MARTIN MARIETTA

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**ENVIRONMENTAL
RESTORATION
PROGRAM**

**Information Management Architecture
for an Integrated Computing
Environment for the Environmental
Restoration Program**

Volume 3. Interim Technical Architecture

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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ENERGY SYSTEMS

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contributed to the preparation of this document and should not be considered an eligible contractor for its review.

**Information Management Architecture
for an Integrated Computing
Environment for the Environmental
Restoration Program**

Volume 3. Interim Technical Architecture

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PREFACE

The Environmental Restoration (ER) Program, Martin Marietta Energy Systems, Inc., recognizes that the management of information resources is an integral part of its mission. Information in all its forms regarding the technical aspects of both remedial action and decommissioning and decontamination activities is key to the effective assessment and remediation of contaminated sites and facilities. Similarly, effective management of the many projects required to address ER missions requires efficient access to accurate and timely information on all aspects of these projects.

Since the value of ER Program-generated information is widely recognized, it is imperative that information be collected, analyzed, stored, and disseminated in a cost-effective manner. If the goal of cost-effective information management is to be achieved, a high degree of coordination among the various sites and projects must exist. This coordination is required to prevent unnecessary duplication of effort and expenditure of funds in the acquisition, deployment, and use of the computing infrastructure that in turn supports the management of ER information assets.

The first step in providing this coordination is the development of a common vision for a computing environment that will support the various needs of the ER Program. The technical architecture presented in this document is as an interim step in helping to achieve this vision.

CONTENTS

ACKNOWLEDGMENTS	iii
PREFACE	v
FIGURES	xi
TABLES	xi
ACRONYMS	xiii
EXECUTIVE SUMMARY	xvii
1. INTRODUCTION	1
1.1 PURPOSE	1
1.2 DESIGN GOALS AND CONSIDERATIONS	1
1.3 SCOPE	2
1.4 TECHNICAL GUIDANCE STRUCTURE	2
1.5 CURRENT BUSINESS ENVIRONMENT	3
2. ENVIRONMENTAL RESTORATION IMPLEMENTATION AND CONFIGURATION CONTROL	6
3. ENVIRONMENTAL RESTORATION COMPUTING PHILOSOPHY ...	7
3.1 PREFERRED ARCHITECTURE	7
3.2 OPEN SYSTEMS	7
3.3 CLIENT-SERVER ARCHITECTURE	8
3.4 THREE-TIER ARCHITECTURE	9
4. INFORMATION TECHNOLOGY REFERENCE	11
4.1 INTRODUCTION	11
4.1.1 Environmental Restoration Technical Architecture Service Areas	11
4.1.2 Environmental Restoration Technical Architecture Tiers	12
4.2 ENVIRONMENTAL RESTORATION TECHNOLOGY REFERENCE SUMMARY	13
4.3 OPERATING SYSTEM SERVICES	13
4.4 HUMAN/COMPUTER INTERACTION SERVICES	24
4.4.1 Client/Server Operations	25
4.4.2 Window Management	26
4.5 APPLICATIONS DEVELOPMENT AND MAINTENANCE SERVICES	28
4.5.1 Computer-Aided Software Engineering Tools	28
4.5.2 Application Generators and Fourth Generation Languages ...	29
4.5.3 Other Tool Categories	31

4.5.4	Distributed Computing Tools	31
4.5.5	Compilers	33
4.6	DATA MANAGEMENT SERVICES	34
4.6.1	Directory Services/Name Services	34
4.6.2	Data Dictionary/Repository	34
4.6.3	Database Management	35
4.7	ELECTRONIC MAIL SERVICES	36
4.7.1	Transport and Store Agents	37
4.7.2	User Agents	39
4.8	NETWORK SERVICES	40
4.8.1	Transmission Media	40
4.8.2	Data Link Services	41
4.8.3	Data Communications	43
4.8.4	File Services	44
4.8.5	Network Management	46
4.8.6	Time Services	47
4.8.7	Electronic Mail Interchange	48
4.8.8	External Connectivity	49
4.9	SECURITY SERVICES	51
4.10	DATA INTERCHANGE SERVICES	55
4.10.1	Document/Text	56
4.10.2	Hypermedia/Multimedia	56
4.10.3	Raster Graphics	57
4.10.4	Tabular Data Interchange	58
4.10.5	Vector Graphics	59
4.10.6	Product Data	59
4.10.7	Electronic Data Interchange	60
4.10.8	Electronic Fund Transfer	60
4.10.9	Geographical Information	61
4.11	OUTPUT SERVICES	62
4.11.1	Page Description Format	62
4.11.2	Raster Graphics Format	63
4.11.3	Vector Graphics Format	63
4.12	DESKTOP TOOLS	64
5.	IMPLEMENTATION STRATEGIES	66
5.1	OVERVIEW	66
5.2	GENERAL STRATEGY ASSUMPTIONS	66
5.2.1	Coordination Via Architectures	66
5.2.2	Use of Available Support Groups	67
5.3	ELECTRONIC MAIL STRATEGIES	67
5.3.1	Issues	67
5.3.2	Strategy	68
5.4	DESKTOP TOOLS STRATEGY	69
5.5	GRAPHICAL USER INTERFACE STRATEGY	70
5.6	SYSTEM AND NETWORK MANAGEMENT STRATEGY	72

5.7	APPLICATION DISTRIBUTION STRATEGIES	74
5.7.1	General Considerations	74
5.7.2	Data Distribution Considerations	74
5.7.3	Business Logic Distribution Considerations	75
5.7.4	User Interface Distribution Considerations	75
5.8	SERVER STRATEGY	75
5.8.1	Requirements	76
5.8.2	Topology	77
5.8.3	Issues	77
5.8.4	Specific Strategy Recommendations	78
5.9	NETWORKING STRATEGY	79
5.9.1	Long-Range Goals—Intrasite and Intersite	79
5.9.2	Physical Components	80
5.9.3	Network Infrastructure	82
5.9.4	External Connectivity	84
5.9.5	Protocols	86
5.9.6	Network Management	87
5.9.7	Related Issues	87
APPENDIX A.	CURRENT ENVIRONMENTAL RESTORATION DESKTOP COMPUTING ENVIRONMENT	A-1
APPENDIX B.	ENERGY SYSTEMS REFERENCE LISTS	B-1
APPENDIX C.	CURRENT ENVIRONMENTAL RESTORATION HOST AND NETWORK ENVIRONMENT	C-1

FIGURES

1	Client-server interaction	8
2	Representative three-tier architecture	9
3	Environmental Restoration Technical Architecture reference summary format	11
4	ERWM network connectivity long-range plan	81
5	ERWM network connectivity network diagram	83
6	ERWM network connectivity (external networks)	85
A.1	Environmental Restoration Program workstations	A-4
A.2	Environmental Restoration Program GUI usage	A-5
C.1	Current Environmental Restoration host and network environment ...	C-5

TABLES

1	Environmental Restoration technology reference summary	14
A.1	Current Environmental Restoration desktop computing environment ..	A-6

 

ACRONYMS

ACH	Automated Clearinghouse
ADP	Automated Data Processing
AFS	Andrew File System
ANSI	American National Standards Institute
API	Applications Programming Interface
APP	Applications Portability Profile
APT	Applications Programming Tool
ATM	Asynchronous Transfer Mode
A/UX	Apple UNIX
AVID	Advance Vendor Inventory Delivery System
CAD	Computing Applications Department
CALS	Computer-Aided Acquisition and Logistics Support
CASE	Computer-Aided Software Engineering
OCITT	Consultative Committee on the International Telephone and Telegraph
CDE	Common Desktop Environment
CDM	Camp, Dresser, and McKee Federal Programs, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CGM	Computer Graphics Metafile
COSE	Common Open Software Environment
COTS	Commercial Off-The-Shelf
CPU	Computer Processing Unit
CRRRI	Clinch River Remedial Investigation
C&TS	Computing and Telecommunications Services
CTSO	Computing and Telecommunications Security Organization
CUA	Common User Access
DBMS	Database Management System
DCE	Distributed Computing Environment
D&D	Decontamination and Decommissioning
DDN	Defense Data Network
DEC	Digital Equipment Corporation
DECds	DEC Distributed Naming Services, a proprietary DEC product
DFS	Distributed File System
DMC	Document Management Center
DML	Data Manipulation Language
DMP	Data Management Plan
DoD	Department of Defense
DOE	Department of Energy
DOECN	Department of Energy Communications Network
DSRD	Data Systems Research and Development
DTS	Distributed Time System
DXF	Drawing Exchange Format
EDI	Electronic Data Interchange

EFT	Electronic Fund Transfer
E-Mail	Electronic Mail
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	Environmental Protection Agency
EPS	Encapsulated PostScript
ER	Environmental Restoration
ER TA	Environmental Restoration Technical Architecture
ESnet	Energy Sciences Network
FDDI	Fiber Distributed Digital Interface
FIPS	Federal Information Processing Standards
FIPS PUB	Federal Information Processing Standard Publication
FTAM	File Transfer, Access, and Management
FTP	File Transfer Protocol
4GL	Fourth Generation Language
GIF	Graphics Interchange Format
GIS	Graphical Interface System
GOSIP	Government Open Systems Interconnection Profile
GUI	Graphical User Interface
HCBS	Host Computer Basic Software
HDF	Hierarchical Data Format
HP	Hewlett-Packard
HPGL	Hewlett-Packard Graphics Language
IAB	Internet Activities Board
IBM	International Business Machines
IDTS	Intelligent Document Tracking System
I&E	Inspection and Evaluation
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IEF	Information Engineering Facility
IEW	Information Engineering Workbench
IGES	Initial Graphics Exchange Specification
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
LAN	Local Area Network
MIT	Massachusetts Institute of Technology
MS	Microsoft
NACHA	National Automated Clearinghouse Association
NFS	Network File System
NIST	National Institute for Standards and Technology
NTP	Network Time Protocol
ONC	Open Network Computing
OREIS	Oak Ridge Environmental Information System
ORFICN	Oak Ridge Federal Integrated Communications Network
ORNL	Oak Ridge National Laboratory
OS	Operating System
OSF	Open Software Foundation
OSI	Open Systems Interconnection

PC	Personal Computer
PCL	Printer Control Language
PI&A	Program Integration and Administration
POP	Post Office Protocol
POSIX	Portable Operating System Interface for Computer Environment
PPP	Point-to-Point Protocol
RCP	Remote Copy Protocol
RISC	Reduced Instruction Set Computer
RMON	Remote Monitoring MIB
RPC	Remote Procedure Call
SCODL	Object Description Language
SDTS	Spatial Data Transfer System
SGML	Standard Generalized Markup Language
SLIP	Serial Line Internet Protocol
SMTP	Simple Mail Transport Protocol
SNMP	Simple Network Management Protocol
SQL	Software Query Language
SSN	System Select Network
STEP	Standard for the Exchange of Product Data
SURAnet	Southeastern Universities Research Association Network
SWP	Standard Wiring Plan
TAC	Technical Advisory Council
3GL	Third Generation Language
TARGA	TrueVision Raster Graphics Array
TAS	Energy Systems Technical Architecture Specification
TCP	Transmission Control Protocol
TI	Texas Instruments
TIFF	Tagged Image File Format
UID	User Identification
UISRM	User Interface System Reference Model
USSS	User Services and Systems Support
VCGO	Vector C Graphic Objects

 

EXECUTIVE SUMMARY

This third volume of the *Information Management Architecture for an Integrated Computing Environment for the Environmental Restoration Program*—the Interim Technical Architecture (TA) (referred to throughout the remainder of this document as the ER TA)—represents a key milestone in establishing a coordinated information management environment in which information initiatives can be pursued with the confidence that redundancy and inconsistencies will be held to a minimum. This architecture is intended to be used as a reference by anyone whose responsibilities include the acquisition or development of information technology for use by the ER Program.

The interim ER TA provides technical guidance at three levels. At the highest level, the technical architecture provides an overall *computing philosophy* or direction. At this level, the guidance does not address specific technologies or products but addresses more general concepts, such as the use of open systems, modular architectures, graphical user interfaces, and architecture-based development. At the next level, the technical architecture provides *specific information technology recommendations* regarding a wide variety of specific technologies. These technologies include computing hardware, operating systems, communications software, database management software, application development software, and personal productivity software, among others. These recommendations range from the adoption of specific industry or Martin Marietta Energy Systems, Inc. (Energy Systems) standards to the specification of individual products. At the third level, the architecture provides guidance regarding *implementation strategies* for the recommended technologies that can be applied to individual projects and to the ER Program as a whole.

A significant omission in this interim document is a set of recommendations regarding the distribution of specific information resources, such as application systems and databases, to various computing systems. For example, no analysis has been made regarding the potential for a records management system that could share common hardware or database management systems with other administrative systems, such as the Management Control Information System. This omission is due to the absence of a strategic plan within ER for its application systems. While existing systems could have been used as the basis of such an analysis, the results would have been excessively influenced by each system's history rather than by the ER Program's current strategic direction.

Another significant omission in this interim document is an adequate treatment of the Portsmouth and Paducah sites. Additional work is required to ensure that the architecture provides adequately for interoperability among systems at all sites and for the portability of common systems among the sites.

The above issues should be addressed in a future update to the architecture.

Some of the most significant recommendations put forward by this document are summarized below:

- An architecture-driven information management environment should be created, with appropriate review processes in place.

- The ER Program's information management environment should be an open system, distributed environment using graphical user interfaces as the primary means of user access.
- ER personnel and support staff should access ER information from industry standard workstations, such as Microsoft (MS) DOS/Windows systems and X-Window-capable devices.
- While Banyan VINES is currently the recommended local area network (LAN) operating system, a reassessment of currently available technology (including Novell NetWare and Microsoft Windows NT) should be conducted by Energy Systems.
- The software development environment should use the Information Engineering methodology, standardizing on Texas Instrument's Information Engineering Facility for information systems planning and analysis.
- In general, the use of products compliant with the Open Software Foundation Distributed Computing Environment is encouraged as these products become widely adopted.
- The ER Program should actively support the installation of a fiber optic trunk system at the Oak Ridge K-25 Site.
- ER personnel and support staff should be provided with Ethernet network access, eliminating the use of the existing system select network as quickly as possible.
- The ER Program should consider a gradual migration to LAN-based electronic mail (such as Eudora) as this technology matures; however, there is no compelling need for a hurried transition.
- The Transmission Control Protocol/Internet Protocol suite should be the network protocol of choice for use within the ER Program.
- In general, the ER Program should continue to benefit from standardization of Energy Systems-supported personal computer hardware and software.
- The ER Program should use available support organizations, wherever possible, to manage its computing infrastructure, allowing ER personnel to focus on the primary mission of environmental restoration.
- Program-level procedures should be developed for the management of ER-owned computer systems and networks. Support organizations such as Computing and Telecommunications Services (C&TS) should be used for this function where possible. Regardless of the source of the system or network management, compliance with ER procedures should be required.

1. INTRODUCTION

1.1 PURPOSE

This *Information Management Architecture for an Integrated Computing Environment for the Environmental Restoration Program—Volume 3. Interim Technical Architecture* [referred to herein as the interim Environmental Restoration Technical Architecture (ER TA)] is intended to provide a framework within which ER project teams and management can make decisions relative to the acquisition and deployment of information technology in support of program activities. Because a cohesive set of recommended technologies and products for use within the ER Program at Martin Marietta Energy Systems, Inc. (Energy Systems) has been defined in this document, project teams are relieved of having to perform individual evaluations in these areas; support organizations can focus their resources toward maintaining required skills in a minimal set of technologies; and ER management can feel confident that resources—such as computer systems, operating systems (OSs), database management systems (DBMSs), and networks—are being acquired and used in a consistent, coordinated, and cost-effective manner. The implementation of such an architecture is a necessary step toward ensuring that the business systems or applications developed by individual projects can work together in a coordinated, nonredundant manner.

Additionally, the ER TA provides a basis for preparing technical requirement specifications for subcontract information technology resources, such as computing hardware, applications software, and network components.

1.2 DESIGN GOALS AND CONSIDERATIONS

A primary goal of the ER TA is not to over-restrict a project's technical options but rather to support the needs of individual ER projects in a manner that offers attractive solutions to common project problems. The primary objective of a remedial action or decontamination and decommissioning (D&D) project should focus on environmental restoration, not information management. This objective is enhanced to the extent that the ER TA can help individual projects reduce the amount of time, money, and effort expended to make effective decisions regarding information technology acquisition and usage. Individual sites and projects can also benefit from the existence of ER Program-wide initiatives for information infrastructure (such as intra-site network upgrades) that they would be unable to identify and justify individually.

ER Program management has an additional goal of achieving sufficient consistency across projects to allow for the re-use of technical facilities, software systems, data, and project personnel with as little waste as possible. Often, project-level information must be summarized for additional analysis or reporting at the site or program levels; this summary is greatly facilitated by the use of common systems, data structures, conventions, and technical facilities.

However, management also looks to foster innovation and use of industry "best practices." Balancing innovation with standardization requires a controlled environment in which "standard" approaches are documented and available for comparison with alternative

proposals. The ER TA seeks to satisfy these management needs without overly constraining specific sites or projects.

Implied in these two primary goals is a recognition of the need to support the demands of other ER Program stakeholders, including the Department of Energy (DOE); local, state and federal regulatory agencies; the public; and other ER Program contractors in an effective, cost-efficient manner.

1.3 SCOPE

The ER TA is to be applied equally to technology purchased and technology developed, internally or under subcontract.

The ER TA is intended to address all programs, sites, and projects overseen directly or indirectly by the Energy Systems ER Program. This includes both remedial action projects and D&D projects, as well as projects supporting program administration functions such as document management and risk assessment.

The architecture is also intended to address all facilities currently managed by the Energy Systems ER Program, including the Oak Ridge Reservation and facilities at the Paducah Gaseous Diffusion Plant and the Portsmouth site.

The architecture must, however, be sensitive to the fact that Energy Systems does not control the technical infrastructure at the Portsmouth and Paducah sites and, thus, must work within the existing environment at those sites. Nonetheless, it is critical that, where appropriate, ER Program activities at these sites be able to use common systems to interface with site-specific systems and supply required information consistent with accepted standards.

It should be noted that the Portsmouth and Paducah sites have *not* yet been addressed to the same extent as the Oak Ridge sites by this architecture. Further analysis is required to fully assess any additions or modifications to the architecture that would be required to adequately address these sites.

1.4 TECHNICAL GUIDANCE STRUCTURE

This ER TA, in this interim release, provides technical guidance at three levels: (1) an overall computing philosophy, (2) specific information technology recommendations, and (3) implementation strategies. The type of guidance presented at each level is described below, and specific recommendations for each level are presented in Chaps. 3, 4, and 5, respectively.

At the highest level, the technical architecture provides an overall *computing philosophy* or direction. Given the rate of change in both information technology and the ER business, it is important to have a stable foundation upon which to base technical decisions. The technical architecture provides this foundation, with consistent direction, and provides the flexibility to allow for the smooth and coordinated adoption of new technologies required to keep up with a changing environment. At this level, the guidance does not address specific technologies or products but more general concepts, such as the use of open systems, modular

architectures, graphical user interfaces (GUIs), and architecture-based development. Although guidance at this level should be more stable than at lower levels, an annual review of the computing philosophy is recommended.

At the next level, the technical architecture provides *specific information technology recommendations* regarding a wide variety of specific technologies. This type of guidance is referred to as a *information technology reference*. These recommendations range from the adoption of specific industry or Energy Systems standards to the specification of individual products. By specifying a consistent set of standards and products, the architecture simplifies the task of selecting specific computing tools at the individual project level. Recommendations at this level are expected to be more dynamic than the more general philosophical recommendations described above; therefore, an annual review is strongly recommended.

At the third level, the architecture provides guidance regarding *implementation strategies* for the recommended technologies that can be applied to both individual projects and the ER Program as a whole. Recommendations at this level address such areas as data communications infrastructure, desktop workstation selection, and strategies for the appropriate distribution of both applications and data. Whereas the technology references of the previous level might recommend the use of a specific network operating system on file servers, the *technology implementation strategies* would address how and when to use file servers. This type of guidance tends to be more stable but should be reviewed upon the design of new business systems or upon the major upgrade of existing systems.

When the ER Program has had an opportunity to develop an overall strategic plan for the business systems or software applications required to support the program, future revisions of the ER TA can provide more specific recommendations as to the technical direction of individual business systems. For example, as a business system architecture takes shape to define the functionality, interface requirements, and user community of individual business systems, the ER TA can be expanded to address in more detail such issues as the desired distribution of specific resources (database servers, applications servers, file and print servers) and the required networking infrastructure. This type of guidance should be reviewed with each new system design or significant upgrade of an existing system.

It should be noted that the design for individual projects occurs today in the absence of any guiding architectures. The value added by the existence of an architecture is the ability to look at the planned business system environment as a whole and, where appropriate, include the interoperability among the various business systems and shared information resources (such as networking, common site servers, and common workstation environments) in all project plans. Individual projects seldom are allowed the luxury of adopting this broad perspective as they struggle to meet aggressive deadlines. In addition to the benefits that may be realized from a higher degree of coordination, the maintenance and use of a technical architecture can significantly reduce the sheer cost of technology evaluation and selection at all project and management levels.

1.5 CURRENT BUSINESS ENVIRONMENT

The Energy Systems ER Program currently consists of formerly independent groups that have recently been shifting, organizationally, toward a more consolidated unit. Responsibility for remedial action projects continues to be distinct from that for facility D&D. Groups at

each of the five sites for which the ER Program has responsibility have traditionally operated in a very autonomous manner.

This mix of independent groups exhibits itself not only in varied approaches to, and procedures for, doing business, but also in varied system designs employed to support various aspects of the ER Program. Each group, subgroup, or project typically has had the responsibility and authority to identify its own system needs and acquire desired information technology from a variety of Energy Systems and subcontractor sources.

Information management is an inherent part of each ER project, whether remedial action or D&D. Information about contaminated sites or facilities must be collected, organized, analyzed, stored for future use, reported, and often shared with other groups. Outside the actual projects, there is a strong need for rigorous budgeting and cost accounting, records management, risk assessment, and project prioritization. In lieu of having existing information systems available to support these needs, each project team or administrative support group is faced with the need to develop or otherwise acquire its own solutions, which often includes not only the application software, but complete computing systems (processors, local networks and associated system software).

Project teams have responded to this challenge in ways that are individually effective, but that when viewed as a whole, have sometimes produced redundant or incompatible systems, deploying a variety of tools and technologies that require a growing amount of ongoing support. These support requirements have the potential for placing a growing financial burden on the ER Program, as well as taxing the abilities of internal support organizations to maintain expertise in diverse technologies.

The situation is complicated by the fact that ER uses a wide variety of information technology providers. These providers include C&TS, the Data Systems Research and Development group (DSRD), the Oak Ridge National Laboratory (ORNL) Computing Applications Department (CAD), the ORNL Environmental Sciences Division, and numerous subcontractors. At best, each of these sources of support complies with their own internal standards or preferences regarding the use of specific products or technologies. This situation alone leads to a sometimes unjustified mix of approaches. Additionally, these groups often respond directly to project-specific requirements, requests, or personal preferences and implement an excessively varied mix of redundant or incompatible technologies.

