# NETWORKING

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## 3.1 A short history of Open Systems' Interconnection

In the end of the 1960ties and beginning of the 1970ties several computer manufacturers had their own network facility. The networks differed in policy concerning "who is the master" of the network. IBM had their Master-Slave concept in SNA networks (SNA = Systems Network Architecture), Siemens and Digital Equipment Corporation had their peer-to-peer concept etc. But each network consisted of computers (called hosts or nodes) from only one manufacturer. There could be different IBM computers in an IBM network, but they were all IBM computers. Likewise, different Siemens computers could be linked in a Siemens network, but only Siemens computers.

Computer systems communicate by exchange of messages. A message sent from one computer may pass through several computers before it reaches its destination.

A computer network consists of transmission lines, switching elements and hosts. The hosts are computers running user application systems such as library systems, and the messages originate in a host. The switching elements are specialised computers used to connect two or more transmission lines. The switching elements were called IMPs (Interface Message Processors) in ARPANET. The task for the IMPs is to receive a message on an incomming line and to decide which outgoing line to forward it on. In some networks the task of the IMPs is taken care of by the regular hosts.

The transmission lines may be special cables, ordinary telephone lines, optical fibers, radio waves etc. The transmission lines connects the computers in the network, but the computers are not directly linked to all other computers in the network. The path from computer A to computer B may go via several other computers.

The network project in ARPA (Advanced Research Projects Agency) changed the computer networks from being limited to computers of one and the same manufacturer to become networks between different types and models of computers. The ARPA network project started in the late 1960ties and the result of the project was the network called the ARPANET. This is the most important ancestor of Internet.
In the beginning all nodes in the ARPANET were located in USA, but in the early 1970ties a computer at Kjeller outside Oslo was included as a node.

The ARPANET was a nettwork model with different types and makes of computers as hosts and IMPs. The Open Systems' Network was the new model.

During the 1970-ties a lot of work was carried out in the field of network protocols for this new model of networks.

In the last half of the 1970ties the Model for Open System Interconnection (OSI) emerged. ISO defined a 7-layer model for computer communication in an Open Environment. An Open Environment meant that computers from different manufacturers and of different types could be hosts in the same computer network. The model, referred to as the ISO OSI model, was a structured model for communication between systems running on hetereogenious computers. The seven layers were called:

physical, link, network, transport, session, presentation and application.

This model should enable end users to use different remote systems via their own local system. It should also enable end users to connect to a remote system directly, to transfer files between computers, to communicate via e-mail and use other communication facilities.

The communication between systems in the OSI model had to follow the rules defined for each of the seven layers: the seven different protocols.

The ISO standard for the OSI model was published in 1984 [6].

The protocols for the layers 1 to 6 (physical to presentation) were defined by computer scientists, but the application protocols had to be defined by specialists in each application field such as the library field.
Two application protocols were defined for the library field. They were protocols for:

- Search and Retrieve of bibliographic records (SR) [13], [14]
- Interlibrary Loan (ILL) [11], [12]

The basis for the SR-protocol were the protocol defined in the Norwegian BIBNETT projects.
The standardisation of the SR-protocol started in 1983. The standardisation work on the ILL-protocol was carried out in parallel with the SR-protocol and the two standards were agreed upon in September 1991. The standards were published in 1993.

## 3.2 OSI network projects in the Nordic countries

The Nordic countries were pioneers in the area of network communication between information systems.
The library community wanted to test the possibilities of the OSI model for communication between library systems. The first OSI-project in the Nordic countries, the BIBNETT project, started in 1980. Both BIBNETT (1980 - 1982) and BIBNETT 2 (1983 - 1984) were pure Norwegian projects, but in 1985 the project "Prøvedrift av informasjonsnettverk" (User Trial of an Information network) started, with financial support from NORDINFO. This project had partners from Norway and Sweden and a reference group from Denmark, Finland, Iceland and Sweden.

In October 1991 the project Nordic SR-Net started with participants from all five nordic countries and financed mainly by NORDINFO. The project ended in February 1994.

In January 1995 the EU project ONE (OPAC Network in Europe) started using the results from Nordic SR-Net as a basis. Four of the five nordic countries participated in ONE. ONE was finished in December 1997 and the work continued in the EU-project ONE-2 (1998 - 2001).
When the network application protocols for the library community were finalised in September 1991, it took only one month before the project NORDIC SR-Net was launched.

A successful network project depends on several factors. Some important factors are:
- availability of financial resources
- availability of the correct tools
- avaliability of operational databases

Both national library bodies in the Nordic countries and NORDINFO were willing, and able, to finance network projects. In addition the participating institutions were willing to offer human resources (work force) and computer time.

Good tools were not easily available. Both the two BIBNETT projects, the User trial project and Nordic SR-Net took place too early for this.

The participating institutions made their databases available for all these projects.

### 3.2.1 Tools to be used

The main aim of the computer network projects in the library sector in the 1980ties and 1990ties were to test the feasibility of, and the need for, network communication between library systems.

The tools we needed in order to implement network communication between hetereogenious systems were:
- stable network protocols
- implementation of basic communication services (protocols)
- source code for library systems

#### *3.2.1.1 Network Protocols*

All communication between systems in a computer network is carried out by exchange of messages. The syntax of such messages and the functionality they support, vary from one type of network to another.

