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D E U T S C H E S F O R S C H U N G S N E T Z (D F N)

Development and Operation of an OSI-based
Network for the Scientific Community

K. Ullmann, DFN-Verein
Pariser Str. 44
D 1000 Berlin 15
Tel.:49 / 30 / 88 42 99 20

Summary

Development and operation issues for an OSI-based data communication network for scientific users in Germany are described. For that purpose the users, their profile and their requirements to those services are sketched. The DFN-protocol architecture, the DFN-services and the technical scenario then define the overall development problem. The future operation of DFN-services is described in technical and in economical terms. The project DFN is sponsored by the German Ministry for Research and Technology (BMFT).

I. Introduction

The first ideas for building up a data communication network for scientific users in Germany on an OSI-basis came up in 1982. A project plan was the result of a one year planning phase. Since 1983/1984 the realization of this plan is under way. In the following chapters developement and operation issues are described and the main project decisions are motivated.

II. Development Issues

1. DFN-Users

The starting management decision for DFN had been made in 1982. It expressed, that a set of data communication services should be established for users in the scientific community in Germany. There has been no restriction just to academic users in universities - on the contrary those services should be available as well to scientists in public or private research laboratories. The rationale behind was a large number of cooperations between research groups in different university locations and industry laboratories especially in the "high-tech" field. These cooperations should be intensified or even enabled with DFN-services.

It was the first major technical task in the planning phase of DFN (1982-1983) to derive a profile of the users and their needs, coming from the decision mentioned above. Five major points have been identified within that part of the planning process:

a) The user demand for data communication services did not restrict to a national service but it included a demand for international communication as well, because scientific work in most cases involves international relationships.

b) The second decision was to develop data communication services for the computing centres of research organisations, because in this subset of the DFN user community there was an urgent demand for a specific service: some of the end-user of those Electronic Data Processing (EDP-) Centres wanted to run their jobs on specialized *remote machines (i. e. vector processors), and the actual use of some regional data communication services showed, that this demand could be generalized.*

c) A general and common characteristic of inter-institutional user-groups and those computing centres oriented groups was the need for an unrestricted use of EDP-resources by means of DFN-services, i.e. the service should enable the user to transfer data to all important EDP-equipment in his environment. This data transfer should only be dependent on the users scientific environment (i.e. actual scientific program, budget etc.) but not on network specific properties. From this requirement for "open" (in the sense of system independent) communication, DFN-planners derived a list of those 10 machines, which are most important for future DFN-users.

d) The most important communication services, which should be implemented for the scientific users could be derived from an analysis of the user profile (see b and c) and from experiences either made in regional networking in Germany or foreign networking. It has been decided that the following basic services should be realized for DFN on the most important machines:

- *dialogue service for interactive access to remote computers,*
- *file transfer service for transfer of data,*
- *remote job entry service for sending jobs and receiving the resulting output automatically.*

It had been decided furthermore to realize a message service in DFN in order to ease cooperation between scientists.

e) Finally it had been decided to study new services in the field of data communication, if some real needs could be identified and if a technical basis for them could be described in realistic terms. This was achieved for some graphical- and CAD-data oriented services, which enable users to send (and receive) specific data structures by means of DFN-services.

2. Protocol Architecture and Services in DFN

In order to satisfy the user requirements described in chapter 1 the next major step in the development of DFN was to define the protocol architecture for the data communication services. There were different possible ways to do this:

- *definition of a (new) DFN-specific protocol architecture,*
- *taking a manufacturer specific architecture or*
- *relying on international standards.*

If the user just looks at the functionality of future DFN-services, the choice of the protocol architecture is (nearly) irrelevant to him, but if he looks at the availability of those services in the context of his international collaborations and in the context of (different!) manufacturer products, it is clear, that only international standards based on the OSI-architecture could be a reliable platform for DFN-developements. A standard in that sense is either an ISO-IS (International Standard), an ISO-DIS (Draft International Standard) or a CCITT-recommendation. Based on that policy issue the following protocol decisions have been made:

a) The network service should be mainly based on the X.25 network of the PTT. The reason for that are legal aspects in the technical scenario of data communications: The PTTs in Europe have a monopoly in wide-area data communication.

b) Resulting from the user requirements (see chapter 1) the basic services, the message service and the graphic services had to be defined.

