when using very large packets. Similar results have been reported by the TCP community. One agreement that resulted from the U.S. discussions was that for point-to-point transfer between two devices with very large amounts of data to transfer, TP4 appears adequate given the minor modifications (which could possibly be handled through the ISO 8073 incremental improvement effort already in-process).

6.3 New Functional Capabilities

The new requirements identified for transport protocols came from very challenging applications having many processor based devices communicating among themselves (e.g. via a high performance LAN interconnect). A need for multicast and reliable multicast communications was identified. A need to control maximum latency for some messages at the cost of increased latency for others was identified as well as the ability to transfer small high priority messages in the middle of on-going large file transfers. Selectable error control, efficient datagrams and support for time synchronization were also identified.

New functional capabilities are by their very nature beyond the scope of the present protocols. As standard development proceeds a determination is needed to see if the new functional capabilities can be added to existing services and protocols or if there is a paradigm conflict which precludes their addition.

6.4 Implementation Efficiency

Protracted U.S. discussions were held on the issue of implementation efficiency. The issue presented was reduced protocol complexity in order to achieve higher performance (i.e. faster execution achieving lower transfer latencies and performing more operations per second). A number of "measures" of complexity were proposed (i.e. number of C language instructions to carry out a critical function, die size of an integrated circuit and electronic board "real estate" consumed), however all were deemed arbitrary and none were generally accepted. It is proposed here to utilize "number of decision points" to carry out a critical function. While not perfect this provides a measure which is applicable to any implementation method.

Some expressed doubts as to the importance of implementation efficiency at a time when processors are getting faster and memory is getting cheaper; however, data rates by high speed networks are also growing at least a similar rate and for the application areas considered in this paper it appears justifiable that 10% or greater potential efficiency improvements are worth pursuing.

The means to achieve such efficiencies is by cutting the number of options within the "critical path" of the protocol to a minimum and by fixing such options to a point within the header or trailer. The placement of a field within a protocol data unit (PDU) can be very important; for example, placing the checksum in the trailer of a PDU has a major advantage when calculating a checksum on a PDU received.

A disadvantage in optimizing the protocol for efficiency is that it takes away the tremendous flexibility in calling out (and later adding) options that protocols such as TP4 have where a parameter code-length-value approach is used.

6.5 Use of "Hard" Numbers

In the beginning of the requirements study it was anticipated that "hard" numbers would play a major role in defining the requirements. Examples of such numbers are a one millisecond maximum latency requirement for a complete transaction or a requirement to set up a connection in ten milliseconds. In pursuing the requirements study it was soon determined that numbers such as these exist but are typically events at the Application Layer which do not directly translate into "hard" numbers at the Transport Layer. Numbers considered are typically from existing systems which may have been designed a number of years ago before the technology assumed by this effort became available. Worst case "hard" numbers which will hold over the next twenty years are not obtainable.

The approach proposed is to bring out numbers wherever they can be found as “ballpark” estimates of what is foreseen, but assume that as technology improves such numbers will be stressed more. Thus as LANs go to 100 Megabit/second and beyond and point-to-point communications go to 800 Megabit/second and beyond that very capable applications will be developed which will stress these technologies and continue to require more.

7 Identification of Requirements

Step(1) of the effort was the identification of requirements. The requirements that the U.S. utilized for this study effort came primarily from four application areas that represented the use of new data communication services and functions. The areas selected included the Use of Technical Workstations, Process Control, Real-time Military Systems and Scientific Supercomputing. Annex A describes how all of the requirements were identified and categorized.

8 Identification of Significant Requirements

Step(2) of the effort was the determination of which of these requirements identified in Step(1) go beyond what is currently provided by existing standards or actions that are presently in development. This was accomplished by identifying the ***significant*** requirements which are the drivers for the actions of Step(3) and Step(4) developments. The U.S. effort to determine the significant requirements is described in Annex A. The significant requirements identified were:

*Efficient Transactions

*Multicast Transfer

*Selectable Error Control

*Latency Control Facilities

*Efficient Implementation

*Time Synchronization Support

The significant requirement identified all involve new capabilities that are not contained within the present OSI Transport level services and protocols. As described in Annex A many of the requirements seen by the authors of the papers analyzed involve services and protocol functions that are met by the current protocol standards. The focus of the U.S. study has been at the new requirements presented to the Transport layer. Along with the needs of the Transport layer, the requirements of Multicast Transfer, Latency Control Facilities, Efficient Implementation and Time Synchronization also drive requirements at the Network and Data Link layers. The discussions within the U.S. identified the Multicast and Latency Control as the primary requirement drivers for changes to the Network layer.