In all computer networks the communication must follow a common set of rules, the so called protocols.

In propriatary networks the computer manufacturer has full control of the definition of the protocols, in Open

Systems' Network many different parties must agree to the content and syntax of the protocol. These protocols are therefore standardised by, or at least accepted by, ISO.

Computer Network communication has been designed in a hierarchical way. One speaks of up to 7 levels, or layers, of communication (physical (lowest level), link, network, transport, session, presentation and application level).

For each level one, or a set of, protocol(s) have been defined. Each "level" uses services offered by the level below. In this model it should only be necessary for the library community to define and implement application protocols.

The work of standardising network protocols for library applications (top level) started in 1983 using results from the norwegian BIBNETT projects and the american LSP project (Linked Systems Project with WLN, RLG and LC as partners) [19].

The result from this standardisation were two protocols:

ISO 10160/61 for Interlibrary Loan (ILL protocol) [11], [12]
ISO 10162/63 for Search and Retrieve (SR protocol) [13], [14]

The SR protocol has developed further and has been completely aligned with the american z39.50 v3 [5] into ISO 23950 Search and Retrieve [15].

Use of Z39.50/ISO 23950 (SR) and ILL/ISO 10160 (ILL) protocols

The SR- and ILL- protocols are described both in the standards themselves and in several articles. Both protocols focus on support of functions, and not on explisit knowledge of the remote systems.

According to the SR-protocol communication between two systems is carried out as follows:

The communication parties are the Origin (starting the communication) and the Target (the called upon system). The Origin requests certain, specified services from the Target. The Target carries out the request according to the specifications. But the target does not have to have the same datamodel or indexing practice as the Origin.

For instance: If the origin is indexing personal names as <last name>, <first name> and requests a search for "Hansen, Ole", the Target can fullfill this request even if the Target has two indexes, one for <last name> and one for <first name>, or if the Target indexes personal names in direct order (<first name> <last name>). In both cases the Target must convert the search criteria to the form used by the Target. How the search is carried out is irrelevant to the Origin.

### *3.2.1.2 Implementation of basic communication services*

The library community should concentrate on defining, and implementing, application level protocols. We were to suppose that the programs responsible for carrying the application messages between the systems were available. That is, protocols for all levels below the application level should exist and implementations of these protocols should be available.

The existence of such modules was necessary in order to test the feasibility of Open Systems' Network for libraries.

When the BIBNETT projects and the Nordinfo project "User Trial of an Information network" were carried out, there existed drafts for ISO protocols for the lower levels and implementations of the three lowest levels (physical, link and network levels). The CCITT X.25 protocol (packetswitching network) [4] covered these layers and was accepted by ISO as a standard for the lowest three levels [7], [8]. The X.25 protocol was implemented, but such implementations were not available for all partners and the implementations were not stable.

There were no implementation of the levels between network and application (transport, session and presentation). Actually, the protocols were not stable either. The functionality planned for these levels had to be taken care of by our applications.

### *3.2.1.3 Source code for library systems*

The third type of tool necessary in order to cary out our projects was the access to the library systems' source code. Both in the BIBNETT projects and in "User Trial of an Information network" we had full access to the source code in all the participating systems. This was a major benefit and made it possible to carry out the projects.
In Nordic SR-net we did not have access to the source code for two of the participating systems and this caused delays and some problems.

## 3.2.2 Two Norwegian projects

The two Norwegian projects were:
- BIBNETT (1980 - 1982) [2]
- BIBNETT 2 (1983 - 1984) [3]

### *3.2.2.1 BIBNETT*

BIBNETT started on February 8th.1980 and was finished March 31st. 1982. The project management was by Norsk dokumentdata.

In 1980 there existed many automated library catalogues and many online reference databases. But to use two different systems one had to use two different user dialogues and often one had to use specific terminals for each system.

The important question was:

Is it possible to use ISO OSI network model in such a way that the end user can use one and the same terminal to all other, remote systems and also use the same user dialogue to all remote systems. That is, each user should be able to use the local dialogue to all systems regardless of what this local dialogue looked like.

BIBNETT was a cooperation project between
- Norsk dokumentdata
- BIBSYS
- University library in Oslo
- University library in Bergen
- Directorate for research libraries
- UNINETT

The main aim of the project was:
- to test and influence UNINETT's properties for performing library tasks
- to clarify whether program-to-program communication between independently developed library systems executing on different computers is technically and economically feasible in Norway
- to increase the participation institutions' competence to the degree they themselves wish in those fields the project will involve

In order to fulfill this main aim a more practical, intermediate target was defined:
- to make it possible to retrieve "automatically" records from BIBSYS, NORMARC and UBB/TEST for editing and storing in one's own local database
- to transfer bibliographic data of variable length from one computer to another using UNINETT

BIBSYS was at this time running on a UNIVAC 1100/62 and supporting acquisition, cataloguing and searching.

NORMARC (later called UBO:BOK) was running on a DEC-10 and supporting cataloguing and searching.

UBB/TEST was running on a UNIVAC 1100/82 and was a NOVA*STATUS system supporting information retrieval.

