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X.500 Directory Services: A Survey of Activities, Standards and Products

Debra ANSEN, Berne

1 Introduction

The Swiss PTT is entering a new phase in which competition, costs and service quality play a greater role than ever before. A great variety of telecommunications users and services exist, both nationally and internationally. It is necessary to make communications between users of different systems in different countries possible and easy. Products and services based on the CCITT X.500 Recommendations have the potential to fulfill this requirement.

Recent activity, such as the initiation of X.500 pilot projects, the appearance of X.500 products in the marketplace, and stabilization of the standards, indicates that this technology should not be ignored. Actually, few products have been developed and put into service, but supportive activities are laying the groundwork for future use of X.500 technology. Standards bodies have corrected problematic aspects of the standards. Pilot services are under test by PTTs and other organizations in Europe and America. Some commercial applications are available, although they are limited in scope.

In this article:

- X.500 projects within and outside of Switzerland are identified
- the status of the X.500 Standards is reported on
- some conclusions are formulated, and the Swiss PTT's view on X.500 is presented.

2 Worldwide Activities

X.500 projects have begun throughout the world. Currently, the leading players are the *Cosine Paradise* project in Europe, the *IETF (Internet Engineering Task Force) Directory Working Group* which serves as a forum for Internet directory activities and the *North American Directory Forum*. These last two groups are based in the US. The academic communities have strong representation in the IETF and in Paradise. Previous research projects gave the academic communities much practical experience with X.500, and as a result, the IETF and Paradise groups are adept at producing workable solutions.

A description of some of the major projects outside of Switzerland follows.

21 Paradise

Paradise is a pilot international directory service under the umbrella of the *Eureka Cosine* projects. Its role is to coordinate the activities of the European national X.500 pilots and to provide a central operational service across Europe with access to North America and the rest of the world.

18 countries participate in the Cosine project. They are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and Yugoslavia.

The software used in this trial is *QUIPU*. It was developed at University College, London, under the *Esprit Inca* project and later received funding from the *Joint Network Team (JNT)*, an academic networking organization. *X-Tel Services*, a private company in the United Kingdom, has a contract with JNT to provide *QUIPU* support.

There is only one non-*QUIPU* implementation connected to the directory at the moment. This is *DirWiz*, developed by *Systems Wizards* in Ivrea, Italy, under the *Esprit Thorn* and *Proof* projects. *Pizarro*, a French implementation from *Inria* which also evolved from *Thorn*, is shortly expected to take the country node for France.

It is unclear how much real use, as opposed to experimental one, is being made of the directory systems involved in *Paradise*.

In addition, *Paradise* is a sponsor of a study regarding European PTT plans for X.500 services. The study is being jointly conducted by the Swiss PTT, PTT Telecom of The Netherlands and the Finnish PTT. Several interim reports on the findings and progress of the work will be issued. At the end of 1992, a formal report will be made to the European Commission. It will suggest actions to promote X.500 service adoption and utilization within Europe.

22 North American Directory Forum

The North American Directory Forum (NADF) is a group comprised of about 20 public network administrators in the US and Canada. Membership is limited to those who 'plan to operate a public directory service in North America'. A small membership fee to cover administra-

tive costs is charged. All members are considered active members.

The group sets policy, defines service and schema definitions and works to promote implementation of interconnected public directory services. Current plans call for a pilot interconnection of at least two members by 1992. It is hoped that by 1993 at least eight commercial vendors will participate in this project.

23 FOX

The *FOX* project is a US-government-funded effort to provide a basis for operational X.500 development in the Internet. This work is being carried out by the following companies: *Merit*, *Nsyernet/PSI*, *SR* and *ISI*. Funding is provided by the *Darpa* (Defense Advanced Research Projects Agency) and the *NSF* (National Science Foundation). QUIPU software is being used by the members of FOX. Members of FOX are very active in the IETF Directory Working Group which is a government-funded working group concerned with the development of X.500 services for research networks in America, in particular the Internet.