This section provides descriptions on the significant requirements that resulted from this effort.

8.1 Efficient Transactions

The Efficient Transaction is a new function proposed to handle a function occurring increasingly in the application areas considered here. A request by a service user causes an indication to a user(s) at a remote processor, upon completing an operation this remote user issues a response to its service provider which ends with a confirm to the initially requesting service user. This four legged exchange is used for Remote Procedure Calls (RPCs) and other Client-Server exchanges.

This exchange can be accomplished using TP4; however, a number of operations are required such as a four legged exchange to first set up a connection, a data transfer phase and a disconnect phase. Using this technique results in many communication actions over the network which can greatly increase latency. Latency and number of transactions per unit of time are the primary metrics for this type of exchange and thus efficiency in carrying out this function is important. In addition if implementations use multiple service requests between service user and provider than an increase in latency can result which is detrimental to time critical systems. An additional requirement discussed in the Workstation application area was that the data sent via the transaction not be restricted in length. Thus the data may need to be passed via many PDUs at the lower layers.

8.2 Multicast Transfer

The Multicast Transfer is the simultaneous sending of the same PDU to a number of peer entities. It can be assumed for the application areas discussed here that the underlying layer services support multicast communication down to the communication media used.

The simultaneous transfer allows critical information to be distributed to all very quickly which is important in time critical applications. The application area of interest is anticipated to be larger than just Process Control and Real-Time Military applications but encompass embedded systems of all kinds that involve many processing elements. Other examples of such systems are discrete manufacturing industry, air traffic control complexes and flight simulation systems.

8.3 Selectable Error Control

Selectable Error Control provides a means for the service user to specify the amount of error control to apply to a specific Transport Service Access Point (TSAP). The two extremes are complete assurance and no error control. This feature has great utility when applied to Multicast Transfers; however utility for this feature has been seen when applied to point-to-point transfers in time critical applications. Along with the two extremes of selecting error control, intermediate levels are needed for Multicast Transfers. Another feature to provide is “hole” preservation in large transfers even when no error control is applied, this has value in transferring video images in time critical applications. The application areas of interest are the same as those listed under the Multicast Transfer section.

8.4 Latency Control Facilities

Latency Control Facilities provide a means for selecting data for transfer from one TSAP at the expense of others. In order to make the facility useful it needs to be implemented consistently (i.e. of global scope) across a system in order to achieve the desired results. A major need in time critical applications is to transfer small high priority (e.g. Efficient Transactions) messages in the middle of large on-going file transfers. Control of latency is not found in any present Transport standard. The application areas of interest are the same as those listed under the Multicast Transfer section.

8.5 Efficient Implementation

Efficient Implementation as used here refers to a protocol design discipline. As described earlier in this report, minimizing the number of options within the “critical path” of the protocol, fixing such options to a point within the header or trailer and considering the placement of fields can be very important to the bandwidth/latency potentials of the protocol.

An important point is that a number of factors need to be considered when assessing efficiency including bandwidth, latency, amount of local resources required (i.e. memory for control structures and buffers). The only measurements that are meaningful are those made within the environment an application runs in. Thus for considering Technical Workstation efficiency, timings of two Workstations transferring a large file may be meaningless if it is assumed that such workstation's run in an X-Windows environment.

8.6 Time Synchronization Support

The Time Synchronization Support requirement can be treated separately from the other requirements since this is not a need of a basic transport service but a requirement for hooks within this and lower layers. Time critical systems have a need for maintaining a consistent value of time and supplying it to the applications that run in all of the computing elements.

The type of support needed is a means to accurately determine or predict the local time that a PDU carrying synchronization information is placed on a network as well as when such a PDU is received from a remote time service.