When the BIBNETT project started, the ISO OSI model was defined, but the protocols for the different levels were not stable and few were implemented.

Further, there existed a framework for an application protocol for library and information work written by NCLIS/NBS Task Force on Computer Network Protocol [16]. This protocol was just a framework and had therefore not been implemented anywhere.

An application protocol is dependent on functioning protocols below. That is, the communication between the computers, the handling of synchronisation of messages, errors in the transfer of messages etc. should be taken care of by the levels below the application.

At the time when the BIBNETT project was carried out, very few of these requirements were fulfilled. We had to disregard some of these requirements and for others we had to improvise.

We meant to use DATAPAK for the actual communication between the hosts in the network. The implementations of this had begun, but was not finished.
UNINETT had defined two services:

- the Interactive Service (UIS)
- the File Transfer service (UFTS)

When BIBNETT started, UIS was partly implemented and the implementation of UFTS had not yet started.

The evaluation of the protocols defined for these services concluded that the UFTS was not suitable. The UIS was not ideal, but could be used with some modifications. The best service for BIBNETT would be a Program-to-Program Service (PPS) which included a Communication Process (CP) for each host. These CPs should cover the functionality of the session and presentation levels in the OSI model.

We defined a Communication Process Protocol for this purpose.

The application protocol had to be defined using the framwork from NCLIS.

The BIBNETT model consisted of the following modules:

- library system
- application protocol implementation (SRPM)
- Communication Process implementation (CP-module)
- UNINETT Interactive Service

and the architecture was as shown in figure 1.

< fig. 1>

All messages passed through the CP-modules and were logged there with a time stamp. This way we could log any delays in the network itself. The messages consisted of only ASCII characters.

The results from BIBNETT were:

- the Application Protocol [1]
- the communication process protocol (CP)
- implementation of both the application protocol and the CP protocol in all three systems
- increased know-how concerning computer networks and protocol specifications

The conclusion from the project was that it was quite possible to use an open systems network for communication between heterogenous library systems. The time needed for connecting two systems were the only noticable delay in a searching session compared to using a system locally.

The MARC records could be transferred without problems.

Program-to-Program communication between library systems is dependent on stable networks and clear and informative error messages if an error occurs.

Economically it is quite feasible to use an OSI network in searching in, and retrieveing data from, remote systems.

The Application Protocol was handed over to ISO TC 46/SC4 as a basis for defining an ISO standard for network communication between information systems.

### *3.2.2.2 BIBNETT 2*

The results from BIBNETT were positive and a new project was defined: BIBNETT 2. The new project lasted from January 1st. 1983 to December 31st. 1984.

The participants in BIBNETT 2 were:

- BIBSYS
- BRODD - Norwegian School of library and Information Science
- NSI - Norwegian Centre for Informatics
- University library in Bergen
- University library in Oslo

NTNF (Norges Teknisk-Naturvitenskapelig Forskningsråd) and RBT (Directorate for research libraries) gave economic support to the project.

BRODD was the project manager.

The main aim of BIBNETT 2 was:

On the basis of the results from BIBNETT 1 and UNINETT to contribute to and encourage the research in computer networks by:

- carrying out more complex dialogues between independently developed information systems running on different mainframe computers, than those carried out in BIBNETT 1
- to implement the same possibilities for complex dialogues between micro computers and mainframe computers
- to allow IR-systems and cataloguing systems to update each others databases
- to analyse the multicasting problems seen from the side of the network user

In order to fulfill this aim the following practical goal was defined:

The complete application protocol from BIBNETT 1 should be implemented in the following systems:

- BIBSYS running on UNIVAC 1100 and supporting library housekeeping functions
- Mikro-Polydoc running on CP/M and MP/M computers supporting IR
- SAMKAT running on DEC 10, a union catalogue
- UBO:BOK running on DEC 10, but with different software from SAMKAT, supporting IR

The multicast problems should be analysed, but no solutions should be tested.
In BIBNETT 1 a need for a PPS (Program-to-Program Service) was identified. At the start of BIBNETT 2 this services was not yet available. Furthermore, the CP developed in BIBNETT 1 had been removed from one of the hosts and

the use of the protocol X.25 directly was one option. The new host (with Mikro-Polydoc) was not connected to UNINETT at all and used their own communication module.

The application protocol from BIBNETT 1 was implemented, but it became obvious that it needed to be enhanced in several aspects. The need for optimisation of the size of protocol messages as well as the need for more attributes to describe the search criteria and the need for new functionality, resulted in a new and enhanced application protocol. This new version of the protocol was then implemented.

The functions covered by the protocol at this point were as follows. In parenteses are written general commands in many IR systems.

- Begin Session (Start)
- End Session (Stop)
- Purge message
- Purge Session (Abort)
- Wait (Detach)
- Continue (Attach)
- Help (Help)
- Choice of database(s) (Base)
- Send own (use of special query form such as CCL)
- Result set handling (e.g. Delete)
- Thesaurus search
- Neighbour search (List terms or Scan)
- Search (Find)
- Continue search
- Modify (Modify search result)
- Record request (Show, Print)
- Loan Search (Circulation status)
- Loan Update (Update circulation status)

The thesaurus Search facility should enable searching/navigating in a thesaurus.