24 CEPT 51 and TPH 28

The *CEPT 51 Group* (Conférence européenne des administrations des postes et des télécommunications) has responsibility for the TPH 28 protocol. This protocol is used by PTTs in Europe to electronically connect directory assistance operators to the directory systems of other national PTTs (within Europe only) in order to obtain telephone numbers.

In September 1991, it was decided that the definition of enhancements to this protocol would be discontinued and future development work would concentrate on defining an application of X.500 for electronic telephone directory inquiry systems.

25 PTT Telecom, The Netherlands

PTT Telecom has been quite active in the X.500 area. On behalf of PTT Telecom NL, PTT-NL Research is a participant in the CTS2 project on European directory conformance testing. In this project a group of European companies has written test suites for several OSI protocols. Test suites for the Directory Access Protocol (DAP) are included among them.

For Paradise participants, PTT Telecom NL offers a testing service for the Session, Presentation and Application layers and for the Directory applications.

PTT Telecom is also participating in the strategic study of the European PTTs sponsored by Paradise.

26 France Telecom

France Telecom continues with two efforts:

- It is working actively in standards bodies to promote the replacement of the TPH 28 protocol for international telephone directory inquiries with X.500.

- It is developing an X.500 Directory Service that can be used by electronic messaging services.

27 Swedish PTT

Televerket, the Swedish PTT, started an X.500 project in 1990. The name of the project is Direct500. Its main objectives are:

- to establish a platform for X.500 tests. The basis for these tests is an internally developed prototype written in C and using an *Oracle* database
- to gain experience for commercial X.500 service operation
- to offer an X.500 service within Televerket. A field test will take place in Autumn 1991.

28 European Space Agency

The European Space Agency (ESA) has analyzed its requirements, and X.500 concepts have been applied to these requirements. Architectural design documents are being written.

3 Activities in Switzerland

The activities listed here are a subset of the international activities. Switzerland has been active in this area. There is a good base of knowledge about X.500 as shown in the following list.

31 Swiss PTT Activities

311 QUIPU Activities

The Swiss PTT is a participant in the Paradise project. The PTT is a subordinate node of the *Swiss Federal Institute of Technology* in Zurich (ETHZ). The PTT has provided its internal telephone directory. There are about 470 organizational units and 9727 leaf entries. The main goal of this activity is to gain X.500 experience for future activity and evaluate QUIPU as a product.

312 OSI-LAB

OSI-LAB is a conformance-testing service for OSI that is operated by the Swiss PTT. Time can be bought on the system so that interested parties can test products for OSI conformance. OSI-LAB already has the software to test the X.500 protocols. X.500 conformance tests will be able to be performed as soon as executable test suites are available.

313 ETV Project

The *Terco* customer database will be replaced by a new system. One of the main goals of this project is to provide a database that is capable of containing all customer White Pages information. This project presents an opportunity to unify all subscriber information. The need for an X.500 interface to this database is accepted.

314 TPH 28

The Swiss PTT plays an active role in defining the evolution of the TPH 28 protocol. When the TPH 28 protocol is replaced by X.500, the PTT will take action to implement X.500 for international electronic directory inquiry services.

315 Strategic Study of the European PTT's

The Swiss PTT, as part of the Paradise project, together with PTT Telecom of the Netherlands and the Finnish PTT, is conducting a study on the suitability and expected acceptance of X.500-based Directory Services for European PTTs and service providers. An extensive questionnaire has been distributed, and most PTTs have responded to date.

Analysis of the data is underway. Detailed interviews with PTTs and several European companies are being conducted in order to pinpoint X.500 service needs. During 1992, the focus will be on making recommendations based on the results of the questionnaire and interviews. The final report will be available to the European Commission by December 1992.

316 Directory Working Group

This PTT-internal group serves as a forum for the discussion of all directory activities within the PTT and other Swiss government organizations. For example, members of the GRD (Gruppe für Rüstungsdienste, Armament Group, Part of Swiss Federal Department of Military Affairs) and BFI (Bundesamt für Informatik, Federal Office of Information Technology) also participate in the discussions. Discussion is primarily X.500-oriented.