9 Modification of OSI Standards

Step(3) of the procedure calls out the modification/extension of existing OSI services and/or protocols as the preferred method of meeting the significant requirements. The U.S. after identifying the significant requirements then studied whether these requirements could be met by modification to the current service and protocol standards.

This section describes which significant requirements are expected to be met in whole or in part by changing the current OSI standards. The issues described here are not expected to be candidates for step(4) efforts. The section is broken down by layer.

9.1 Transport Layer

The U.S. has concluded that major changes are needed to the OSI Transport services and protocols to meet the significant requirements identified. The only significant requirement that could be satisfied at least in part, by a "minor" change to the current OSI Transport protocols, is the addition of multicast capabilities to the ISO Connectionless Transport protocol (ISO 8602). Work has been initiated within the U.S. to provide a proposal for a modification to ISO 8602 to provide multicast capabilities. Such capability is very useful for a class of applications found in Process Control and Real-Time Military Systems. A similar capability is being implemented and used in the Internet via the UDP protocol utilizing the IP protocol with multicast extensions.

In addition to the ISO 8602 capability, a means of providing multicast transmission with error control is needed. Further discussion is provided in the section "Major New Efforts" which describes how other transport layer functionality can be incorporated.

9.2 Network Layer

The U.S. effort to support multicast facilities at the Network layer has concentrated at accomplishing the needed changes for both services and protocols via changes to the existing OSI standards. The U.S. has identified multicast capabilities that are needed and has initiated NWI proposals in the areas of extensions to the Network service definition (ISO 8348) both for services needed to support multicast and the addition of a group Network addressing capability. The group Network addressing project has been started and is JTC1.06.32.01.05.

In the area of multicast extensions to the OSI connectionless Networking, the U.S. has initiated NWI proposals in the areas of, the Connectionless Network Protocol (ISO 8473), the ES-IS routeing exchange protocol (ISO 9542) and the IS-IS Intra-Domain routeing information exchange protocol (ISO 10589). While this is a major effort, it does appear that this can be fit in to the present connectionless Network architecture.

In addition, the U.S. is involved in the development of the CCITT X.6 multicast service description. Future work is anticipated that will lead to multicast extensions for CONS networks.

9.3 Data Link Layer

Discussion on the impact of the significant requirements to the Data Link layer and what possible modifications may result have been initiated but no conclusions have been made at this time.

10 Major New Efforts

This section describes the aspects of the significant requirements described in this report that lead to major new efforts. At this time these are all being performed as step(3) efforts and may remain as modifications to existing standards. The issues discussed may result in a paradigm shift and thus may need to become step(4) efforts. The progression of the technical work is the critical issue and the decision as to which approach to take (modification or new standard) can be made at a later time. The section is broken down by layer.

10.1 Transport Layer

The U.S. effort has concluded that there is a need for major new Transport efforts to meet the significant requirements identified here; however, no determination has been made as to whether a new service class (to ISO 8073) is needed or whether an entire new protocol is needed. The U.S. is proceeding on this work assuming a new protocol class. The following points were made by the U.S. study effort:

> In particular, multicast transmissions and selective error control are two fundamentally new services which will necessitate either a new class of protocol or a new protocol entirely.
>
> To adequately address the design of a new Transport Protocol, a service definition must be created outlining the service provided. The service definition should incorporate new features such as user error control, QOS management, multicast transmission, group management, and other issues that are not currently present. Without a new service definition, it is very difficult to measure the degree of success in defining the new protocol.
>
> The addition of multicast will require a major redefinition of the Transport Protocols. The first step would be to define the multicast service required at the Transport Layer (reliable or unreliable). Second, the appropriate multicast management procedures would need to be introduced. Finally, the new protocol or features would be integrated into the existing Transport Layer standards or new Transport Layer standard. Two possible choices are seen: new class or new version.
>
> It is in the area of selectable error control that major conceptual changes are required in the Transport Service and Protocol. The selection provided should span the range of no action on errors to complete recovery schemes.
>
> A major design constraint would be the development of a coordinated approach to user selectable error control, latency control, QOS management, and the existing functions.

> The Transport Protocols are not designed at this time to provide any control over latency. They are designed with completely different parameter aimed at providing maximum bandwidth over connections. Also, the Transport Protocols are concerned with being general purpose solutions; not tailored for specific environments. To achieve latency control the Transport Protocols need to be redesigned considering this requirement. Finally, it needs the addition of QOS management facilities that permit the user to control the aspects of QOS that are important on a particular connection.

