contributed both the driver for the new CAMTEC X.25 interface and the CAMTEC CONS interface (X.25 over 802 networks). This latter driver was later removed from the distribution for lack of use.

In addition, Andrew Worsley of the Department of Computer Science at the University of Melbourne in Australia pointed out several problems with the FTAM DIS implementation. He also developed a replacement for *pepy* and *posy* called *pepsy*. After moving to University College London, he improved this system and integrated into the ISODE.

Olivier Dubous of BIM sa in Belgium contributed some fixes to concurrency control in the FTAM initiator to allow better interworking with the VMS[3] implementation of the filestore. He also suggested some changes to allow interworking with the FTAM T1 and A/111 profiles.

Olli Finni of Nokia Telecommunications provided several fixes found when testing interoperability with the TOSI implementation of FTAM.

Mark R. Horton of AT&T Bell Laboratories also provided some help in verifying the operation of the software on a 3B2 system running UNIX System V release 2. In addition, Greg Lavender of NetWorks One, under contract to the U.S. Navy Regional Data Automation Center (NARDAC), provided modifications to allow the software to run on a generic port of UNIX System V release 3.

Steve D. Miller of the University of Maryland provided several fixes to make the software run better on the ULTRIX variant of UNIX.

Jem Taylor of the Computer Science Department at the University of Glasgow provided some comments on the documentation.

Hans-Werner Braun of the University of Michigan provided the inspiration for the initial part of Section 1.2.

A previous release of the software contained an ISO TP4/CLNP package derived from a public-domain implementation developed by the National Institute of Standards and Technology (then called the National Bureau of Standards). The purpose of including the NIST package (and associated support) was to give an example of how one would interface the code to a "generic" TP4 implementation. As the software has now been interfaced to various native TP4 implementations, the NIST package is no longer present in the distribution.

John A. Scott of the MITRE Corporation contributed the SunLink OSI

[3]VMS is a trademark of Digital Equipment Corporation.

interface for TP4. He also wrote the FTAM/FTP gateway which the MITRE Corporation has generously donated to this package.

Philip B. Jelfs of the Wollongong Group upgraded the FTAM/FTP gateway to the "IS-level" (International Standard) FTAM.

Rick Wilder and Don Chirieleison of the MITRE Corporation contributed the VT implementation which the MITRE Corporation has generously donated to this package.

Jacob Rekhter of the T. J. Watson Research Center, IBM Corporation, provided some suggestions as to how the system should be ported to the IBM RT/PC running either AIX or 4.3BSD. He also fixed the incompatibilities of the FTAM/FTP gateway when running on 4.3BSD systems.

Ashar Aziz and Peter Vanderbilt, both of of Sun Microsystems Inc., provided some very useful information on modifying the SunLink OSI interface for TP4.

Later on, elements of the SunNet 7.0 Development Team (Hemma Prafullchandra, Raj Srinivasan, Daniel Weller, and Erik Nordmark) made numerous enhancements and fixes to the system.

John Brezak of Apollo Computer, Incorporated ported the ISODE to the Apollo workstation. Don Preuss, also of Apollo, contributed several enhancements and minor fixes.

Ole-Jorgen Jacobsen of Advanced Computing Environments provided some suggestions on the presentation of the material herein.

Nandor Horvath of the Computer and Automation Institute of the Hungarian Academy of Sciences while a guest researcher at the DFN/GMD in Darmstadt, FRG, provided several fixes to the FTAM implementation and documentation.

George Pavlou and Graham Knight of University College London contributed some management instrumentation to the *libtsap*(3n) library.

Juha Heinänen of Tampere University of Technology provided many valuable comments and fixes on the ISODE.

Paul Keogh of the Nixdorf Research and Development Center, in Dublin, Ireland, provided some fixes to the FTAM implementation.

Oliver Wenzel of GMD Berlin contributed the RFA system.