Due to difficulties in the implementations of communication protocols on the lower levels in the OSI model the implementations in BIBNETT 2 could not be fully tested. One system could only be an originator, i.e. not receive search requests from the other systems. One could only be a target, i.e. only receive requests from the other systems, not sending requests itself.

Both UNINETT and DATAPAK were unstable throughout the project. This caused the testing of the implementations to be delayed. All technical testing was carried out, but end-user testing became greatly limited.

Apart from that each facility was tested for at least two systems and the results were:

Technically, the systems can communicate and perform searches, send records and update each others' databases. The possibility to update remote databases over the network will be limited by administrative rules, not technical solutions.

The protocol works well for Norwegian systems both on mainframes and on micro computers.

### 3.2.3 Two Nordinfo OSI projects

The two OSI projects financed by NORDINFO were:

- User Trial of an Information network (Prøvedrift av informasjonssystemnettverk) [18]
- Nordisk SR-nett (Nordic SR-net) [17]

#### *3.2.3.1 User Trial of an Information network*

The end-user testing of BIBNETT 2 implementations were limited due to technical problems with the network. This testing should be carried out. In addition it was important to test how the model would work across national boundaries using different network carriers.

The BIBNETT-model was communication between library systems using the OSI model in such a way that end users could search in different, remote library catalogues using the user interface of their local library system.

This project was carried out in the period January 1985 to September 1985 and the participants were:
- BHS - School of Library and Information Science, Borås, Sweden
- BIBSYS - RUNIT, Trondheim, Norway
- BRODD - Oslo University College, Norway
- NSI - Norwegian Centre for Informatics
- UBO - University Library in Oslo

BRODD was project manager.

This project had a reference group consisting of specialists from:
- The library at the Karolinska institutet (KIBIC), Sweden
- Upplýsingabjónusta, Island
- Forskningsbibliotekernes EDB-kontor (FEK), Denmark
- Forskningsbibliotekens adb-enhet, Finland

The main aim of the project was to:
- Test the BIBNETT 2-model for library systems in two or three Nordic countries.

The plan was to test the model with systems in Denmark, Norway and Sweden. Regrettfully, Denmark was not able to implement the software in time. The test was therefore carried out between the following systems:
- BIBSYS in Norway (at this time a union catalogue and housekeeping system for many academic libraries)
- Mikro-Polydic in Sweden (School of Library and Information Science in Borås, Sweden)
- UBO:BOK in Norway (the National bibliography)

In addition two installations of Mikro-Polydoc in Norway (NSI and BRODD) were used to some extent.

The two Mikro-Polydoc systems had been enhanced with a network communication module in order to be able to initiate a communication. But the Mikro-Polydoc system could not act as a Target due to the limited communication module.

In 1985 both SUNET (academic network in Sweden) and UNINETT (academic network in Norway) were operational and could offer network services up to, and including, the transport level (level 4 in the OSI 7-level model). This was a major improvement from the BIBNETT projects. But it was uncertain how, or if, the communication between SUNET and UNINETT would work satisfactory. Or if we could use these networks at all.

Users of all three systems were selected and were to search as follows:

- Users of BIBSYS should search in UBO:BOK
- Users of UBO:BOK should search in BIBSYS
- Users of Mikro-Polydoc in Sweden should search in BIBSYS and UBO:BOK
- Users of Mikro-Polydoc in Oslo (NSI and BRODD) should do some searches in BIBSYS and UBO:BOK

The definition of a session in an OSI environment is the period from the originating system says "Begin" until either the originating or the target system says "End". A session-log consists of all messages sent from the origin and target systems during a session. The sessions in this User Trial project contained searching, record retrieval, use of help-functions, scanning of result sets, use of previous search results etc.

The session logs showed that during the project:
- 160 sessions were carried out from Mikro-Polydoc in Borås,
- 29 sessions were carried out from BIBSYS
- 160 sessions were carried out from BRODD

In these sessions a total of 831 searches were carried out. Online update of the union catalogue was tested technically, but due to administrative decisions it could not be tested fully.

UBO:BOK could only act as a Target due to communication problems.

Communication problems such as unstable networks, missing Transport level (due to difficulties in using SUNET), unstable network software etc. caused the number of sessions to be severely reduced compared to the project plan.

The concrete result from the project was an improved application protocol (the BIBNETT Search and Retrieve protocol). It was the error-handling part of the protocol in particular that was improved.

The project taught us that:

- It is important that all implementers interpret the application protocol the same way. This led to the definition of profiles of the protocol
- The communication between two heteorogenous library systems works well if the network communication is stable. There is no extra response time in communication across national borders crossing over from one network to another, compared to searching in a local system.

The results and experiences from this project were used both to improve and enhance the SR-protocol and as a basis for the next NORDINFO OSI project.

### *3.2.3.2 Nordic SR-net*

In September 1991 the application protocols for the library community had been agreed upon as a standard by ISO TC 46/SC 4/WG 4 and handed over to the ISO office for publication. The time had come for a project to test the protocol as it now was defined. The ISO protocol, ISO 10162/63 [13] and [14], covered fewer functions than the BIBNETT-protocol, but it was more general because it covered information systems outside libraries.

