X/Open Snapshot

Systems Management: Problem Statement

X/Open Company, Ltd.

X/Open Snapshot

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Preface

X/Open

X/Open is an independent, worldwide, open systems organisation supported by most of the world's largest information systems suppliers, user organisations and software companies. Its mission is to bring to users greater value from computing, through the practical implementation of open systems.

X/Open's strategy for achieving this goal is to combine existing and emerging standards into a comprehensive, integrated, high-value and usable system environment, called the Common Applications Environment (CAE). This environment covers the standards, above the hardware level, that are needed to support open systems. It provides for portability and interoperability of applications, and allows users to move between systems with a minimum of retraining.

The components of the Common Applications Environment are defined in X/Open CAE Specifications. These contain, among other things, an evolving portfolio of practical application programming interfaces (APIs), which significantly enhance portability of application programs at the source code level, and definitions of, and references to, protocols and protocol profiles, which significantly enhance the interoperability of applications.

The X/Open CAE Specifications are supported by an extensive set of conformance tests and a distinct X/Open trademark - the XPG brand - that is licensed by X/Open and may be carried only on products that comply with the X/Open CAE Specifications.

The XPG brand, when associated with a vendor's product, communicates clearly and unambiguously to a procurer that the software bearing the brand correctly implements the corresponding X/Open CAE Specifications. Users specifying XPG-conformance in their procurements are therefore certain that the branded products they buy conform to the CAE Specifications.

X/Open is primarily concerned with the selection and adoption of standards. The policy is to use formal approved *de jure* standards, where they exist, and to adopt widely supported *de facto* standards in other cases.

Where formal standards do not exist, it is X/Open policy to work closely with standards development organisations to assist in the creation of formal standards covering the needed functions, and to make its own work freely available to such organisations. Additionally, X/Open has a commitment to align its definitions with formal approved standards.

X/Open Specifications

There are two types of X/Open specification:

- *CAE Specifications*

  CAE (Common Applications Environment) Specifications are the long-life specifications that form the basis for conformant and branded X/Open systems. They are intended to be used widely within the industry for product development and procurement purposes.

  Developers who base their products on a current CAE Specification can be sure that either the current specification or an upwards-compatible version of it will be referenced by a future XPG brand (if not referenced already), and that a variety of compatible, XPG-branded systems capable of hosting their products will be available, either immediately or in the near future.

  CAE Specifications are not published to coincide with the launch of a particular XPG brand, but are published as soon as they are developed. By providing access to its specifications in this way, X/Open makes it possible for products that conform to the CAE (and hence are eligible for a future XPG brand) to be developed as soon as practicable, enhancing the value of the XPG brand as a procurement aid to users.

- *Preliminary Specifications*

  These are specifications, usually addressing an emerging area of technology, and consequently not yet supported by a base of conformant product implementations, that are released in a controlled manner for the purpose of validation through practical implementation or prototyping. A Preliminary Specification is not a ‘‘draft’’ specification. Indeed, it is as stable as X/Open can make it, and on publication has gone through the same rigorous X/Open development and review procedures as a CAE Specification.

  Preliminary Specifications are analogous with the ‘‘trial-use’’ standards issued by formal standards organisations, and product development teams are intended to develop products on the basis of them. However, because of the nature of the technology that a Preliminary Specification is addressing, it is untried in practice and may therefore change before being published as a CAE Specification. In such a case the CAE Specification will be made as upwards-compatible as possible with the corresponding Preliminary Specification, but complete upwards-compatibility in all cases is not guaranteed.

In addition, X/Open periodically publishes:

- *Snapshots*

  Snapshots are ‘‘draft’’ documents, which provide a mechanism for X/Open to disseminate information on its current direction and thinking to an interested audience, in advance of formal publication, with a view to soliciting feedback and comment.

  A Snapshot represents the interim results of an X/Open technical activity. Although at the time of publication X/Open intends to progress the activity towards publication of an X/Open Preliminary or CAE Specification, X/Open is a consensus organisation, and makes no commitment regarding publication.

Similarly, a Snapshot does not represent any commitment by any X/Open member to make any specific products available.

X/Open Guides

X/Open Guides provide information that X/Open believes is useful in the evaluation, procurement, development or management of open systems, particularly those that are X/Open-compliant.

X/Open Guides are not normative, and should not be referenced for purposes of specifying or claiming X/Open-conformance.

This Document

This document is a Snapshot (see above). It is intended as a foundation document for the X/Open Systems Management programme.

The document reviews the current state of related standards efforts in the field of systems management. It sets out the scope of the X/Open Systems Management programme.

The Problem Statement sets out various aspects of the problem space as a preliminary step towards defining the solution space. It discusses the particular contribution that X/Open can make to this area. Finally, two scenarios based on everyday experience are included to illustrate the scope and need for the X/Open Systems Management programme.

Disclaimer:

This document represents the interim results of an X/Open technical activity. While X/Open currently intends to progress this activity towards publication of an X/Open specification, X/Open is a consensus organisation, and makes no commitment regarding publication.

Similarly, this document does not represent any commitment on behalf of any X/Open member to make any specific products available now or in the future.

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NetView is a trademark of International Business Machines Corporation.

Referenced Documents

The following documents are referenced in this document:

- X/Open Open Systems Directive 1989
- X/Open Open Systems Directive 1990
- ISO/IEC 7498, Information Processing Systems, Open Systems Interconnection, Basic Reference Model, October 1984
- ISO/IEC 7498-4, Information Processing Systems, Open Systems Interconnection, Basic Reference Model, Part 4: Management Framework, International Standard, 1989
- ISO/IEC 9595, Information Technology, Open Systems Interconnection, Common Management Information Service Definition, International Standard, 1990
- ISO/IEC 9596, Information Technology, Open Systems Interconnection, Common Management Information Protocol, International Standard, 1990
- ISO/IEC 10040, Information Processing Systems, Open Systems Interconnection, Systems Management Overview, Draft International Standard, June 1990
- ISO/IEC 10164, Information Technology, Open Systems Interconnection, Systems Management Functions (including 10164-1 to 10164-13)
- ISO/IEC 10165-1, Information Technology, Open Systems Interconnection, Management Information Services, Structure of Management Information, Part 1: Management Information Model, Draft International Standard, June 1990
- ISO/IEC 10165-2, Information Technology, Open Systems Interconnection, Management Information Services, Structure of Management Information, Part 2: Definition of Management Information, June 1990
- ISO/IEC 10165-4, Information Processing Systems, Open Systems Interconnection, Management Information Services, Structure of Management Information, Part 4: Guidelines for the Definition of Managed Objects, Draft International Standard, June 1990.
- ISO/IEC JTC1 TR-10000
- ISO 8649, ASN.1
- ISO 8650, ASN.1 BER
- NIST Network Management Functional Requirements
- Network Management Forum Architecture Documents
- Network Management Forum Object Specification Framework
- Network Management Forum GDMO Migration Strategy
- Network Management Forum Management Information Model (MIM)

- Network Management Forum Application Services Documents
- RFC 1098, SNMP, April 1989
- RFC 1067, early SNMP
- RFC 1189, Implementors' Agreements for Common Management Information Services and Protocol for the Internet
- RFC 1006 (1006 CMIP)
- RFC 1065, Structure and Identification of Management Information for TCP/IP-based Internets, August 1988
- RFC 1213, Management Information Base for Network Management of TCP/IP-Based Internets (MIB-II)
- RFC 1214, OSI Internet Management (OIM), MIB-II-OIM
- UNIX International Atlas Distributed Computing Architecture
- CNMA Management System Architecture
- CNMA Implementation Guide (IG4.1)
- CNMA IG-Addendum 1
- CNMA Network Management System Functional Specification

Chapter 1

Introduction

1.1 RATIONALE

This section discusses the reasons for the preparation of an initial Problem Statement document at this stage in the X/Open Systems Management programme.