Several initiatives over the last few years have been aimed at rectifying this situation. The Oak Ridge Environmental Information System (OREIS) has been established as the single official repository of environmental data managed by the ER Program. Additionally, despite pressing deadlines, several projects have recognized the need for greater consistency and commonality within their information support environments and have taken action in that direction. Examples of such teaming include the joint efforts of the Waste Area Group (WAG) 6 and Clinch River Remedial Investigation (CRRI) projects. Additional efforts—such as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process mapping initiative—are aimed at promoting greater consistency in the business practices within the ER Program. Organizational initiatives, such as the formation of the Program Integration and Administration (PI&A) organization, are other indications of a recognition of the need for greater coordination among ER-sponsored projects.

Given the relative youth of the ER Program, there is a significant opportunity for introducing a degree of coordination and consistency before an excessive amount of money is invested in redundant or incompatible technical facilities. Despite the recognition of a need for increased coordination of information management activities within the ER Program and the willingness of most ER personnel to work toward common solutions to common problems, the lack of an overall blueprint or target environment has remained a substantial barrier toward progress on this front. Filling this void is the primary reason for the development of this interim ER TA.

This interim ER TA can provide a necessary step toward bringing more order to the computing environment, reducing redundancy, reducing efforts required to provide connectivity "after the fact," and reducing support costs inflated by the need to support multiple overlapping technologies and the bridges between them. As with all initiatives for change, the first step is recognition of the need. This step has been taken. Next, a vision must be developed describing the desired information infrastructure. This interim technical architecture represents the first cut at describing such a vision. But for the vision to be realized, implementation plans must be developed and executed. This is the challenge that remains.

2. ENVIRONMENTAL RESTORATION TECHNICAL ARCHITECTURE IMPLEMENTATION AND CONFIGURATION CONTROL

To have an impact on the computing environment within the ER Program, the interim ER TA must be supported by management systems geared to ensuring that the desired degree of compliance is achieved. Additionally, certain technology initiatives that benefit all areas (such as the K-25 Site Fiber Optic Backbone) are recommended by this document, even though they are not specific to a particular program or project. Sponsorship of these initiatives should originate from these same management systems.

Configuration control of the interim ER TA is another area that must be supported by this management infrastructure. The architecture will require periodic review and update based on changes in the needs of the ER Program and advances in computing technology. Additionally, a growing level of experience using the recommended technologies will undoubtedly reveal weaknesses that should be addressed by future revisions. Configuration control mechanisms that actively seek and respond to proposals for revisions to the architecture should be implemented.

A detailed discussion of these topics and a proposed strawman management structure are presented in Chap. 4 of the *Information Management Architecture for an Integrated Computing Environment for the Environmental Restoration Program, Volume 1. Introduction* (ES/ER/TM-120/V1).

3. ENVIRONMENTAL RESTORATION COMPUTING PHILOSOPHY

3.1 PREFERRED ARCHITECTURE

The preferred architecture for information technologies acquired, deployed, and used in support of the ER Program is an *open, three-tiered, client-server* architecture. This architecture has the functionality needed to provide interoperability, scalability, and portability of computer-based applications across networks of heterogeneous hardware, software, and communications platforms. These key industry concepts can be summarized as follows:

Interoperability—Applications operating on the same or different platforms can communicate, exchange data, share common databases, or share a common service function (such as data management) without having to be significantly modified.

Scalability—An application can operate without extensive modification on multiple tiers of one or more vendor's product lines or representative platform classes, including mainframes, department computers, workstations, and personal computers.

Portability—An application can operate without significant modification across multiple heterogeneous (different vendor or class) platforms.

3.2 OPEN SYSTEMS

Open Systems, in this context, is a difficult term to rigorously define. To some, open systems are those that comply with *formal* standards—those freely available, documented specifications sanctioned by recognized standards bodies such as the National Institute for Standards and Technologies (NIST). Others include systems that comply with *de facto* standards, or standards resulting from a high degree of market acceptance and usage. This architecture, while supporting formal standardization initiatives, adopts the latter definition. When assessing the degree of openness exhibited by a particular product or technology, the basic intent of openness must be kept in mind. Openness strives first and foremost to facilitate interoperability or to allow users of information technology to choose from the widest possible selection of products with a high level of confidence that the resulting product mix will work well together. This is the result desired; whether it is achieved by formal or *de facto* standards is less critical.

Portability is another highly desirable result of adopting an open architecture. Through a focus on compliance with standards, software applications can operate on a wide variety of platforms from a variety of vendors. This type of portability protects the user from vendor

lock-in and allows the use of the most cost-effective systems, even as new technology is introduced.

3.3 CLIENT-SERVER ARCHITECTURE

A *client-server architecture* is characterized by a highly modular design. Applications and system services are divided into discrete components, each with a well-defined interface. These individual components or functions can then be allocated to relatively specialized hardware platforms, which are in turn connected by a high-speed network infrastructure. *Client* modules (or processes) communicate predefined types of requests to *server* processes, which in turn perform the requested function and typically return the results to the appropriate client process. The client-server relationship is shown in Fig. 1.

Fig. 1. Client-server interaction.

Encapsulating individual functions in this way has two primary benefits. First of all, each individual function can be allocated to a hardware platform that provides the best support for that function. Furthermore, since the interfaces are well defined, the most cost-effective software products can be chosen from multiple vendors' offerings with the assurance that the products will operate in a functionally equivalent manner. Scalability is enhanced—since performance bottlenecks can be addressed by upgrading individual components of the overall system independent of other components—and often with a smaller fiscal impact.

A typical example of this design is the use of a database server—which is located on a processor optimized for storing and accessing large volumes of data—in conjunction with an ad hoc query application—which is located on a user's desktop personal computer optimized for a highly intuitive user interface. Other examples of typical server functions include compute servers (supercomputers used to process complex modeling algorithms); print servers (used to manage high-quality, high-cost output equipment); and file servers (used to manage large volumes of shared files).

3.4 THREE-TIER ARCHITECTURE

In general, the client-server architecture is characterized by *pairs* of communicating processes. The recognition that there exists a large installed base of mission-critical, host-based applications leads to the introduction of a third level to the architecture—thus the *three-tier* approach. In a three-tier client-server architecture, there are conceptually three levels (or tiers) within the computing environment, as shown in Fig. 2:

Fig. 2. Representative three-tier architecture.

- **Tier 1 (Workstation or Client level):** The Tier 1 component of the architecture focuses on the person requesting some form of service. (User access typically, but not always, involves an intelligent workstation and a GUI. This interface provides a "window" into the information resource infrastructure and convenient, consistent mechanisms for accessing the infrastructure.) The interface allows the user to access a variety of applications and service functions (such as data management, electronic mail, and information query) via a convenient window environment that can easily be adapted to the unique needs and preferences of the user.
- **Tier 2 (Server level):** The Tier 2 component of the architecture includes all of the computing platforms that communicate with various clients via a network and respond to client requests for services. When the client software needs information or a service it cannot satisfy itself, it uses the network to communicate with one or more servers that can meet the need. These server functions often reside on dedicated platforms and are able to serve multiple clients simultaneously. Typically, the user is not aware of the calls and navigation instructions issued throughout the information technology infrastructure in response to commands issued at the client level. The system takes care of these calls automatically. This is a basic requirement for providing the appearance of logical or virtual connectivity in an environment characterized by extensive legacy resources and heterogeneous systems.
- **Tier 3 (Host level):** The Tier 3 component of the architecture, which may not be relevant in some environments, often includes mainframe and department computers. These are used as data warehouses, support platforms for major transaction-oriented production applications, and support platforms for proprietary systems that cannot be easily integrated into a fully distributed, networked infrastructure. The hub or gateway server concept allows these legacy resources to coexist in a beneficial way by providing a linkage from the client tier to the host tier (through the server tier).

4. INFORMATION TECHNOLOGY REFERENCE

4.1 INTRODUCTION

This chapter describes the reference model used by the ER TA to organize and present information technology recommendations. Section 4.2 presents the ER TA reference model recommendations in the form of a matrix. (See Fig. 3.)

ER Technology Reference			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Service Area	Service Area Breakout	Current ER					
		TAS					
		ER Preferred					

Fig. 3. Environmental Restoration Technical Architecture reference summary format.

The matrix components (service areas, elements, status, and tiers) are introduced in Sects. 4.1.1 and 4.1.2. A detailed discussion of each service area—covering the current situation within the ER Program, the recommendations of the Energy Systems Technical Architecture Specification (TAS) regarding the service area, and recommendations for the ER Program—is then presented in the remainder of this chapter (in Sects. 4.3–4.12).

4.1.1 Environmental Restoration Technical Architecture Service Areas

The ER TA reference model is similar in structure to the Energy Systems TAS, which in turn is based upon the Open Software Foundation's (OSF's) Distributed Computing Environment (DCE) and the NIST Application Portability/Open Systems Environment Profile. The model is based on several interdependent components called services. These service areas are listed below and described in more detail in Sects. 4.3 through 4.12.

- Operating System (OS) Services (Sect. 4.3),
- Human/Computer Interaction Services (Sect. 4.4),
- Applications Development and Maintenance Services (Sect. 4.5),
- Data Management Services (Sect. 4.6),
- Electronic Mail Services (Sect. 4.7),
- Network Services (Sect. 4.8),
- Security Services (Sect. 4.9),
- Data Interchange Services (Sect. 4.10),
- Output Services (Sect. 4.11), and
- Desktop Tools (Sect. 4.12).

Some of these service areas are further divided into subordinate levels called *elements*. The element breakout is necessary to provide meaningful guidance in instances where products or standards relate to more than one aspect of a service area.

Each horizontal row also includes a *status* indicator for each service area. Where a service area is further divided into elements, there are a status indicators for each element. The status indicators are *Current ER*, *TAS*, and *ER Preferred*. These are defined as follows:

- *Current ER*: This status indicator relates to products or technologies that are presently in use within the ER Program.
- *TAS*: This indicator designates products or technologies that are preferred within Energy Systems. The use of these items will contribute to the orderly migration of the Energy Systems information technology infrastructure toward the company's overall information environment vision objectives. Moreover, the selection of items recommended by the TAS will ensure the user has available sound technical support. In most instances, the selection and use of these items will also save the user time and money.
- *ER Preferred*: This indicator designates those products or technologies that are preferred within the ER Program and, for the most part, enjoy technical support within Energy Systems. Recommendations made by the Energy Systems TAS have been modified, extended, or otherwise tailored, where required, to more effectively support the specific needs of the ER Program. Most deviations from the TAS recommendations are justified by the current widespread use of a technology by the ER Program.

NOTE: In order to ensure making a fully informed decision, a system designer will want to carefully examine the Energy Systems TAS target recommendations (available in the Technical Architecture Specification document, ES/ESH-40), as well as the "TAS" and "Preferred ER" categories in this document. There might be instances when the prudent course of action would be to wait or perhaps to design a minimal system pending the acquisition of a target product or technology, the availability of which is imminent.

4.1.2 Environmental Restoration Technical Architecture Tiers

The vertical components of the matrix are organized into *tiers*. Each tier represents a component of the preferred distributed computing configuration. Tier 1 represents the workstation or client level. Tier 2 represents the server level. And Tier 3 represents the host level, as described in Sect. 3.4.

Within the ER TA, Tier 1 is further subdivided into three classes: UNIX workstations, Personal Computers (PCs), and Macintoshes. While these terms admittedly mix the concepts of hardware architecture, OS, and even vendor, their use is sufficiently common throughout the industry to warrant their use herein. In general, the term *UNIX workstation* refers to a Reduced Instruction Set Computer (RISC)-based personal workstation. "PC" as used herein refers to Intel-based systems, and "Macintosh" refers to the Macintosh line of computers marketed by Apple.

The intersections of the tiers and service rows of the matrix create the matrix cells that contain the various standards, products, and technology options. When multiple items are shown in a cell, there is no significance suggested their order or arrangement. The supporting text should be consulted for additional information.

4.2 ENVIRONMENTAL RESTORATION TECHNOLOGY REFERENCE SUMMARY

The ER TA recommendations are presented in summary form in Table 1 on the following ten pages. A detailed discussion of each service area—covering the current situation within the ER Program, the recommendations of the Energy Systems TAS regarding the service area, and recommendations for the ER Program—then follows in Sects. 4.3–4.12.

4.3 OPERATING SYSTEM SERVICES

OSs provide the core services needed to execute and administer application systems running on computing platforms. These systems also provide an interface between applications software and the computing platform. OS services include the subcomponent functions of kernel operations, including program execution and file and directory management; system administration commands and utilities (such as resource accounting and command scripts); real-time extension to support application domains requiring deterministic execution, processing, and responsiveness; and system management, which includes authorization of resource usage, configuration and performance management of devices, and system backup.

As described in the TAS, the Portable Operating System Interface for Computer Environment (POSIX) interface standards defined in FIPS PUB 151-2 are the accepted standards for the OS service area. OSs are measured against these standards in order to determine to what degree they are POSIX compliant. This measurement of POSIX compliance indicates the openness of an OS's environment.

Current ER Environment

Tier 1 UNIX is the current OS used by ER on the UNIX workstations. The Intelligent Document Tracking System (IDTS) is an example of an ER information management system that operates under UNIX.

The current environment for PCs within ER supports DOS, Windows, and NeXT OSs.

Macintosh OS (System 7) is the current OS used by ER on the Macintosh.

NOTE: See Appendix A, Current Environmental Restoration Desktop Computing Environment, for current environment survey results for ER.

Tier 2 The current Tier 2 server level within ER supports UNIX and Banyan VINES network OS. Information systems such as OREIS, WAG 6/CRRI, and the Management Control Information System use UNIX. The Document Management System uses Banyan VINES network OS.

Tier 3 DEC's ALL-IN-1 electronic messaging product runs on the VAX using the VMS OS. However, there are no ER applications currently supported on Tier 3 platforms.

Table 1. Environmental Restoration technology reference summary

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Operating System Services (4.3)		Current ER	UNIX	DOS, Windows, NeXT	Macintosh OS (System 7)	UNIX, VINES NOS	VMs
		TAS	POSIX Compliance	Windows, OS/2	Macintosh OS, A/UX	POSIX Compliance	
		ER Preferred	UNIX	Windows, OS/2	Macintosh OS, A/UX	UNIX, LAN OS	
Human/Computer Interaction Service (4.4)	Client-Server Operations	Current ER	X Window System	eXceed/W, PMX	None		
		TAS	X Window System Compliance	X Window System Emulators (tbd)	X Window System Emulators (tbd)		
		ER Preferred	X Window System	eXceed/W, PMX	MacX		
	Window Management	Current ER	Motif, Open Look	Windows	Macintosh		
		TAS	Motif Look & Feel	Windows, OS/2 Presentation Manager	Macintosh		
		ER Preferred	Motif/CDE Look & Feel	Windows, ? Presentation Manager	Macintosh		
Application Development and Maintenance Services (4.5)	CASE Tools	Current ER	None	IEF	None	ORACLE CASE	None
		TAS	IEF	IEF			
		ER Preferred	IEF	IEF			
	Applications Generators & 4GLs	Current ER	None	None	None	None	None
		TAS	UNIFACE, PowerBuilder	UNIFACE, PowerBuilder			
		ER Preferred	UNIFACE, PowerBuilder	UNIFACE, PowerBuilder			

Table 1 (continued)

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Application Development and Maintenance Services (4.5) (Continued)	Other Tools	Current ER	None	SYBASE APT Workbench, ORACLE SQL*Forms, FoxPro, dBASE	None	None	None
		TAS	In the absence of mature standards, the target strategy will be to employ tools that support TAS portability objectives and other TAS target standards/preferred products.				
		ER Preferred	SYBASE APT Workbench, ORACLE SQL*Forms				
	Distributed Computing Tools	Current ER	Berkeley Sockets and ONC/RPC-Based Tools				
		TAS	Compliance with OSF DCE API, OSF DCE RPC, OSF DCE Threads Service				
		ER Preferred	Compliance with OSF DCE API, OSF DCE RPC, OSF DCE Threads Service				
	Compilers	Current ER	FORTRAN, COBOL, C				
		TAS	ANSI/FIPS-Compliant Compilers for code generated with higher order tools, ANSI C, C++				
		ER Preferred	ANSI/FIPS-Compliant Compilers for code generated with higher order tools, ANSI C				

Table 1 (continued)

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Data Management Services (4.6)	Directory Services / Name Services	Current ER	None	None	None	DNS, Novell Bindery, Banyan VINES, StreetTalk	None
		TAS	DCE's Directory Service, StreetTalk, DNS, DECdss				
		ER Preferred	DCE's Directory Service, StreetTalk, DNS, DECdss				
	Data Dictionary / Repository	Current ER				ORACLE CASE	MSP, Data Manager, Design Manager, IEF
		TAS	TBD	TBD	TBD	TBD	IEF
		ER Preferred					IEF
	Database Management	Current ER	None	FoxPro, dBASE, Superbase, Informix	None	ORACLE, SYBASE	None
		TAS	ORACLE	FoxPro	FoxBASE	ORACLE (SYBASE, Informix)	DB2, IDMS, Rdb, SAS, ORACLE, Ingres, CA:DB
		ER Preferred	ORACLE	FoxPro	FoxBASE	ORACLE (SYBASE, Informix)	DB2, IDMS, Rdb, SAS, ORACLE, Ingres, CA:DB
Electronic Mail Services (4.7)	User Agents	Current ER	UNIX Mail	SmartTerm	VersaTerm	ALL-IN-1	ALL-IN-1
		TAS	TBD	Sharkmail, Eudora	VINES, Eudora	--	--
		ER Preferred	TBD	Sharkmail, Eudora	VINES, Eudora	--	--
	Transport and Store Agents	Current ER				VINES, UNIX Mail	ALL-IN-1
		TAS				SMTP Compliance	
		ER Preferred				SMTP Compliance	

Table 1 (continued)

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Network Services (4.8)	Transmission Media	Current ER	Standard Wiring Plan, Non-standard Twisted-Pair Wiring				Point-to-Point Fiber and T-1
		TAS	Standard Wiring Plan --> Fiber, as required				Fiber (Star Wired)
		ER Preferred	Standard Wiring Plan --> Fiber, as required				Fiber (Star Wired)
	Data Link Services	Current ER	SSN, Ethernet			Ethernet	SSN, Ethernet
		TAS	802.3 Ethernet, 802.5 Token Ring, FDDI			Ethernet 2, FDDI, 802.3 Ethernet	FDDI
		ER Preferred	802.3 Ethernet, FDDI				
	Data Communications	Current ER	SSN Operating System, TCP/IP, Banyan VINES, Appletalk				
		TAS	TCP/IP				
		ER Preferred	TCP/IP, Appletalk				

Table 1 (continued)

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Network Services (4.8) (Continued)	File Services	Current ER	NFS				
		TAS	AFS → DCE: DFS				
		ER Preferred	AFS → DCE: DFS				
	Network Management	Current ER	SNMP Compliance				
		TAS	SNMP Compliance				
		ER Preferred	SNMP Compliance				
	Time Services	Current ER	NTP				
		TAS	NTP → DCE: DTS				
		ER Preferred	NTP				

Table 1 (continued)

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Network Services (4.8) (Continued)	Electronic Mail Interchange	Current ER	ALL-IN-1 (host based)				
		TAS	Internet, X.400 Compliance				
		ER Preferred	Internet, X.400, POP Server, Banyan VINES				
	External Connectivity	Current ER	Dial-in Modem, Internet, Point-to-Point Leased Line, FTS-2000				
		TAS	Not addressed				
		ER Preferred	Dial-in-Modem, ISDN, Internet, Point-to-Point Leased Line, FTS-2000				
Security Services (4.9)		Current ER	Native security systems for nodes, Daemon for dial-in network security				
		TAS	Full C2 capabilities for nodes; Daemon, Kerberos, DCE Security Services for networks				
		ER Preferred	Full C2 capabilities for nodes; Daemon, native security systems for networks (until Energy Systems Kerberos is implemented)				

Table 1 (continued)

ER Technology Reference (8/94)			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Data Interchange Services (4.10)	Document/Text	Current ER	ASCII, WordPerfect, Microsoft Word, ALL-IN-1				
		TAS	ASCII, WordPerfect, Word				
		ER Preferred	Target SOML-compliant software: ASCII, WordPerfect, Microsoft Word, ALL-IN-1				
	Hypermedia/Multimedia	Current ER	No products are currently being used for hypermedia/multimedia				
		TAS	None	Hypertalk	Hypertalk	None	None
		ER Preferred	Hytime and Hypertalk				
	Raster Graphics	Current ER	TIFF, CGM, HDF, EPS, GIF	TIFF, TARGA, GIF, EPS	TIFF, EPS, PICT, HDF, GIF	TIFF, HDF, EPS	None
		TAS	TIFF, CGM, HDF, EPS	TIFF, TARGA, GIF, EPS	TIFF, EPS, PICT, HDF	TIFF, HDF, EPS	None
		ER Preferred	(target) TIFF, GIF, HDF, EPS				
							TIFF with CCITT Group IV compression algorithms

Table 1 (continued)

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Data Interchange Services (4.10) (Continued)	Tabular Data Exchange	Current ER	Tabular ASCII Data and Export				
		TAS					
		ER Preferred	Tabular ASCII Data and Export				
	Vector Graphics	Current ER	HPGL, CGM, VCGL, Calcomp's HLBS; can do import/export of HPGL and CGM				
		TAS	HPGL → CGM Compliance				
		ER Preferred	HPGL → CGM Compliance				
	Product	Current ER	DXF, Export, IGDS				
		TAS	IGES → STEP, SQML Compliance				
		ER Preferred	DXF, Export, IGDS				
	Electronic Data Interchange (EDI)	Current ER					
		TAS	None	In-House	None	DOE Auto. Transp. Mgt. System	None
		ER Preferred					

Table 1 (continued)

ER Technology Reference (8/94)			TIER 1			TIER 2	TIER 3	
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST	
Data Interchange Services (4.10) (Continued)	Electronic Funds Transfer (EFT)	Current ER						
		TAS	None	In-House ACH format	None	None	In-House ACH format	
		ER Preferred						
	Geographic Information	Current ER	ARC/INFO, MapInfo, Intergraph, AutoCAD native formats					
		TAS						
		ER Preferred	ARC/INFO format (vector), ERDAS 7.1 Jan format (raster); SDTS as tools become available					
Output Services (4.11)	Page Description Format	Current ER	HP PCL					
		TAS	Postscript Compliance					
		ER Preferred	HP PCL					
	Raster Graphics Format	Current ER	TARGA, TIFF	TARGA, TIFFs, SCODL, Xbitmap	PICT			
		TAS	TARGA Compliance					
		ER Preferred	TARGA Compliance					

Table 1 (continued)

<i>ER Technology Reference (8/94)</i>			TIER 1			TIER 2	TIER 3
SERVICE AREA	ELEMENT	STATUS	UNIX WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST
Output Services (4.11) (Continued)	Vector Graphics Format	Current ER	HPGL Compliance				
		TAS	HPGL Compliance				
		ER Preferred	HPGL Compliance				
Desktop Tools (4.12)		Current ER	See Appendix A: Current ER Desktop Computing Environment				
		TAS					
		ER Preferred	See Energy Systems supported and recommended PC hardware and software lists on VTX.				