32 Activities outside of the PTT

321 Paradise in Switzerland

The ETHZ is participating in the Paradise project. Main responsibility for the Swiss X.500 pilot resides with the ETHZ. In addition to running the master Directory System Agent (DSA) for Switzerland, the ETHZ is engaged in the development of new DSA and Directory User Agent (DUA) concepts.

The Swiss X.500 pilot project is part of a nationally funded project which aims at providing a basis for operational directory deployment in Switzerland and coordination of local X.500 activities with those in other countries. The pilot is mainly concerned with the integration of data from the Swiss research and development community into the global directory and is funded by the KWF (Kommision für Wissenschaft und Forschung), as well as the pilot's commercial partners. The main contractor is the ETHZ, participating with the Swiss PTT, DEC and *Alcatel/STR*. The project started in October 1988 and will end in September 1991.

Switch (the Swiss Academic and Research Network) will have main responsibility for the project after September

1991. It is the main service provider of both Internet (a US-funded research network) and IXI (International X.25 Interconnection – a Cosine-funded project for international X.25 research networks connection within Europe) connectivity and is cooperating with the ETHZ to ensure a smooth handover of the running of the Swiss X.500 service at the end of the pilot.

4 Status of the Standards

Since 1988, when standards for Directory Services were formalized, additions and modifications have been made to them. Various groups like ETSI (European Telecommunications Standards Institute) and EWOS (European Workshop on Open Systems) have worked on specifications of the protocol elements that will be implemented by vendors. Outside of Europe, there has been work on other functional standards.

41 Base Standards

The 1988 CCITT X.500 Recommendations and ISO/IEC Standard IS 9594, Parts 1–8, were developed by a joint CCITT/ISO working group. They are technically equivalent aside from the inclusion of clauses on the 'Use of Lower Layer Services' in X.519, but not in 9594-5. The CCITT Recommendations and ISO Standards consist of the documents listed in *Table I*.

Changes to IS 9594, Parts 1–8, became Draft Amendments (DAM) in November 1991 and will be circulated for country ballot. If approved, they will become Amendments to the 1988 standards in mid-1992.

Part 9 of IS 9594 is new. It specifies a shadow abstract service that can be used to replicate Directory information. When information is replicated, service to users of the Directory can be improved. This document was approved as a Draft International Standard (DIS) in November 1991 and, if approved after country balloting, will become an International Standard (IS) in mid-1992.

CCITT will meet in April 1992 to decide upon the issuance of the amended 1988 Recommendations as the new 1992 X.500 Recommendations. It will also decide about the adoption of DIS 9594, Part 9, as a CCITT X.500 Series Recommendation.

Table I. Cross-reference of CCITT Directory Recommendations and ISO Standards

ISO	CCITT	Title
9594-1	X.500	Overview of Concepts, Models and Services
9594-2	X.501	Models
9594-3	X.511	Abstract Service Definition
9594-4	X.518	Procedures for Distributed Operations
9594-5	X.519	Protocol Specifications
9594-6	X.520	Selected Attribute Types
9594-7	X.521	Selected Object Classes
9594-8	X.509	Authentication Framework

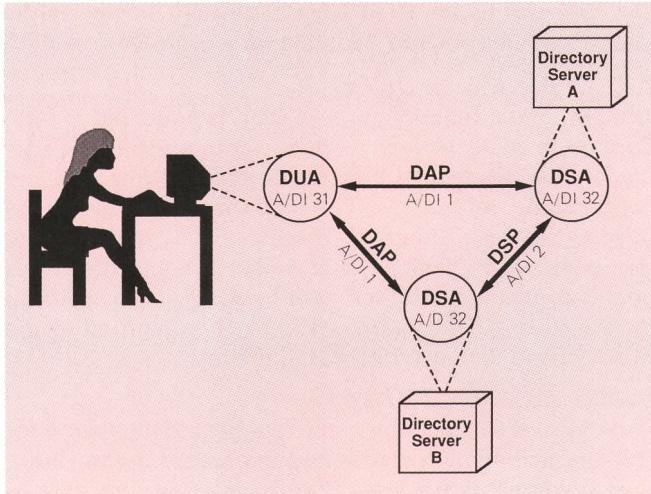


Fig. 1 Components of the Directory and their relation to the ETSI/EWOS Profiles

DUA	Directory User Agent
DSA	Directory System Agent
DAP	Directory Access Protocol
DSP	Directory System Protocol
A/DIx	ETSI/EWOS Directory Profiles

411 Features

The most pertinent features of the Directory are its protocols and the organization of information contained within it. They are described below. The functions of the Directory protocols are illustrated in *Figure 1*.