A number of requirements for work in the area of the management of systems and networks have been identified. They include management of networks by open systems; in this case an application programming interface (API) to network management services, such as those implied by OSI Management. Correspondingly, there is a potential need for standardisation of access to systems management of open systems; in this case an API and command-line interface to systems management services, such as those in preparation by the POSIX System Administration working group (P1003.7). The X/Open Technical Programme Plan includes areas of systems administration, distributed applications and networking and communications. All of these have direct or indirect management implications. There is a widely recognised need for convergence of network management and systems management, but it is also clear that the two areas do not overlap completely.

From the foregoing it should be obvious that the area of interest for the X/Open Systems Management programme is a large and confused one. This is compounded by the diversity of standardisation bodies working in the area (see **Chapter 2, Current Status and Potential of Standards and Related Work**). In these circumstances it is essential that the X/Open Systems Management working group has a clear starting point for its discussions. This has to include some agreed terminology, a statement of the scope of the work, and some initial ideas as to what might be done, with a rationale for the choices. In addition, the work can proceed most effectively on the basis of an agreed analysis of the characteristic set of problems to be solved, the ''problem space''. It is to accomplish these purposes that this document has been written.

1.2 CONTRIBUTORS AND AUDIENCE FOR X/OPEN SYSTEMS MANAGEMENT

Given the diversity of the subject, it is especially important that the X/Open Systems Management programme and other contributors to this work should include a wide range of talents drawn from the X/Open member companies. The X/Open Systems Management programme will strive to involve the following categories of individual as part of the group itself, or as reviewers of documents:

- implementors of systems management tools
- implementors of network management tools
- implementors of network management protocols and services
- system managers, especially in a distributed context
- implementors of systems and software requiring management

In general, the X/Open Systems Management programme will also be aimed at individuals with this range of talents, but they will, of course, work for organisations both within and beyond the X/Open membership.

1.2.1 Definitions

In order to assist in communicating the ideas developed later, some extended definitions will be helpful.

In the context of the X/Open Systems Management programme, ''management'' encompasses both the ongoing activity of administering systems (in the broad sense) and the more strategic activity associated with setting out policy and defining the procedures which will execute the policy. We believe that the equation:

Management = Administration + Policy

defines the operational relationship between the three areas.

In common with X/Open generally, the X/Open Systems Management programme is not itself concerned with the definition of policy. Rather it is concerned with the definition of tools which support the definition of policy by users and user organisations.

Network management and systems management are familiar terms, but even these are subject to varying interpretations. Distributed systems management is a relatively new term which encompasses elements of systems management and network management, but also extends to applications management. In the context of this Problem Statement, the following meanings will be applied.

Systems Management

> Management of single systems (which may or may not be connected to a network); for example the administration of the system filestore and password file. This can vary in scale from administration of a single-user system (usually, but not exclusively, by the user) to the management and operation of a large mainframe involving a large number of software support tools and a substantial (human) management hierarchy.

Network Management

Management of the network infrastructure; for example, performance monitoring of an X.25 or Ethernet network. This can also vary in scale from the administration of a small LAN to the management and operation of a large network on behalf of many users. Network management is concerned with the management of resources such as communications equipment and protocol stacks.

Applications Management

Management of applications software; for example, the provision of environment information to application packages, provision of version control of application packages, installation and update of application packages, and configuration or reconfiguration of application packages. Applications management varies in scale from the self-management practised by the user of a PC-based application to the management of large custom applications running on mainframes. An important example is the rapidly growing requirement to manage distributed applications running on systems attached to a large local area network.

Distributed Systems Management

Management of a combination of systems and their supporting infrastructure; for example, the administration of a distributed filestore. Distributed systems management is a term which covers activities which have, in practice, been taking place for many years, often under the name of network management or systems management. Distributed systems management is not confined to those systems which are inherently distributed, such as those under consideration in the ISO work in Open Distributed Processing. It also includes those systems that are effectively an aggregation of individual systems.

The boundaries of distributed systems management may be drawn in a number of ways, dependent largely upon managerial convenience or efficiency. Distributed systems management may, nevertheless, vary in scale from the management of a small group of PCs and their fileserver to the management and operation of large corporate networks and their attached user-accessible systems. In the general case, distributed systems management can include distributed management of distributed systems, but it also includes centralised management of distributed systems, much the most common situation currently.

For the purposes of the X/Open Systems Management programme, the management of networks operated as public utilities is specifically excluded from distributed systems management.

When considering the remote and local effects of the four management categories it is important to be clear about the extent to which remote effects are visibly different from local ones. For the purposes of this Problem Statement, the term ‘‘transparent’’ should imply that the function concerned is effective without the function user being aware of the relative location of the various entities concerned. The qualifier ‘‘transparent’’ therefore has similar meaning here to that of the POSIX activity - Transparent File Access - which aims to define mechanisms which allow the use of a distributed filestore with minimal or zero semantic differences, from the user’s point of view, with respect to a

conventional local filestore. In contrast, where effects are explicitly local and remote these terms are used. The qualifier ‘‘remote’’ therefore has similar meaning here to that in BSD *rcp*, remote copy, where the specific system concerned is explicitly identified by the user.

1.3 SCOPE OF WORK

This section discusses the area to be covered by the X/Open Systems Management programme. In particular it discusses the relationships between systems management and network management and brings them together under the general topic of distributed systems management. It also extends into the generic aspects of applications management.

The X/Open Technical Managers have agreed that the X/Open Systems Management programme should define interfaces and select profiles so that competing, portable, interoperable, management applications can be produced. The first meeting of the X/Open Systems Management working group discussed the interpretation of this and, amongst other decisions, concluded that a base document, including an initial architecture, was required. The architecture will be defined after consideration of a number of submissions from X/Open member companies evaluated according to a separately developed set of criteria.