TAS Recommendations

- Tier 1** The TAS recommendation for the UNIX workstation is an OS that is fully POSIX compliant.
- The current strategy for the PC is OS/2 and Windows. However, DOS must be factored into all planning decisions due to the existing significant investment in this product. The TAS states that the target environment will be determined by an Energy Systems evaluation team as 32-bit OS technology evolves.
- The current strategy for the Macintosh is Macintosh OS and Apple/UNIX (A/UX). The target environment will be determined by an Energy Systems evaluation team as 32-bit OS technology evolves.
- Tier 2** The TAS recommendation for the server level is a POSIX-compliant version of the UNIX-based OS.
- Tier 3** Since the long-term objective is migration to a two-tier environment, there is no recommendation to change the current OSs at this level.

Recommendations for ER

- Tier 1** Until a fully POSIX-compliant OS becomes available, the recommendation is the continued use of UNIX on UNIX-based workstations.
- In support of the TAS, the recommendation is the use of Windows and OS/2 OSs on PCs.
- Until a fully POSIX-compliant OS is available on the Macintosh, the recommendation is the use of Macintosh OS and A/UX.
- Tier 2** Until a fully POSIX-compliant version of the UNIX-based OS is available, the recommendation is the continued use of UNIX on the Tier 2 server level.
- LAN OS (Banyan VINES and Novell NetWare) servers are recommended for use in a PC-based network environment for functions such as file printing and sharing and electronic messaging.
- Tier 3** In keeping with the TAS recommendation and the long-term objective of migration to a two-tier environment, there is no recommendation to change the current OSs at this level.

4.4 HUMAN/COMPUTER INTERACTION SERVICES

Human/Computer Interaction Services define how people can interact with computer applications, often referred to as the *user interface*. The two principle varieties of user interfaces are character-based interfaces and graphical user interfaces (GUIs).

A character-based user interface typically involves a display screen and a keyboard; each application is manipulated via keyboard responses to displayed command prompts. The principle components of a GUI are a display screen containing one or more windows or panels; a keyboard; a pointing device such as a mouse, trackball, or touch screen; and a set

of graphical objects on the screen that can be directly manipulated by the user through the pointing device or through keyboard responses.

Depending on the capabilities required by the user and the application, an application's user interface may include client/server operations and window management.

4.4.1 Client/Server Operations

Client/server operations define the interactions between client and server software processes, typically operating on separate computers within a network. In the context of human/computer interaction services, the process that controls each display unit is a server process (the *display server*), and the various application processes are clients who request that the server perform various display functions.

Using client/server techniques to provide human/computer interaction services is often called *distributed presentation*. Distributed presentation is typically used in several situations. One such situation is that in which the application demands a GUI yet also requires more computing or data handling capability than is available (or practical) on desktop platforms. In this case, distributed presentation allows the use of a desktop system—such as a personal workstation to provide the required GUI—in conjunction with more powerful (and expensive) servers for the bulk of the application.

Distributed presentation is also desirable for applications that require the capability for widespread access without the maintenance of separate versions of the application for separate desktop platforms. With the use of standard client software, users can be provided access to such systems via a wide range of desktop platforms and network connections. Other factors that might lead a designer to choose distributed presentation include software distribution or licensing issues and configuration control concerns.

Currently, the only formal standards definition effort in this area is the NIST-sponsored User Interface System Reference Model (UISRM), a seven-layer model developed by NIST and based on the Massachusetts Institute of Technology (MIT) X Window System. Practically speaking, the X Window System itself is today's *de facto* standard, both within Energy Systems and in the industry at large.

Current ER Environment

Tier 1 Currently, distributed presentation is used in several ER systems. These systems are primarily confined to the technical data collection and analysis functions, such as OREIS and the CRR and WAG 6 measurements data collection projects. These systems use the X Window System and are primarily accessed from Tier 1 UNIX clients or X terminals, where the native X Windows software inherent to that environment is used. Where accessed from PC environments, a variety of X Windows emulators are utilized, primarily the Hummingbird eXceed/W product for Microsoft Windows and the International Business Machine's (IBM's) PMX package for OS/2. There is no known use of X-Windows software on Macintosh systems within the ER Program.

Tiers 2&3 Not applicable.

TAS Recommendations

- Tier 1** The TAS recommends products implementing the X Window System for distributed presentation. X Windows compliance is standard on all approved Tier 1 UNIX clients. X Windows terminal emulation software is available for both PC and Macintosh systems. Recommendations for these products will be made by an Energy Systems evaluation committee and published via the list of company-recommended software. (See Appendix B.)

Tiers 2&3 Not applicable.

Recommendations for ER

- Tier 1** As described in the TAS, native X Windows products on UNIX workstations are preferred. For recommended X Windows emulation software for PCs and Macintosh systems, refer to the list of company recommended software. Until recommendations are made on this list, the Apple MacX product is recommended for the Macintosh; the Hummingbird eXceed/W product is recommended for PCs using MS Windows; and the IBM PMX product is recommended for the OS/2 environment. These recommendations are based on the current widespread satisfactory use of these products within the ER Program. Until recommendation to the contrary are published in either the list of company-recommended software or in future revisions of this document, continued use will leverage the existing level of experience with these products and minimize the need to develop the expertise required to support additional products.

Tiers 2&3 Not applicable.

4.4.2 Window Management

Window management describes the use of windows on a screen, including how the windows can be created, moved, stored, retrieved, and deleted and how they relate to each other.

A *window manager* is a program designed to manage windows (e.g., move, re-size, establish icons) and to provide a GUI with a particular behavior and appearance. The X Window System is not a complete GUI. Rather, it is a package of windowing, graphics, and event handling routines that forms the basis for several popular GUIs, such as OSF's Motif, SUN's Open Look, and DECwindows. Even though the X Window environment may be sufficient for many applications, it is usually complemented by a window manager. Different GUIs, even though based on the X Window System, can demonstrate different behavior and appearance because they employ different window managers and different programming interfaces.

The Institute of Electrical and Electronics Engineers, Inc. (IEEE), P1201.2 standard, which defines the drivability/usability of user interfaces (i.e., the general location of on-screen symbols and what happens when a mouse click is detected), is currently under development. Otherwise, the predominant standards in this area are *de facto* standards and include SUN's Open Look, OSF's Motif, Hewlett Packard's (HP's) Visual User Environment (VUE), Apple's Macintosh Style Guide, IBM's Common User Access (CUA)-based Presentation

Manager, and Microsoft's Windows. The recently formed Common Open Software Environment (COSE) consortium is in the process of developing the Common Desktop Environment (CDE), which is based on Motif. It is notable that SUN is a member of the COSE consortium and has committed to support CDE over its current Open Look. This change in direction by the industry's leading vendor promises increased consistency across UNIX window managers.

Current ER Environment

- Tier 1** Currently, many ER personnel use mostly character-based, non-windowed applications, typically accessed via terminal emulation from PCs using the Energy Systems System Select Network (SSN). Sometimes this is by choice (e.g., these applications have served them well and there is no perceived need to change). Examples include ALL-IN-1 E-Mail, Open Plan project management, and various DOS-based personal productivity tools. Sometimes, this is due to a lack of options (e.g., no GUI application exists for a specific need, or appropriate desktop hardware or network connectivity is not available).

Where viable options are available, there is significant use of Microsoft Windows applications, as evidenced by the growing number of Lotus 1-2-3, WordPerfect, FoxPro, and SmartTerm users using the Windows versions of these products. (Refer to Appendix A for details.)

Very few Macintosh systems (~2%) are used by personnel supporting the ER Program. Those personnel who have chosen the Macintosh enjoy a high degree of "look-and-feel" consistency among applications in the environment, based on the Apple Macintosh Style Guide.

Within the technical community currently supporting the ER Program, there is a solid contingent of UNIX workstation users. While workstations from a variety of vendors are used, SUN and its Open Look window management have been predominant. However, as SUN migrates toward the Motif-based CDE look-and-feel, many SUN users have become, or are in the process of becoming, equally comfortable with the Motif style.

Tiers 2&3 Not applicable.

TAS Recommendations

- Tier 1** The TAS recommendations for window management are specific to each of the recommended workstation environments at Energy Systems. The preferred product on UNIX workstations is a product with the Motif look and feel. Both OSF/Motif and a growing number of third-party applications development tools that support OSF/Motif are available on this platform.

For PCs, Microsoft's Windows and IBM's Presentation Manager are the preferred products. These two products share a common lineage with Motif, resulting in a very similar look and feel among these three environments.

The Macintosh windowing environment will continue to be the preferred product for the Macintosh platform. The appearance and behavior of the Macintosh GUI is sufficiently similar to that of Motif to warrant continued use.

Tiers 2&3 Not applicable.

Recommendations for ER

Tier 1 It is recommended that the ER Program adopt a GUI-based computing environment. This recommendation is discussed in more detail in Sect. 5.5. Given this recommendation, the specific preferred products/technologies remain as recommended by the TAS. OSF/Motif is recommended for UNIX workstations, Microsoft Windows and IBM Presentation Manager for PCs, and the native Macintosh environment for Macintosh systems.

Tiers 2&3 Not applicable.

4.5 APPLICATIONS DEVELOPMENT AND MAINTENANCE SERVICES

The tools used to develop and maintain a computer-based application capture the procedural logic of the application. The choice of tools and methods of capture can have a significant impact on initial development and ongoing maintenance costs. The general strategy in this area is to develop open applications (i.e., applications that have portability, scalability, and interoperability) and to use the highest-level tools available to ensure time economy of application system developers.

Applications development and maintenance tools for the distributed computing environment already provide a broad range of required capabilities. Integrated tools that presently address the centralized mainframe environment are being reengineered for the distributed environment.

NOTE: While the tools outlined in this section are preferred for new systems, their use should also be examined carefully when major revisions or upgrades are being made to existing systems.

4.5.1 Computer-Aided Software Engineering Tools

The term CASE (Computer-Aided Software Engineering) was coined in the mid-1980s to describe a category of power tools for systems analysts. CASE tools facilitate the generation of diagrams to represent such things as planning information, data models, activity models, data flows, detailed designs, and program structures. CASE tools cover one or more of the four phases of the information systems development life cycle: planning, analysis, design, and construction. These tools may or may not be integrated, meaning the information acquired in one phase of development is used in the next phase. A common encyclopedia may be used by the CASE tool to store information and allow data sharing among users.

Current ER Environment

Tier 1 CASE tools are not currently used on the UNIX workstations within ER. Texas Instrument's Information Engineering Facility (IEF) is the Energy Systems standard CASE tool. ER systems/projects making use of IEF on PCs include WAG 6/CRRI, Groundwater, and the Data Management Plan. Some ER models (e.g., the Management Control Information System and the ER

LAN Feasibility Study) currently exist in KnowledgeWare's Information Engineering Workbench (IEW). CASE tools are not currently used on the Macintosh within ER.

- Tier 2** ORACLE CASE is currently being used within ER on the UNIX servers. OREIS is one such information system using ORACLE CASE.
- Tier 3** CASE tools are not currently used on host components within ER. Even though the IEF Central Encyclopedia—which includes tools for managing, distributing, merging, and controlling versions of and access to models—resides on the host, the IEF CASE toolset functions on the PC.

TAS Recommendations

In the absence of mature standards, the target strategy is to employ tools that will support the TAS objectives of portability, scalability, and interoperability and that support other TAS target standards/preferred products.

- Tier 1** In applications in which information being created or updated is to be shared among various business units of Energy Systems, the TAS recommends the continued use of IEF—specifically, its code generation component. (This does not preclude the use of IEF on any project within ER.) The IEF developer's environment currently exists on the UNIX workstation and the PC. The IEF will produce applications that will operate in the UNIX workstation and PC environments. Currently, the IEF does not plan to support the Macintosh platform for development, although the Macintosh is targeted as a future workstation platform for which applications can be generated.

In situations in which the IEF cannot support a Tier 1 target, the use of other development tools should be considered. (See Sects. 4.5.2 and 4.5.3.)

- Tiers 2&3** The IEF is the preferred tool for the development of applications targeted for Tiers 2 and 3. In situations in which the IEF cannot support applications development for Tiers 2 and 3, other development tools should be considered. (See Sects. 4.5.2 and 4.5.3.)

Recommendations for ER

In keeping with the TAS, the recommendation for ER is the use of the IEF CASE tool for applications development and maintenance. In situations in which the IEF cannot support the full life cycle development, the recommendation is to use the IEF as far as possible through the life cycle and consider other development tools for the remaining development phases. (See Sects. 4.5.2 and 4.5.3.)

4.5.2 Application Generators and Fourth Generation Languages

Application generators and fourth generation languages (4GLs) are tools that can be used to construct corporate applications but that do not provide support for early life cycle activities such as information strategy planning, requirements definition, or analysis and design. They typically provide centralized facilities to assist in managing analysis and design information that can be shared between tool users/project teams. Some of these tools provide the flexibility that allows a single development process to generate applications for a variety

of workstation environments, communicating with multiple, heterogeneous structured query language (SQL)-compliant databases. These are the preferred tools for generating applications across multiple groups at Energy Systems (if IEF is not appropriate). A prominent tool in this category at Energy Systems is UNIFACE. Other tools are limited to more specific target environments, such as Powersoft's PowerBuilder for the MicroSoft Windows environment. These tools may be appropriate for applications intended for more limited groups of users. Given the heterogeneous target environments (DBMS, user interface, etc.) that permeate the whole Energy Systems environment, it is recommended that the developer give consideration to tools that enhance the future portability options for an application [e.g., that can target multiple DBMSs and user interface mechanisms (MOTIF, Windows, Macintosh, and terminal emulation)].

Current ER Environment

There are no application generators or 4GLs currently in use within ER.

TAS Recommendations

In the absence of standards in this area, the target strategy is to employ tools in all tiers that will support the TAS objectives of portability, scalability, and interoperability, and that interact well with other target standards/preferred products specified elsewhere in the TAS (e.g., windowing standards, DBMS technology, and 3GL standards).

Tier 1 Whenever possible, application development tools should leverage the power of the workstation. In the interim, developers should use the UNIFACE 4GL tools when building applications that access databases and deploy to both character-based (terminal emulation) and multiple GUI environments (e.g., Windows and Motif). The UNIFACE developer's environment currently exists on the UNIX workstations and PCs. UNIFACE can produce applications that operate in all Tier 1 environments. When a Windows-only GUI environment is targeted, PowerBuilder may be considered.

There will be situations in which these tools cannot be successfully used to deploy an application; in these cases, the developer should consider alternatives that leave the application in a state in which it can be migrated to the target environments at a later date. (See Sect. 4.5.3.)

Tiers 2&3 No recommendations are made.

Recommendations for ER

In keeping with the TAS, the recommendation for ER is the use of the IEF CASE tool for applications development and maintenance. In situations where the IEF cannot support the full life cycle development, the recommendation is to use the IEF as far as possible through the life cycle and to use UNIFACE (for character-based and multiple GUI environments) or PowerBuilder (for Windows-only GUI environments) for the remaining development phases. In situations in which UNIFACE or PowerBuilder cannot be successfully used, other development tools for the remaining application development phases should be considered. (See Sect. 4.5.3.)

4.5.3 Other Tool Categories

Many application development tools in this category are workstation-based, stand-alone tools that lack a central resource for the management of analysis and design information. These tools typically include facilities for creating a database, screens (forms) and the navigation between them, and the procedural logic of the application (the use of 3GLs or 4GLs or syntax unique to that tool). Query and report generation facilities are intended for easy retrieval and manipulation of information, such as those that would be presented to end users in on-line queries or hard-copy reports. These tools may reside on different tiers.

Current ER Environment

Tier 1 No tools in this category are currently used within ER on the UNIX workstations.

Development teams are presently using SYBASE Applications Programming Tool (APT) Workbench (e.g., the Management Control Information System) and ORACLE's SQL*Forms (e.g., WAG 6/CRR1) on PCs. FoxPro and dBASE are also being used within ER.

No tools in this category are currently used within ER on the Macintosh.

Tiers 2&3 No tools in this category are currently used within ER on these tiers.

TAS Recommendation

In the absence of standards in this area, the target strategy is to employ tools in all tiers that will support the TAS objectives of portability, scalability, and interoperability and that interact well with other target standards/preferred products specified elsewhere in the TAS (e.g., windowing standards, DBMS technology, and 3GL standards).

Recommendations for ER

In keeping with the TAS, the recommendation for ER is the use of the IEF CASE tool for applications development and maintenance. In situations in which the IEF, application generators, and the 4GLs cannot support the full life cycle development, the recommendation is to use the IEF as far as possible through the life cycle and to use either SYBASE APT Workbench or ORACLE SQL*Forms for the remaining development phases.

4.5.4 Distributed Computing Tools

Software development in a distributed environment (e.g., client/server and cooperative processing deployments) differs from that targeted for other environments. There are several key concepts and approaches that should be taken into account for applications development in a distributed environment.

- *Applications Programming Interface (API)*. This is the formally defined programming language interface between the application and the service it uses. An API is constant, regardless of the implementations of the services provided on different platforms, since both the application and the services are written to expect the same linkage semantics. This allows APIs to surround and insulate an application from the environment. This

simplifies the application's development process by allowing the focus to be on the application's functionality, not the underlying technical complexities and inconsistencies.

- **Remote Procedure Call (RPC).** A procedure is a code module that performs a single function. In ordinary programming, the basic application and the procedures that perform its functions are linked to one another and comprise a single executable entity (the application itself), which runs on a single computer. In a distributed application, functions might be performed on network nodes physically separated from each other (for reasons of performance optimization, data control, etc.). RPC tools conceal the complexities of network programming from the application programmer, allowing the programmer to write procedures that comprise the application on as many nodes as appropriate.

A specialized form of the RPC is referred to as a *trigger*. These are event-driven RPCs that provide a new level of functionality in the applications development process. These allow the programmer to incorporate real-time decision parameters (triggers) into the application logic. As the program code is executed, trigger status indicators are interpreted in real-time, giving the program code its run-time logic.

- **Threads.** In a traditional computer program, there is only one thread of control. Execution of the program proceeds sequentially. At any given time there is only one point of control as the program executes. It is sometimes useful, however, to write a program that contains multiple threads of control. Some programs show better performance when they are multi-threaded.

Current ER Environment

Berkeley sockets and open network computing (ONC) RPC-based tools are being used by standard OSs on all tiers. However, custom code is not being developed within ER using these tools.

TAS Recommendations

Tiers 1&2 API. Use of the OSF DCE API is the recommended strategy for Tiers 1 and 2. The OSF DCE is service independent and is based on the X/Open Directory Services (XDS) API specifications. Applications developed using the DCE API specifications work transparently with DCE Directory Services, X.500, and XDS. Longer-term, NIST-developed API standards may be applicable. These standards will be included in future versions of the Applications Portability Profile (APP).

RPCs. Use of the OSF DCE RPC mechanism is the recommended strategy for Tiers 1 and 2. The DCE RPC mechanism is easy to use and is designed to work transparently with the various network architectures. In addition, it contains full support for threads. (See below.) There is a fundamental difference between the OSF DCE RPC mechanism and the UNIX International ONC solution. One key difference is in the way ONC encourages fundamental RPC protocol modifications by users (thereby increasing the risk that products from two vendors might not be able to interoperate).

Threads. The use of OSF/DCE threads is preferred for Tiers 1 and 2. The DCE threads library is based upon POSIX 1003.4a (draft 4) and contains an

API that gives programmers the ability to create and manipulate threads. The other DCE technologies assume the availability of threads support. DCE threads are provided for use on platforms that do not already provide threads. The concept of shared address space within the executing program is the preferred form of threads control.

Tier 3 **Not Applicable**

Recommendations for ER

Tiers 1&2 *API.* As recommended by the TAS, the use of the OSF DCE API is the recommended strategy for the applications programming interface.

RPC. As recommended by the TAS, the use of the OSF DCE RPC is the recommended strategy for the remote procedure calls.

Threads. As recommended by the TAS, the use of OSF/DCE threads is the recommended strategy for threads.

Tier 3 **Not Applicable**

4.5.5 Compilers

Compilers translate the higher-level programming languages used to code applications software into a lower-level code that can be interpreted and executed by a computer. American National Standards Institute, Federal Information Processing Standards (ANSI-FIPS) standards for application portability are the accepted standards to which compilers should comply.

Current ER Environment

Current languages include FORTRAN, COBOL, and C. (Refer to Volume 2 of this document, Interim Business Systems Guidance, for additional information on current systems.)

TAS Recommendations

The TAS strategy is to focus on the higher-level tools that generate 3GL code. In certain situations today, these tools cannot provide the needed support. In these cases, the use of the preferred 4GL development tool is the alternative. (See Sect. 5.3.3.) In situations in which higher-level tool environments cannot be used and manual coding is required, the preferred products are ANSI C and, in special cases, C++. The use of manually generated COBOL and FORTRAN for new applications is generally not preferred.

Recommendations for ER

Since the use of the IEF in applications development has been recommended, the recommendations for ER in the area of compilers are COBOL and C for manually generated code.

Due to the limited knowledge-base for the object-oriented approach and the immature status of C++ standards, the use of C++ is not recommended for the interim.

4.6 DATA MANAGEMENT SERVICES

Through the use of data management technologies and products, data can be defined independent of the processes that create or use it, shared among many processes, and maintained indefinitely. Data management services include data directory services, data dictionaries, and DBMSs.

4.6.1 Directory Services/Name Services

Directory Services provide a repository that describes the resources that comprise a distributed system. This information is usually referred to as *metadata* (data about data). Typical resources are users, platforms, and workstation-based services. Typical metadata consists of the name of the resource and its associated attributes. Typical attributes may include the address of an RPC-based server or a user's home directory address. Users and programmers, given appropriate access privileges, may access and modify the metadata stored in the repository.

Metadata aids in navigation throughout a distributed network and provides users and system services with a means for accessing data and utilities without having to know their physical locations. Directory Services provide a method for locating an object in a manner analogous to a telephone directory. Directory Services rely upon "Name Services" to identify objects, to record information about the objects, and to provide a method for accessing the objects.

Current ER Environment

- Tier 1 No directory services/name services were identified.
- Tier 2 Domain Name Service, Banyan VINES StreetTalk, and Novell Bindary are in use at Energy Systems.
- Tier 3 No directory services/name services were identified.

TAS Recommendations

The OSF/DCE Directory Services product, Banyan VINES StreetTalk, the DEC Distributed Naming Services (DECdns), and the Domain Name Service are recommended by the TAS. For more information, refer to Sect. 4.11 of the TAS.

Recommendations for ER

No specific requirements within the ER Program have been identified to cause deviation from the TAS.

4.6.2 Data Dictionary/Repository

Data Dictionary Services allow users and programmers to access and modify metadata about the information stored within a database or series of databases. Data attributes maintained by Data Dictionary Services may include data names, data definitions, internal and external formats, integrity and security rules, and triggers.

Data Dictionary Services include passive dictionary tools used primarily for documentation of data definitions and for logical and database physical design. They also include comprehensive encyclopedia or repository products that can provide capabilities for data integration and, when integrated with CASE toolsets, can provide extensive support for an expanded set of objects and automated life cycle activities.