#### *3.2.3.2.1 Project description*

Nordic SR-net was an OSI project were all five nordic countries participated. The partners were:

- FEK (Forskningsbibliotekernes EDB-kontor) in Denmark with ALBA (today DANBIB)
- TKAY (Automation Unit of Finnish Research Libraries i Helsinki University Library) in Finland with LINNEA a VTLS system
- University of Iceland with a LIBERTAS system (using STAIRS) with GEGNIR
- BIBSYS in Norway with BIBSYS
- University of Oslo in Norway with UBO:BOK (local software and using TRIP)
- LIBRIS in Sweden with LIBRIS
- BRODD (R & D department of the Norwegian school of library and information science) in Norway
- National Office for Research and Special Libraries in Norway

BRODD was project manager.

The project Nordic SR-net was carried out from October 1991 to February 1994.

The main aim of the project was:

to implement the ISO 10162/63 protocol for Search and Retrieve (SR), communication between all the participating systems in a way that makes differencies in user-dialogues and database structures completely invisible to the end user.

More specifically the aims of the project were:

- To connect main library catalogues, in the Nordic countries, in a computer network for the purpose of simplifying the reference work and at the same time to be able to benefit from the other institutions' classiflcation and indexing work.
- To improve the knowledge of the use of library OSI protocols in the Nordic countries.
- To influence further development of the library OSI protocols based on our own experience with the use of such protocols.
- To simplify the search and retrieval of MARC records from bibliographic databases with different command syntaxes, in Europe and North America.

- To prepare a basis for the general use of SR in the academic networks and in the library community, by making available a general implementation of SR together with the experiences gained in the project.
- To make it possible to search different types of databases using IANI in general.

As with the previous projects, the main tools would be:
- implementations of computer network protocols
- implementation of basic communication services
- source code for library systems

But in addition we now needed format converters and it became evident that also a stand-alone client would be needed, at least for testing.

#### *3.2.3.2.2 Computer network protocols*

In 1991 we had two possible sets of network communication protocols:
- OSI
- TCP/IP

The OSI set of protocols includes a wider range of functions/services, but this lead to problems of availability of implementations. Implementations of the full OSI model was expensive and very little existed in 1991.

Implementations of the TCP/IP set of protocols on the other hand, were much cheaper and thus easier available.

In the project we implemented the use of both sets of protocols.

#### *3.2.3.2.3 Implementation of basic communication services*

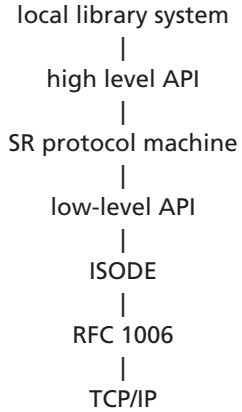
In 1991 a package was made available for free for implementing the different levels of the OSI model. The package was named ISODE. This package made it possible to use the services defined in the OSI protocols for levels up to (and including) Session layer. The implementation of these protocols required a relatively small part of the mandays available in the project.

This made it possible for the Nordic SR-Net project to concentrate on the application layer and to really rely on services below the application layer to be offered and to be stable. This was a big step forward from the situation for the previous project, the "User Trial of an Information network".

One decided to make one implementation of the application protocol (SR), that is a program that could handle the building of, sending of, receiving of and interpretation of application level messages. This program was called the SRPM (SR Protocol Machine). This program module had to communicate both with the underlying communication system (ISODE) and with the local library system.
This program was ported to each participating system.

The task for each partner was to implement an interface between the local system (client and/or server) and the SRPM.

The structure for a local installation was:



The two types of API (Application Programmers' Interface) were made in order to have a standard way of interfacing the ISODE (low-level API) and the library systems (high-level API).

#### *3.2.3.2.4 Source code for library systems*

A program module like SRPM ought to be integrated in the local system, but it is also possible to run it as a module between the local system and the communication system. To make a socalled proxy to handle the SRPM tasks had not been tested in 1991.

When one has access to the source code of the library system, the first solution is possible. Two of the systems in the project were commercial systems (LIBERTAS and VTLS) and we had no access to the source code for these. Although both systems had plans for implementing an SR protocol, they both wanted to implement Z.39.50 version 2.

At this time there were some discrepancies between ISO 10163 and Z39.50 v2. The ISO protocol included a SCAN service while the Z39.50 included Access Control Services. There were also different interpretation of some of the message attributes. All these discrepancies between the two protocols have later been resolved.

These discrepancies could be overcome, but also the implementation of Z39.50 v2 were delayed for both systems.

#### *3.2.3.2.5 Converters*

The systems participating in Nordic SR-Net used several MARC formats, a total of seven MARC formats were involved. A conversion between these formats was necessary.

The command language CCL (ISO 8777 Common Command Language) [9] was in use to such a degree that it was decided to make a conversion between RPN (Reverse Polish Notation), which is mandatory to support within the protocol, and CCL.

Such converters did not exist and had to be developed within the project. The decicion to make a Toolbox with different common tools was made.