b.1) Dialogue Service

For a teletype based dialogue the X.3/X.28/X.29 recommendations of CCITT were available and were taken for DFN-purposes. A lot of X.3, X.28 and X.29-oriented equipment can be bought on the market (i.e. hardware-PAD's) and a large number of user end systems have teletype characteristics. This reason and the fact, that the recommendations are relatively easy to realize are the rationale for that decision.

b.2) File Transfer Service (FT)

In the case of file transfer the decision making process was not so easy, because an international ISO-standard was evolving, which should define a File Transfer, Access and Management (FTAM) architecture. At the time the decision had to be made (summer 1983), it was risky to take an interim solution (special DFN-FT) but the standardisation process showed to be slow: FTAM is assumed to be released as an ISO-DIS in the first half of 1986.

b.3) Remote Job Entry Service (RJE)

As no international standard is available, DFN took an earlier definition of an OSI-oriented but DFN-specific RJE-protocol.

b.4) Message Handling System (MHS)

In 1984 CCITT released the series of X.400 specifications, which define the behaviour of an MHS. DFN decided to take those specifications as a protocol basis in all projects for MHS-services.

b.5) Graphical Services

As there were no standards and no existing protocol and service definitions available, a lot of protocol engineering tasks have to be done by DFN-projects in this area.

b.6) Transport Service

The protocol decision has been made for the T.70 (ISO-Class 0), because it is adequate in the X.400-context, it fulfills all other DFN-requirements and it is relatively easy to implement.

b.7) Session Service

The session protocol is the ISO-BAS, because it is compatible with the CCITT-T.62, which is used in the X.400-specifications.

These protocol decisions are summarized in figure 1.

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I--------I--------I--------I--------I--------I--------I ISO-Layer
I PAD    I X.29   I  FT    I  RJE   I Graph. I X.400  I   6-7
I        I        I        I        I Serv.  I--------I
I        I        I        I        I        I  BAS   I    5
I        I        I--------I--------I--------I--------I
I        I        I             ISO-Class 0           I    4
I--------I--------I-----------------------------------I
I                       X.25                          I   1-3
I-----------------------------------------------------I
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Figure 1: DFN Protocol Architecture

3. Technical Scenario

Having decided the protocol architecture for DFN services these protocol algorithms had to be implemented into the end-systems of the users. The ensemble of these end-systems combined with the wide-area and the local-area communication equipment has to be described in a technical scenario. The overall scenario can be divided into four major parts, which (should) have well defined interfaces.

a) The wide-area communication is organized under the authority of the PTTs. The (main) technical interface is defined by the X.25-recommendation of the CCITT.

b) The local-area communication cannot be described in such simple terms. There is no internationally agreed standard, that fits the interconnection requirements (to the public X.25 data network) of DFN. Therefore specialized gateways have to be built for several local area networks.

c) Resulting from the user requirements analysis the service realizations have to be done on 10 different machines. For maintenance reasons it has been decided to take manufacturer products for the realization, if they are available and if it is possible to get them for a reasonable license fee.

d) A more future oriented part of the scenario is concerned with broadband data communication and the future ISDN-network of the PTT. For a first approach gateways should connect the different networks.

The main developments in the first phase of DFN (1984-1986) in terms of financial and manpower effort are related to issues a) and c) of the overall technical scenario, which is sketched in figure 2.