Current ER Environment

Passive products in use include the Manager Software Products, DataManager, and DesignManager, which are the current dictionary tools for the CAS data definitions. CAS is to be migrated to the IEF Central Encyclopedia from Texas Instruments. IEF is the tool in widest use [e.g., WAG 6, CRRI, Data Management Plan (DMP) efforts] and is an example of a more comprehensive data dictionary product. ORACLE CASE is being used for the OREIS project.

TAS Recommendations

The IEF Central Encyclopedia is supported as a standard dictionary/repository product. Serving as an Energy Systems standard in the CASE environment (Sect. 4.5, Applications Development and Maintenance Services), it supports an active data dictionary across all tiers. IEF supports multiple relational database management systems across multiple platforms (including IBM and DEC, as well as others in the open systems arena).

Recommendations for ER

Texas Instruments' IEF Central Encyclopedia is the recommended data dictionary product for ER.

4.6.3 Database Management

DBMSs provide mechanisms for controlled access to and modification of structured data. To manage the data, the DBMS provides concurrent control procedures and facilities to combine data from different schemas. For efficiency, DBMSs generally provide specific services to define, create, populate, maintain, move, backup, restore, query, archive, and protect the integrity of databases.

Current ER Environment

A variety of DBMSs are currently in use within the ER Program. The DBMSs vary depending upon the operating environment:

- Tier 1 FoxPro, dBASE, Superbase, and Informix. (One example here is the Intelligent Document Tracking System.)
- Tier 2 ORACLE. ORACLE is being used in the following efforts: WAG 6, CRRI, Biota Monitoring Program, and OREIS. SYBASE is being used for the Management Control Information System.
- Tier 3 No DBMSs were identified.

TAS Recommendations

Product recommendations vary depending on the operating environment:

- Tier 1 *Standalone Intel based*—FoxPro is recommended.
 Standalone Macintosh—FoxBASE is recommended.
 Client/server environment—Match the DBMS in use on the applicable Tier 2 server.
 UNIX—ORACLE is recommended; however, purchase agreements have been established for SYBASE and Informix for use where specialized application requirements exist.
- Tier 2 ORACLE is recommended; however, purchase agreements have been established for SYBASE and Informix for use where specialized application requirements exist.
- Tier 3 The use of the standard Energy Systems DBMS, licensed and supported on the target computer platform (e.g., Rdb for VAXes) is recommended.

For more information, refer to Sect. 4.11.3.2 of the TAS.

Recommendations for ER

Product recommendations vary depending on the operating environment:

- Tier 1 *Standalone Intel based*—FoxPro is recommended.
 Standalone Macintosh—FoxBASE is recommended.
 Client/server environment—Match the DBMS in use on the applicable Tier 2 server.
 UNIX—ORACLE is recommended; however, purchase agreements have been established for SYBASE and Informix for use where specialized application requirements exist.
- Tier 2 The preferred database management product for ER is ORACLE. However, where specialized application requirements exist, purchase agreements have been established within Energy Systems for SYBASE or Informix.
- Tier 3 The use of the standard Energy Systems DBMS, licensed and supported on the target computer platform (e.g., Rdb for VAXes), is recommended.

4.7 ELECTRONIC MAIL SERVICES

Electronic Mail (or the more general term electronic messaging) describes a service that facilitates communications by providing computer users with the capability to manage messages electronically. Key message management functions include the ability to compose, edit, send, receive, answer, and forward from a desktop workstation or PC a variety of electronic messages. These include text messages; documents in electronic form; and multimedia messages comprising text, graphics, images, and sound. The primary subcomponents of electronic messaging systems include the following:

- directory services, which provide names and addresses for routing messages;
- message transport agents, which transfer messages from one location to other locations such as other mail users, message stores, or user agents;
- message stores, which provide staging areas for messages as they await processing;
- user agents (the actual programs that interact with the user), providing screen images and processing options; and
- mail gateways, which convert messages between the different formats required by different transport agents.

Several interconnected mail services exist at Energy Systems. Selecting the appropriate service; purchasing the correct user agent; and learning how to maneuver through directory services, gateways, etc., can be time consuming. This remainder of this section of the ER TA draws upon various sources to explain what these service options are and where they are used and to identify some trends within the ER current environment that lead to the ER recommended mail service(s) and the user interface to this service(s).

4.7.1 Transport and Store Agents

Message Transport Agents transfer messages from one location to other locations such as other mail users, message stores, or user agents. Message Store Agents are the places where messages reside while awaiting processing. At Energy Systems, this function is currently provided primarily at the Tier 3 level on host mainframe computers. But the strategic direction for Energy Systems is to move toward distributed, client/server electronic mail systems and away from host-based electronic mail. However, there are pros and cons to be considered prior to undertaking or implementing any strategic alternative.

C&TS offers host-based mail service on most mainframes. The advantage offered by such a system is that many requirements, procedures, maintenance functions, and general management are performed for the user(s). For example, Security requires that E-mail messages be traceable for all E-mail User Agents at Energy Systems. This is enforced on central systems managed by C&TS, and it is the user's responsibility on non-C&TS-managed PCs or workstations. Routine operations such as backups, OS upgrades, and disk management are performed by trained operators in the computer centers. In addition, many Energy Systems applications [Advanced Vendor Inventory Delivery System (AVID), Maintenance Job Requests, Computer Account Authorization Approvals, Personnel Time System, etc.] use E-mail on a central host or hosts to distribute information or notifications.

The disadvantages of using a central host mail system are that sometimes the traffic load on the host can slow response time, and file transfers from PC to the host can be cumbersome.

A Post Office Protocol (POP) server is a computer processing unit (CPU) sized according to the number of users. The CPU can range from a 486-based machine handling 3 to 10 users up to a SUN SparcStation handling over 100 users. It receives mail from a central E-mail router via Simple Mail Transport Protocol (SMTP), stores messages until they are requested by a user, then forwards the messages to the user workstation using the POP. The E-mail is manipulated on the user's workstation/PC. POP servers within Energy Systems typically reside

on the Ethernet or Token Ring Networks. C&TS does maintain several POP servers in the computer centers.

The advantage offered by the servers is that they basically provide a file transfer capability. Once mail is transferred to a user's PC, all operations are local. The user reads, edits, etc., as fast as the PC can operate. The disadvantages are that the user must be responsible for creating his/her own distribution lists, cleaning up junk mail, performing backups of the PC to protect stored mail, and ensuring the security of his/her mail via the protection mechanism of the PC or workstation. If a user desires to set up a POP server for a department, then the management of that device also becomes the responsibility of the user.

The term "network-based mail" is actually a misnomer but will be used here to identify the E-mail function as it operates on a file server residing on a departmental LAN. The Banyan VINES Network Operating System includes a mail program. The server performs the transport and store functions using the VINES software to communicate with the user and with other VINES servers. A VINES Gateway has been installed to permit interface with the Energy Systems mail system.

The advantages of network- or server-based mail is that the mail function is localized to the departmental LAN. In addition, mail is combined with other functions of the server enabling ease of file transfer, etc. Mail is kept on the server and is backed up as the server is backed up.

The disadvantages of a LAN-based mail system are actually disadvantages for having a server. Someone must be designated as the server administrator responsible for the operation and maintenance of the server. Training and operations can be time consuming.

Standards in the area of electronic mail primarily involve directory services and mail interchange not transport and store agents or user agents. The one existing *de facto* standard for transport agents is SMTP. This area is addressed in Sect. 4.8.7, Electronic Mail Interchange.

Current ER Environment

As indicated by the results of the "User Survey," ER predominantly uses host-based electronic mail, specifically DEC's ALL-IN-1, accessed through the SSN. Transport and storage of messages is handled by the host, or hosts, using DEC's MAILbus, a proprietary Message Transfer System (MTS).

ER is in the process of installing Ethernet LANs to connect all ER personnel. (See Sect. 4.8, Network Services.) Therefore, mail services will be accessed over the LAN, whether host-based, POP server-based, or LAN based.

TAS Recommendations

The strategic direction for Energy Systems to move toward distributed, client/server electronic mail systems is tied in with the direction toward higher performance networking capability. The TAS specifies the use of server-based electronic mail products: Banyan VINES

for LAN-based electronic mail and public domain POP mail servers for other UNIX-based mail.

Recommendations for ER

The new Ethernet LANs currently being installed (Sect. 4.8.2, Data Link Services) will provide greater file sharing and user-to-user connectivity, enable faster applications and support high-end users, allow shared resources such as printers, and allow external connectivity. In addition, the LANs will allow the propagation of LAN-based mail service within ER. This ER TA recommends that ER's long range goal be to migrate to LAN-based mail service through the adoption of Banyan VINES (or some other network OS) or through the use of POP mail using the Eudora product for PC users. Staying on host-based ALL-IN-1 is recommended as an interim strategy until server managers and users can be instructed in the operation of the network OSs and until they can be informed of their responsibilities with regard to the initiation of actions for preventing loss of data and avoiding a security incident.

4.7.2 User Agents

User Agents are the programs that interact with the user, providing screen images and processing options. Standards in the area of electronic mail primarily involve directory services and mail exchange not transport and store agents or user agents.

Current ER Environment

The user survey indicated that ER was predominantly using ALL-IN-1, and the primary software packages in use were SmarTerm 340 or SmarTerm for Windows. Most UNIX workstations are using an SMTP of some version.

TAS Recommendations

The strategic direction for Energy Systems to move is toward distributed, client/server electronic mail systems. Therefore, the TAS did not address host-based mail or the terminal emulation software as a user agent, nor did it specify an E-mail user agent for UNIX-based personal workstation clients. However, it stated that a project will be initiated to evaluate features and functions of various commercial and public domain E-mail user agents for this platform.

The TAS did specify products for PCs. Banyan VINES has a simple user agent built into the software for a client Intel-based machine and also has an agent for Macintosh clients for use with a VINES server. For a system running Windows, Sharkmail is the preferred user agent for VINES. The preferred product for users with a POP mail server is Eudora.

Recommendations for ER

The recommendation for ER is dictated by the recommendations for the selection of network, transport agent, and PC or workstation that has been made, is being made, or will be made in the future. The User Agent should be selected based on the selection of E-mail service. (See Sect. 4.7.1.) The ER TA recommends that the TAS recommendation for network-based mail be followed.

4.8 NETWORK SERVICES

Network Services include API and protocol specifications to enable reliable, transparent, end-to-end data transmission across communications networks; transparent file access to local and remote files; microcomputer support for the interoperability of proprietary systems; and provision of RPC services to a distributed environment.

Elements of Network Services include the following:

- transmission media,
- data link services,
- data communication,
- file services,
- network management,
- time services,
- electronic mail interchange, and
- external connectivity.

4.8.1 Transmission Media

A network infrastructure must be flexible enough to support continuing increases in the power and speed of desktop systems (doubling every 18 to 24 months). Networking bandwidth is being pushed higher to meet this challenge. Extending the bandwidth horizon requires careful planning and selection of media and infrastructure.

The following transmission media discussion is presented in reference to building distribution topology (user connectivity), backbone topology, and host connectivity.

Current ER Environment

Existing SSN and Ethernet networks have been installed upon a myriad of transmission media. Some SSN cabling dates back to the 1970s and barely supports the 9.6-Kbps data speeds that are run on it. The latter part of the 1980s brought the introduction of a Standard Wiring Plan (SWP) developed by Telecommunications and Engineering to meet an Energy Systems requirement for standardization. The SWP, which is capable of supporting a 10-Mbps Ethernet over twisted-pair wiring (supplanting the tapped Ethernet cable and Thinwire type cable installations), stipulates the installation of a central communications room for phone and data distribution in a building. Currently, the SWP has been upgraded to provide for 100-Mbps, Type 5 cabling that will support a Fiber Distributed Digital Interface (FDDI) over twisted-pair cabling. All new buildings and major remodeling projects must include the SWP.

Backbone connections are achieved through the use of leased phone lines including 9.6-Kbps, 56-Kbps, and T-1 lines; the broadband cable system Ethernet Bridging Service; or a fiber cable to a new site FDDI Fiber Distribution Hub.

TAS Recommendation

The TAS endorses the SWP. "The SWP provides each office or laboratory with two primary circuits: the standard telephone AT&T circuit and a Type 5 twisted pair data circuit. The wiring should be used in newly constructed buildings and in buildings undergoing extensive construction modifications." An option of the SWP is a fiber to the desktop to support higher speeds above 100 Mbps. Fiber is the medium of choice for connection to the Site backbone Fiber Network.

Recommendations for ER

ER is in the process of installing new Ethernet LANs to connect all ER personnel. (See Sect. 4.8.2.) Plans are to use the existing SWP or to install new SWP cabling as the building distribution system for these installations. Future installations should include the use of SWP. Because fiber will carry data speeds of Ethernet and FDDI for the distances required and copper cable will not, the backbone connections will preferably use fiber to the nearest site hub. However, in some instances where the ER location (i.e., some trailer locations) is remote to the hub, it will prove cost effective to install a leased T-1 line between the ER building and the site's main distribution hub.

Some temporary locations, confined networks (to a single room), or other special mitigating circumstances may warrant the installation of Thinwire Ethernet cabling as a cost-effective measure.

NOTE: Installations at all levels should be made only after consultation with C&TS Telecommunications to ensure that the media planned will interoperate with installed network facilities.

4.8.2 Data Link Services

The Data Link Layer of a network architecture ensures effective physical transfer of data between network nodes. This layer is subdivided into two sublayers: the Logical Link Control layer and the Media Access Control layer.

The IEEE 802.2 Standard defines logical link control. The following multiple standards have been defined for media access control:

- Ethernet Standard 2 (DEC, Intel, Xerox), published 1982;
- IEEE 802.3 for Carrier Sense Multiple Access with Collision Detection used primarily for Ethernets;
- IEEE 802.4 for Token Passing Bus;
- IEEE 802.5 for Token Passing Ring; and
- ANSI X3T9.5 for FDDI Token Ring.

The above standards address LANs. The SSN uses Ethernet topology as its primary backbone and host connection(s). However, the SSN is a terminal service with a proprietary OS.

Current ER Environment

ER currently uses the SSN as its primary communications medium at all five sites. This network is used for slow-speed, client-to-host data communications. The client, usually a desktop PC with a terminal emulation package, accesses the host for E-mail, word processing, and limited file transfer capability. The Ethernet LAN is a high-speed network encompassing all three tiers. It retains all the host connectivity of the SSN but is much faster and has a wider range of applications. It also provides user-to-user connectivity, enabling shared files (a requirement of the Management Control Information System) in the office environment; support for technical/engineering users of high-speed applications such as OREIS; and shared resources such as printers. In addition, the role a node can play on the LAN may be changed to fit the user's demands, or a node can play multiple roles at the same time. Suffice to say, the LAN can actually enhance the working performance of its users and can provide a degree of cost savings by reducing host-based CPU charges for activities that become LAN-based applications.

ER has some Ethernet networks installed, such as a standalone system in the Document Management Center (DMC) in K-1002 (plans are being implemented to connect this network to the K-25 backbone), and ER is sharing some existing public or private Ethernets, such as is the case with the OREIS project on the 1503 and 4500N networks. Public networks infer that the departmental network is managed (owned, operated, and maintained) by C&TS, whereas private networks are managed by the department using the network.

ER is currently relying on the SSN for most of its general office data communications. However, ER is in the process of installing Ethernet LANs to connect all ER personnel and is interconnecting them across the C&TS-managed backbone. The proposed LANs will be installed at the three main Oak Ridge Reservation sites managed by Energy Systems (the Y-12 Plant, ORNL, and the Oak Ridge K-25 Site); at downtown Oak Ridge office locations; at Oliver Springs Tri-County Shopping Center office locations; at the Portsmouth, Ohio, site; and at the Paducah, Kentucky, site. The included buildings at the three Oak Ridge Reservation site locations are as follows:

Y-12	ORNL	K-25
Trailers 9983-AH, AG	Trailers at 6026	K-1330
Trailers 9983-58, 67	Trailers 7078-A, B, C	K-1037
9204-1	1505	K-1001
9766	3001	Trailers K-1310-H, -J, -K
	1000	K-1210
	1503	
	6556C	
	4500-N (existing Host Network)	

Host connections are typically made through host Ethernets in each computer center that is bridge/routed to each site's backbone service. These computer center networks are in the process of being upgraded to FDDI speeds at K-25 and Y-12. ORNL hosts are connected to the site FDDI Network. A Multiple-Gigabit per Second Switch is planned for the ORNL Super Computer Center.

Additional information may be obtained from Telecommunications Proposal #TP-366, *Environmental Restoration and Waste Management Networking*. Figure C.1 in Appendix C depicts the ER Network Architecture.

TAS Recommendation

The TAS specifies Ethernet and Token Ring topologies for Tier 1 and 2 systems and endorses FDDI for the high-speed, high-volume traffic among Tier 3 systems and among Tier 3 and Tier 2 systems conforming to the standards listed in this section.

Recommendations for ER

The installation of Ethernet LANs in support of ER initiatives as outlined in Telecommunications Proposal #TP-366 will allow the implementation of a distributed computing environment for ER. This will provide communications between several departments. The LANs will allow multi-site access to information, help to reduce duplication of effort in programming, provide critical backup capability, and provide electronic functionality to replace the current manual methods of file access and retrieval. The proposed system also offers the potential for reduced cost. The high-speed communications will enable the ER organization to use the latest in database processing and performance while permitting users to maximize their use of familiar computer skills.

The proposed networks will also provide access to Energy Systems host-based resources such as E-mail, the Central Accounting System, and the Material Management System.

Some applications, such as high-speed modeling programs, will require that the interconnection between the user's workstation and host (parallel processor) operate at a higher throughput than the 10-Mbps Ethernet can provide. In such cases, an FDDI connection to the user will be required. The user-to-host connection may traverse the FDDI backbone, or a dedicated FDDI link directly to the host may be installed.

4.8.3 Data Communications

This section addresses the data communications protocols that operate over the communications networks. Two standards have been or are being developed: the Open Systems Interconnection (OSI) standard developed by the International Standards Organization (ISO) and the Transmission Control Protocol/Internet Protocol (TCP/IP) suite of protocols. The federal government has established two profiles of the OSI standard—Government Open Systems Interconnectivity Profile (GOSIP) Version 1 and Version 2—and has mandated GOSIP compliance in procurement calls. DOE has the stated goal of achieving open systems interconnectivity among its sites by October 1995. However, because of its availability and interoperability, the TCP/IP suite has become the *de facto* standard throughout industry as well as within Energy Systems. The various working groups and committees have proposed some merging of the protocols, which should result in one or more hybrid protocol stacks that will be a mixture of both architectures.

Research and development groups within Energy Systems are presently examining the high-speed switching technology provided by the Asynchronous Transfer Mode (ATM) concept, which uses fast-packet switching technology. ATM appears to be a natural successor

to the FDDI in the LAN environment and to the narrow Integrated Services Digital Network (ISDN) as well.

Current ER Environment

As stated previously, TCP/IP is the *de facto* standard within Energy Systems. It is supported across the backbone networks and on hosts. In the DOS arena, most network OSs are based on TCP/IP or are migrating to TCP/IP. TCP/IP is included in some software packages such as SmartTerm 340 for PCs and is generally loaded on SUN workstations with the UNIX OS. The basic services offered with TCP/IP include File Transfer Protocol (FTP), Telnet Protocol for remote login, and the SMTP.

TAS Recommendations

TCP/IP will provide an interim, *ad hoc* standard for intercommunications between devices at all tiers in the distributed architecture, and it is the preferred protocol.

The target standard for all tiers is expected to be a combination of the present OSI and TCP/IP suites.

Recommendations for ER

TCP/IP should be adopted by ER as the preferred protocol for intercommunications between devices at all tiers in the distributed architecture.

4.8.4 File Services

File Services are used for resource sharing, file transfer, and remote backup capability in the LAN communications environment. The types of software used for LAN services in the DOS, OS/2, UNIX, NeXT, and Apple environments include Banyan VINES, Novell NetWare, IBM LAN Program/LAN Server, LANtastic, and AppleTalk. The following discussion includes those protocols in use at Energy Systems that are germane to ER.

Banyan VINES is used primarily in a PC environment in which multiple types of DOS-based and Macintosh hardware and OSs are networked. VINES is the C&TS-supported LAN service for Energy Systems.

Novell NetWare enjoys wide industry support and has been used at Energy Systems on several small departmental LANs.

Every Macintosh computer and Apple LaserWriter comes with AppleTalk support for file and printer sharing as part of the OS. Appletalk is supported by Energy Systems C&TS.

Many desktop computer workstations, in industry and at Energy Systems, are configured to access remote file servers using a variety of file server protocols such as the Network File System (NFS) from SUN Microsystems and the Andrew File System (AFS) from Transarc Corporation.

NFS is the *de facto* distributed file system for the UNIX OS environment at Energy Systems. It was developed to allow computer workstations to share disk space on a file server.

NFS assumes the use of a robust LAN to provide reliable transfer of packets with only minimal losses. It also assumes that there is a single administrative domain across all machines sharing a file server. These assumptions may be valid for a small group of workstations, but there is a tendency for failure in a large network such as the Energy Systems network. Security problems are also of great concern.

AFS has been implemented at Energy Systems as a technology demonstration project by the Advanced Technology Integration and Development group within C&TS. AFS, which was developed after NFS, attempts to correct many of the problems that plague NFS when used in a large network, such as those at Energy Systems. It should be noted that AFS has been adopted as part of the DCE Distributed File System (DFS) and has also been integrated in the overall DCE.

The following are applicable Internet and ISO standards:

- RFC1094, NFS: Network File System Protocol Spec., SUN Microsystems, March 1989;
- RFC0959, File Transfer Protocol, Postel, October 1985; and
- ISO 8571, File Transfer, Access, and Management.

Current ER Environment

Energy Systems currently uses a diverse suite of proprietary, internally developed, and open systems software to support file transfers both between hosts and among other devices. Examples of this software are the DECnet COPY command; FILETRAN; TRANFILE between IBM Mainframes; TCP/IP Remote Copy (RCP) and FTP; and OSI File Transfer, Access, and Management (FTAM).

Driven by the government and major industry, Energy Systems currently uses several standards relative to File Services, such as TCP/IP, NFS, AFS, and Banyan VINES. TCP/IP's RCP and FTP (which are currently well established) and OSI's FTAM (which is still in the developmental stages) are considered to be predominant in the open systems area. NFS is considered to be the current standard for file services across multiple platforms but will probably succumb to AFS. Banyan VINES is the *de facto* standard for Energy Systems for LAN file services.

The majority of ER users are using host-based protocols commensurate with OS software installed on existing C&TS-managed hosts. This would include the Kermit protocol included with SmarTerm 240, 340, etc. Workstation users addressing high-end applications typically use NFS. The ER standalone network in the DMC is a PC-server-based network using the Banyan VINES OS. It should be noted that some investment has been made for file servers using both the Banyan VINES and Novell network OSs on ER networks.

TAS Recommendation

The preferred protocol for handling files over the Enterprise network is the AFS. To establish an open computing environment, Energy Systems will migrate toward the DCE standard product, DFS, as it becomes available.

PC networking was not addressed in this section of the TAS.