L. McLoughlin of Imperial College contributed Kerberos support for the FTAM responder.

Kevin E. Jordan of CDC provided many enhancements to the G3FAX library.

John A. Reinart of Cray Research contributed many performance enhancements.

Ed Pring of the T. J. Watson Research Center, IBM Corporation, provided several fixes to the SMUX implementation in ISODE's SNMP agent.

Uli Betzler of University of Karlsruhe donated the HP X.25 interface and other HP-UX modifications.

Alan Young of Concurrent Computer Corporation contributed many helpful changes to the transport code.

James Gosling, author of the superb Emacs screen editor for UNIX, and Leslie Lamport, author of the excellent LaTeX document preparation system both deserve much praise for such winning software. Of course, the whole crew at U.C. Berkeley also deserves tremendous praise for their wonderful work on their variant of UNIX.

Finally, full credit for this release must be given to Marshall T. Rose. Marshall has for so long master-minded the whole ISODE effort. Although he has not been involved in the last month or so leading upto this release, the vast majority of the effort getting ISODE-7.0 into shape came from Marshall.

jpo & cjr

Nottingham, England
July, 1991

Part I

Introduction

Chapter 1

Overview

This document describes a non-proprietary implementation of some of the protocols defined by the International Organisation for Standardisation and International Electrotechnical Commission (ISO/IEC), the International Telegraph and Telephone Consultative Committee (CCITT), and the European Computer Manufacturer Association (ECMA).[1]

The purpose of making this software openly available is to accelerate the process of the development of applications in the OSI protocol suite. Experience indicates that the development of application level protocols takes as long as or significantly longer than the lower level protocols. By producing a non-proprietary implementation of the OSI protocol stack, it is hoped that researchers in the academic, public, and commercial arenas may begin working on applications immediately. Another motivation for this work is to foster the development of OSI protocols both in the European RARE and the U.S. Internet communities. The Internet community is widely known as having pioneered computer-communications since the early 1970's. This community is rich in knowledge in the field, but currently is not actively experimenting with the OSI protocols. By producing an openly available implementation, it is hoped that the OSI protocols will become quickly widespread in the Internet, and that a productive (and *painless*) transition in the defense data network (DDN) might be promoted. The RARE community is the set of corresponding European academic and research organisations. While they do not have the same long implementation experience as the Internet

[1] In the interests of brevity, unless otherwise noted, the term "OSI" is used to denote these parallel protocol suites.

community, they have a deep commitment to international standards. It is intended that this release gives vital early access to prototype facilities.

1.1 Fanatics Need Not Read Further

This software can support several different network services below the transport service access point (TSAP). One of these network services is the DoD transmission control protocol (TCP)[Pos81].[2] This permits the development of the higher level protocols in a robust and mature internet environment, while providing us the luxury of not having to recode anything when moving to a network where the OSI transport protocol (TP) is used to provide the TSAP. However, the software also operates over pure OSI lower levels of software. It is mainly used in that fashion — outside of the United States.

Of course, there will always be "zealots of the pure faith" making claims to the effect that:

> *TCP/IP is dead! Any work involving TCP/IP simply dilutes the momentum of OSI.*

or, from the opposite end of the spectrum, that

> *The OSI protocols will never work!*

Both of these statements, from diametrically opposing protocol camps are, of course, completely unfounded and largely inflammatory. TCP/IP is here, works well, and enjoys a tremendous base of support. OSI is coming, and will work well, and when it eventually comes of age, it will enjoy an even larger base of support.

The role of ISODE, in this maelstrom that generates much heat and little light, is to provide a useful transition path between the two protocol suites in which complementary efforts can occur. The ISODE approach is to use the strengths of both the DDN and OSI protocol suites in a cooperative and positive manner. For a more detailed exposition of these ideas, kindly refer to [Ros90] or the earlier work [RC86].

[2] Although the TCP corresponds most closely to offering a transport service in the OSI model, the TCP is used as a connection-oriented network protocol (i.e., as coservice to X.25).