10.2 Network Layer

Discussion on the impact of the significant requirements to the Network layer and what new efforts may result have been initiated but no conclusions have been made at this time. One significant requirement cannot be met by "minor changes" to the existing OSI standards and that relates to providing Latency Control Facilities:

> Neither X.25 nor ISO 8473 provides any means of controlling latency dispersion or low latency dispersion operation modes.

10.3 Data Link Layer

Discussion on the impact of the significant requirements to the Data Link layer and what new efforts may result have been initiated but no conclusions have been made at this time.

11 Conclusions

The combination of new functional requirements along with the requirement for efficient implementation provides a strong justification for further Transport standard development. The significant requirements identified are the drivers for further Transport standardization efforts. In the Transport Layer the service definition is the highest priority. It is necessary to develop a new Transport Layer protocol incorporating the required services and functions. The U.S. has not concluded as to whether a new transport protocol should be a new class (class 5) in ISO 8073, or a new standard with a separate number. The ability to design the protocol with compatible header formats may be a deciding factor. The effort should consider all of the significant requirements. It is recommended that the decision be made at the conclusion of the technical effort as to whether a new protocol or a new class of transport protocol be standardized.

At the Network Layer, the U.S. has concluded that most of the needed capabilities can be achieved via modifications to the existing standards. Latency control facilities appear to need a more substantial change; however, the U.S. has no recommendation at this time on how to meet this significant requirement.

At the Data Link Layer study efforts are on-going but the U.S. has no recommendations at this time.

Annex A
Development of Significant Requirements

A.1. Overview of U.S. Requirement Identification Effort

This annex describes the process used by the U.S. in identifying the requirements which are significant enough to drive an effort within ISO for modifications to existing OSI standards and/or the development of new OSI service definitions or protocols. The U.S. effort began with a set of technical papers that identified requirements which were emerging that go beyond the present day standard protocols. Upon choosing papers from four technical areas (Technical Workstation usage, Process Control, Real-Time Military systems and Scientific Supercomputing), the requirements were categorized into groups and identical and/or similar requirements were combined. The U.S. then evaluated the resulting categorized requirements and placed them into one of four classes: The identification of the Class 1 requirements was the focus of the U.S. requirements effort.

Class 1 Significant requirements which will drive new protocol and service definition development

Class 2 Requirements which while important are not driving requirement for protocol or service definition development

Class 3 Requirements for which no conclusion as to their importance and for which further investigation is needed.

Class 4 Requirements which are out of scope of the requirement effort.

A.2. Identification of Requirements

The U.S. utilized reference papers which were identified as representative of the new data communication applications which are emerging. The requirements listed are described in detail in the technical papers and are those that the authors felt were not being met by the existing transport protocols (i.e. TP4, Connectionless Transport and the Internet protocols TCP and UDP). In addition two requirements were identified during technical discussions within the U.S.

A.2.1 Technical Workstations

The “Notes on Technical Workstations Requirements” [1] paper identifies two primary requirements of the technical workstations industry. These requirements reflect the very nature of the very competitive workstation market where success depends on delivering the maximum performance at the lowest possible cost across the board. This paper describes the nature of the data traffic, the real drivers within the workstation market and describes six R&D issues for workstation transport protocols. The six R&D issues are new functional capabilities which are being studied but no definitive trend can be identified at this time to consider these as requirements.

The two requirements listed are:

TW1) Deliver excellent performance on a wide range of traffic types with the minimum number of transport protocols

TW2) Deliver maximum performance at the lowest possible cost

A.2.2 Process Control

The "User Requirements for Communications in Time Critical Applications" [3] paper identifies ten requirements for the process control and manufacturing environment's command and control networks which are not being met by MAP 3.0. "Command and control networks interconnect devices such as PLCs, robots, CNCs vision systems and supervisory computers. Traffic on this type of network is essentially real-time, i.e. submitted to tight deadlines".[3]

The ten requirements listed are:

PC1) Prioritization of Messages at the Application Interface

PC2) Predictable Request/Response Times Observable at the Application Interface

PC3) Selection of Error Recovery by the User

PC4) Support for Multicast Communication

PC5) Support for Redundancy

PC6) Existence of Security Mechanisms

PC7) Interworking with Non-Real-Time MAP 3.0

PC8) Low Attachment Cost

PC9) Support for Time Synchronization

PC10) Quality of Service for Congestion Recovery

A.2.3 Real-Time Military Systems

The "Requirements for a High Performance Transport Protocol for Use on Naval Platforms"[2] paper identifies nine requirements from the real-time military environment. This paper describes a Tactical Console Display scenario in which many Display Workstations communicate among themselves, with a Common Data Base Control computer, with various file servers and with controlled subsystems. It is postulated that such requirements may exist for some non-military systems such as air traffic control.

The nine requirements listed are:

MIL1) Multicast Transfer

MIL2) Reliable Multicast Transfer

MIL3) Real-Time Scheduling

MIL4) Very Fast Connection Build-up and Tear Down

MIL5) Limited Routing Capability

MIL6) Special Services (i.e. Time Synchronization and Distributed Transaction Support)

MIL7) Reliable Datagrams

MIL8) Selectable Error Control

MIL9) Support for the Conservation of Local Resources

A.2.4 Scientific Supercomputing

The “Delta-t Transport Protocol: Features and Experience”[4] paper identifies seven requirements from the scientific supercomputing environment. A scientific supercomputing environment is found at a research facility which utilizes a few supercomputers along with many computers of all sizes all of which may communicate. The transport protocol is viewed as a component to support a distributed operating system across such a facility.

The seven requirements listed are:

SC1) Minimum Packet Exchange for Request/Response Transactions

SC2) High Throughput Bulk Data Transport and other Stream services

SC3) Flow Control Without Polling for Reliable Zero Window Opening

SC4) Error Control of Lost, Damaged, Duplicated, and Out-of-sequence Packets

SC5) Large and Flexible Name Space for Transport End Points

SC6) Message Boundary Preservation

SC7) Secure Communications

A.2.5 Additional Requirements Identified

This section contains additional requirements identified outside of the referenced papers that form the primary basis for the requirements presented. Each requirement listed in this section contains additional description (due to the lack of more detailed reference documents).

AD1) Capability of Working in a Global Heterogeneous Internet

This requirement was identified during the U.S. discussions. Thus for any resulting protocol development effort, a requirement exists that it must be capable of working along with existing and developing international standards.

AD2) Congestion Management

This requirement was identified during the U.S. discussions. The three primary issues are congestion avoidance, detection and recovery. It was pointed out that a network experiencing congestion can not be considered high speed by its users at that time and thus a question arose as to whether this was not a concern “by definition”. The U.S. effort concluded that this was an area of concern and should be addressed by this Study effort.

A.3. Requirement Categorization

The section breaks into categories the requirements listed in the previous section. Requirements are combined wherever possible. It is the goal of this section to provide an organized listing of the Transport Layer requirements.

A.3.1 New Functional Capabilities

This section combines requirements which are not part of the present Transport protocols (i.e. TP4 and Connectionless Transport). Further analysis is required to determine if the capabilities listed here are outside of the present Transport protocol paradigm where a change in paradigm necessitates a new protocol.

NF1) Efficient Transactions. Incorporates MIL4, MIL7 and SC1.

NF2) Multicast Transfer (Both Unreliable and Reliable Options). Incorporates PC4, MIL1 and MIL2.

NF3) Selectable Error Control. Incorporates PC3, PC10 and MIL8.

NF4) Latency Control Facilities. Incorporates PC1, PC2 and MIL3.

NF5) Support for Time Synchronization. Incorporates PC9 and MIL6.

NF6) Large and Flexible Name Space for Transport End Points. Incorporates SC5.

NF7) Support for Redundancy. Incorporates PC5.

NF8) Distributed Transaction Support. Incorporates MIL6.

NF9) Support for Limited Switching and Relaying at the Sub-net Level. Incorporates MIL5.

NF10) Congestion Management. Incorporates AD2.

A.3.2 Efficient Protocol Implementations

The requirements listed in this section can be viewed as a need to ensure that the performance being provided by new standards at lower layers (e.g. FDDI and HSC) are being carried through the Transport Layer. As technology at these lower layers progress, performance must be carried up.