Recommendations for ER

NFS is the *de facto* distributed file system for the UNIX OS environment at Energy Systems for both workstations and host mainframes. AFS is recommended for implementation in the interim period, pending the availability of DFS.

Banyan VINES is the preferred Energy Systems PC network file system supported by C&TS. However, Novell NetWare commands approximately 90% market share compared to 6% for Banyan VINES. VINES was originally selected primarily for its global naming convention. VINES could support an Enterprise network the size of Energy Systems whereas Novell NetWare capability was 256 users or the size of a large departmental LAN. Novell capabilities have expanded with subsequent revisions of the system software, and they have always had a lead over Banyan regarding the number and availability of applications written to Novell. A new network OS, Microsoft Windows NT, exists in the windowing environment and exposes the user to an easier interface to use and understand, while providing increased functionality over other network OSs. For these reasons, it is recommended that ER support a reevaluation of the Banyan VINES network OS by C&TS prior to making a wholesale commitment to Banyan VINES.

4.8.5 Network Management

A network management system provides the capability for rapid troubleshooting, network monitoring of operational status, audit trails, network traffic statistics, and loading. It may also provide limited remote control capabilities. These tools will be used in the planning, design, and implementation of new expansions or upgrades to existing services to improve the functionality of the networks. An integral part of network management is configuration control to ensure security regulations are met, to ensure the harmonious operation of the networks, and to provide cost effective solutions to networking requirements.

An Integrated Network Management System will be inaugurated in the C&TS public Network Management Center that will perform the following functions for all C&TS unclassified networks at Energy Systems:

- administrative monitoring of network traffic statistics, network loading, and report generation as well as limited administrative control useful in the analysis, planning, and design of the networks;
- alarm monitoring and correlation to be accomplished on a hierarchical basis by identifying and differentiating between critical and routine failures and administrative operations;
- logging functions, such as maintaining "event logger" and "trouble call" databases; and
- "help desk" capabilities provided to network operators to facilitate resolution of customer problems/queries.

The target product for network management is a combination of OSI Common Management Information Protocol (CMIP) and the Internet Activities Board (IAB) Simple Network Management Protocol (SNMP), if standards completion and product availability allow. SNMP Version 2 is currently being addressed for standardization by the IAB. The OSF/Distributed Management Environment might provide the tools necessary for implementing both OSI CMIP and IAB SNMP in a hierarchical, distributed network

management environment. Alternatively, SNMP Version 2 will serve as the standard for network management. While OSI standards are maturing, SNMP version 2 is expected to be accepted as the interim target by the international standards community.

Current ER Environment

Routers, concentrators, and other networking components all with SNMP loaded as part of the management software are used in Telecommunications-managed networks. The ER Ethernet LANs, as proposed in TP-0366, will include SNMP management agents in the devices.

TAS Recommendation

SNMP will be the preferred protocol for network management within Energy Systems networks in the near term. All network elements (bridges, routers, hosts, workstations, etc.) managed by the Energy Systems Network Management Center must run the SNMP software. Managed and controlled objects require SNMP-based software agents.

Recommendations for ER

File servers (Banyan Servers, UNIX servers, etc.) should have an SNMP agent installed in accordance with the Zayineta concept.

Networking components that will make up the ER networks will have SNMP agents and proprietary management system software compatible with the management system currently in operation on the C&TS public networks.

4.8.6 Time Services

A distributed time service synchronizes host clocks on LANs and wide area networks (WANs), eliminating time skew over the network. A time service allows distributed applications to determine sequencing and duration and to schedule events irrespective of where they occur. The applicable standard to be pursued is the DCE Distributed Time System (DTS), which provides interoperability with Network Time Protocol (NTP).

Current ER Environment

The current *de facto* time service within Energy Systems is the Internet community's NTP. Three primary servers (including a radio-clock based unit) within Energy Systems provide NTP time service to most computer platforms.

TAS Recommendation

The TAS recommends that external time be provided to the internal network from a standard source of time and in Coordinated Universal Time. Because DCE integrates its various services (security, file, time, etc.), the overall support cost to the company for all these DCE services would be less than the support of unintegrated versions of duplicate services (such as DCE's time service and NTP). Accordingly, transition from NTP toward the more integrated DCE DTS is recommended.

Recommendations for ER

Basically, ER hosts or workstations requiring time service should receive it from an Energy Systems NTP server.

4.8.7 Electronic Mail Interchange

As addressed in Sect. 4.7 (Electronic Mail Services), an Enterprise message transport system is made up of a collection of mail transport agents, all of which must be interconnected. The resulting internal mail system must also be able to interchange messages with external mail systems, many of which use other transport agents.

The Consultative Committee on the International Telephone and Telegraph (CCITT) Standard X.400 addresses electronic mail interchange. In addition, an Internet standard exists for electronic mail interchange based on SMTP with extensions. Both standards have limitations. The target standard for internal mail is expected to be a combination of the X.400 and Internet electronic mail standards.

The Energy Systems strategy for internal mail interchange includes the following:

- migration toward internal mail systems that use SMTP and its future extensions;
- the use of gateways based on X.400 to access external systems (e.g., to DOE, Martin Marietta Corporation, and other external commercial systems);
- the use of SMTP and its extensions for interchange of mail through Internet; and
- an evaluation of commercial and locally developed gateways for interconnection of internal legacy mail systems based on different transport agents.

Current ER Environment

ER currently uses the existing Energy Systems E-mail system. This system provides limited interchange capability. Simple text messages and binary files (as attachments) are routinely routed among all the internal mail systems with few restrictions.

TAS Recommendation

The TAS specifies that until an overall standard product is available and accepted, Energy Systems will migrate toward internal mail systems that use SMTP and its future extensions. Gateways based on X.400 will be required for interconnections with some external mail systems (e.g., DOE, Martin Marietta Corporation, and other commercial mail systems). Mail through the Internet will continue to use SMTP and its extensions.

Recommendations for ER

The recommendation from this section supports the recommendations outlined in Sect. 4.7, Electronic Mail Services, and Sect. 4.8.8, External Connectivity, as services provided by C&TS to Energy Systems users such as ER. These recommendations are based on the networking protocols and the strategic direction outlined in the TAS.

4.8.8 External Connectivity

Energy Systems connections to external networks are established over point-to-point links and leased lines and via satellite. Access is provided to WANs and value-added networks reaching as far as Europe and Japan. They primarily serve the research and development community. Specialized nationwide networks such as the Defense Data Network (DDN) and point-to-point communications between DOE facilities in Oak Ridge, Paducah, and Portsmouth are used daily for mail and collaboration. A variety of protocols are supported including TCP/IP, DECnet, and IBM's Systems Network Architecture. The full range of security classification is supported.

User connections to external services will be through local public networks to the central point of connection whenever possible and through leased point-to-point links when required. Multiple user access to external networks has been established through existing Ethernets, token rings, and terminal services. These connections will be made through the FDDI networks as user networks are migrated to them. In some cases, service may be provided using dedicated fiber optic links. Some connections to or from external services may be through dedicated dial-up ports using Serial Line Internet Protocol (SLIP) or ISDN services. Present applications are limited in speed by external line capabilities; however, it is anticipated that T-1 and T-3 services will become commonplace as capabilities evolve and needs for faster services develop.

External network connections are served on a case-by-case basis. Leased links, point-to-point circuits, packet switched services, connections to special application external networks, and connections to value added services are examples of these connections. At the present time, most of these circuits are brought directly to the local node or are connected to a computer that is operated by the users and that serves as the terminal or control station for the application. The local node may also be functioning as the local gateway, providing access to users through a local system such as Ethernet. In some cases local leased lines are used to connect a user to an external service application.

Current ER Environment

Some ER personnel are using the services described in the following sections to obtain access to Internet services, as dial-in to Energy Systems resources, and as point-to-point links interconnecting specific project servers to contract companies (e.g., WAG 6 server to Camp, Dresser, and McKee, Federal Programs, Inc.).

TAS Recommendation

This area was not specifically addressed by the TAS, and therefore there is no TAS recommendation.

Recommendations for ER

The exact requirements for external connectivity have not been determined at this time. Generally, ER has received requests from the following:

- the Department of Energy,
- Martin Marietta Corporation,
- the Information Resource Center,
- the Environmental Protection Agency,
- the Tennessee Department of Environment and Conservation, and
- subcontractors to ER.

In addition, external access will be required for ER personnel at home, on travel, or located in the field where direct access to a network connection is not possible. In most instances, the specifics (technical requirements) of these connections are not known at this time.

The following services are listed in order of performance capability as possible suggestions for meeting the needs of external connectivity for ER. These possibilities are known; are supported; and meet C&TS, Security, and DOE requirements. Decisions regarding appropriate technology to be used must be made based on the specific requirements of a customer needing access to Energy Systems resources. As stated previously, external network connections are served on a case-by-case basis. Assistance in the selection of network means is available from C&TS Telecommunications Services.

The use of dial-up modems over standard telephone lines provides a low-cost alternative to a dedicated installation. These devices are recommended for temporary or one-shot data links, for use by Energy Systems personnel at home requiring access to Energy Systems resources, or for external users whose requirements may be served by a low-speed means of connection. Typically, these modems operate at speeds up to 9.6 Kbps. They are used with PC platforms used as terminal emulation devices. Energy Systems' means of access from an external source is through the Daemon service (modem pool), which provides password authentication prior to connecting a user into the SSN service.

A SLIP and/or Point-to-Point Protocol (PPP) server provides Ethernet connectivity to the host Ethernet service over an asynchronous phone line. Password authentication and login functions are provided. Modem speeds operate at 14.4 Kbps or 9.6 Kbps. Also, a "1-800" number is planned for installation into this service.

The Federal Telecommunications System, FTS2000, operated by AT&T provides a 1-800 Packet Switched Service that operates at 2.4 Kbps and 4.8 Kbps. A user can then access the Daemon modem pool for connectivity to Energy Systems resources. As such, this service provides terminal-to-host data communications for domestic travel use.

ISDN capability has recently been installed by the local exchange carrier, South Central Bell, in the Oak Ridge and Knoxville areas. Telecommunications Services is in the process of leasing ISDN capability to each of the three Oak Ridge sites and has been evaluating ISDN equipment that would enable residential connectivity at data rates exceeding the standard dial-up modem. In fact, workstation connectivity to Energy Systems high-speed backbone services has been achieved. Typically, an ISDN line operates at 64 Kbps, and such a line can be bonded (multiplexed) for greater speeds. The use of ISDN is expected in the direct point-to-point arena, and plans are underway to establish a firewall gateway/router

through which sources external to Energy Systems may establish communications to Energy Systems resources at higher speeds via an "External Ethernet Gateway."

Direct point-to-point links up to T-1 speeds (1.544 Mbps) may be established within Oak Ridge for minimal cost and can be installed across the FTS2000 system at reduced rates to other sites or customers.

External Network connectivity exists to the Energy Sciences Network (ESnet) and the Southeastern Universities Research Association Network (SURAnet) via the Internet through the External Communications Ethernet Segment Router at ORNL. Federal DOE facilities are interconnected through the DOE Communications Network (DOECN). Basically, these services operate at T-1 speeds and may be used for packetized data communications to universities, vendors, and contractors on the Internet and to sister labs, weapons facilities, etc., on the DOECN.

4.9 SECURITY SERVICES

Security Services include those services that provide user and process authentication, authorization, and data protection throughout the entire computing infrastructure. The key areas to consider in defining the target environment for secure open client/server applications are authentication, authorization, auditing, secure network management, and system administration.

- *Authentication.* Authentication is the mechanism by which network entities (i.e., users and services) establish their identity to one another. Many applications today base the identity of a user on one of two popular mechanisms: (1) clear text user name and password or (2) client-supplied UID (a unique identifier assigned to each system user) and protocol address (e.g., IP address). These mechanisms are not sufficient for use in the network environment where clear-text passwords are vulnerable on broadcast networks and UIDs and node addresses are easily spoofed.

The desire for interoperability among distributed, networked systems has driven the development of open systems and standards. In this regard, the key technology is clearly the Kerberos system developed at the Massachusetts Institute of Technology. Kerberos Version 4 has been widely implemented, and a new version, Version 5, has been developed to address some of the limitations with Version 4 [e.g., dependency on the Data Encryption Standard and TCP/IP]. The OSF chose Kerberos Version 5 as the basis of its upcoming DCE Security Service.

- *Authorization.* Authorization can be broken into two issues. First, there is authorization for access to the computing system itself. This authorization involves (1) getting management agreement that access to the system is justified and required for an individual to perform his/her work, (2) defining and distributing unique UIDs and passwords, and (3) establishing the user account on the authorized system. Basically, this authorization is account management and control.

Once authorization for access to a computing system has been established, there is a need for additional authorization for access to specific applications or information on that computing system. This authorization involves the process of managing access to controlled resources and data. The function of granting and revoking access is usually

performed either by a person in the organization responsible for the resources or data (the owner) or by someone in a position to assess the requester's need (the requester's management).

Without any clear standards available at this time concerning authorization in an open system, client-server environment, Energy Systems has developed the standards, procedures and software needed to accomplish this function. The Energy Systems Unclassified Computer Account Management System is currently under development to meet the account management needs for major Energy Systems hosts. Information and application access management continues to be implemented on a case-by-case basis.

- **Auditing.** The ability to audit all attempted accesses to computing resources is necessary in order to document whether protection measures are being enforced. This functionality is required for all systems rated C2 or higher by the Orange Book.
- **Secure Network Management.** Simply stated, managing a network involves controlling the performance and quality of service of all LANS, bridges, routers, gateways, multiplexers, switches, backbones, and WANs that comprise the network. By definition, in an organization of any size, the network components are often geographically remote and heterogeneous. Some of these internetworked components may be parts of a subnet, and others may reside in hosts. From a security perspective, network management addresses the distribution of encryption keys and access privileges, the reporting of security-related events (network intrusion, violation of access privileges, etc.), and the management of security related mechanisms/services.

There is no single, universally approved and supported scheme for secure network management. The contenders in this area include IBM's NetView, the ISO's CMIP, the Internet Engineering Task Force's SNMP, and NIST's Government Network Management Profile.

SNMP, even without the backing of the industry giants, has quickly emerged as the *de facto* standard for network management being implemented in over 200 vendor products. Network management implementations based on SNMP are the most widely used LAN control and reporting systems in major networks today. By definition, SNMP is "a structure for formatting messages and for transmitting information between reporting devices and data-collection programs." It was developed for the Internet and its over one-million users through collaboration by the Department of Defense (DoD), the private industry, and the academic community. It provides the current network standard management protocol for the Internet, which has a collection of heterogeneous hosts communicating via the TCP/IP suite of protocols. To address the security deficiencies in SNMP, its original developers have just recently released the SNMP Version 2, which adds security, bulk data retrieval, and support for high speed networks.

- **System Administration.** The increased complexity of computer systems on the desktop brings a corresponding increase in the complexity of managing these systems. In an environment in which the workstation is a stand-alone device whose only external connection is through a serial port to a mainframe computer, the major security issue is merely one of controlling physical access to the workstation. System administration and configuration in this environment do not require unusual skills. In a distributed computing environment in which the computer is accessible by hundreds or even thousands of other computers, proper system configuration and administration to ensure a secure computing environment require special knowledge and abilities.

Good system administration is key to a secure distributed computing environment. Systems that process or control sensitive corporate information must have system administrators who are professional and knowledgeable. Administrative controls can ensure that those who are responsible for computing systems are trained in system administration techniques and security requirements. Corporate level procedures can be developed requiring division management to take responsibility for ensuring the proper administration of computing systems within their control. Courses are available or can be developed to provide new system administrators with the needed training. Such administrative controls can be reinforced by denying network access to those systems for which the managers have not demonstrated appropriate system administration expertise.

Current ER Environment

The current ER network environment can be thought of in two major categories. The first category consists of technical systems, including those that collect, analyze, maintain and disseminate analytical data regarding environmental conditions, either past, present or projected, at sites managed by the ER Program. The second consists of systems oriented toward general administrative support, including financial systems, project reporting, record management and personal productivity tools.

The technical environment is characterized by the use of UNIX workstations and servers, primarily SUN, connected via Ethernet using the TCP/IP protocol. Heavy use is made of the Berkley "R utilities" (rlogin, rcp, etc.) and NFS remote file services. Tabular data is typically managed by the ORACLE DBMS, with remote access provided by the ORACLE SQL*net product line.

Although high-speed networks have become popular in recent years, the majority of users in the office support environment within the ER Program are still connected to the asynchronous Energy Systems SSN. However, this picture is changing as ER pursues an aggressive program to provide ER Program staff with LAN access. These LANs run a mixture of Novel NetWare and Banyan VINES. Each of these LAN OSs provides its own proprietary security mechanisms, most of which are characterized by similar strengths and vulnerabilities as the predominantly UNIX technical environment.

One source of many potential problems is the broadcast nature of Ethernet LANs. (Ethernet is by far the most popular type of high speed network within the ER Program today.) On a broadcast network, nodes on the same physical network segment see every transmitted packet of information regardless of the destination address. Normally, the Ethernet interface discards packets addressed to other nodes, but users may enable a promiscuous mode that will allow them to examine all packets on the local segment. Bridges reduce the scope of this problem by not forwarding packets from the local segment to another segment if the destination addresses on those packets are known to belong to nodes on the local segment. The most immediate concern is the disclosure of passwords, which could provide unauthorized access to data and resources.

Another important factor in network security is external network connectivity. An important part of the R&D conducted at ORNL involves collaboration with users at external sites. This has led to several high-speed external connections to the DDN/Advanced Research Projects Agency Internet. Additionally, as ER systems such as OREIS and the WAG 6 Management Information System are deployed, off-site access from such entities as DOE, the

Tennessee Department of Environment and Conservation, and other subcontractors is required. Although great benefit is derived from this connectivity, it also involves potential risks, especially when sensitive data processing is performed on networks that are open to external access. Gateways (routers) provide facilities for monitoring and filtering selected network traffic to and from the Internet and other external connections, but it is not possible to eliminate all risks.

Dial-up is another form of external access that has traditionally involved low-speed terminal-to-host traffic and controlled access. However, with the availability of low-cost, high-speed modems, the usefulness of dial-up network connectivity has increased dramatically. Additionally, protocols, such as SLIP and PPP, have emerged allowing support for the TCP/IP protocol over dial-up ports.

In general, physical access to Energy Systems unclassified networks is not tightly controlled, but the ability to communicate from one physical network segment to another is. Bridges interconnect physical segments to form an extended internet throughout the company. These bridges are configured to forward packets only from those nodes registered with Telecommunications in C&TS.

TAS Recommendations

The Energy Systems TAS recommends that network security within Energy Systems be accomplished by implementation of products compliant with DCE Security Services. Recognizing the current scarcity of products conforming to DCE specifications, the TAS indicates that specific products will be specified as they become available and can be evaluated. In the meantime, network security in highly sensitive areas should be enhanced by the implementation of Kerberos (or other encryption). Dial-in access to any network should be controlled by the use of a daemon.

Recommendations for ER

In general, the ER Program at Energy Systems is not characterized by a strong need to restrict read access to the information maintained by the program. While the business information developed, maintained, and utilized within the program should be protected to a reasonable degree, its inadvertent disclosure would not typically adversely affect the ability of the program to perform its mission. In fact, much of the information collected, developed and maintained by the program is destined for public disclosure via appropriate DOE-approved mechanisms.

Protection against unauthorized disclosure, however, is only one aspect of information security. It is extremely important that the ER Program have a high degree of confidence that its records have not been altered in any way by unauthorized personnel. Chain of custody issues are such that in the event of legal proceedings in which program data may be used in evidence, the integrity of that data must be impeccable.

Nonetheless, the provision of effective security mechanisms currently comes with a price, both in cost and in the useability of ER applications and data. Thus, a balance must be achieved between an adequate degree of security and the availability and useability of the information resources developed by the program. With today's technology, this balance is

dependent more on system and network administration policies than it is on technology choices.

Given this situation, the most prudent course of action for the ER Program is to formalize sound system administration practices utilizing existing technologies while maintaining awareness of evolving technologies that promise to improve overall system security without significant compromises in terms of cost or useability. See Sect. 5.6 for more discussion of this topic.

4.10 DATA INTERCHANGE SERVICES

To facilitate effective communications, data must be moved among organizations, across platforms and systems, and among applications and information products. This data may be in the form of text, graphics, still images, video, or audio. Some common examples of data interchange include the movement of text from one document to another, the transfer of data from a spreadsheet to a report, the transfer of structured data from a mainframe to a PC, the transfer of data from a statistical analysis tool to/from a geographical interface system (GIS), and the transmission of product data from a design group to a manufacturing group. Data interchange implies that data will be manipulated after they have been transmitted. Elements of data interchange formats should be easily modifiable. This is a contrast to elements of the output formats (discussed in Sect. 5.9), which should be relatively inflexible to minimize the decisions that must be made by output devices.

Data interchange services provide support for the interchange of data among applications on the same or different (heterogeneous) platforms. NIST's APP describes several levels of data interchange complexity. At the lowest level are representations of the actual data to be exchanged. The next higher level represents data content formats (e.g., text, raster images, audio). The next level contains object representations. These may be combinations of different content types, as in a complex document. Above the object level is the language level, which contains representations in a format that permits human understanding. The application level is the highest level of complexity and may use any of the lower levels of data representation to interchange data among applications.

Neutral formats are the most cost effective method of data interchange. (A neutral format is defined independently of any application.) The Initial Graphic Exchange Specification (IGES) and the Standard Generalized Markup Language (SGML) are examples of neutral formats.

The elements of data interchange services are described in the following subsections:

- Document/Text,
- Hypermedia/Multimedia,
- Raster Graphics,
- Tabular Data Interchange,
- Vector Graphics,
- Product Definition,

- Electronic Data Interchange, and
- Geographical Information Interchange.

4.10.1 Document/Text

Document/text data include specifications for the logical and visual structure of electronic documents as well as for the encoding of document data (e.g., text, pictures, numerics, special characters, tables, line art, and equations).

SGML is an ISO standard that defines a neutral format capable of describing information structures of considerable complexity. SGML has been adopted by DOE as its sole document interchange standard. In the near future DOE is expected to require SGML electronic deliverables in place of paper documents. FIPS PUB 152 requires the use of SGML on all federal computer systems performing large-scale text processing tasks.

SGML is also a Computer-Aided Acquisition and Logistics Support (CALS)-enabling standard. CALS is a strategy for transition to the automated interchange of technical data and is mandatory for all DoD contractors. While not mandatory for DOE contractors, CALS is expected to have a pervasive effect on both the private and public sectors of the weapons industry. Accordingly, CALS compliance is necessary for competitive reasons.

Current ER Environment

ER currently uses ASCII, WordPerfect, Microsoft Word, and All-In-1 for document/text processing.

TAS Recommendation

SGML-compliant software products are recommended.

Recommendations for ER

Because of the investment in the products listed in the current environment, it is recommended that ER continue using the existing products. SGML-compliant software products are targeted, and as these products become available, their capabilities will be reviewed for use within ER.

NOTE: The Energy Systems Information Management Services organization currently has a pilot-level capability consisting of SGML editors for Macintosh and PCs and a general-purpose SGML parser/translator/converter licensed for several platforms. This organization will also be serving as a beta-test site for the new version of WordPerfect with SGML functionality.