Protocols: A *Directory User Agent* (DUA) applies the *Directory operations* of the *Directory Access Protocol* (DAP) to read, search, modify, etc., the information held in a *Directory System Agent* (DSA). If the DSA that is accessed by the DUA does not itself possess the information, it can pass the request on to one or more other DSAs by using a corresponding *chained operation* of the *Directory System Protocol* (DSP).

Directory Information: The information about a real world object stored in a Directory consists of a collection of *attributes* which conforms to an *object class* definition. Attributes have *types* and *syntaxes*. Directory information is structured in a *Directory Information Tree* (DIT). To encourage consistency in Directory applications, various attribute types, attribute syntaxes, and object classes are defined in the base standard, and suggested rules are given for structuring the DIT; however, it is not a conformance requirement that a directory system agent be able to support any of the above elements other than what is necessary for the general operation of the Directory.

412 Extensions

At the beginning of 1988, the standards work entered a second phase, the aim of which was to develop extensions to the current Directory Standard by the end of 1992. These extensions include the following:

- **Access Control:** The 1988 Directory Standard does not define access control mechanisms. As 1992 approaches, this section of the standard is still weak.

- **Extended Information Model:** The model will describe all the information contained in the Directory. This includes *operational attributes* used by the Directory for internal purposes and attributes that a set of entries within a defined subtree of the directory information tree can inherit.
- **Schema:** Components for the dynamic definition of directory information tree and name structures are to be added to the schema framework.
- **Attribute Classes:** These will introduce a hierarchical class concept for attributes (similar to that for object classes).
- **Enhancements are being made to the Directory Abstract Service.** For example, the matching rules used for search operations are being extended, and new service controls such as attribute size limit, cost limit and chaining limit are being introduced.
- **Directory System Agent operational framework:** This framework has been developed to describe DSA interactions. The basic element within this framework is the *operational binding* between DSAs. An operational binding is an agreement between two DSAs to engage in some type of interaction together. This interaction allows operations from a well-defined set to be invoked by one or the other party to the agreement. A protocol has been defined for establishing and terminating operational bindings of various types between DSAs. An operational binding type used for replications has been defined.
- **Replication:** An additional Directory Standard, Part 9, has been prepared that is concerned with replication. It will contain definitions of the replication model, the service and the protocol.
- **Knowledge management** is concerned with the representation of knowledge about information distribution.
- A revised version of Part 4 of IS 9594/CCITT X.518, Procedures for Distributed Operations, is under development. The description will be restructured, extensions such as replication will be included, and omissions in the original text will be inserted.

The documents reflecting the current status of these extensions are listed in *Table II*.

413 Defects

The correction of recognized defects and ambiguities in the Base Standard is documented in the *Directory Implementor's Guide*, which is regularly updated. The corrections are subject to ISO/IEC JTC1 ballot and CCITT approval.

42 ETSI/EWOS Functional Standards

ETSI TE 6 and the EWOS Expert Group on Directories (EGDIR) have developed functional standards that specify what must be implemented for protocol and distributed operation capabilities of the Directory so that interworking between systems can occur. These functional standards are known as profiles. Figure 1 relates the ETSI/EWOS profiles to the Directory Functions.