#### *3.2.3.2.6 Carrying out the project*

The project was divided into seven phases:

- phase 1: Study and requirement
- phase 2: Test of tools
- phase 3: Implementation of common software (SRPM and Toolbox)
- phase 4: Porting of common software; possible integration of IANI
- phase 5: Implementing the interfaces between the local systems and the common software modules, including necessary changes to the local systems
- phase 6: User testing of the system communication in ordinary library environment
- phase 7: Evaluation and final report

Each phase was completed and evaluated before the decision to continue the project was taken.

Among the experiences gained from BIBNETT 2 was the need for a protocol profile. A draft profile was made in phase 1 and it was updated throughout the project.

Another experience from BIBNETT 2 was the need for structured testing of all implementations. At this time it was highly recommended to carry out conformance testing according to ISO 9646 [10]. Therefore a Conformance Test Suite for the SR protocol was made and used in the testing of the implementations.

In addition to the Conformance Test Suite an End-User Test Suite was defined. This test suite should clarify whether searching in remote databases resulted in a relevant set of records. That is, will search for a given topic give the expected result?
We would also investigate how the different systems reacted to result sets of different sizes (from 1 record up to 1000 records).

The MARC conversion program was made flexible by using conversion tables and codes in the table for how to convert one field/subfield to another, how to merge or split subfields etc.

The plan was to make a MARC-convertor that read one large tabel for all formats. This turned out to be too complex. The MARC-convertor had to be made for conversion between two and two formats.

Phase 6 was planned as a pure testing phase. However, implementations were not ready and the end-user testing had to be limited to 3 intensive weeks.

30 end-users participated in the end-user testing. They carried out approximately 800 search sessions. It became clear that error-handling was still not sufficient, but the end-users found the possibilities for searching unfamiliar systems very good.

#### *3.2.3.2.7 Results from the project*

The results of the project were:

- An Impletnentation of the application protocol ISO 10163 (SRPM) on a UNIX platform. The implementations was tested on VAX running ULTRIX (version 4.3.a), HP running HP-UX and SUN running SunOS (version 4.1.3).
- Implementation of the Origin (client) became operational in one system, and during the testing phase of two other systems.
- Implementation of the Target (server) were operational in three systems and became operational during the testing phase in another system.
- An Application Programmers' Interface (API) between a local library or information system and the SR protocol was developed (low level API).
- A high-level API was defined and implemented
- A toolbox for implementors which includes an RPN parser and a MARC conversion programme was developed.
- A MARC conversion table for conversion between 7 different formats was created, but had to be split up in sets of tables for two and two MARC formats.
- The implernentation of using either ISODE over TCP/IP or TCP/ IP directly for transmitting the application messages (APDUs) were finished, tested and used
- A Conformance Test Suite for the SR protocol was defined.
- A test machine for conformance testing of implernentations of SR was developed

The addendi SCAN and EXPLAIN to the SR protocol were not passed as international standards before the project ended and were therefore not included in the implementation.

The project was based on the services offered by the Nordic academic networks (DENet, FUNET, ISNET, UNINETT and SUNET). These networks offer both the use of OSI protocols (X.25 for the lower layers), and TCP/IP protocols.

Within the project we could therefore choose which network stack to use. For practical reasons we chose to use TCP/IP for the lower layers, but the software that was used (ISODE) made it possible to change this decision or to offer several stacks.

## 3.3 Conclusions form the projects

The projects BIBNETT 1, BIBNETT 2 and "User Trial of an Information network" were very early OSI projects. The basic communication protocols were not inplace and the library specific protocols were still under development. But these projects made the Nordic library community aware of the possibilities, and the problems, of using OSI between libray systems. It put us in a position to influence the development of the application protocols and to get early implementations of system-to-system communication between library systems.

The project Nordic SR-Net gave several important results which were used both in further development of the protocol and in enhancements of products such as SRPM, MARC-converter, command-language converters etc.

The results from NORDINFOs engagement in OSI projects are very important and they are a basis for several of the protocols, profiles, tools, implementations and solutions we use today.

Some of the conclusions from Nordic SR-Net can stand as a conclusion for NORDINFOs OSI projects:

1) The SR protocol is possible to implement as is, and such implementations offer better services to end-users (librarians and library users) than other methods of connecting to the same remote databases. The nordic projects have made important contributions to defining, implementing and testing the SR protocol (Z39.50 v3).
2) Several tasks outside the scope of the protocol needed to be addressed before different implementations would give interoperability between systems. Two of these tasks were:
   - format conversion
   - character conversion

Two MARC converter have been developed. MARCconv from Nordic SR-Net and the ONE projects, and USEMARCON from the EU project USEMARCON. The character converter CHASE has been developed by British Library. Both CHASE and MARCconv are available in the Toolbox from the projects ONE and ONE-2.

3) Versions 7 and 8 of ISODE were used in the Nordic SR-Net project. The use of ISODE made it easier, and quicker, to implement the network access module for the OSI stack.
   It was an important tool during the Nordic SR-Net project and much experience were gained by using it.

The use of ISODE was dropped when the package was no longer free of charge. The protocol stack TCP/IP is by far the most used protocol stack between library systems today. From the Nordic SR-Net we got experience in using both the OSI stack and the TCP/IP stack.