4.10.2 Hypermedia/Multimedia

Hypermedia/multimedia data are non-static in nature; that is, a hypermedia document has a structure that allows the reader to follow a non-sequential path through the document. Hypercard is a familiar example of software that can create hypermedia documents.

Multimedia documents, which are often built on a hypermedia base, contain audio and/or video in addition to the static text and graphics of conventional documents.

HyTime (Hypermedia, time-based structuring language) is an ISO standard and is based on, and extends, SGML. It provides a means for incorporating digitized audio and video in conventional documents. Hypertalk is a *de facto* interchange standard for the Macintosh and other PC applications.

Current ER Environment

No products for hypermedia/multimedia data interchange services are currently used within ER.

TAS Recommendations

Because of the immaturity of the hypermedia/multimedia area, no products are targeted at this time for any tier. Preferred products for all tiers are based on HyTime and Hypertalk.

Recommendations for ER

In keeping with the TAS, no products are targeted at this time in the hypermedia/multimedia area. Preferred products for all tiers are based on HyTime and Hypertalk.

4.10.3 Raster Graphics

Raster graphics are a form of computer graphics in which an image is represented as a matrix of values—each element of the matrix representing a single cell in a regular, homogeneous grid of the image. The cell values are used to provide depth information (either grey-scale level or color). The large number of legacy products in this area reflects the diversity of raster graphics needs within Energy Systems. This area has many proprietary products that are *de facto* standards, and interchange is driven by major vendors.

The Tagged Image File Format (TIFF) is widely supported on DOS, Macintosh, and UNIX platforms and is more flexible and extensible than other raster formats. The diversity of the existing raster graphics environment necessitates the multiple standard formats available in preferred software. Encapsulated Postscript (EPS) is the form of Postscript that facilitates true interchange (e.g., components are easily modified). The Graphic Interchange Format (GIF) is a popular raster format for PCs because the software is capable of producing highly compressed files.

Current ER Environment

Tier 1 The following raster graphics formats are currently used on UNIX workstations within ER: TIFF, Computer Graphics Metafile (CGM), Hierarchical Data Format (HDF), EPS, and GIF.

The following raster graphics formats are currently used on PCs within ER: TIFF, TrueVision Raster Graphics Array (TARGA), GIF, EPS, and LAN.

The following raster graphics formats are currently used on the Macintosh computer within ER: TIFF, EPS, PICT, HDF, and GIF.

- Tier 2 The following raster graphics formats are currently used at the server level within ER: TIFF, HDF, and EPS.
- Tier 3 No raster graphics formats are currently used at the Tier 3 level within ER.

TAS Recommendations

- Tiers 1&2 Preferred products for these tiers are those capable of importing/exporting TIFF, GIF, HDF, and/or EPS files. The targeted products are those products able to import/export TIFF files with CCITT Group IV compression algorithms.
- Tier 3 In the area of raster graphics format for Tier 3, the preferred and targeted products are those products able to import/export TIFF files with CCITT Group IV compression algorithms.

Recommendations for ER

- Tiers 1&2 In keeping with the TAS, the recommended software products in the area of raster graphics formats for Tiers 1 and 2 are those capable of importing/exporting TIFF, GIF, HDF, and/or EPS files, with TIFF being the targeted format.
- Tier 3 In keeping with the TAS, the recommendation for Tier 3 raster graphics format is the use of products able to import/export TIFF files with CCITT Group IV compression algorithms.

4.10.4 Tabular Data Interchange

Tabular data are numeric, text, or image data in a structured digital data file that is organized in a row and column fashion.

Current ER Environment

The following Tabular Data Interchange formats are currently used at the UNIX workstation level, the server level, and the host level: Tabular ASCII Data and Export.

TAS Recommendation

Tabular Data Interchange formats are not addressed by the TAS.

Recommendations for ER

It is recommended that ER continue with its current environment in respect to Tabular Data Interchange.

4.10.5 Vector Graphics

Vector graphics are generally thought of as containing lines, polygons, text, arcs, colors, and other "elements" that make up a computer graphic.

The HP Graphics Language (HPGL) is a *de facto* standard. The majority of graphics drawing packages on the market can import and export HPGL files. CGM is both an ANSI/ISO standard and a CALS-enabling standard. The CGM standard, as contained in FIPS PUB 128, is a component of the Data Interchange portion of the NIST APP.

Current ER Environment

The following Vector Graphic formats are used on all tiers: HPGL, CGM, Vector C Graphic Objects (VCGO), and CALCOMP's Host Computer Basic Software (HCBS). ER has the capability to import/export HPGL and CGM formats. ARC/INFO and Intergraph can export HPGL and CGM formats. ARC/INFO cannot import CGM formats.

TAS Recommendations

The preferred and targeted products in the area of vector graphics formats are software products capable of importing/exporting CGM or HPGL files. Intergraph and AutoCAD can export HPGL files.

Recommendations for ER

In keeping with the TAS, the recommendation for vector graphics formats is the use of software products able to import/export CGM or HPGL files.

4.10.6 Product Data

Product data are the drawings, maps, documentation, and other digital product definitions that describe the geometry, topology, tolerances, and properties of the product. These data are required for the production of drawings and maps.

Current ER Environment

The following product data formats are used on all tiers: Drawing Exchange Format (DXF), Export, and IGES.

TAS Recommendations

Although migration away from IGES is desired, preferred products will be able to interchange the IGES and/or SGML formats. Targeted products will be able to interchange the Standard for the Exchange of Product Data (STEP) neutral format.

Recommendations for ER

In keeping with the current ER environment, the recommendation for ER in the area of product data formats is the use of products able to interchange the formats of IGES, SGML, and/or the STEP neutral format.

4.10.7 Electronic Data Interchange

Electronic Data Interchange (EDI) was originally developed as a computerized method for exchanging standard business documents in the transportation, warehouse, and grocery industries. In the ensuing years, the boundaries of EDI have expanded to include other areas, including finance, manufacturing, and retail. Energy Systems has supported the EDI/Electronic Fund Transfer (EFT) initiative since December 1988. For the past three years, the Treasury Services Department has sponsored the electronic transaction of tax and other payments. Energy Systems managers are also evaluating EDI transportation routing and information exchange. An additional area of interest includes procurement information exchange with vendors, financial EDI/EFT exchange with the DoD, and future expansions of financial capabilities.

EDI is supported by ANSI standards that have been in existence for some time. In 1979, the ANSI X12 Standards Committee was chartered. The X12 standard consists of transaction set standards, a data dictionary, and transmission control standards. There are over 140 transaction sets defined in the latest release (December 1992) of the X12 standard. Most of them pertain to common business transactions, such as purchase orders, invoicing, payment, request for quote, and cash disbursement associated with provision of products and services.

The X12 standard has also become a FIPS and has been endorsed by the Canadian government. An important step toward legitimizing EDI technology within government was the publication of FIPS 161 by the NIST. FIPS 161 does not mandate the use of EDI by federal agencies; however, it does stipulate the use of either ANSI X12 or EDIFACT (the international EDI version), marking the establishment of the first federal standards for EDI use.

Current ER Environment

Not applicable to ER.

TAS Recommendations

At all tiers of the architecture, commercial off-the-shelf (COTS) products that comply with the ANSI X12 standards are preferred. Because of the high level of maturity of this environment, there is a rich variety of third-party products and services from which to choose.

Recommendations for ER

Not applicable to ER.

4.10.8 Electronic Fund Transfer

EFT is a method of payment for goods and services. Instead of using the traditional printed paper check, electronic media are used, completely replacing the traditional paper trail. Payment data, normally printed on paper checks, may now be sent electronically to the payee's bank. The remittance detail accompanying the payment may be transmitted to the payee directly or to the payee's bank for distribution to the payee.

Electronic payment to a small group of vendors is the first step of a fully electronic payment strategy that includes employee reimbursements, transportation payments, and state tax payments, in addition to vendor payments for goods and services. Execution of this strategy will begin with a roll-out of the electronic funds payment program to both vendors and Energy Systems employees.

The National Automated Clearinghouse Association (NACHA) is an organization composed of the various regional and private clearing house associations in the United States. NACHA formulates and administers rules and procedures for transferring data electronically through the Automated Clearinghouse (ACH) network and for executing clearings between its member organizations. The legal basis for NACHA rules is Section UCC-4a of the Uniform Commercial Code of the United States.

NACHA guidelines provide definitions for a number of accepted and warranted formats for transferring funds through the ACH. Some of the transactions are Corporate Trade Payment, Corporate Trade Exchange, Prearranged Payment or Deposit, and Cash Concentration or Disbursement. These formats have been enveloped into the ANSI X12 Request for Payment and Remittance Advice transaction set (820). This enveloping mechanism provides ease of transmission through Value Added Networks and the ACH. It works especially well in tightly integrated EDI applications in which payable and receivable systems of trading partners exchange related data.

Current ER Environment

Not applicable to ER.

TAS Recommendations

COTS products that are compliant with the NACHA standards are preferred. Because of the high level of maturity of this environment, there is a rich variety of third-party products and services from which to choose.

Recommendations for ER

Not applicable to ER.

4.10.9 Geographical Information

A GIS is a system of computer hardware, software, databases, personnel and procedures designed to capture, manage, analyze, and display spatially referenced information for use in decision-making processes. One important function of a GIS is to integrate and analyze many different types of geographic information simultaneously so that underlying relationships and patterns may be determined. The ability to reliably exchange information among different GIS software packages, with minimal loss of data, is a key element in the ER Program's ability to capture and reuse historical information or information developed for other purposes but useful to ER. Current interchange capabilities among these packages are limited, especially regarding linkages to tabular data and topology information. Given the cost of developing these data, improvements in GIS data interchange capability can result in direct cost reductions to the ER program.

The Spatial Data Transfer System (SDTS) will become the federally mandated method for disseminating geographical data. This standard will specify the formats, structure, and contents for both vector and raster spatial data. Although a profile for vector data has been approved, the draft profile for raster data was only released in July 1994.

Current ER Environment

Currently, the following software packages and their associated data formats are used within the ER program and by other related organizations within Energy Systems: Environmental Systems Research Institute's ARC/INFO; MapInfo, Inc.'s MapInfo; Intergraph's Intergraph, and Autodesk's AutoCAD. ARC/INFO has been chosen as the standard format for the vector data in the OREIS system. For raster data, such as gridded elevation or imagery, the ERDAS 7.5 .lan format has been chosen as the standard format. Geographical information systems at Energy Systems can be found on all three tiers, although they are becoming more commonly used on tier 1 workstations.

TAS Recommendation

The TAS did not address the area of geographical information.

Recommendations for ER

Given the current lack of commercial implementations of SDTS for vector data and the continued development on the SDTS for raster data, the native ARC/INFO data format and ERDAS 7.5 .lan format are the preferred formats for vector GIS and image data, respectively, within the ER program. Where is it not feasible to utilize ARC/INFO, the other widely used formats in Energy Systems (MapInfo, Intergraph and AutoCAD) are acceptable. For further information concerning the appropriate interchange formats for a specific application, contact R. C. Durfee.

4.11 OUTPUT SERVICES

Output services provide the means of transmitting data files to output devices (printers, plotters, etc.) or other computers in a format recognizable to, and usable, by the target devices. Most standards regarding input/output relate to specifications of what file formats are acceptable to which output devices. These formats can be divided into three major categories:

- Page Description Format,
- Raster Graphics Format, and
- Vector Graphics Format.

4.11.1 Page Description Format

A page description language is used to describe the final form of an output page. A page description device is any output device that interprets all of the data for a page before transferring the image to an output medium.

Current ER Environment

The page description language used within ER is the HP Printer Control Language (PCL). Most wordprocessing and graphics packages used within ER (e.g., WordPerfect, Word, Harvard Graphics) can produce HP PCL.

TAS Recommendation

PostScript is the preferred page description language. Page description devices at all tiers are expected to recognize the format of the PostScript language.

Recommendations for ER

Because of the quantity of non-PostScript laser printers within ER, PostScript is not the preferred page description format for ER. The recommendation for ER in the area of page description format is the use of HP PCL and the use of page description devices that recognize HP PCL. (See Appendix A, Current Environmental Restoration Desktop Computing Environment, for current environment survey results.)

4.11.2 Raster Graphics Format

Raster graphics are a form of computer graphics in which an image is represented as a matrix of values—each element of the matrix representing a single cell in a regular, homogeneous grid of the image. The cell values are used to provide depth information (either grey-scale level or color).

Current ER Environment

Tier 1 Products now in use include TARGA and TIFF formats for UNIX workstations; TARGA, TIFF, Object Description Language (SCODL), and X bitmap (for X Windows systems) formats for PCs; and PICT format for Macintoshes. (Refer to Sect. 4.10.4, Raster Graphics.)

TAS Recommendation

The TARGA format provides the best possibility for use on all platforms and is, therefore, the recommended standard.

Recommendations for ER

In keeping with the TAS, the recommendation for ER in the area of raster graphics format is the TARGA format.

4.11.3 Vector Graphics Format

Vector graphics are computer graphics in which a picture is composed of straight line segments of varying lengths and directions.

Current ER Environment

HPGL is the most widely used and accepted vector graphics language in ER.

TAS Recommendation

HPGL provides all of the vector graphics functionality likely to be needed by administrative applications. HPGL has achieved widespread acceptance since its introduction for graphics plotters and should remain viable for the foreseeable future.

Recommendations for ER

In keeping with the TAS, the recommendation for ER in the area of vector graphics format is HPGL.

4.12 DESKTOP TOOLS

This service area consists of desktop hardware and personal productivity software—such as word processing, spreadsheets, presentation graphics, etc.

Current ER Environment

The current environment in this area is described in Appendix A, Current Environmental Restoration Desktop Computing Environment.

TAS Recommendation

The Energy Systems TAS did not address technologies in this area.

Recommendations for ER

It is recommended that the ER Program use desktop hardware and software recommended and supported by the appropriate Energy Systems support groups. These recommendations are available electronically and are updated routinely. Working definitions of the terms *recommended* and *supported* are given below.

- **Company-Recommended Hardware/Software.** Company-recommended hardware/software includes a large group of product categories that have been identified as being of interest to Energy Systems staff. Software products in this group are considered to be less strategic in nature than supported software products and/or do not enjoy wide enough demand to warrant inclusion in the supported group. All products in the recommended group have been reviewed by Energy Systems technical staff and are suitable choices for Energy Systems employees. (The supported products list is a subset of the recommended products list; thus supported products are also recommended.)
- **Company-Supported Software.** Company supported software includes a select group of software product categories (spreadsheet, database, word processing, graphics, communications, etc.) that have been identified as strategic to Energy Systems. This list of supported products includes products that have been tested and evaluated by Energy

Systems staff and judged to be the best products for use at Energy Systems in their respective categories. These products should be the first choice for use.

The Videotex (VTX) system on the OCU unclassified cluster provides a listing of company-recommended hardware/software and company-supported software. Appendix B provides more details on how to access this information on the VTX and what the system includes.

5. IMPLEMENTATION STRATEGIES

5.1 OVERVIEW

This section discusses a variety of issues related to implementation of the technologies discussed in the previous section. For some cases in which specific technologies are currently being deployed in support of the ER Program that differ from those recommended by this architecture, issues related to the migration to the recommended technologies are discussed (e.g., E-mail, network servers, networking). For other cases (GUI, system and network management, application distribution), strategies for the optimal use of the recommended technology (as opposed to technology selection issues) are discussed.

In practice, detailed implementation planning is much more involved than may be implied in this section. No claim is made to having all the answers related to the appropriate deployment of the technologies discussed in this architecture. The recommendations in this section may best be interpreted as a starting point for further analysis. In some cases, relevant alternatives and associated issues are merely presented for the consideration of the reader.

In general, there are no revolutionary technology recommendations contained in this document. For the most part, alignment of the existing environment with the recommendations of this document can be achieved by minor course corrections and the exercise of discipline in future technology acquisitions and deployments.

In the future, when both existing and planned applications (or business systems) can be more fully identified and assessed, this section should be expanded to explicitly address the mapping of these applications to specific information technologies, such as hardware, a DBMS, and geographic location, allowing a better assessment of existing or planning inconsistencies.

5.2 GENERAL STRATEGY ASSUMPTIONS

5.2.1 Coordination Via Architectures

It is recommended that the ER Program develop, maintain, and utilize a program-level architecture as the coordination point for the acquisition and use of information technologies required to support its mission. This architecture should provide the ER Program with optimal access to, and interoperability with, other Energy Systems information resources and should provide an alignment with industry directions that allows for the effective utilization of off-the-shelf technology.

The architecture should be independent of the source of the technology in question. Whether technologies are developed internally or acquired from other Energy Systems organizations, external subcontractors, or vendors, a high degree of compliance with the technical architecture is required to realize the desired benefits.

5.2.2 Use of Available Support Groups

A common theme throughout the strategies recommended by this architecture is the use by the ER Program of any of the many support groups available, both internally and externally, to Energy Systems, as opposed to the development of ER-specific support groups. Groups internal to Energy Systems include the Environmental Sciences Division, C&TS, Computing Applications, DSRD, Information Management Services, and Engineering, among others. External to Energy Systems, there are numerous vendors possessing a wealth of expertise. Use of these resources, within the guidance of the appropriate architectures, allows the ER Program to focus on its business missions while taking advantage of the best technology available.

5.3 ELECTRONIC MAIL STRATEGIES

E-mail is the largest single application in use on the Energy Systems hosts, servers and networks today. ER, likewise, is very dependent upon the E-mail system in the conduct of its business. Consequently, an E-mail strategy must take into consideration the effectiveness of the E-mail system in the conduct of business, the effects of a migration to an alternative system, and the cost of a migration to a new system.

The E-mail strategy for ER is derived from the following recommendations from sections 4.7, "Electronic Mail Services," and 4.8, "Network Services."

- Migrate to LAN-based mail service through the adoption of Banyan VINES or some other network operating system, or through the use of POP mail using the Eudora product for PC users.
- The User Agent should be chosen based on the selection of E-mail service.
- Banyan VINES is the preferred Energy Systems PC network file system supported by C&TS. However, ER should support a reevaluation of the network operating system as compared to other network operating systems such as Novell NetWare and Windows NT, by C&TS prior to making a wholesale commitment to Banyan VINES.

Discussion of the E-mail strategy is preceded by a discussion of relative issues. In addition, this strategy should be considered as part of the overall strategy, including networks and file servers in Sects. 5.9 and 5.8, respectively.

5.3.1 Issues

Cost is the primary driver behind the migration to server-based mail systems. For heavy users, localizing their mail to their machine with POP mail or to a local file server can provide considerable cost savings in mainframe computing fees. Of course, the cost saving must be weighed against the cost of installing and managing a file server or of using a POP mail server, including as well the added cost of providing new communications software and retraining for the users. Normally this evaluation is conducted on a departmental rather than an individual basis.

The pluses and minuses of each version are discussed in detail in Sect. 4.7, Electronic Mail. In general, it is agreed that host or mainframe-based mail (ALL-IN-1) is feature rich

compared to the Energy Systems-endorsed POP mail servers (Eudora) or network-based (Banyan VINES) server products. The management structure is already in place for host-based mail to perform necessary tasks such as backups. In addition, the reliability and availability of the servers is dependent upon their location. A computer room with adequate air conditioning, clean power, and a relatively dust free environment is more conducive to a dependable server than a closet or office with inadequate cooling or air flow. However, a local server installation means that local communications can still occur when the backbone network is down.

A major issue of Banyan VINES mail is the market share of Banyan compared to Novell and the functionality of Microsoft Windows NT as compared to Banyan VINES. Novell's latest version of the Network Operating System addresses the "Enterprise LAN," which was a major reason for the selection of Banyan VINES. Windows NT exists in the windowing environment and exposes the user to an easier interface to use and understand while providing increased functionality over other network operating systems. The reassessment must also take into account the needs of today and whether or not the change warrants the cost of totally changing the existing structure (which includes manpower, hardware, and providing support for both network operating systems for a while).

The issue of public versus private management of the servers is of interest to ER. The cost of training personnel to manage the servers should be evaluated against the cost of having some other organization manage the server(s) for ER, whether it is C&TS or some other group.

A final issue is security. POP mail servers typically "download" mail to the user's workstation or PC where it is stored. Protecting the user's mail from unauthorized access or tampering is a problem that now must be addressed by each individual user. Whereas hosts are located in protected computer rooms, now the user must provide both physical protection, by keeping office doors locked, and software protection, through the use of screen savers requiring passwords and "power-on" passwords to access the PC. In some areas of the Oak Ridge Reservation, other configurations must be used to protect the data.

5.3.2 Strategy

This ER TA does not endorse a mass move to another mail system in the short-term period. Such a move would have a disastrous effect on the flow of business pending the completion of retraining personnel to use the new system. Rather, users should be encouraged to purchase TCP/IP software and use the new Ethernet. The "Telnet" protocol, which is the virtual terminal software of TCP/IP, may be used to communicate to the host mainframe while continuing to use ALL-IN-1, only at Ethernet speeds. Users can then begin learning about FTP software for file transfers or learn to use Banyan VINES software to communicate with file servers at their leisure without causing a major impact to the conduct of business. In addition, servers then may be installed as funding permits over a period of time.

It is recognized that some of the current server-based mail systems (like Banyan VINES) are limited in features compared to the much more mature host-based systems, even though improvements in user interfaces and features have been made with the use of third-party vendor products such as Shark!mail for Banyan VINES. This strategy will allow time for these systems to mature. In addition, this strategy will allow time for the revaluation of the Banyan

VINES network operating system by C&TS prior to making a wholesale commitment to Banyan VINES.

The long term strategy is to provide server-based mail. After file servers have been installed, users have become comfortable with the new software, and procedures are implemented to provide reliable operation, it is recommended that ER TA migrate to a POP-based mail system in which user machines are configured either to store the mailboxes on the local file server or implement server-based mail such as the Banyan VINES mail system. This has the benefits of providing a somewhat more secure and reliable environment for the ER mail system; relieving the individual users of the responsibility of backups, etc.; and permitting implementation on an individual basis, rather than en masse.

One further note of importance. ORNL has undertaken, as a strategic direction, to migrate all mail to desktop mail/server-based mail systems using Banyan VINES (or equivalent) and/or POP mail. This mandate was published in the "Strategic Plan for Computing at ORNL," Nov. 1993, (ORNL/PPA/INT-93/2) by the Office of Laboratory Computing. The strategy outlined in this ER TA will align ER at ORNL with the facility's objective.

5.4 DESKTOP TOOLS STRATEGY

In today's computing environment, attention must be given to the direction in which the current technology is moving. This future plan helps by preventing significant investments from being made in outdated, and eventually unsupported, hardware and software.

As a part of this planning, the recommendations made in the Energy Systems TAS, and those issued by such organizations as PC Support and PC Technologies, were reviewed to determine their applicability to ER. The results of this effort are the following desktop tools strategies for the ER Program:

- Migrate towards a Windows environment. This strategy not only moves ER more in line with the current technology trends, but also establishes a compatible tools environment for data sharing. (See Sect. 5.7 more information.)
- Migrate from the SSN toward Ethernet access to E-mail and other applications. This strategy supports the ER long-term network strategy of making backbone network connections. (See Sect. 5.12 for more information.)
- Establish a plan for PC replacements/upgrades that strives to keep PC configurations equivalent to at least the low-end hardware/software configuration stated in the Energy Systems Hardware and Software Recommendations list. (See Sect. 4.10.)