Table II. Extensions to the Directory Standards

ISO	Amend- ment/ New part	Title
9594-1	DAM-1	Replication, Schema and Access Control
9594-2	DAM-1	Access Control
	DAM-2	Schema
	DAM-3	Replication
9594-3	DAM-1	Access Control
	DAM-2	Enhanced Search
9594-4	DAM-1	Access Control
	DAM-2	Replication
9594-5	DAM-1	Replication
9594-6	DAM-1	Schema Extensions
9594-7	DAM-1	Schema Extensions
9594-8	DAM-1	Access Control
9594-9	DIS	Replication

There are two types of Directory Profiles: A-Profiles and F-Profiles. The former relates to protocol and distributed operations capabilities. The latter relates to information and naming structures. (Note: Until the summer of 1991, A-Profiles were known as A71-Series Profiles and F-Profiles were known as Q51-Series Profiles.)

The ETSI/EWOS Directory Profiles have been used as the input documents for European Norms. To be approved as a European standard, called an EN, a document goes through several voting cycles. In each cycle it has a different status. First it is a pre-ENV (an ENV is a trial standard); then, after approval by country balloting, it becomes an ENV; finally, after two years (so that the document may stabilize), it becomes an EN.

ENs and ENVs use a different naming scheme than the ETSI/EWOS functional standards:

- ENV41210 is the equivalent of A/DI1
- ENV41512 is the equivalent of F/DI11.

421 A-Profiles

Four A-Profiles exist. They are described below, and their roles in defining Directory functioning are depicted in Figure 1.

A/DI1: Directory Access

This specification profiles the interworking between a Directory and a Directory User Agent: the Directory Access Protocol (DAP). The meaning of Directory System Agent support for the DAP is elaborated for both centralized and cooperative DSAs. A/DI1 was approved by both EWOS and ETSI in 1990. It became a ENV in June 1991.

A/DI2: Directory System Protocol

This is very similar to A/DI1, except that it specifies a profile for the Directory System Protocol. A/DI2 was approved by the EWOS Technical Assembly (TA) in Janu-

ary, 1991 and by the ETSI TE in June 1991. It is currently under member country balloting as a pre-ENV.

A/DI31: Behavior of DUAs

The automatic functioning of a DUA is specified in relation to the DSAs with which it can communicate, in particular with respect to previously returned referrals and continuation references. The material in general goes beyond the Base Standard. Therefore, only those behaviors which are considered universal are specified. The goal is to make interaction with the DUA less confusing for the user. A/DI31 is expected to be submitted to the EWOS TA in January 1992 for approval.

A/DI32: Behavior of DSAs

It defines the prescribed and suggested behavior for DSA participation in distributed operations in the Directory. It augments the Base Standards where unclear descriptions are found. It was approved by the EWOS TA in April 1991 and by the ETSI TE in June 1991. It is currently under member country balloting as a pre-ENV.

For a centralized Directory, the Functional Standard A/DI1 by itself profiles the externally visible behavior of the DSA. For a distributed Directory, cooperative DSA behavior is profiled by Functional Standard A/DI32 together with A/DI1 and/or A/DI2, depending on whether the DSA supports the DAP, the DSP or both.

422 F-Profiles

The purpose of the Directory F-Profiles is to define groups of object classes for recognized usages of the Directory and to define the naming structure and the use of attributes for the selected object classes.

A DSA may claim conformance to a subset of F-Profiles, depending on what applications should be supported. It is likely that the number of F-Profiles will increase as new applications are found.

One of the main goals of Directory F-Profiles is to avoid proliferation of information as new applications are introduced; therefore, the F/DI11 Profile has been designed to provide schema definitions usable by a wide variety of applications.

F/DI1

This specifies a profile of the Schema within the scope of IS 9594, Parts 6 and 7, and CCITT X.520 and X.521, with one exception. An informative annex in IS 9594 has been made normative in F/DI11. The meanings of DSA support for object classes, attribute types, attribute syntaxes and DIT structure rules are elaborated. This profile was approved by ETSI and EWOS in 1990. It was approved as an ENV in June 1991.

F/DIx

These are delta documents to F/DI11. They will specify those Directory information structures to be supported for particular application profiles, in addition to those required in F/DI11. The profiles that will be developed are:

- F/DI2: Directory Use by MHS
- F/DI3: Directory Use by FTAM
- F/DI4: Directory Use by EDI.