The area of interest of the X/Open Systems Management programme is defined by the topic of distributed systems management. However, it is important to establish what this means. In particular, distributed systems management encompasses both network management and systems management, but the X/Open Systems Management programme is not concerned with those areas of network management which encompass provision of public network services. On the other hand, the X/Open Systems Management programme is concerned with the definition of facilities for the generic management of applications software, applications management.

The scale of systems to be addressed by the X/Open Systems Management programme includes the whole range from single-user systems used for office automation purposes, to substantial mainframes and supercomputers. In network terms it includes the whole range from small office LANs to major high-speed backbone networks and international corporate WANs.

The three topics of systems management, network management and distributed systems management form an overlapping set both for actual operational purposes and in terms of the tools needed to support them (see **Figure 1**, below).

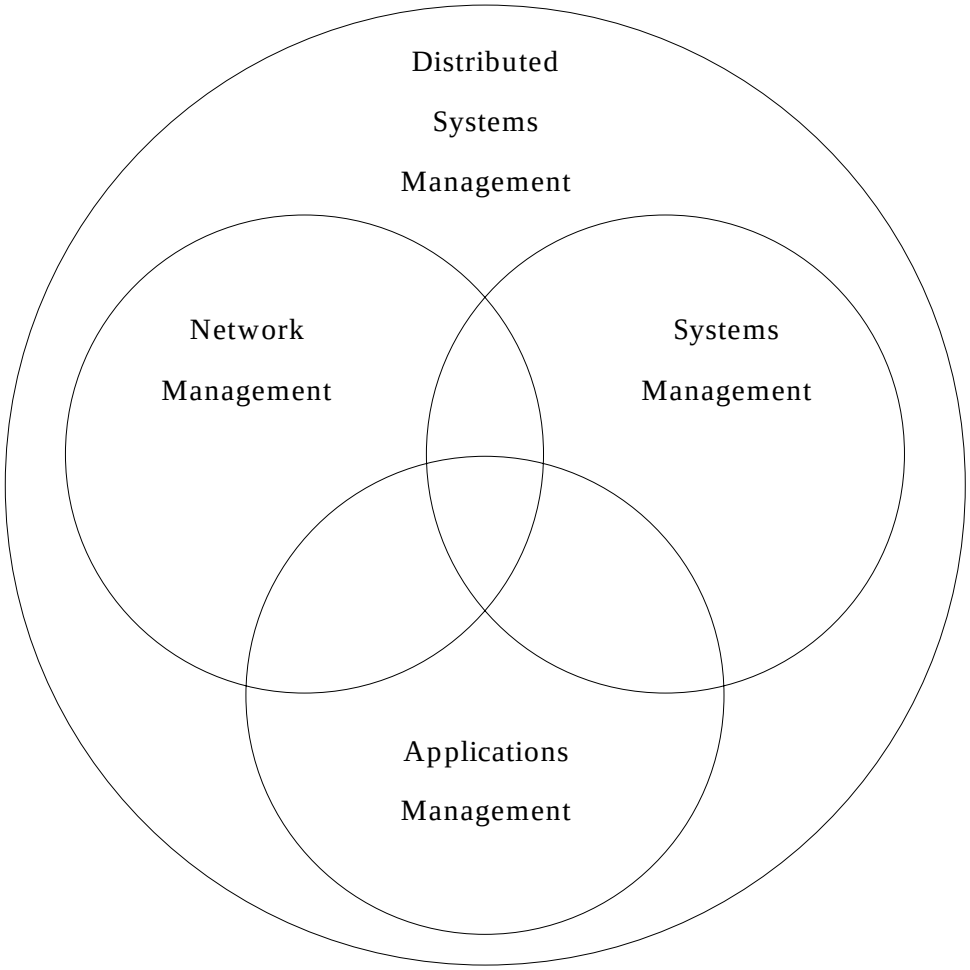

Figure 1. Overlapping Components of Distributed Systems Management

This figure may be applied in a number of different ways, for example, to the management services visible to the end-user, but its principal relevance to the X/Open Systems Management programme is as a way of analysing the various categories of management functionality which might be offered by services defined as part of the X/Open Systems Management effort.

Chapter 2

Current Status and Potential of Standards and Related Work

A large number of organisation are contributing to standards and standards-related work in the areas of systems management, network management and distributed systems management. This section of the Problem Statement describes work which is potentially relevant to the X/Open Systems Management programme. This review is not exhaustive and it describes the situation as of April/May 1991.

2.1 ISO

Within ISO, the principal area of relevance to the X/Open Systems Management programme is the work on Open Systems Interconnection (OSI), and in particular the work on OSI Management. This is a definition of management standards aimed at the management of OSI facilities and is applicable therefore to both end-systems and network devices. The standards are divided into layer management and systems management.

- Layer management is management specific to each layer and is the responsibility of the individual groups defining each OSI layer. Progress here has been limited.
- Systems management is the definition of standards that are common to all the layers and those that apply at the application layer, the latter being necessary since layer entities take part in management via their local application layer. This work has progressed substantially in recent years. It should be noted that whilst the initial aim of OSI Management was limited to OSI, the later standards implicitly acknowledge that the applicability of the standards is much wider.

From the above it will be noted that the term ‘‘systems management’’ within OSI Management refers to the application level facilities for managing the layers, whereas in this document it refers to the management of computer end-systems and their subsidiary devices. OSI systems management facilities can and are being used for this latter type of management.

In addition to the top-level OSI standard, **ISO/IEC 7498**, the systems management standards in **Table 1** below exist and have the status as indicated. A date indicates the expected date when the item will achieve the status.

ISO / IEC†	Title	CD‡	DIS‡	IS‡
7498-4	Management Framework	-	-	Y
9595	Common Management Information Service (CMIS)	-	-	Y
9596	Common Management Information Protocol (CMIP)	-	-	Y
10040	Systems Management Overview (SMO)	-	Y	7/91
10164	Systems Management Functions (SMF)	*See separate table*		
10165	Structure of Management Information (SMI)			
10165-1	SMI - Management Information Model (MIM)	-	Y	7/91
10165-2	SMI - Definition of Management Information (DMI)	-	Y	8/91
10165-4	SMI - Guidelines for the Definition of Managed Objects (GDMO)	-	Y	7/91

TABLE 1. OSI Management: ISO Standards

ISO/IEC 10164, Systems Management Functions (SMF) defines various functions that can be used by management and is split into parts of which there are currently thirteen which have reached the stage of CD‡ or DIS‡. These are shown, together with their current status, in **Table 2** below. There are work items in progress which will lead to further parts of **ISO/IEC 10164**.