Several factors must be considered when making desktop tool selections, including the level of computing power needed and the types of applications accessed.

When determining the level of computing power needed, an assessment must be made of the types of processing to be performed. The following categories are provided with an associated list of anticipated processes:

- **Low End**—simple word processing and terminal emulation.
- **Moderate**—intermediate-level word processing, terminal emulation, spreadsheet analysis, some drawing, and database activity.
- **High End**—advanced word processing (including some page layout and graphics integration, equations, tables, etc.), terminal emulation, complicated spreadsheet analysis and plotting, moderate drawing, and extensive database activity.
- **Technical Drawing** (variation of High End)—drafting and engineering design (more than simple drawing).
- **Desktop Publishing** (variation of High End)—extensive page layout in the publishing environment.

5.5 GRAPHICAL USER INTERFACE STRATEGY

The fundamental recommendation of the ER TA in the area of Human/Computer Interaction is the use of applications with windowed GUIs. Applications with well designed, standards-based GUIs can increase the productivity of both experienced and novice users. While some users may initially experience difficulty and frustration when moving from a character-based application, with which they are experienced, to an unfamiliar GUI application, any "transition pain" is overshadowed by their increasing ability to productively utilize subsequent GUI applications with little or no training. This transition will result not only in increased productivity of program personnel as they interact with custom-developed applications, it will also align both Energy Systems and contractor personnel with established industry directions, allowing a synergism between custom applications and leading COTS packages.

However, the benefits of a GUI environment should not, by itself, be considered sufficient justification for replacing one's computing environment. Nor should the style of the user interface necessarily outweigh all other functional aspects when comparing alternative system solutions. Rather, as other business factors drive changes to the computing environment, a migration to a GUI environment should be encouraged.

In particular, the IEF CASE environment is the preferred development environment within the ER Program. Even though its capabilities to generate applications with GUI for such platforms as the Macintosh or certain UNIX environments is currently limited, IEF's overall integration, platform independence and other capabilities may outweigh these limitations, especially given the fact that IEF's support for GUI environments is rapidly increasing.

Several actions can be taken now, both to encourage a migration to GUI applications and to remove the barriers to such a migration. The following actions can be taken to encourage migration toward a GUI environment:

- The ER Program should support the development of an Energy Systems (preferably) or ER Program (at least) GUI style guide to ensure that as many applications as possible with which ER personnel will interact will follow a consistent style. To achieve the desired benefits in this area, the style guide itself must be consistent with established industry directions.

- Compliance with the style guide should be required for custom software, whether developed internally or externally.
- In the absence of either an Energy Systems or ER Program GUI style guide, existing industry guidance should be adopted. For the Motif environment, this is the *OSF/Motif Style Guide*. For the OS/2 environment, this is the IBM Common User Access (CUA) standard. For the Microsoft Windows environment, applications should conform to the Microsoft guidelines published in *The Windows Interface: An Application Design Guide*. Macintosh applications should adopt the recommendations of Apple's *Macintosh Human Interface Guidelines*.
- Many COTS packages are available in both character and graphical interface versions. The use of recommended GUI versions of COTS software should be encouraged when available. These criteria should be applied both at the time of the initial purchase as well as upon subsequent upgrades.
- Weight should be given to the availability of recommended GUI interfaces during COTS software procurements.

The following actions can be taken to remove existing barriers to the widespread adoption of GUIs:

- High-speed (i.e., Ethernet or better) network connectivity should be provided to all on-site ER personnel. Connectivity from off-site stakeholders should also be enhanced via high-speed modem pools, ISDN, or dedicated leased circuits, as required. While such connectivity is not a prerequisite for the use of stand-alone applications, the use of shared data or central systems in a GUI mode is increasingly dependent on the availability of such access.
- Workstations should be procured with sufficient resources to support a GUI environment. The workstation attributes that most directly impact the successful use of GUI applications are processor speed, memory size, graphics adapter speed and memory, and monitor size. This implies that most ER personnel would require the "Moderate" or "High End" PC configurations defined by the Energy Systems hardware and software recommendation list. Should the "Moderate" configuration be selected, consideration should be given to the substitution of a 17-in. monitor.
- During the transition to a GUI environment, situations will arise where certain users are not currently equipped or trained to comfortably utilize GUI applications. In these cases, the cost of upgrading equipment or training these individuals should be weighed against the cost of developing dual (character-based and graphical) versions of the application or against the cost of using a character-based version alone. The latter costs include increased software development and maintenance costs, mainframe usage charges, increased user training, lower user productivity, and increased central host processing requirements. Upgrade or training costs should also be considered in light of the overwhelming likelihood that regardless of the decision with respect to a particular application, industry trends indicate that such training or upgrades will eventually be required.

Recognizing the expense of developing and maintaining applications for multiple GUI environments (such as Windows and Motif), emphasis should be placed on the use of cross-

platform development tools such as IEF, UNIFACE, etc. (See Sects. 4.4.2 and 4.5 for further details.)

5.6 SYSTEM AND NETWORK MANAGEMENT STRATEGY

System management, as discussed in this section, includes the following functions:

- Capacity planning, including budgeting for upgrades, maintenance, etc.
- Configuration management, including the procurement and installation of upgrades, software procurement, and licensing management.
- Security management, including physical access control, electronic access control, and authorization management.
- Maintenance, including planning for reliability, maintainability and availability, fault detection, diagnosis and correction, preventative maintenance, and management of maintenance contracts.
- Performance management, including routine monitoring of system performance, system tuning, and interaction with capacity planning functions.
- User services, including interaction with system users regarding problems, questions, or requests.
- Output device operation (if applicable), including the operation of any attached output devices such as plotters or printers.
- Tape management (if applicable), including the operations of tape equipment (mounting and dismounting tapes), and tape library management.
- Data backup and restoration services, including routine backups of both system and user data, as well as data recovery, in the case of media or system failure.
- Contingency planning, including the creation and routine testing of required disaster recovery plans, identification of backup systems, etc.
- Accounting management (if applicable), including support for the effective and equitable recovery of system costs.

The ER Program is supported by computing systems at a variety of levels, ranging from central Energy Systems and ER systems, to project, departmental, and individual systems. The system management issues vary according to the type of system being examined.

Central Energy Systems systems are managed by the User Services and System Support (USSS) department of C&TS. Management of these systems has been the responsibility of this organization for many years. It has successfully withstood routine audits and more focused DOE Inspection and Evaluation (I&E) team reviews. From an ER Program perspective, continued use of these facilities under the current system management approach is recommended.

Central ER systems are systems used by the ER Program as a whole, either by personnel internal to Energy Systems or by external subcontractors and/or stakeholders such as DOE or the Environmental Protection Agency (EPA). They include such systems as the Kendall

Square and Paragon supercomputers located at ORNL, the central file servers used for storage of geographical information, the central OREIS host, and the central and site MCIS hosts. These systems are managed by qualified individuals, but are lacking in the availability and use of common, formal procedures, leading to a lack of consistency in system management approaches from system to system. Consistency of system management allows increased flexibility in the use of common resources (system, procedural, and human). Common system management also aids in the ability of ER personnel to use the variety of ER systems without first familiarizing themselves with the idiosyncracies of each system. This type of consistency is best accomplished not only by a common set of formal procedures, but also by the implementation of these procedures by a common pool of system managers. This approach minimizes the likelihood of multiple, different interpretations of the procedures, while providing economies of scale and reducing the risks due to inevitable personnel turnover. It should be noted that the pool of system managers being recommended does not necessarily need to reside in a particular organization such as C&TS; although, a high level of coordination with C&TS staff will be required due to requirements to utilize and communicate with C&TS-managed systems and networks. Additionally, awareness of evolving technology in the security arena is best accomplished via a continuing relationship with the Energy Systems Computing and Telecommunications Security Organization (CTSO). This group maintains the required expertise within its own staff as well as through a network of contacts to knowledgeable groups within and external to Energy Systems.

Project-specific and group-level systems are those acquired and operated in support of a particular ER project or organization. Examples include the SUN workstations procured for the WAG 6 and CRR1 projects and the VINES servers that support the Records Management function. These systems are managed in a way similar to the central ER system discussed above but tend to exhibit a higher degree of variability. Given the dynamic environment in which these systems operate, management by a central pool of system managers may not be desirable in all cases. In such cases, adoption of the central system management procedures could yield many of the same benefits. In environments requiring a higher degree of rigor, a certification process could be developed to ensure that system managers, whether Energy Systems or subcontractor personnel, possess the required skills.

Individual systems are those systems used primarily by a single individual. They include personal computers, Macintoshes, and personal UNIX workstations. Management of these systems is usually accomplished by the individual user, often with the assistance of a group specialist. Consistency is found only to the degree that the same specialist is involved. While there are currently approaches being proposed, within the industry at large and within Energy Systems, to provide for more effective and cost-efficient management of these systems, these approaches have yet to be successfully implemented on a large scale by very many organizations. Two options currently exist within Energy Systems and should be considered. For users of UNIX workstations, the Workstation Support group with the USSS department offers a variety of system management services, ranging from simple, on-demand assistance to complete setup and configuration of a system. For users of personal computers, the PC Technologies group is prototyping a subscription service called Zayineta that entitles subscribers to system configuration support, access to private and public file areas on shared servers (with associated backup and recovery services), and access to pre-configured PC software packages (along with the associated license management).

5.7 APPLICATION DISTRIBUTION STRATEGIES

In the absence of a business system architecture to specify the particular applications required by the ER Program, their data requirements, their interactions among themselves and with external applications, and their user access requirements, this interim ER TA cannot address the mapping of individual business systems to specific computers, sites, databases, etc. However, there are certain conclusions or rules of thumb that can be stated, based on the overall technical direction described in this document. This section offers considerations to be made concerning general application development, data distribution, business logic distribution, and user interface distribution. It is acknowledged that these rules of thumb sometimes contradict each other or inhibit the use of otherwise recommended technologies. The balancing of these criteria requires skill and experience on the part of the designer.

5.7.1 General Considerations

General considerations to be made in the development of applications to fit into the technical direction of the ER TA are given below.

- The application should fit into the user's world as seamlessly as possible. As large numbers of users migrate to a Windows environment, applications should follow this lead. Where an existing base is equipped with workstations, that environment should be used.
- Application design should be structured in a modular fashion to allow redeployment of the application in a different fashion at a later time (or in multiple fashions at a given time). Technology changes, and designs based on today's technology constraints should be sufficiently robust to adapt to technology improvements with a minimal amount of rework.
- Applications should be implemented in a portable fashion. Portability allows an application to take advantage of improvements in technology and pricing. Reliance on specific vendors should be avoided. It should be noted, however, that reliance on a particular vendor in one service area (such as application development tools) can actually facilitate vendor independence in other areas (such as operating systems or DBMSs).

5.7.2 Data Distribution Considerations

The design for distribution of the data used or produced by an application should consider the following points.

- User-specific data, such as personal preferences, currently selected default values, or working versions of data or documents, should be stored and maintained as local to the user as possible, such as on the user's personal workstation or group-level file server.
- Data specific to small groups, project teams, or sections, may also be distributed to group-specific file or database servers.
- Program-wide data should be maintained in a central fashion when performance considerations allow. Distributing program-wide data, either as full copies or as subsets, should be avoided whenever possible, because it introduces significant complexity into a design.

5.7.3 Business Logic Distribution Considerations

The distribution of business logic to various resources should be designed in light of the following considerations.

- The computing power users are acquiring on their desktops should be used as much as possible.
- Data integrity constraints should be implemented via the DBMS when possible. Stored procedures and/or triggers should be used when appropriate. Referential integrity features of the DBMS should be used when available. The database should be treated as a separate resource; access to databases should not be assumed to originate from any given application.
- Access control should be implemented via the DBMS when possible. DBMS features such as views and user roles should be used independently to control access by all applications. Databases will be shared across applications, often from user workstations.
- Often, distribution of specific business functions must be addressed on a case-by-case basis. Factors to be considered include performance (network and CPU) and configuration control issues, such as the impact of the use of "faulty" logic. Preference should be given to the distribution of business logic; a modular design will facilitate making required changes to the distribution approach.
- As experience is gained in a more distributed environment, other criteria will certainly come to light. Options should be kept as open as possible in all aspects of a design.

5.7.4 User Interface Distribution Considerations

The following considerations are presented for distribution of the user interface facilities.

- The user interface should be distributed to the user's workstations as much as possible. The use of GUIs demands such distribution. The need for powerful, intuitive user interfaces demands the use of GUIs.
- When using X-windows, X's network bandwidth requirements should be kept in mind. While standards efforts are ongoing to reduce these requirements, for the time being, X is a very verbose protocol. The physical location of the X clients and servers should be considered. If heavy X terminal usage is being considered, the issue of boot and font services for the terminals should consciously be addressed. Inter-site X should be avoided where possible.
- The current use of terminal emulation and the SSN should not constrain a design to a character-mode interface. The relative cost and impact of upgrading the environment should be considered. It may be cheaper to install additional network drops or purchase new PCs than it would be to develop and maintain a system around such a constraint.

5.8 SERVER STRATEGY

The network is the "transparent" backbone upon which users communicate with servers and servers communicate with other servers. The server strategy is built upon the need to provide this communication as efficiently and as cost effectively as possible. Further, the

number and placement of servers is dependent upon the service they are designed for, based on user requirements.

The server strategy for ER is derived from the following recommendations from Sects. 4.7, "Electronic Mail Services" and 4.8, "Network Services."

- Migration should be made to a LAN-based mail service through the adoption of Banyan VINES or some other network operating system, or through the use of POP mail using the Eudora product for PC users.
- The User Agent should be selected based on the selection of E-mail service.
- Banyan VINES is the preferred Energy Systems PC network file system, supported by C&TS. However, ER should support a reevaluation by C&TS of the network operating system as compared to other network operating systems, such as Novell NetWare and Windows NT, prior to making a wholesale commitment to Banyan VINES.

The server strategy is divided into four sections. A requirements section addresses the uses of the servers. The placement of servers is discussed in a section on Topology. Several issues are discussed in the third section, including the strategy on when and how to implement a server. And the fourth section addresses specific strategies or recommendations.

5.8.1 Requirements

A server may be installed to provide a multitude of functions from individual or specialized applications to general services. Further, the size, speed, and storage capability of the server is dependent upon the requirements placed on it by the application and the users, meaning the number of users and how intensively they use the server. In this context, a server can range in size from an individual PC to a mainframe supercomputer. ER currently is using, or plans to use, a wide variety of servers.

Several individual systems are in operation today. These include OREIS, MCIS, and the DMC. These systems are dedicated to a single application. For example, MCIS is actually composed of six SUN Sparc Workstations (one per site, including Portsmouth and Paducah, and one central) running the SYBASE DBMS and FoxPro. The system is intended to provide a centralized project management functionality, performance measurement, and reporting capability for all of ER.

Departmental servers are localized to a single department usually within a single building. These servers consist of a fairly fast DOS-based platform (such as a 486, 66-MHz PC with a large hard drive) running the Banyan VINES network operating system. Network based applications of WordPerfect, Harvard Graphics, FoxPro, Lotus 1-2-3, and other software may be installed on the machine. In addition, Banyan VINES includes a mail system for which C&TS has installed a gateway into the Energy Systems mail system, ALL-IN-1. The departmental server is used for file storage, file sharing, and resource sharing (such as printers), in addition to mail service and software distribution.

A user's PC may also be classified as a server when transferring a file between two individuals. This designation is dependent upon who makes the request for the file.

Public servers are those servers available for use by all of Energy Systems; they are usually managed by C&TS within Energy Systems. Examples of these are the POP mail servers located at each site and some of the bulletin board servers on Internet. Some servers require individual user accounts; others are provided as a free service and are accessed through a generic "anonymous" or "guest" account.

5.8.2 Topology

All of the servers discussed above are described in the context of being connected to an Ethernet network. The subject of this section is the placement of the various types of servers within the network framework.

There is one general guideline to follow regarding the placement of a server. The designer should consider the server's user base (where they are located, what applications are being served, and what communications protocols are used), and place the server at the lowest point in the networking hierarchy in which all its customers may be served. Departmental servers should reside on the department's network. A server, such as the K-25 MCIS server, should reside on a K-25 network. An external interface server should be located on the external communications network at ORNL. A COSMail POP mail server is located at each site to handle POP mail within that site. ALL-IN-1 mainframes are installed in the computer centers at each site to serve that site.

The reasoning for this guideline is to provide the most efficient communications as possible. This provides more efficient use of the bandwidth available on the networks and presents the user community with the most responsive service possible. There are other factors that could determine a servers location, security being the primary determinant.

5.8.3 Issues

The departmental server is useful for file sharing, resource sharing, and providing a departmental mail service. A typical DOS-based file server can support approximately 20 to 40 clients, depending on usage and required storage capability. Multiple servers can be provided as demand requires, and they may be used as backups for each other.

Despite efforts to distribute most processing to PCs, workstations, or departmental machines, there will be continuing demands for central (remote) services. These services will be mainly indirect services, such as boot service, backup service, database service, mail delivery services, cost accounting/tracking, etc. The networks will also provide access to Energy Systems host-based resources, such as E-mail or POP mail, the Central Accounting System, and the Material Management System.

The issue of the use of Banyan VINES as a standard network operating system has been addressed in Sect. 5.9, "Networking Strategy." The short-term strategy is that if a server is to be purchased and installed, it should be a Banyan VINES server. The long term strategy is to support a reevaluation by C&TS of the network operating system as compared to other network operating systems, such as Windows NT or Novell. The reason for this request is that Novell commands a much larger market share (90% compared to 6% for Banyan VINES); Novell capabilities have expanded with subsequent revisions to the system software (including the latest revision that addresses the "Enterprise LAN," a strong selling point for Banyan VINES); and many more applications are written to Novell than to Banyan VINES. Windows

NT is recommended because of the migration to a windowing environment within Energy Systems and the increased functionality of the network operating system. This reassessment must take into account the needs of today weighed against the cost of totally changing the existing structure within Energy Systems in regard to manpower, hardware, and support required to run both network operating systems for a period of time.

The final issue facing ER is the management of the file servers, whether the departmental Banyan VINES servers or a UNIX application/file server. This issue may be addressed on an individual server basis, depending upon the competency, the available time to dedicate to the server, the degree of difficulty in managing the server, and the desire to manage the server by the prospective manager(s). Section 5.8, "System Management," includes a listing of management functions for computing systems at a variety of levels, including ER managed, C&TS managed, subcontractor managed, and personal systems. The decision as to who will manage a server should be made as early as possible in order to get them on board during the planning stages. One highly recommended alternative is to pursue the management of servers by C&TS until competency by an ER-designated manager is obtained; then, the C&TS services may be terminated.

5.8.4 Specific Strategy Recommendations

This section is intended to briefly propose several solutions to be considered by ER regarding the strategy to implement specific servers. The use of servers to provide printer sharing may be one possible means of cost savings within ER. Currently within Energy Systems, and typical for ER, a costly LaserJet Printer is provided to every single user within the department. These printers generally sit dormant on the user's desktop. A shared network printer could provide the high-quality documents required for the department and low-cost, dot-matrix type or low quality LaserJet printers could be distributed to the desktops for general printing.

Two scenarios exist for the implementation of POP servers to provide E-mail service, ER stand alone or C&TS. This ER TA suggests using COSMail 1,2,3 at each site initially. If the ER load warrants a separate server, then C&TS can be requested to install and manage an ER-dedicated machine at each site that would basically be the same as the COSMail machines, operated by same folks, located in the same computer room, etc.

External interfaces, such as DOE, outside contractors, etc., could be routed to a server dedicated to only external customers of ER. This would provide a more secure environment by helping to prevent the random internal wandering of an unauthorized person through ER files. This server would serve as an external contact distribution center and could also provide a bulletin board service to external customers.

In keeping with the E-mail strategy outlined in Sect. 5.3, this ER TA suggests that ER install several servers to allow users to become familiar with server operations prior to migrating more important applications, such as E-mail, to the server.

5.9 NETWORKING STRATEGY

The networking strategy forms the basis of the strategies for E-mail, servers, and external connectivity. As a strategic element, the network can facilitate the conduct of business through electronic means rather than physical conveyance of documentation, products, and personnel. In addition, the strategic direction of the network infrastructure has a decisive impact on future capabilities within an organization.

The strategy presented in this section is obviously intended to endorse the already underway implementation of high-speed networking within the ER organization. In addition, this section, and related sections, will build on this premise and provide some "next step" guidance and capability education to the ER user community.

The networking strategy for ER is derived from the following recommendations from Sect. 4.8, "Network Services."

- Use the existing SWP, or install new SWP cabling as the building distribution system for network installations.
- Install fiber to the nearest Site Hub.
- Continue the installation of Ethernet LANs in support of ER initiatives, as outlined in Telecommunications Proposal #TP-366.
- Consider FDDI connections to the user for high-speed applications.
- Adopt TCP/IP as the preferred protocol for intercommunications between devices at all tiers in the distributed architecture.
- Use the preferred Energy Systems PC network file system: Banyan VINES.
- Use NFS: the *de facto* distributed file system for the UNIX operating system environment at Energy Systems, both for workstations and host mainframes.
- Install an SNMP agent to file servers (Banyan servers, UNIX file servers) in accordance with the Zayineta concept.
- Arrange for ER hosts or workstations to receive time service from an ES NTP server.
- Make use of External Connectivity to be provided by dial-up modems over standard telephone lines, the 1-800 Packet Switched Service of the FTS2000, ISDN, direct point-to-point links up to T-1 speeds, and External Network connectivity via ESnet, SURAnet, Internet, and the DOE/CN.

5.9.1 Long-Range Goals—Intrasite and Intersite

The networking goals of ER stem from a need to provide departmental interconnectivity, service mobility, and user connectivity for the more advanced applications, such as some of the modeling programs. These goals are dependent upon the installation of the C&TS backbone system. Therefore, a brief status of the individual plant systems and interplant network is pertinent at this point, in addition to an overlay of the ER networks. Alternative plans are included where appropriate.

The X-10 Fiber Optic Trunk System is now complete. A FDDI backbone network service has been activated on the fiber trunk system. The connection to the service is a bridged connection using DEC 620 bridges.

The Y-12 Fiber Optic Trunk System is complete, and an unclassified FDDI backbone network service has been activated based on 3-COM Routers. A classified fiber backbone has been installed in some areas of the facility, and the classified FDDI service is also based on 3-COM Routers. The classified service primarily supports the ANVIL System and Workstream programs.

The K-25 Fiber Optic Trunk System is conceptually designed, and funding sources for a Capital GPP are being pursued through the Landlord Program, through the Capital Budget Committee, and ER. No funding has been obtained at this time for the \$1.6 Million Project or any specific portion thereof. Funding has been obtained to implement an "Interim FDDI Backbone" using existing fiber links. The electronics that will make up this backbone will be transferred to the new fiber system when it is installed.