Additionally, discussion has been on the possibility of developing an F-Profile for electronic telephone inquiry

Table III. X.500 Products

Com- pany	Product name	Availability	Operating environment	Interworking environment	Comments
Bellcore	Xdi	publicly available	Sun/UNIX	ISODE	DUA only
DEC	—	not yet	Ultrix: end 1991 VMS: late 1992	DECnet	no official public statement from DEC yet
E3.X	Ucom X.500	commercially available	UNIX	TCP/IP X.25 — TP 0	DSA, DUA, API
Hewlett- Packard	HP X.500 Distr. Direct. Software	commercially available	HP-UNIX	X.25 — TP 0 or TP 4	DSA, DUA, pilot software, available for organizations wishing to learn about offering
ICL	Carrier 400 Directory	fully X.500-con- formant, stage 3 is not yet available	UNIX OS/2	X.25	DSA, DUA, DAP, very tightly coupled with ICL X.400 product
OSF	DCE/GDS	commercially available	SINIX (UNIX SV.4) OSF/1.1, AIX 3.1, Ultrix	OSI TP 4 with CLNP; OSI TP 0, TP 2, TP 4, with X.25; TCP/IP	API, DUA, DSA, DAP, ASN.1 compiler, ACSE, ROSE; presen- tation and session
OSIware	Directory 500	commercially available	UNIX	TP 0 with X.25	DSA, DUA, DAP, DSP
PSI	xwp	commercially available	BSD UNIX supporting X-Windows	ISODE	graphical user interface
QUIPU	—	publicly available	UNIX	ISODE	basic software of Paradise project; currently running in Swiss PTT
Retix	DS-500	commercially available	UNIX	OSI transport stack interface, TCP/IP	DSA, DUA, DSA manager, used by many OEMs
Touch	Alliance OSI X.500	commercially available	UNIX	OSI transport, TCP/IP	DUA, DSA
Unisys	OSI-DSA/DUA	commercially available	UNIX V.3 UNIX V.4 (1992)	X.25 with TP 0—4, TCP/IP	2 separate products, Unisys hardware platform
Wollon- gong	WIN/DS	not yet commer- cially available	UNIX	X.25, TCP/IP	DSA/DUA, develop- ment moving along rapidly
X-Tel	MDUA (motif DUA)	commercially available	UNIX, supporting X-Windows	as for QUIPU	DUA only — graphical user interface; X-Tel provides official sup- port for PARADISE
3Com	X.500 DUA process	commercially available	multiple-vendor platforms support- ing X-Windows	OSI CLNP and TP 4	intended for use with QUIPU, DUA only

systems. This profile would define an X.500 application that performs the same role as TPH 28 currently does, but also uses features of X.500 to enhance that functionality.

43 Other Profile Work

The North American OSI Implementors Workshop (OIW), hosted by NIST (National Institute of Standards and Technology), has produced the NIST Stable Directory Agreements, which are updated regularly. Technical coordination has taken place between OIW and ETSI/EWOS in the Directory area.

In August 1990, ETSI/EWOS, OIW and the Asia Oceanic Workshop (AOW), which also produces directory profiles agreed to cooperate on the production of International Standardized Profiles (ISP) for the Directory. The taxonomy of the ISPs will be closely aligned with the Directory section of M-IT-02 (which catalogs the proposed and existing European functional standards). No time scale has been formally agreed upon for the progression of this work.

5 X.500 Products

There has been a considerable amount of X.500 product development since the standards were finalized in 1988. At Telecom 91, the telecommunications exhibition sponsored by the ITU (International Telecommunications Union), four vendors exhibited X.500 products. These vendors were *Unisys*, *Hewlett-Packard*, *Digital Equipment Corporation* (DEC) and *OSF* (Open Software Foundation).

Although they were not exhibited at Telecom 91, many other firms have X.500 implementations. They run on a wide range of operating systems, with the majority running on UNIX. It is possible to buy DUAs and DSAs separately as well as combined. Some products are available commercially, while others are publicly available. QUIPU is probably the best known publicly available X.500 software.