ISO / IEC	Title	CD	DIS	IS
10164-1	Object Management Function	-	Y	7/91
10164-2	State Management Function	-	Y	7/91
10164-3	Attributes for representing Relationships	-	Y	7/91
10164-4	Alarm Reporting Function	-	Y	7/91
10164-5	Event Report Function	-	Y	7/91
10164-6	Log Control Function	-	Y	7/91
10164-7	Security Alarm Reporting Function	-	Y	7/91
10164-8	Security Audit Trail Function	Y	6/91	6/92
10164-9	Objects and Attributes for Access Control	Y	6/91	6/92
10164-10	International Organisation for Standardization - ISO Account Meter Function	Y	6/91	6/92
10164-11	Workload Monitoring Function	Y	6/91	6/92
10164-12	Test Management Function	Y	11/91	11/92
10164-13	Summarization Function	Y	11/91	11/92

TABLE 2. OSI Management: Functions

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† ISO and the International Electrotechnical Commission (IEC) have established a joint technical committee for information technology (ISO / IEC JTC 1). The standards are therefore referenced ISO / IEC.

‡ CD Committee Draft Documents being worked on by the committees.
DIS Draft International Standard Proposal for an IS.
IS International Standard Ratified Standard

The purpose of these documents and their interrelationship is as follows:

- **ISO/IEC 7498** is the **Basic Reference Model for OSI**, and **ISO/IEC 7498-4, Management Framework** is an extension to this which sets out the general principles and architecture of management. It concentrates on the communications principles used for OSI Management.
- **ISO/IEC 9595** and **ISO/IEC 9596** describe the Common Management Information Service and Protocol (CMIS and CMIP), which are definitions of an application service and protocol in the classic manner of standards such as the Transport Service and Protocol (ISO / IEC 8072 and ISO / IEC 8073).
- **ISO/IEC 10040, Systems Management Overview (SMO)**, describes the relationships between the other standards. It also describes some concepts which are generic throughout OSI Management, and is a major advance on **ISO/IEC 7498-4**.
- **ISO/IEC 10165, Structure of Management Information (SMI)**, describes how information is represented in OSI Management; it gives an object-oriented perspective to OSI Management data and the operations which may be performed upon it. This standard currently consists of three parts which give general guidance on the definition of objects, both within the standards and outside them, how they are to be described and a catalogue of those objects defined by OSI Management. Objects are intended to be registered through the mechanism of registration trees in a way defined by ISO.
- **ISO/IEC 10164, Systems Management Functions (SMF)** describes uses of the general facilities of OSI systems management in order to perform specific functions. Individual functions define the semantics of various managed objects, whilst the syntax is contained in **ISO/IEC 10165-2, SMI - Definition of Management Information (DMI)**. The use and provision of particular systems management functions is negotiable.

2.2 CCITT

CCITT (Comité Consultatif Internationale de Télégraphique et Téléphonique) is an international consultative committee that produces international communications recommendations which are frequently adopted as standards. CCITT is a member of the International Telecommunications Union (a United Nations treaty organisation). Members of CCITT include PTTs, scientific and trade associations and private companies concerned with the telecommunications market. CCITT recommendations (of primary concern in this context) are of the form X.n (e.g., X.25, X.400). CCITT recommendations of concern to the X/Open Systems Management programme are technically aligned with ISO standards, to the extent that up to the point a standard (recommendation) is ratified the documents share a common text differentiated by textual device to derive the appropriate organisation's format. In view of this alignment it is unnecessary for the X/Open Systems Management programme to consider CCITT recommendations separately from ISO standards.

2.3 OSI REGIONAL WORKSHOPS

The primary function of the OSI regional workshops is the development of OSI profiles. Their aim is to produce harmonised International Standard Profiles (ISPs) as defined in **ISO/IEC JTC1 TR-10000**.

2.3.1 European Workshop for Open Systems (EWOS)

In 1990, EWOS established an Expert Group (EG) on network management (NM). The EG NM is chartered to specify a taxonomy of profiles for OSI Management, and within this taxonomy, profiles (functional standards) for protocols, management functions and managed object definitions.

The taxonomy will refer to ISO standards at CD, DIS and IS status as well as CCITT recommendations, whereas the profiles will be based on agreed ISO base standards at the IS or DIS stage and upon CCITT recommendations only.

It is not within the main purpose of the EG NM to define managed objects, but if a gap is discovered, EG NM will consider working on actual definitions of managed objects.

Profiles will be developed jointly with the NIST OIW NMSIG, AOW NMSIG, ETSI and others with which formal liaison has been established.

The initial focus of the EG NM is to develop an approved taxonomy of profiles. In addition to this, the EG NM is currently working on a profile for management communications based on the ISO CMIP standard.

2.3.2 NIST OSI Implementors' Workshop (OIW)

NIST Network Management Functional Requirements gives the NIST view of requirements for network management. It is based upon the OSI Management model but it recognises that the standards process is slow and states that ''the U.S. Government cannot afford to wait until post-1994''. It indicates that NIST-approved implementation agreements will form the basis for vendor-independent standards for network management. The major contributor here is the Network Management Special Interest Group (NMSIG) of the NIST OSI Implementors' Workshop, although the contribution of the OSI Network Management Forum (NMF) is also acknowledged.

The requirements analysis is based upon the original ''famous five'' functional areas of OSI Management: Configuration, Fault, Security, Performance and Accounting, together with an Architectural category. It forms phase one of a three-phase programme. The second phase, formulating requirements and evaluating the suitability of standards, is presumably now in progress. The third phase will establish a laboratory to ''build solutions''.

2.3.3 Asia and Oceania Workshop for Implementors of OSI (AOW)

The third regional workshop is the Asia and Oceania Workshop (AOW). AOW also has a network management group, and along with EWOS and OIW has contributed to the proposed Draft ISPs in the area of OSI Management.

2.4 IEEE POSIX 1003.7

The POSIX System Administration working group (P1003.7) was formed in January 1989. It's goal is to define interfaces for systems administration functions concerned with managing entities such as users, filesystems, devices, printers, etc.

The group started by considering current practice, but soon concluded that there was too much diversity and insufficient functionality to simply codify the existing commands. The only command common to all the systems surveyed was *sync*, and the most widely used systems administration tool was felt to be *vi*.

The group concluded that the existing practise was focussed almost exclusively on the administration of a single system, and that to standardise this functionality would be of very limited benefit, given that the trend was towards networks of systems.

P1003.7 has adopted a goal that it's target environment is a network of heterogeneous systems (from which homogeneous networks and single systems can be derived as degenerate cases). In common with other activities in the field of management, the group has adopted an object-oriented approach to the problem of systems administration.

From its initial broad scope, P1003.7 has narrowed the field of its activities to the definition of the managed objects needed for systems management. In addition, the group is also defining systems administration tasks, which provide a systems administrator's view of the operations that have to be performed. The tasks will be mapped into sets of operations performed on managed objects.

At the April 1991 meeting in Chicago, it was proposed that the work of P1003.7 should be sub-divided into a number of sub-projects, each representing a functional subset of the whole problem space. The motivation for this proposal was the recognition that it was possible to make progress in some functional areas at a faster rate than in others. Thus, those areas where there is a consensus need not be held up while other areas are developed. It is expected that among the first functional areas to be separated out will be the topics of Print Management, Software Management and User Environment Management. Other areas will be developed as the initial topics are progressed through the IEEE balloting process.