4) Good documentation of a software package is necessary for it to be used.
   In order to be able to use the software developed within Nordic SR-Net, it was necessary to be able to have communication between the SRPM (SR Protocol Machine) and the local system. The SRPM and the local system may reside on different machines or on the same machine.

To run the SR-Net software one needed:

- ANSI C-compiler
- TCP/IP SOCKET library
- the local system software must be able to call, and be called by, C-procedures

The communication between the SRPM and the local system will be handled by the SR-Net software package. Thus making available the high-level API on the local system machine.

These software packages were not well enough documented. And although they worked well they were exchanged for a better documented package developed in the projects DBV-OSI, ONE and ONE-2. But the development of the Nordic SR-net common software increased our know-how in this area.

5) The problems connected with use of different character sets were not studied within Nordic SR-Net or the projects prior to that. This was recognised as an area that had to be addressed. One concluded that the identification of, and choice of, character sets could be included in the SR protocol.
   The character set handling (negotiation) is today included in the SR-protocol and conversion between character sets can be handled by a module in the Toolbox.
6) It was not possible to test the use of IANI in Nordic SR-Net due to the lack of working IANI-clients at the participating institutions. Therefore the OSI projects within NORDINFO have not given any increased knowledge in how a IANI installation could work in a z39.50 environment..

## References


[1] Application protocol for library and information systems : the network protocol from the BIBNETT project / by Liv A. Holm et. al.- Oslo : Norsk dokumentdata, 1982
ISBN: 82-7212-038-0

[2] The BIBNETT project : system to system communication using a computer network / Liv A. Holm et al. - Oslo : Norsk dokumentdata, 1982
ISBN: 82-7212-039-9

[3] BIBNETT 2 : kommunikasjon mellom systemer på små og mellomstore maskiner / Liv A. Holm et al. - Oslo: BRODD, 1985
BRODD report 85001
[4] CCITT x.25 Packet Layer Protocol (1976); consists of x.25 LAPB for the link layer and x.25 PLP for the network layer. The equivalent ISO standards are ISO 7776 HDLC and ISO 8208 Packet Layer Protocol for Data Terminal Equipment (CCITT changed to ITU)
[5] Information Retrieval (z39.50): Application Service Definition and Protocol Specification : Z39.50 Maintenance Agency Official Text for Z39.50-1995
http:/lcweb.loc.gov/z3950/agency/document.html
[6] ISO 7498 (1984) Information processing systems - Open Systems Interconnection - Basic Reference Model
[7] ISO 7776 Information processing systems - Data communication - High-level data link control procedure - Description of the X.25 LAPB-compatible DTE data link procedures"
[8] ISO 8208 Information technology - - Data communication - X.25 Packet layer Protocol for Data Terminal Equipment
[9] ISO 8777 Information and documentation - Commands for interactive text searching
[10] ISO 9646 Information processing systems : Open Systems Interconnectio - Conformance Testing Methodology and Framework
[11] ISO 10160 Information and documentation - Open Systems Interconnection - Interlibrary Loan Application Service Definition
http://www.nlc-bnc.ca./iso/ill/standard.htm
[12] ISO 10161 Information and documentation - Open Systems Interconnection - Interlibrary Loan Application Protocol Specification
http://www.nlc-bnc.ca./iso/ill/standard.htm
[13] ISO 10162 Information and documentation - Open Systems Interconnection - Search and Retrieve Application Service Definition
[14] ISO 10163 Information and documentation - Open Systems Interconnection - Search and Retrieve Application Protocol Specification
[15] ISO 23950 Information and documentation - Information retrieval (z39.50) - Application service definition and protocol specification
http://lcweb.loc.gov/z3950/agency/document.html
[16] NCLIS/NBS Task Force on Computer Network Protocol. A computer network protocol for library and information science applications. 1977.
[17] Nordic SR-Net : communication between different systems. Final report from the project. Asbo : NORDINFO c/o Tekniska högskolans bibliotek, 1994.
ISBN: 951-47-9511-3
[18] Prøvedrift av informasjonssystemnettverk / Liv A. Holm et.al. - Oslo : BRODD, 1985
ISBN: 82-579-0013-3.
[19] The WLN/RLG/LC Linked Systems Project / Davison, Wayne E.
In: Information Technology and Libraries, March 1983

## Abbreviations and terms

| Abbreviation or term | Meaning |
|---|---|
| APDU | Application Protocol Data Unit; a computer network message on the application level (level 7) |
| API | Application Programmers' Interface |
| Application protocol | Computer network protocol on 7th. Level in the ISO OSI network model. It defines the syntax and content of messages sent between applications such as library systems |
| ARPA | Advanced Research Projects Agency |
| ARPANET | Computer network made by ARPA |
| ASCII | American Standard Code for Information Exchange (1963) |