Table III contains a brief summary of some of the available X.500 products. Products are listed alphabetically by company. The name of the product, its availability, the software operating systems it runs on, a list of the network environments in the which the implementation can be used and product-specific information are detailed.

6 Conclusions

As can be seen from the developments since the X.500 standards were published in 1988, X.500 as a technology has progressed. There is more interest in it than previously, and many pilot projects and products exist. The potential of X.500 to provide a standardized access method to a database is very strong.

Unfortunately, the reality is that in spite of these developments X.500 is a technology that will not be suitable for commercial application for at least two more years. Little interconnection testing has been done. The ETSI/EWOS profiles have helped to resolve technical issues

like service definition, quality of service, schema and knowledge information distribution, role of first-level DSAs, supported character repertoires and conversion procedures, but more needs to be known about how products actually interwork. Additionally, neither the technical nor the commercial aspects of charging, accounting and settlement have been addressed in Europe.

However, the PTT will not ignore X.500. It is specified as a requirement by the EC in some procurement documents. Some countries, such as England, also have government procurement specifications (UK Gosip) that require X.500. In light of this, it can be expected that X.500 systems will exist and be used in the future.

Considering the new Swiss telecommunications laws (Fernmeldegesetz) and the fact that PTT will be reorganized so that many services will need to generate a profit in order to justify their continued operation, the PTT needs to have a comprehensive directory of both electronic mail and telephone addresses that users will want to use. Easy electronic access will be important. It will be essential as a supportive service and a key selling point. The PTT will continue to follow X.500 developments as part of its efforts to make such a service possible.

Panel 1: Key terms in this paper

Directory User Agent (DUA): A DUA acts as the interface between users and directories. A user may be human or another application.

Directory System Agent (DSA): Allows a DUA access to the directory database. It also forwards requests for information to other DSAs.

Directory Access Protocol (DAP): Permits the exchange of information between a DUA and DSAs.

Directory System Protocol (DSP): Defines how information is exchanged between different DSAs. It is this protocol which allows a directory to be distributed. DAP and DSP are very much alike, but normally, the DSP protocol runs on a server.

Directory Information Tree (DIT): Is a hierarchical, logical structure that defines the relationship of DSAs to each other. It permits the unambiguous naming and positioning of each DSA in the structure. It can be used to organize collections of DSAs into directory management domains.

Attribute: An entry in the directory contains information about a single object. All objects have attributes associated with them. Each attribute provides a piece of information about or describes a particular characteristic of the object to which the entry corresponds.

Object class: Is an identified family of objects which share certain attributes. Every object belongs to at least one class.

Panel 2: Abbreviations in this paper

ACSE:	Application Control Service Element (OSI Application Layer)
API	Application Programming Interface
ASN.1	Abstract Syntax Notation One

CCITT	International Telegraph and Telephone Consultative Committee	ITU	International Telecommunication Union
CEPT	Conférence européenne des administrations des postes et des télécommunications	IXI	International X.25 Interconnection
CLNP	Connectionless Network Protocol	KWF	Kommision für Wissenschaft und Forschung (Commission for Science and Research — Swiss)
COSINE	Cooperation for Open Systems Interconnection Networking in Europe	NADF	North American Directory Forum
DAM	Draft Amendment (ISO)	NIST	National Institute of Standards and Technology (U.S.)
DECnet	Digital Equipment Corp. Network Architecture (based on OSI, runs on point-to-point, X.25, Ethernet)	OIW	OSI Implementor's Workshop
DIS	Draft International Standard (ISO)	OSI	Open Systems Interconnection
DIT	Directory Information Tree	Paradise	Piloting a Research Directory in Europe, a COSINE-sponsored project
DAP	Directory Access Protocol	QUIPU	An X.500 software implementation
DSA	Directory System Agent	ROSE	Remote Operations Service Element (OSI Application Layer)
DSP	Directory System Protocol	SWITCH	Swiss Academic and Research Network
DUA	Directory User Agent	TERCO	Telefonationalisierung mit Computer (Swiss PTT telephony database)
EN	European Norm	TCP/IP	Transmission Control Protocol/Internet Protocol
ENV	European pre-Norm Document	TP	Transport Protocol (OSI Layer 4)
ETSI	European Telecommunications Standards Institute	TPO	TP class 0 — simple
ETHZ	Swiss Federal Institute of Technology, Zurich	TP1	TP class 1 — basic error recovery
ETV	Elektronisches Telekommunikationsverzeichnis (Swiss PTT Electronic Telecommunication Directory)	TP2	TP class 2 — multiplexing
EWOS	European Workshops on Open Systems	TP3	TP class 3 — error recovery and multiplexing
IETF	Internet Engineering Task Force	TP4	TP class 4 — error detection and recovery (used with connectionless network service)
IS	International Standard	TPH 28	Telephone 28, a protocol for international electronic access of the telephony database of a PTT (within Europe only)
ISO	International Organization for Standardization	X.25	Interface between data terminal equipment (OSI/physical layer) and data circuit terminating equipment for packet mode
ISODE	ISO Development Environment (public domain code for OSI application services and lower layers)		