Currently, P1003.7 is not dealing with the details of interoperability and the management framework. The group recognises that other bodies, such as the OSI Network Management Forum and X/Open, are active in these areas and has made a conscious decision to concentrate on the areas of managed objects and administrative tasks in order to avoid unnecessary duplication of effort. The group will revisit areas such as interoperability in due course, at which time it hopes to be able to review the work available from other groups.

2.5 OSI NETWORK MANAGEMENT FORUM (NMF)

This is a consortium of information technology (IT) vendors in the broad sense. These include PTTs (and their private equivalents, Recognised Private Operating Agencies (RPOA), such as BT and AT&T); and system vendors, large and small, e.g., IBM, DEC and HP.

Its objective is to accelerate the introduction and use of interoperable network management products and to support the migration of those products to meet international standards.

Its activities to date have been to produce technical agreements which are intercepts of planned public standards, together with the conformance testing supports (tools, documentation, etc.) to assure conformance and interoperability.

The agreed specifications produced by the NMF cover:

- A profile of CMIS/P over LAN and WAN OSI stacks, which has recently been aligned in R1.0.1 with International Standard CMIS, Version 2.
- An Object Specification Framework (OSF) for defining managed objects, and a strategy for migrating to the **ISO Guidelines for the Definition of Managed Objects (GDMO)** documented as a Technical Report.
- A definition of a set of Application Services, each of which could be the basis of an API.
- A Managed Object library with a set of internally self-consistent internationally registered managed objects.
- A set of documents covering Architecture, Naming and Addressing and Schema Knowledge.
- Technical Reports on **Registration of Managed Objects**, **FORUM Testing Strategy**, **Conformance Testing Report Pro-formas** and **Modelling Principles for Managed Objects**.

Recent and current work includes:

- Update to Protocol Specifications to include references to emerging International Standardised Profiles (ISPs) and LAN-WAN Interworking Guidelines.
- Application Services enhancements to cover Testing Management and Scheduling.
- Translation rules from GDMO to the Object Specification Framework.
- Requirement analysis for security of management and performance management.

The clearest exposition of the NMF approach is in the **Architecture Documents** which show how the various aspects of network management documentation sit together. The Object Specification Framework together with the GDMO migration strategy provide the principles for specification of the Management Information Model (MIM). These principles are used by the Application Services documents.

The protocol specifications provide the mechanism for exchanging information based upon the MIM, and the NMF has put much effort into the migration of the protocol stack to align with the ISPs.

2.6 INTERNET WORK

The Internet advisory board has encouraged two approaches to management among the community which uses the Internet Protocol Suite (IPS). At the February 1988 meeting of an Ad Hoc Network Management Review Group the SNMP and CMIP approaches were approved.

2.6.1 Simple Network Management Protocol (SNMP)

SNMP is a descendent of the earlier SGMP (Simple Gateway Monitoring Protocol). It is not, however, backwards-compatible with it. The current definition is **RFC 1098** (April 1989). The first release was **RFC 1067**. SNMP is deliberately a ''minimum solution''. It models all operations as alterations or inspections of variables on remote systems. The intended carrier protocol is the connectionless UDP (user datagram protocol) of the IPS set.

2.6.2 CMIP

Implementors' Agreements for Common Management Information Services and Protocol for the Internet provides a set of implementors' agreements for the OSI Management protocol. These implementors' agreements allow the services of OSI Management to exist within either an OSI-based or an IPS-based network. The OSI elements used are CMIP/CMIS (based on **ISO/IEC 9595:1990 (Rev 2)** and **ISO/IEC 9596:1990 (Rev 2)**), and service elements in the OSI application layer: ACSE (**ISO 8649** and **ISO 8650**) and ROSE (based on ISO working papers and CCITT X.219 and 229). The current proposed standard is **RFC 1189**. These application layer elements may use either a full OSI stack or a mixed OSI Upper Layer stack (Presentation through Transport) on top of TCP/IP (as specified in **RFC 1006**; this is referred to as ''1006 CMIP'').

2.6.3 The IETF SMI

The **Structure and Identification of Management Information for TCP/IP-based Internets**, **RFC 1065** (August 1988) provides common definitions and naming for the object-based management information which is manipulated by SNMP.

2.6.4 MIBs

The **Management Information Base for Network Management of TCP/IP-Based Internets (MIB-II)**, **RFC 1213**, represents the revision of the first set of managed objects defined for the management of IPS-based networks. About 100 objects are defined, and the intention is that they should be mandatory wherever functionally appropriate (for example, gateway elements should not be expected in a host system).

The **OSI Internet Management (OIM)**, **MIB-II-OIM**, represents an extension of the MIB-II for use by OSI Management-based systems. This extension includes additional distinguished attributes, mapping of SNMP traps to OSI events, and mapping of MIB-II into OSI GDMO form.

2.7 OTHER WORK

Both the Open Software Foundation and UNIX International are working in the area of systems management. Within the European ESPRIT initiative, the CNMA project is concerned with issues of network management.

2.7.1 Open Software Foundation (OSF)

The Open Software Foundation is addressing the critical area of distributed systems management. Using its Request for Technology (RFT) process, the Open Software Foundation has solicited proposals from the worldwide computer industry that define and implement a Distributed Management Environment (DME). The DME technology that OSF selects is intended ''to fulfill the open systems promise of a unified approach for efficiently managing systems, networks and user applications by providing a framework that supports a consistent administrative approach, as well as applications for managing distributed systems''.

OSF is also sponsoring a working group to define managed objects to manage OSF technologies using the DME.

2.7.2 UNIX International

UNIX International (UI) established a work group to develop a common model for distributed systems management and a detailed set of requirements for an open management framework. This team consists of over forty members representing end-users, ISVs and vendors from Asia, Europe and North America.

The group has developed a framework based on a common distributed object model to shield administrators and management applications from the complexities of how specific management operations are performed on the diverse systems in the network. This model consists of four major elements:

- **The Framework Common Facilities**

  The framework common facilities ease the development of management applications and the integration of heterogeneous systems. The common facilities provide distributed services that are useful in the many application domains. They are drawn from the **UI Atlas Distributed Computing Architecture**. The heart of the framework is the distributed object management facility. The facility allows management information and procedures to be encapsulated within objects that provide standard services through a common API. Hidden within the object are the complexities of how the services are actually performed on a particular managed entity on a particular system in the network. The distributed object management facility uses the Atlas naming and security services to provide secure, location-independent access to the services of the object.

- **Application Objects**

  Application objects encapsulate a particular set of management functionality within an object. Application objects can range from small objects that manage a particular piece of equipment (e.g., a modem) or system resource (e.g., a password file) to substantial management applications like network configuration or security. Larger applications are built out of smaller application objects. The smaller application objects hide the diversity that exists in a heterogeneous network. The larger

application objects can worry about implementing specific management policies or addressing the needs of a particular set of administrators. Since the services of an application object are offered through a standard object-oriented API, application developers can use application objects developed by other parties.