EP1) Maximize Efficiency (over a wide range of traffic types, lowest possible cost and concern for conserving local resources). Incorporates TW1, TW2, MIL9

EP2) High Throughput Bulk Data Transport and other Stream Services. Incorporates SC2.

A.3.3 Design Features

The requirements listed in this section are important features needed in developing a transport protocol. These features may already be incorporated or could be incorporated (through the ongoing standard maintenance efforts) within the existing Transport standards.

DF1) User Selectable Security Options. Incorporates PC6 and SC7.

DF2) Flow Control Without Polling for Reliable Zero Window Opening. Incorporates SC3.

DF3) Error Control of Lost, Damaged, Duplicated, and Out-of-sequence Packets. Incorporates SC4.

DF4) Message Boundary Preservation. Incorporates SC6.

A.3.4 Interoperability Capabilities

The requirements listed in this section provide a context for any standard considered by this effort to exist within.

IC1) Capability of Working in a Global Heterogeneous Internet. Incorporates AD1.

IC2) Interworking with non real-time MAP3.0. Incorporates PC7.

A.3.5 Other Requirements

This section lists any requirement which does not fit in one of the above categories.

OT1) Low Attachment Cost. Incorporates PC8.

A.4. Requirement Evaluation

This section takes the requirements that have been described earlier and evaluates them according to their impact on the present study effort. The primary issue addressed here are to identify the requirements that significantly impact the present standard Transport protocols. The classification for the requirements are (by class number):

A.4.1 Class 1

These requirements are considered to be significant enough to drive a new SD3 development proposal for modification to existing OSI standards and/or the development of new OSI protocols.

NF1) Efficient Transactions

NF2) Multicast Transfer (Both Unreliable and Reliable Options)

NF3) Selectable Error Control

NF4) Latency Control Facilities

NF5) Support for Time Synchronization

EP1) Efficient Implementation

A.4.2 Class 2

These requirements are an important part of any transport protocol considered by the SD3 study task but are not expected to drive towards a new SD3 proposal.

DF1) User Selectable Security Options

DF2) Flow Control Without Polling for Reliable Zero Window Opening

DF3) Error Control of Lost, Damaged, Duplicated, and Out-of-sequence Packets

DF4) Message Boundary Preservation

EP2) High Throughput Bulk Data Transport and other Stream Services

IC1) Capability of Working in a Global Heterogeneous Internet

A.4.3 Class 3

Those requirements needing further investigation.

NF6) Large and Flexible Name Space for Transport End Points

NF7) Support for Redundancy

NF8) Distributed Transaction Support

NF9) Support for Limited Switching and Relaying at the Sub-net Level

NF10) Congestion Management

A.4.4 Class 4

Those requirements viewed as being out of scope for the present requirement study.

IC2) Interworking with non real-time MAP3.0

OT1) Low Attachment Cost.

A.5. Significant Requirement Assessment

This section further discusses the requirements evaluated to be significant (i.e. Class 1) as to their importance to each of the application areas. Table 1 identifies the requirements by application area.

Table 1
Significant Requirement Assessment

Requirement	Workstation	Process Control	Military	Super-computing
NF1-Efficient Transaction	X		X	X
NF2- Multicast Transfer		X	X	
NF3- Selectable Error Control		X	X	
NF4- Latency Control Facilities		X	X	
EP1- Efficient Implementation	X	X	X	X
NF5- Time Synchronization		X	X	

Table 1 can be used to cross-reference the significant requirements to the application areas that they are needed in. During the U.S. discussions a request was made to prioritize the requirements. Such a prioritization does not appear meaningful, what does appear useful is to consider the significant requirements by application area. Using Table 1, it can be determined which significant requirement is important to each application area. Within the application areas the requirements are inter-related and thus prioritizing is not an issue.

The study effort found a similar set of requirements for both the Process Control and Real-Time Military application areas. The time critical nature of these environments have brought out a similar need for new transport level functionality of Multicast Transfer, Selectable Error Control and Latency Control features. The Time Synchronization requirement which is needed by both of these application areas is outside of the normal transport protocol issues.

A.6. References

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