Zusammenfassung Résumé

X.500 Verzeichnisdienste: Übersicht über Aktivitäten, Standards und Produkte

Seit der Publikation der X.500-Empfehlungen für Verzeichnisdienste im Jahre 1988 entstand auf diesem Gebiet eine rege Tätigkeit. Internationale Pilotprojekte wurden in Gang gebracht, und kommerzielle Produkte sind erhältlich. Für 1992 werden erweiterte Empfehlungen vom CCITT erwartet. In diesem Artikel wird beschrieben, was die Schweizerischen PTT-Betriebe bezüglich X.500 unternehmen, und wichtige schweizerische und ausländische Bestrebungen für den Einsatz sowie Produkte und Normenänderungen werden gezeigt. Am Schluss wird kurz erläutert, warum der Benutzer bis zur allgemeinen Verfügbarkeit kommerzieller X.500-Verzeichnisdienste noch einige Zeit warten muss.

Services d'annuaires X.500: surveillance des activités, des normes et des produits

Depuis la publication des recommandations X.500 pour les services d'annuaires en 1988, une activité très intense s'est développée. Des projets pilotes internationaux ont été mis en place et des produits commercialisés peuvent être obtenus sur le marché. Pour 1992, on s'attend à des recommandations élargies du CCITT. Le présent article décrit les démarches entreprises par les PTT suisses en ce qui concerne X.500 ainsi que les efforts importants émanant d'autorités suisses et étrangères pour la mise en œuvre, l'utilisation des produits et les modifications de norme. En conclusion, on explique pourquoi l'utilisateur devra patienter encore quelque temps avant que des services d'annuaires X.500 soient commercialisés.

Riassunto

Servizi degli elenchi X.500: attività, standard e prodotti

In seguito alla pubblicazione, nel 1988, delle raccomandazioni X.500 relative ai servizi degli elenchi, le attività in questo campo sono notevolmente aumentate. Sono stati avviati progetti pilota internazionali e messi in commercio diversi prodotti. Nel 1992 il CCITT pubblicherà raccomandazioni più vaste. L'autore descrive l'attività svolta dall'azienda delle PTT nel settore dei servizi X.500 e gli sforzi intrapresi dalla Svizzera e dall'estero per quanto riguarda l'impiego di questi servizi, i prodotti e i cambiamenti di norme. Spiega infine brevemente perché si dovrà aspettare ancora un po' di tempo prima di poter disporre dei servizi degli elenchi X.500 su basi commerciali.

Summary

X.500 Directory Services: A Survey of Activities, Standards and Products

Since the X.500 Directory Service Recommendations were published in 1988 there has been a great deal of activity in this arena. International pilot projects have been started and commercial products are available. In 1992, enhancements to the X.500 recommendations will be published by CCITT. In this article, the undertakings of the Swiss PTT in relation to X.500 Directory Services are described and important Swiss and international implementation activities, products and changes to the standards are identified. It is concluded with a brief discussion of the reasons why users will have to wait a few years before commercial X.500 Directory Services are generally available.