- **Application Presentation Layer**

  The application presentation layer provides application objects with a common, object-oriented API for human interaction. The API is look and feel-independent and shields the application object developer from the complexities of user interface programming.

- **Application Programming Interface**

  The application programming interface is a standard, object-oriented interface through which application objects access the services of other application objects. The interface provides applications with a location-independent means to access management services throughout the network. This interface is the key to building large, heterogeneous management applications out of smaller piece parts.

The intent of this model is to deliver tangible benefits to end-users and the open systems market including extensibility, flexibility, scalability and adherence to emerging open systems standards.

2.7.3 Communications Network Manufacturing Applications (CNMA)

The CNMA project objectives are to specify, develop, validate and demonstrate communication and network management protocols and applications.

This project comprises the major players of the European computer market:

Vendors:	Bull, GEC, Olivetti, Robotiker, Siemens Automation and SNI.
Users:	Aerospatiale, British Aerospace, Magnetti-Marelli and Renault.
Research centres and engineering houses:	Fraunhofer Gesellschaft and Alcatel-TITN.
Universities:	University of Stuttgart and University of Porto.

Within the CNMA project, a special interest group was set up to work on network management. This group has defined the **Management System Architecture** and has shared the development of the network management applications, underlying services and infrastructure.

A number of documents have been published: the **CNMA Implementation Guide (IG4.1)**, the **IG-Addendum 1** and the **CNMA Network Management System Functional Specification**. These documents specify the applications developed and the user needs they fulfill. A unique architecture has been specified that has the following properties:

openness — The system is open. New applications may easily be added as new needs emerge.

portability — The architecture groups the various functions in logical levels. These levels are accessed through an application programming interface to ensure application portability.

modularity An object-oriented approach to the system design allows multiple entities (the different partners of the project) to develop modules.

distribution A light infrastructure allows the distribution of the various modules that are developed.

reusability The same architecture can be used for the management of any system by adding new objects and new applications.

The openness of the system is reinforced by the specification of command scripts. The command scripts let the user customise or extend the function coverage of the basic applications.

The Network Management System developed within this project has been successfully demonstrated at several pilot sites where configuration, performance and fault management were running on an ISO network of heterogeneous (different vendors') equipment.

Chapter 3

Problem Space

3.1 INTRODUCTION

This Problem Statement is necessarily an overview definition of the problem set to be dealt with by the X/Open Systems Management programme. It is intended to set out a broad, general-purpose, approach to the problem. There are some implied references to the set of solutions which are, or might be, provided, but it is, for most purposes, too early in the development of the X/Open Systems Management programme to attempt to define the solution space. In particular, the partitioning of the problem space set out below does not necessarily represent a useful subdivision of the solution space.

The problem space, as seen by the X/Open Systems Management working group, must address the requirements derived from the X/Open Xtra process, which is concerned with the identification of market requirements. This following section brings together the identified problem space topics with the requirements defined in Section 4.5, Systems Administration and Management of the **Open Systems Directive 1989** (Xtra '89), and the results of the Xtra '90 process defined in the **Open Systems Directive 1990**.

The increasing scale and complexity of systems management, together with the scarcity and cost of the required skilled personnel, implies a requirement for solutions such as automated management.

The problem space may be represented using a diagram showing orthogonal axes using ideas developed for the CNMA Esprit project (see **Figure 1** below). Such a representation is presented here as a tool for discussion and analysis with the following caveats:

- It should not necessarily be taken to imply any particular dimensionality (at least three dimensions are visible at the present time).
- It should not necessarily be taken to imply that the linear subdivisions are exhaustive in themselves.
- It should not necessarily be taken to imply that they are truly orthogonal.
- The figure should be considered to apply to the totality of the system described by **Figure 1** in **Chapter 1, Introduction**.

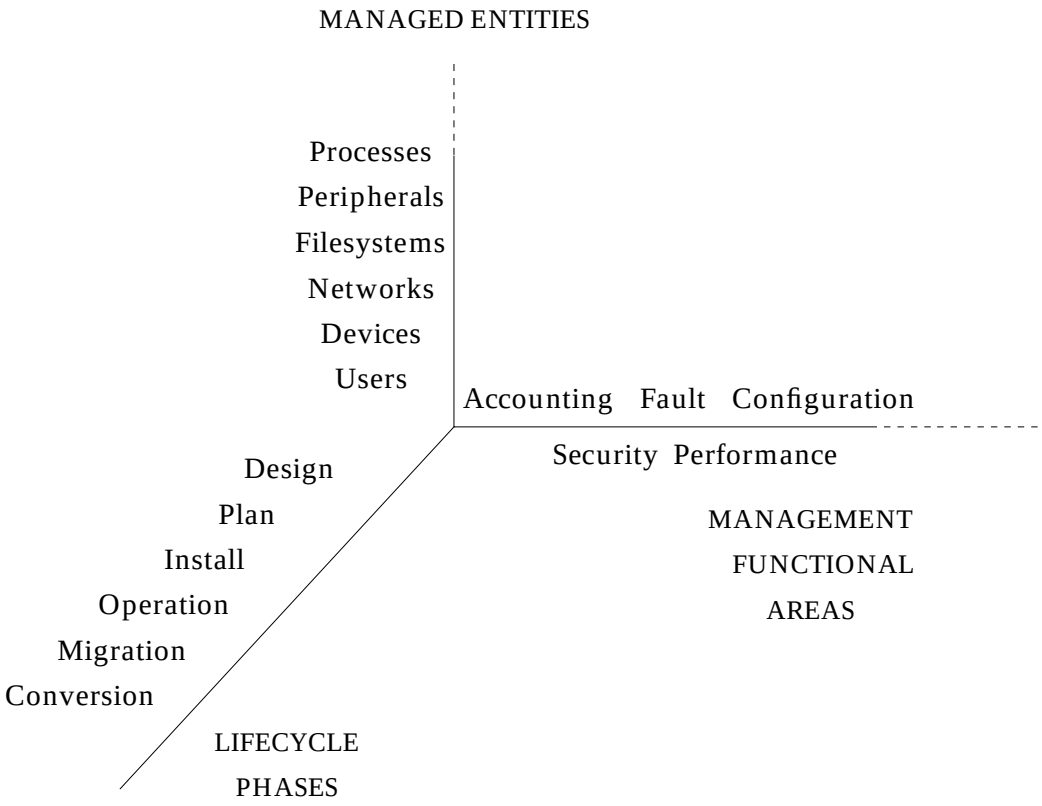

Figure 1. Orthogonal Representation of the Problem Space

3.2 TOPIC AREAS

This initial definition of the problem space consists of lists of topic areas with which the X/Open Systems Management programme is concerned. The objective, at this stage, is to ensure completeness of the analysis while avoiding the chaotic effect of an exhaustive listing of functions and objects.

The topic lists may, in some cases, appear to be mutually orthogonal, but this is not generally the case.