| Abbreviation or term | Meaning |
|---|---|
| ASN.1 | Abstract Syntax Notation 1; a "programming" language in which several computer network protocols are defined |
| BHS | School of Library and Information Science in Borås, Sweden |
| BIBSYS | Library system offering union catalogues as well as housekeeping functions |
| Broadcasting | to send a message to all hosts in the network |
| BRODD | R & D department of the Norwegian school of library and information science |
| CCITT | Comité Consultatif International Télégraphique et Téléphonique |
| CCL | Common Command Language (ISO 8777); command language mainly for IR systems |
| CHASE | Character Set Standardisation; a tool for conversion between character sets resulting from the project CHASE |
| CP/M | operating system for micro computers |
| CP | Communication Process |
| DANBIB | Danish union catalogue for research and public libraries |
| DATAPAK | Public packetswitching computer network in Norway and Sweden |
| DEC-10 | Mainframe computer (1985) |
| DENet | The Danish academic network |
| FEK | Computing office for research libraries in Denmark (Forskningsbibliotekernes EDB-kontor) |
| FUNET | The Finnish academic network |
| Host | A computer in a computer network on which an application such as a library system runs |
| HP | Hewlett Packard computer |
| HP-UX | UNIX version on HP computers |
| IANI | Intelligent Access to Nordic Information systems |
| IBM-PC/XT | IBM personal computer, microcomputer with harddisk (1985) |
| ILL | Interlibrary Loan |
| IMP | Interface Message Processors |
| INIVAC 1100 | Mainframe computer |
| IP | Internet Protocol covers level 1 - 3 in the OSI model. |
| IR-systems | Information Retrieval systems |
| ISNET | The Icelandic academic network |
| ISODE | ISO Development Environment; a free tool for simple implementation of the OSI model (1991). |
| KIBIC | Library of the Karolinska Institutet (Karolinska Institutets Bibliotek och InformationsCentral) |
| KS-500 | Mini-computer produced by Kongsberg Våpenfabrikk, used as UNINETT-node for UNIVAC 1100 in Trondheim (1985) |
| LC | Library of Congress, USA |
| LIBERTAS | English library system from SLS |

| Abbreviation or term | Meaning |
|---|---|
| LSP | Linked Systems Project (SR-project in USA) (1980 - 1985) |
| MARC | Machine Readable Cataloguing; an exchange format for bibliographic records |
| MARCconv | A tool which converts a bibliographic record from one MARC format to another |
| Micro-Polydoc | The IR-system Polydoc implementet on micro-computer (1985) |
| Modem | Modulator/demodulator: for sending/retrieving digital signals over a network using analog telephone lines |
| MP/M | operating system for micro computers |
| Multicasting | to send a message to a selected group of hosts in the network |
| NBS | National Bureau of Standards |
| NCLIS | National Commission on Libraries and Information Science (USA) |
| NIST | National Institute of Standards and Technology (former NBS) |
| Node | A computer in a computer network (all types) |
| NORMARC | Norweagian MARC format |
| NOVA*STATUS | A Norwegian, enhanced version of the information system STATUS |
| NSI | Norwegian Centre for Informatics |
| NTNF | Norges Teknisk-Naturvitenskapelig Forskningsråd (1946 - 1993) |
| ONE | OPAC Network in Europe |
| OPAC | Online Public Access catalogue |
| Origin | The application that initiates the communication |
| OSI | Open Systems' Interconnection |
| PPS | Program-to-Program Service |
| Profile | A subset of the protocol with spesific definitions where the protocol is ambigous |
| Protocol | Set of rules for how to build and interpret messages between two processes on the same level in the network |
| RBT | Directorate for research libraries (Riksbibliotektjenesten) |
| RFC | Request For Comments (documents from Internet Engineering Task Force - IETF) |
| RLG | Research Library Group |
| RPN | Reverse Polish Notation; an unambigious way of writing a boolean combination of search terms |
| RUNIT | Computing centre at the University of Trondheim |
| SBH/SBIH | Norwegian school of library and information science (Statens bibliotekhøgskole) |
| Session | A complete dialog between to systems (connect, exchange of messages, disconnect) |
| SNA | Systems Network Architecture, network model at IBM |
| SRPM | Search and Retrieve Protocil Machine; implementation of the SR protocol |
| STAIRS | STorage And Information Retrieval System; Information Retrieval System running on IBM computers |
| Sun | computer |

| Abbreviation or term | Meaning |
|---|---|
| SUNET | Swedish University network |
| SunOS | UNIX operating system for Sun computers |
| Target | The application that is called on by the Origin |
| TCP | Transmission Control Protocol (covers approximately level 4 in the OSI model) |
| TCP/IP | a set of protocols covering level 1 - 4 in the OSI model. (IP = Internet protocol; TCP = |
| TKAY | Automation Unit of Finnish Research Libraries i Helsinki University Library |
| TRIP | Text Retrieval and Information Processing ?? |
| UBB | University Library in Bergen |
| UBO:BOK | System for the national bibliography in Norway |
| UBO | University Library in Oslo |
| UFTS | UNINETT File Transfer Service |
| UIS | UNINETT Interactive Service |
| ULTRIX | version of UNIX on VAX |
| UNINETT | University network in Norway |
| UNIX | operating system |
| VAX | computer |
| VTLS | Verginia Tech Library System |
| WLN | Washington Library Network |
| X.25 | CCITT-recommendation for protocols for levels 1 - 3 in the OSI 7-level model |
| Z39.50 v3 | Information Retrieval (Z39.50): Application Service Definition and Protocol Specification |