The procurement of the Oak Ridge Federal Integrated Communications Network (ORFICN) includes the installation of a Fiber Optic Triangle between the three Oak Ridge sites and a link from Y-12 to a hub at the DOE federal office building downtown. Optimistic plans are for this intersite triangle to be available for use by October 1995. C&TS intends to implement a high-speed service to interconnect the three plants' FDDI networks using T-3 (45 Mbps), FDDI (100 Mbps), or ATM/SONET (100 Mbps over a 600-Mbps to 2-Gbps trunk), depending on funding availability and customer need. In the interim, two options have been proposed: SmartRing would provide T-3 grade of service over leased lines (fiber) installed by South Central Bell, or multiple T-1 lines may be "bonded" through a multiplexer to yield Ethernet (10 Mbps) throughput. The current intersite communications are provided over single T-1 (1.5 Mbps) lines between sites. ER connectivity is overlaid onto a diagram of the three site network in Fig. 4.

There are two issues facing ER in regard to the backbone networks. The first is whether to move the OREIS users from ORNL to K-25, which would necessitate the installation of a high-speed link between the two sites (host would stay at ORNL), or leave the users at ORNL until the ORFICN triangle is installed. The second issue is that site budget constraints have prevented K-25 from funding a permanent backbone network.

As a major user of this backbone, sponsorship for a portion of the network by ER is being pursued by C&TS and site management.

The long-range strategy for ER is to use these backbone networks and allocate funding to make departmental/user connections to the backbone. On a further note, no additional connections to the SSN should be made. Plans for this network at all three sites are to supersede it with higher speed connectivity, usually Ethernet. The physical components, infrastructure, protocols, and external connectivity are discussed in the following sections.

5.9.2 Physical Components

The Standard Wiring Plan stipulates that a central communications room be provided in a building to house telephone patching and service equipment and the electronics for networking services, including concentrators, repeaters, bridges or routers, and fiber interface

Fig. 4. ERWM network connectivity long range plan.

equipment. From this central room, twisted-pair wiring, capable of supporting 100-Mbps networking, and telephone cable will be run to individual user offices/locations. A single trunk cable consisting of 30 fibers will be run to the nearest site distribution hub to tie the local department network to the site backbone.

Figure 4 depicts the ER backbone connectivity, and the diagram in Fig. 5 shows the configuration of fiber cable and standard wiring in a building distribution. All new building installations and major office renovations are following this strategy.

Thinwire and thickwire (tapped coaxial cable) Ethernets have been installed at Energy Systems. However, these topologies have proven to be unreliable, limited, and difficult to maintain as compared to the twisted pair topology, especially in an office environment with changing personnel and their connections. The only application for coaxial installations is in a test lab environment limited to a single room with minimal device connections, no critical applications or connections to production devices, and thus, no impact to real users.

5.9.3 Network Infrastructure

The departmental Ethernet or CDDI (twisted pair copper wire version of FDDI) network, as implemented on the cable system, is depicted in Fig. 5. Normally, the Ethernet and CDDI concentrators are located in the central building communications room. (See Sect. 5.9.2.) The concentrators should be able to cascade for expanded growth potential with minimal investment for immediate needs. Concentrators may be segregated to provide for more than one network in a single building. The departmental networks are connected to the site backbone via the building distribution fiber optic cable through an FDDI hub in the site distribution hub. Router cards are installed in the FDDI backbone concentrator for each departmental network connection.

A user installs an Ethernet card with a 10 Base T connector, or card with an appropriate adaptor, in his or her PC, workstation, or other network device and connects to the network with a patch cable to the SWP connection in his or her office. File servers, etc., are connected to the network in like manner. CDDI users would also use the SWP, but have a CDDI Interface Card installed in their workstation. After completing the physical connection to the network, users must install and configure the appropriate software on their networked device to "talk" across the network. Protocols are discussed in Sect. 5.9.5, and user software is discussed in Sect. 4.12.

The standard wiring plan includes an option for the installation of fiber optic cable to the desktop. To date, no one at Energy Systems has elected to exercise this option due to the increased cost of fiber installation and because Ethernet capability and 100 Mbps CDDI over twisted pair cable has been deemed more than adequate for even the most advanced user. As with all things, this, too, is expected to change. ER may wish to consider installing fiber to high power users at some time in the future as needs demand. For now, especially for general purpose office users, the SWP more than meets their needs.

The new fiber optic backbones have been planned, specified, and installed to accommodate future networking technologies, such as 2-Gbps ATM/SONET communications. ORNL is already in the process of testing and evaluating a multi-gigabit per second switch that could become the topology of the future.

Fig. 5. ERWM network connectivity network diagram.

5.9.4 External Connectivity

Several departments were identified in Sect. 5.9.1 as potentially having requirements for external connectivity that have not been exactly specified at this time. As a result, several services available through C&TS were described, but exact solutions were not identified. The reader (potential customer) was prompted to seek assistance from Telecommunications Services on a case-by-case basis. This section endorses that philosophy, but also seeks to provide further strategic direction for external connectivity based on the internal resource or user that the external resource or user needs to connect with. In the process, several suggested rules or guidelines will be discussed, especially in the area of security, that could have a direct impact on the network strategy and the file server strategy.

The dial-up lines, including the 1-800 packet service, are used by individuals at home or on travel who require access to E-mail and word processing on a central host mainframe using a terminal emulation package. This service first must clear the Daemon, which provides password authentication prior to connecting the user into the SSN service. This system is the simplest means of external communications and, with the 1-800 number, is also the lowest cost for a user. Total investment for a Hayes Modem is \$600.

Access via SLIP/PPP or ISDN is a low-cost alternative for an individual user or an external department requiring access to resources residing on the Energy Systems Ethernet/FDDI high speed network(s). These services may include C&TS hosts or servers, departmental file servers, or the individual's workstation or PC located in his or her office. Access is via ISDN lines or regular phone lines for SLIP/PPP into the Energy Systems Gateway (ISDN is planned), which provides password authentication prior to connecting the user to the External Communications Segment that is routed to the Energy Systems high-speed backbone network. SLIP/PPP run over a Hayes Modem (\$600). The ISDN connection requires an ISDN card in the user's machine (\$700) and the installation of an ISDN line into the user's location (\$850 plus a monthly recurring charge of \$150 for an average installation). A 1-800 number has been installed for long distance SLIP access. There is a charge for using this number.

High-speed access to resources residing on the Energy Systems Ethernet/FDDI high-speed network(s) may be provided to a department network at a contractor location, government office, or other off-site location via a leased T-1 line. This connection is also made through the Energy Systems Gateway. Routing equipment, T-1 line CSU/DSU (digital line modem, line conditioner), and end user interfaces (\$15,000 plus leased line monthly recurring charges) are required to complete the circuit. This connection is intended for an organization requiring frequent high-volume data traffic access to, or from, external resources.

External connectivity may also be achieved through the Internet, typically at Ethernet data rates. The Internet connection is made through an Internet router installed at ORNL and connected to the External Communications Segment. External sources that also have an Internet connection may gain access to resources residing on the Energy Systems Ethernet/FDDI high speed network(s). Figure 6 illustrates External Network connectivity.

The selection of an external communications medium is dependent upon many factors, including data throughput requirements, number and type of end user or host devices, and

High Speed Service

Dial-in Low Speed Service

ERWM Network Connectivity External Networks

Fig. 6. ERWM network connectivity (external networks).

cost versus need analysis. But the most important consideration in external networking is security. Data must be protected from unauthorized access, and Energy Systems internal networks and all automated data processing (ADP) resources must be protected from threats such as virus attack or hackers. Therefore, the need for authentication and log-in measures, as well as a comprehensive security awareness program, must be in place to prevent the loss or misuse of data. The Energy Systems CTSO has on file a comprehensive risk assessment and threat analysis that can be referenced.

External connectivity should be worked with Telecommunications and CTSO to ensure the proper selection of communications, that security requirements are met, and that communications components may be managed.

5.9.5 Protocols

TCP/IP is the de facto standard at Energy Systems; Banyan VINES is the DOS-based personal computer networking standard. The following is a listing of major protocols and operating systems in use on the current Telecommunications Networks at Energy Systems:

TCP/IP	Banyan VINES	X windows
DECnet	Novell NetWare	Windows NT
LAT	Pathworks	NFS
XNS	Appletalk	AFS
SNA	OS2	SLIP
Netbio	NNTP	FTP
LU-6.2	APPI	POP
Lantastic	Network Management:	LanServer
	SNMP and proprietary	

It should be noted that the complete suite of protocols within a protocol family, such as TCP/IP, may not be supported, features may be disabled, or certain restrictions may be imposed on the protocol to prevent unacceptable consequences, to implement the protocol more efficiently on the networks, or because the feature is just not needed. All protocols are not implemented on all networks. Not all of the above protocols are necessary for ER, are required at this immediate time, or are recommended by this ER TA.

There are three major issues regarding the selection of protocols. The first issue concerns OSI versus TCP/IP, or a combination of the two protocol stacks. When industry momentum began to drive the OSI protocol approximately four to five years ago, the ideology of a standardized protocol suite was attractive to user and vendor alike. The concept of OSI was endorsed by DOE and a mandate, GOSIP, was issued to align all Federal installations to the OSI Protocol Suite. However, in the effort to be all things to all people, the process was slowed to the point of becoming a political faux pas to those who needed to get work done. Therefore, like industry, institutions of higher learning, and the rest of the Energy Systems community, this ER TA recommends that ER continue to implement the TCP/IP protocol suite. Existing workstations within ER are already using TCP/IP as the base communications protocol. Most of them are using SUN's NFS, which is based on TCP/IP—FTP.

This raises the second issue regarding protocol selection: the NFS versus AFS argument. AFS is the preferred product per the TAS. However, it is limited to six platforms, is sold only by Transarc Corporation, and has not been accepted within the Energy Systems community.

Several advantages of AFS over NFS are that Kerberos security software is built in, AFS provides local caching for more efficient wide area networking, and AFS has a distributed database underneath the AFS system that keeps AFS servers synchronized to each other. The TAS recommends AFS as the preferred product with a long-range goal of DCE. DCE uses the next version of AFS (version 4.x) and will be openly distributed by vendors throughout industry, whereas AFS is proprietary. This ER TA recommends that ER continue to use NFS until DCE is readily available and then upgrade to the new system.

The third issue concerns the implementation of DOS-based network operating systems within ER, specifically the Banyan VINES network operations system issue. The strategy is that if a department within ER is implementing a DOS-based network operating system, the recommended selection is Banyan VINES, for three reasons: (1) VINES is supported by C&TS, and training, help, and vendor support is available; (2) a VINES mail gateway is installed, and users may receive their mail through the server with the existing infrastructure; and (3) VINES is available through the AVID system for procurement. In the long term, ER should support a reevaluation by C&TS of the Banyan VINES network operating system versus another network operating system (like Novell NetWare or Windows NT) by C&TS prior to making a wholesale commitment to Banyan VINES.

5.9.6 Network Management

Networking components (such as bridges/routers, concentrators, and some leased-line interfaces as ordered and installed by Telecommunications) will already be SNMP compatible, thus allowing monitoring from the central Network Management Center. In addition, this ER TA is recommending that ER request that a Remote Monitoring (RMON) device be installed on each individual departmental network to allow performance monitoring and diagnosis through SNMP of the LAN to preempt possible problems with corrective actions. Whenever available, an SNMP agent (software) should be purchased and installed on major workstations and file servers to allow centralized monitoring.

5.9.7 Related Issues

This section on networking strategy basically addressed the implementation of Ethernet LAN topology within the ER framework. It did not address the use of the LANs, the distribution of resources and users across the LANs, or the loading of the LANs with data traffic, which is somewhat dependent upon the business requirements for the intercommunication across the LANs. The sections on File Servers, E-mail and Systems/Network Administration are interrelated to this section in this regard, and some impact to the networks is addressed in those sections. Likewise, some of the strategic recommendations in this section reflect on the discussion found in the other sections.

Appendix A

CURRENT ENVIRONMENTAL RESTORATION DESKTOP COMPUTING ENVIRONMENT

 

CURRENT ENVIRONMENTAL RESTORATION DESKTOP COMPUTING ENVIRONMENT

During the course of developing the interim ER Technical Architecture, an assessment of the existing technical environment was conducted. Aspects of the environment that were examined include desktop hardware (i.e., none, versus terminals, versus PCs), network connectivity, and applications utilized (corporate, ER, and personal productivity).

The intent of the assessment was to characterize the existing environment sufficiently to allow for a legitimate comparison between today's situation and any recommendations made by the Energy Systems TAS and/or considered by this ER TA. Cost effectiveness must be a primary consideration in the formulation of a technical architecture, and recommendations for technology that cannot feasibly be implemented are of little use.

The assessment was accomplished through a combination of personal interviews and observation (22 entries), the use of an electronic survey form (71 entries), and by using the results of the recent Energy Systems PC Hardware and Software Audit (61 entries, for a total of 152 entries). (The results of this audit are presented in Table A.1 at the end of this appendix.) This represents approximately 82% of the total ER population identified by the ER TA team. While each of these techniques resulted in some degree of error and incompleteness, it is felt that the combination of all of them resulted in an accurate representation of the current ER Program technical environment.

In many ways, the technical environment currently in place in support of the ER Program is typical of any large business environment. However, there are several aspects of the environment significant enough to deserve special attention:

- ER personnel currently rely heavily on terminals (or PCs with terminal emulation) using asynchronous communication (the SSN) for access to host-based applications such as electronic mail and the Corporate Information Center.
- Personal computers are used heavily for such functions as personal data management (using local database management, file management, and spreadsheet packages), word processing, and graphics. For the most part, these personal computers operate in a stand-alone mode with very little sharing of data.
- There is a notable absence of Macintosh workstations. The Macintosh population represents only 2% of the total personal computer population. For the most part, ER staff use Intel-based personal computers. Figure A.1 indicates that, of those systems identified, 98% were Intel-based personal computers running the DOS operating system.
- The VAX-based ALL-IN-1 office automation system is the primary electronic mail system used by administrative staff within the ER Program. Although not specifically addressed by any data, it is a reasonable assumption that general corporate information (such as the Inside Lines, PC Bulletin Board, policies, and procedures) are accessed primarily via VTX on these same systems.

Fig. A.1. ER Program workstations.

- There seems to be a rather distinct division between the administrative and technical communities supporting the ER Program. The technical community is characterized by the use of UNIX workstations to access shared files and databases managed and analyzed by such tools as ORACLE, SAS and ArcInfo. This group is at home with an open systems environment. The administrative community is characterized currently by the use of personal computers for personal productivity functions and terminal emulation to central systems for electronic mail functions and financial data access.
- Within the personal computer users, there has been a significant movement from character-based (DOS) applications to applications with GUIs (Windows). This is evidenced by the number of users of Windows packages as compared to users of DOS packages for the same function. Figure A.2 shows that from 40% to 60% of workstation users currently use applications with GUIs in all categories except communications (terminal emulation), project management, and electronic mail.
- Approximately 75% of the personal computer users currently have sufficiently powerful hardware to support a networked GUI environment. Figure A.1 reflects the fact that nearly half of the ER Programs personal computers are 486 based; all of these systems are capable of supporting the desired environment. Of the half that are 386 based, a reasonable estimate is that at least half are sufficiently powerful to support the environment proposed by this architecture. The 286-based systems will require replacement to function productively in this environment.

Fig. A.2. ER Program GUI usage.

Table A.1. Current ER desktop computing environment[illegible]

Table A.1 (continued)

Project	Location	Organization	Agency Type	Agency Name	Agency Address	Agency Phone	Agency Fax	Agency Email	Agency Website	Agency Description	Agency Status	Agency Date	Agency Notes	Agency Comments
Project 1	Location 1	Organization 1	Agency Type 1	Agency Name 1	Agency Address 1	Agency Phone 1	Agency Fax 1	Agency Email 1	Agency Website 1	Agency Description 1	Agency Status 1	Agency Date 1	Agency Notes 1	Agency Comments 1
Project 2	Location 2	Organization 2	Agency Type 2	Agency Name 2	Agency Address 2	Agency Phone 2	Agency Fax 2	Agency Email 2	Agency Website 2	Agency Description 2	Agency Status 2	Agency Date 2	Agency Notes 2	Agency Comments 2
Project 3	Location 3	Organization 3	Agency Type 3	Agency Name 3	Agency Address 3	Agency Phone 3	Agency Fax 3	Agency Email 3	Agency Website 3	Agency Description 3	Agency Status 3	Agency Date 3	Agency Notes 3	Agency Comments 3
Project 4	Location 4	Organization 4	Agency Type 4	Agency Name 4	Agency Address 4	Agency Phone 4	Agency Fax 4	Agency Email 4	Agency Website 4	Agency Description 4	Agency Status 4	Agency Date 4	Agency Notes 4	Agency Comments 4
Project 5	Location 5	Organization 5	Agency Type 5	Agency Name 5	Agency Address 5	Agency Phone 5	Agency Fax 5	Agency Email 5	Agency Website 5	Agency Description 5	Agency Status 5	Agency Date 5	Agency Notes 5	Agency Comments 5
Project 6	Location 6	Organization 6	Agency Type 6	Agency Name 6	Agency Address 6	Agency Phone 6	Agency Fax 6	Agency Email 6	Agency Website 6	Agency Description 6	Agency Status 6	Agency Date 6	Agency Notes 6	Agency Comments 6
Project 7	Location 7	Organization 7	Agency Type 7	Agency Name 7	Agency Address 7	Agency Phone 7	Agency Fax 7	Agency Email 7	Agency Website 7	Agency Description 7	Agency Status 7	Agency Date 7	Agency Notes 7	Agency Comments 7
Project 8	Location 8	Organization 8	Agency Type 8	Agency Name 8	Agency Address 8	Agency Phone 8	Agency Fax 8	Agency Email 8	Agency Website 8	Agency Description 8	Agency Status 8	Agency Date 8	Agency Notes 8	Agency Comments 8
Project 9	Location 9	Organization 9	Agency Type 9	Agency Name 9	Agency Address 9	Agency Phone 9	Agency Fax 9	Agency Email 9	Agency Website 9	Agency Description 9	Agency Status 9	Agency Date 9	Agency Notes 9	Agency Comments 9
Project 10	Location 10	Organization 10	Agency Type 10	Agency Name 10	Agency Address 10	Agency Phone 10	Agency Fax 10	Agency Email 10	Agency Website 10	Agency Description 10	Agency Status 10	Agency Date 10	Agency Notes 10	Agency Comments 10

Table A.1 (continued)

Table A.1 (continued)

Topic	Question	Correct/False	Points	Answer	Feedback	Score	Time	Correct	Incorrect	Other	Comments
1. The first step in the scientific method is to ask a question.	True	True	1	True	Correct	100%	0:00	1	0		
2. A hypothesis is a statement that can be tested.	True	True	1	True	Correct	100%	0:00	1	0		
3. The independent variable is the variable that is being tested.	True	True	1	True	Correct	100%	0:00	1	0		
4. The dependent variable is the variable that is being measured.	True	True	1	True	Correct	100%	0:00	1	0		
5. A control group is a group that does not receive the treatment.	True	True	1	True	Correct	100%	0:00	1	0		
6. The experimental group is the group that receives the treatment.	True	True	1	True	Correct	100%	0:00	1	0		
7. A double-blind study is a study in which neither the researcher nor the participant knows who is in the control group and who is in the experimental group.	True	True	1	True	Correct	100%	0:00	1	0		
8. A placebo is a substance that has no therapeutic effect.	True	True	1	True	Correct	100%	0:00	1	0		
9. A placebo effect is a change in a person's condition due to the placebo.	True	True	1	True	Correct	100%	0:00	1	0		
10. A placebo-controlled study is a study in which one group receives a placebo and the other group receives the treatment.	True	True	1	True	Correct	100%	0:00	1	0		
11. A randomized controlled trial is a study in which the participants are randomly assigned to the control group or the experimental group.	True	True	1	True	Correct	100%	0:00	1	0		
12. A meta-analysis is a study that combines the results of many individual studies.	True	True	1	True	Correct	100%	0:00	1	0		
13. A systematic review is a study that summarizes the results of many individual studies.	True	True	1	True	Correct	100%	0:00	1	0		
14. A clinical trial is a study that tests a new treatment or drug.	True	True	1	True	Correct	100%	0:00	1	0		
15. A phase I clinical trial is a study that tests the safety of a new drug.	True	True	1	True	Correct	100%	0:00	1	0		
16. A phase II clinical trial is a study that tests the effectiveness of a new drug.	True	True	1	True	Correct	100%	0:00	1	0		
17. A phase III clinical trial is a study that tests the safety and effectiveness of a new drug.	True	True	1	True	Correct	100%	0:00	1	0		
18. A phase IV clinical trial is a study that monitors the safety and effectiveness of a new drug after it has been approved.	True	True	1	True	Correct	100%	0:00	1	0		
19. A clinical trial is a study that tests a new treatment or drug.	True	True	1	True	Correct	100%	0:00	1	0		
20. A clinical trial is a study that tests a new treatment or drug.	True	True	1	True	Correct	100%	0:00	1	0		

Table A.1 (continued)

[illegible]

ENERGY SYSTEMS REFERENCE LISTS

Appendix B

ENERGY SYSTEMS REFERENCE LISTS

B.1 HOW TO ACCESS VTX

The following instructions can be executed from the VAX \$ prompt or from All-in-1.

At the VAX \$ prompt type:

\$ VTX <carriage return>

From within VTX select options:

- 7 COMPUTING & TELECOMMUNICATIONS INFORMATION
- 3 PC BULLETIN BOARD
- 6 REFERENCE—HARDWARE/SOFTWARE AT ENERGY SYSTEMS

B.2 WHAT VTX INCLUDES

The listings you will find in VTX are broken down into the following categories:

REFERENCE—HARDWARE/SOFTWARE AT ENERGY SYSTEMS

- 1. RECOMMENDED AND SUPPORTED PRODUCTS LISTING UPDATED
- 2. RECOMMENDED PC CONFIGURATIONS
- 3. AVID
- 4. PC ITEMS IN ENERGY SYSTEMS STORES
- 5. ITEMS AVAILABLE FROM USER SERVICES
- 6. COMPANY SUPPORTED SOFTWARE
- 7. COMPANY SUPPORTED AND RECOMMENDED PRODUCTS

RECOMMENDED PC CONFIGURATIONS

Low End Configuration
Moderate Configuration
High End Configuration
Alternate Configurations
Printer Configurations

COMPANY SUPPORTED SOFTWARE

- 1. RECOMMENDED/SUPPORTED PRODUCTS VS AVID PRODUCTS
- 2. GENERAL INFORMATION
- 3. PC PRODUCTS
- 4. MACINTOSH PRODUCTS

COMPANY SUPPORTED AND RECOMMENDED PRODUCTS

1. GENERAL INFORMATION
2. PC HARDWARE
3. PC SOFTWARE
4. MACINTOSH HARDWARE
5. MACINTOSH SOFTWARE

Appendix C

**CURRENT ENVIRONMENTAL RESTORATION
HOST AND NETWORK ENVIRONMENT**

CURRENT ENVIRONMENTAL RESTORATION HOST AND NETWORK ENVIRONMENT

The following page is a graphical representation of the current ER Program's host connections and network environment across the five sites managed by Energy Systems for DOE.