3.2.1 Managed Entities

The following list of topic categories are relevant to the X/Open Systems Management programme. These also form the initial set of object categories for management.

Users
: All functions concerned with adding, deleting and modifying user accounts. Setting the environment for each user and for users in general.

Applications
: All functions concerned with installing, maintaining and removing both system-vendor and third-party software packages.

File Systems
: All functions concerned with storing information on serially-accessed media (including magnetic disk and tape, and optical disc). Formatting, archiving and backup of these media.

Peripherals
: All functions concerned with setting up input-output devices other than those supporting filesystems. Includes terminal and printer setup, printer spooling and configuration of input devices.

Processing
: All functions concerned with process handling, job scheduling and batch processing.

System Configuration
: All functions concerned with installation, monitoring and modification of kernel parameters and device drivers.

Network(s)
: All functions concerned with management of the networking infrastructure, as distinct from the management of distributed users and systems. Includes management of network directories, of front-end and remote communications systems which do not themselves support users directly, of physical network infrastructure such as cabling and patching, and of relationships across boundaries between different management domains such as gateways, and the dealing with public network service providers.

Management
: All functions concerned with the management of the management infrastructure itself. This includes management of software, data, hardware and humans where any of these contribute to the management process.

3.2.2 Management Functional Areas

These are adapted from the categories defined by OSI Management.

Accounting Management
: All functions concerned with recording information about the use of the system for checking, costing and charging purposes.

Security Management
: All functions concerned with control and monitoring of access to system and user resources.

Performance Management
: All functions concerned with the monitoring and optimisation of systems performance.

Fault Management
: All functions concerned with detecting, logging, reporting and investigating systems malfunctions.

Configuration Management
: All functions concerned with controlling and monitoring the resources available to the system or to users, and the relationships between them.

The above list is not intended to be exhaustive. For example, the question of whether inventory management is part of configuration management, or a separate problem area, is not yet resolved.

3.2.3 Lifecycle Phases

Systems management must address all phases of the systems lifecycle:

- Design / Planning
- Installation
- Operation / Maintenance
- Migration / Conversion

This list is a simplification which should match elements of more complex lifecycle analyses.

3.2.4 Other Topic Areas

A number of other decompositions of the problem space are possible. Some of these are more useful in the decomposition of the solution space and are included here in order to capture the analysis process already undertaken by the X / Open Systems Management working group.

- User Categories

  Users vary widely in their relationship to systems management. An initial, incomplete, list of these categories is:

  — Corporate Network Management

- — Telecommunications Management
- — Corporate and Regional Management Information Services
- — Engineering Services
- — Manufacturing Systems Management
- — Divisional and Branch Office Management

- Domains

  A domain is a way of organising the solution space so that the appropriate policies can be fitted into specific solutions.

Chapter 4

Mapping User Requirements into the Problem Space

A set of user requirements, as understood by the X/Open Systems Management working group, is an early necessity in order to ensure that the X/Open Systems Management programme strategy answers user needs as determined by the X/Open Xtra process and by other means.

4.1 XTRA USER REQUIREMENTS

4.1.1 Xtra '89 Requirements

The **Open Systems Directive 1989** defines sixteen programme items. This initial analysis attempts to place them within the problem space topic areas already identified and within the principal management areas (systems management, network management, applications management and distributed systems management). The Xtra '89 programme areas are:

SADM03	Remote System Administration
SADM04	Moveable Management Node
SADM05	Single Mechanism to communicate with the System Operator
SADM07	Divisible and Consolidatable Management Domains
SADM10	Automatic File System Administration
SADM11	Support for Very Large File Systems
SADM12	Backup and Restore
SADM13	Backup and Restore in a Multi-vendor Environment
SADM14	Uniform Application Installation
SADM15	Definition of the Managed Object
SADM16	Management Information Database
SADM17	Object Information Propagation System
SADM18	User Account Management
SADM19	Systems Management Migration Guidance
SADM20	Administration and Operation of Batch Jobs
OS27	Administration of Multi-Processor Systems

4.1.2 Xtra '90 Requirements

The Xtra '90 process also defined requirements in the area of systems management. These requirements, shown below, were rated by the participants on a scale of 1-10. Many of these requirements are the same as those arising from Xtra '89. Others are very general high-level requirements which are compounded from the Xtra '89 detailed requirements.

Code	Rating	Description
5D	8.29	Management of security needs to be integrated with system and network management
8C	7.88	Uniform interface to system administration
2B	7.86	Enable open management of heterogeneous networked systems
8E	6.74	Standard method for software installation and control
3A	6.42	Standardise and simplify the administration, monitoring and management of open systems
7B	6.42	Distributed management of distributed systems in heterogeneous networks in a coherent manner
1D	6.21	Extensible standards for generalised device support including I18N
8D	6.15	Improved backup and restore facilities
3B	6.11	Integration with non-open platforms, particularly DOS
8B	5.98	Service measurement and monitoring facilities
8A	5.12	Queue management facilities
1J		De-skilled system management
6F		Enable organisations to access data in other organisations in a controlled and secure way
75		Interim system management guide

4.2 MAPPING USER REQUIREMENTS

The following table is an initial placement of the Xtra '89 items in the problem space topic areas. As the Xtra '90 requirements are primarily restatements and aggregations of those developed by Xtra '89, they have not been separately included in the table. The **Open Systems Directive 1990** does not elaborate upon the items, and therefore the placement is necessarily based upon an interpretation of the meaning of each of the items.

* The abbreviations DSM, SM and AM used below refer to distributed systems management, systems management and applications management respectively.

	DSM* Area	Managed Entities	Management Functional Area	Lifecycle Phase
SADM03 Remote System Administration	SM	All	All	Operation
SADM04 Moveable Management Node	DSM	Management of Management	All	Operation
SADM05 Single Mechanism ...	SM	Management of Management	-	Operation
SADM07 Divisible ... Domains	DSM	Management of Management	All	Operation
SADM10 Automatic File System Administration	SM	File System Management	All	Operation
SADM11 Support for Very Large File Systems	SM	File System Management	All	Operation
SADM12 Backup and Restore	SM	File System Management	Fault Management	Operation
SADM13 Backup and Restore Multi-vendor	SM	File System Management	Fault Management	Operation
SADM14 Uniform Application Installation	AM	Application Management	All	Installation
SADM15 Definition of Managed Object	DSM	Management of Management	All	Design

	DSM* Area	Managed Entities	Management Functional Area	Lifecycle Phase
SADM16 Management Information Database	DSM	Management of Management	-	Operation
SADM17 Object Information Propagation System	DSM	Management of Management	All	Operation
SADM18 User Account Management	SM	User Management	Accounting Management	Operation
SADM19 Systems Management Migration Guidance	?	?	?	?
SADM20 Administration and Operation of Batch Jobs	SM	All	All	Operation
OS27 Administration of Multi-Processor Systems	DSM	Processor Management	All	Operation

Chapter 5

Role of X/Open

This chapter examines the contribution that X/Open can make to the area of systems management (or, more accurately, distributed systems management, see **Section 1.3, Scope of Work**). The general objective of X/Open is:

- to offer increased value to IT system purchasers
- by ensuring freedom of choice and system continuity
- via application portability and interoperation.