1.2 The Name of the Game

The name of the software is the ISODE. The official pronunciation of the ISODE, takes four syllables: *I-SO-D-E*. This choice is mandated by fiat, not by usage, in order to avoid undue confusion.

Please, as a courtesy, do not spell ISODE any other way. For example, terms such as ISO/DE or ISO-DE do not refer to the software! Similarly, do not try to spell out ISODE in such a way as to imply an affiliation with the International Organisation for Standardization. There is no such relationship. The *ISO* in ISODE is not an acronym for this organisation. In fact, the *ISO* in ISODE doesn't really meaning anything at all. It just has a catchy two syllable sound.

1.3 Operating Environments

This release is coded entirely in the *C* programming language[KR78], and is known to run under the following operating systems (without any kernel modifications):

Berkeley UNIX The software should run on any faithful port of 4.2BSD, 4.3BSD, or 4.4BSD UNIX. Sites have reported the software running: on the Sun-3 workstation running Sun UNIX 4.2 release 3.2 and later; on the Sun Microsystems workstation (Sun-3, Sun-4, and Sun-386i) running SunOS release 4.0 and later; on Digital Equipment Corporation ULTRIX machines (including X.25); the Integrated Solutions workstation; and on the RT/PC running 4.3BSD.[3] In addition to using the native TCP facilities of Berkeley UNIX, the software has also be interfaced to versions 4.0 through 7.0 of the SunLink/SunNet X.25 and OSI packages (although Sun may have to supply you with some modified `sgtty` and `ioctl` include files if you are using an earlier version of Sun-

[3]Do not however, attempt to compile the software with the SunPro *make* program! It is not, contrary to any claims, compatible with the standard *make* facility. Furthermore, note that if you are running a version of SunOS 4.0 prior to release 4.0.3, then you may need to use the *make* program found in */usr/old/*, if the standard *make* you are using is the SunPro *make*. In this case, you will need to put the old, standard *make* in */usr/bin/*, and you can keep the SunPro *make* in */bin/*.

Link X.25). The optional SunLink Communications Processor running DCP 3.0 software has also been tested with the software.

AT&T UNIX The software should run on any faithful port of System V UNIX. The SVR4 port used an ICL DRS6000 as a testbed. One of the other systems tested was running with an Excelan EXOS[4] 8044 TCP/IP card. The Excelan package implements the networking semantics of the 4.1aBSD UNIX kernel. As a consequence, the software should run on any faithful port of 4.1aBSD UNIX, with only a minor amount of difficultly. As of this writing, however, this speculation has not been verified. The particular system used was a Silicon Graphics IRIS workstation.[5]

Another system was running the WIN TCP/IP networking package. The WIN package implements the networking semantics of the 4.2BSD UNIX kernel. The particular system used was a 3B2 running System V release 2.0.4, with WIN/3B2 version 1.0.

Another system was also running the WIN TCP/IP networking package but under System V release 3.0. The WIN package on SVR3 systems emulates the networking semantics of the 4.2BSD UNIX kernel but uses STREAMS and TLI to do so.

Note: The System V port does not include VT or SNMP.

AIX The software should run on the IBM AIX Operating System which is a UNIX-based derivative of AT&T's System V. The particular system used was a RT/PC system running version 2.1.2 of AIX.

HP-UX The software should run on HP's UNIX-like operating system, HP-UX. The particular system used was an Indigo 9000/840 system running version A.B1.01 of HP-UX. The system was also reported to have run on an HP 9000/350 system under version 6.2 of HP-UX. Support for HP's X.25 has been included.

ROS The software should run on the Ridge Operating system, ROS. The particular system used was a Ridge-32 running version 3.4.1 of ROS.

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[4] EXOS is a trademark of Excelan, Incorporated.

[5] This test was made with an earlier release of this software, and access to an SGI workstation was not available when the current version of the software tested. However, the networking interface is still believed to be correct for the Excelan package.