In view of the present diversity of standards and products in the systems and network management areas, it is natural that X/Open should have a contribution to make.

5.1 DIVERSITY OF PRODUCTS

Systems management is an area of strong cost sensitivity for users. Complex networks built from systems with today's diverse systems management interfaces require skilled (and thus expensive) management. Especially when there is a general skill shortage, this expertise is not available to all users. This forces some to adopt single-vendor solutions for reasons of expediency, rather than for functional considerations.

Systems and network management are areas where vendors (of software, hardware and integrated products) have started to respond enthusiastically to a rising demand for solutions. In the past, many offerings either were specific to particular managed product ranges, or lacked scalability, or both. In addition, offerings were focussed on specific problems related to systems management, such as network management or systems configuration management, rather than addressing the overall management objective.

More recently, IT user organisations have been moving towards an overall view of all networks and their attached end-systems, Information Management Systems (IMS). This has been one of the most powerful stimuli encouraging the merging of systems management and network management into distributed systems management. Due to the importance to IT purchasers of this merging, the interest of X/Open in this area is natural. Portability and interoperation of management applications will ensure continuity and freedom of choice for user organisations pursuing overall IMS strategies across the entire range of system and network sizes.

5.2 DIVERSITY OF STANDARDS

The diversity of standards work has already been shown (see **Chapter 2, Current Status and Potential of Standards and Related Work**). Products which support both systems and network management within proprietary architectures have been in existence for some time (notably IBM NetView for SNA networks and attached proprietary systems). Products which provide these facilities either from an open environment or targetting open systems for management have been few. However, in recognition of a need, numerous vendors have announced products which can or will manage open and proprietary systems, e.g., AT&T, DEC, HP, IBM, ICL and Sun. The OSI Network Management Forum demonstrated interoperating management in 1990. In contrast, the POSIX P1003.7 work does not, by its nature, include implementations.

The present market-place for X/Open-compliant systems contains a wide variety of systems management tools. The question of the extent to which any of these could be absorbed into a future common platform for management applications is difficult. Correspondingly, most new tools for vendor-independent network management are designed to run on UNIX or UNIX-like systems. These facts represent both a challenge and an opportunity.

5.3 FUTURE DIRECTIONS

In the long term, the work which is taking place under the ISO Open Distributed Processing initiative may provide general answers to the management of distributed systems and their underlying networks. However, it can only do this effectively if its work has substantial input from those who have developed and implemented from less ambitious standards. Groups who have recognised early that the relationship between systems and network management is close and, potentially, helpful - such as X/Open - will be able to contribute most effectively.

5.3.1 A Distinct Contribution

There is one aspect in which the X/Open Systems Management programme differs substantially from the work of other organisations. No other group is addressing the combined question of the management of distributed systems including their underlying networks. This is despite the fact that groups in systems management (POSIX) and network management (NMF) are using the tools provided by OSI to accomplish functionally similar tasks. X/Open is, moreover, the natural choice for a body to bring these two areas together. Without any work in this area, the movement to open systems would be damaged. There would be a proliferation of tools relying on non-portable underlying interfaces. The end result would be open systems for applications but closed systems for management. This would then, of course, lead to further development of *ad hoc* tools to allow interoperation between different management environments.

In summary, X/Open can make a major contribution to this area, which is clearly set to be of key importance to both IT users and vendors. The window of opportunity is here and X/Open's timely involvement will be of crucial importance.

Appendix A

Scenarios

A number of scenarios based upon actual experience are being gathered by the X/Open Systems Management working group. They are intended to provide illustrative background material for the X/Open Systems Management programme. This version of the Problem Statement includes two such scenarios.

A.1 THE MISSING MAIL MESSAGE

The use of distributed systems technology leads to a tight interdependency between distributed system, application and communication services. Management of these services requires tight integration of management services and information.

A classic example of the interdependence of these services is presented by some mail systems: a user complains to a distributed system administrator that an intended recipient of an electronic mail message has not received the message.

The administrator finds that the Mail User Agent (MUA) passed the outbound message off to a local Mail Transfer Agent (MTA). The log for the MTA indicates that the message was received but was not transferred. The log also indicates that attempts to transfer the message to an MTA closer to the recipient were rejected with a ''resources not available'' error. Checking with the second MTA, the administrator discovers that the message store used by the second MTA has reached the quota limit on the local filesystem. The message store appears to have filled up with outbound messages to a specific site. The log of the second MTA indicates that attempts to send to this site have failed due to a communications error. Investigation of this communications error yields the identity of a critical failed data link.

To fix this problem, management of each of the system, application and communication service ''classes'' is required. Applications management of the MUAs, MTAs and Message Stores is necessary to identify the problem by querying service characteristics, logs and data stores. Systems management of the second MTA's filesystem is necessary to temporarily increase the MTA's quota (allowing the stalled message to make some progress). Applications management of the second MTA may be necessary to pause, re-initialise and resume the service to take advantage of the additional file space. Communications management is necessary to identify the failed data link and perform necessary reconfiguration to adapt to the communications problem.

Having these different types of management would allow the problem to be identified and fixed. But, if the management models, information and services are consistent and integrated, the user's stalled mail will reach the intended recipient much sooner.

A.2 ADDING A USER

Many systems management tasks are made more complex by today's implementations owing to the need to interact with many varied system resources in order to perform an apparently simple task.

A good example of this is the task of adding a new user. A user is an essentially abstract entity whose existence within a system is evidenced by the side-effects that it has on other system data and resources. In order to add a user, the administrator has to interact with several different resources, including the following:

Authentication Data	The user's ''login-name'' has to be made known to the system. In addition, a password or other authentication mechanism has to be set up.
Filesystem	The new user will need a ''home directory'' to provide a default location for any files that may be created.
Environment	The user may need copies of standard configuration files to allow the tailoring of the environment, and these may have to be copied to the home directory.
Mail System	If the new user is to be able to send and receive mail, then the mail system may need to be informed.

In some implementations the complex series of interactions that needs to be performed may be automated within a vendor-specific command script. However, in many cases it still falls to the administrator to perform this process ''by hand'', a process that may involve the direct editing of system data files. A consequence of this is that the process becomes prone to error and, as the administrator is usually operating with a high level of privilege, the possibility of introducing unintended and possibly serious errors is increased.

The final complication arises when the new user has to be added to several machines in a network, possibly supplied by different vendors. In this case the problems of the single machine are compounded by a lack of consistency in the interfaces.

Consistent, well-defined interfaces, and interoperability that would allow the desired function to be performed once for the whole network, would significantly improve both the productivity and reliability of the administrator.

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