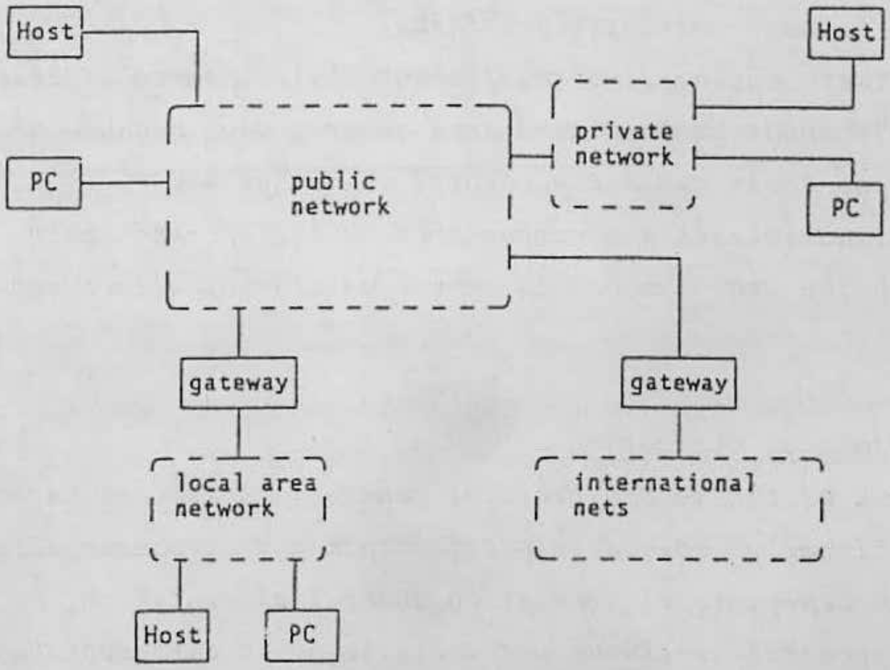

Figure 2: Technical Scenario

4. Engineering Issues

After having defined the protocol architecture and the technical scenario the implementation of DFN services could be planned. The kernel of DFN-implementations is the realization of the services in the 10 machines (see technical scenario point c). Because the DFN subsystem should run in the environment of large computing centres as well as in small research laboratories with unskilled users, the software engineering quality of the implementations should be comparable to industrial standards. This is the reason, why a general software engineering procedure especially concerning documentation of the development *had to be defined.*

A second general requirement (see point c) of the technical scenario) had been formulated. Whenever possible, the communication subsystem (for example X.25 component) of the manufacturer should be taken. This requirement is motivated mainly for maintenance reasons. As a consequence it imposed some other drawbacks to DFN-developments:

1. *As the manufacturer products are embedded into the operating system environment in a very specific way, this requirement is in contrast to some portability efforts.*
2. *Some software engineering requirements (i.e. common implementation language) cannot be fulfilled in a general way, because manufacturers use their own software production systems.*

These two disadvantages are compensated by the enormous gain in support, which the user can obtain from a manufacturer in system maintenance.

5. Future Protocol Generation

The main task of future DFN-protocol generations is the harmonization of internationally agreed standards. This has of course already been done for the DFN-protocol generation under implementation. A harmonization of standards is always necessary to avoid different (and incompatible) interpretations of the same standard. This harmonization should be done on a European basis: There are other European OSI-networks evolving, which are designed for national scientific communities as well. It is obvious, to harmonize the protocol world on this user level. This is one main reason, why different national network organisations created an European organisation for network services. The name of that organisation is RARE. This acronym means "Reseaux Associes pour la Recherche Europeene".

Finally there is a harmonization effort of the Standard Promotion and Application Group (SPAG) of 12 European manufacturers. The SPAG group produces a guide of the use of standards (GUS), which shall be input to a CEN/CENELEC standards committee and will be the basis of product developments in the companies. There are efforts from US-manufactu-

rers to take the GUS for their developments as well. This protocol harmonisation of the SPAG-group is most important for the success of OSI-networks. In that way the SPAG-GUS will be a central issue for the next DFN-protocol generation. From the beginning DFN people have made contributions to the SPAG-working groups and had the opportunity to discuss those central questions with technical committes of SPAG.

In the context of further developments in the X.400 world DFN groups are engaged in protocol engineering for distributed directories. Those developments are embedded in a European ESPRIT project (THORN) and in the IFIP- and CCITT-related working groups. From these groups innovative telematic services will evolve, which have a great product relevance for manufacturers (and users!) in the next decade.

III. DFN-Operation

1. Technical Infrastructure for DFN-operation

In technical terms DFN consists of components, which to a main part are dependant on the operating system environment they are built for. In order to organize the system specific maintenance for that kind of software, "reference machines" will be installed. DFN-users will get all software support they need to run DFN-software by accessing their specific reference machine.

Another important DFN-component in the development and the operation phase is the protocol test laboratory, which makes the conformance testing of protocol implementations (and different versions of them).

A more centralized DFN-component is the information system, which contains network addresses and other useful informations for the users. This information system can be accessed via PAD.

This set of technical infrastructure is a necessary condition to run DFN-services in the heterogenous user environment.

2. Economical Issues

Operation of the whole set of DFN data communication services costs money. There is a statement of the German Ministry for Research and Technology (BMFT), who sponsors DFN-development and the first phase of operation with roughly 50 Mio. DM, that this money will be subsidized by the ministry only for the starting phase of DFN (1985-1988). This is the reason, why a DFN-financing policy had to be formulated in parallel to the developments of the DFN-subsystems. This policy is based on the general assumption, that DFN-users must finance the whole DFN-operation. For the formulation of a financing strategy some further general policies had to be defined:

a) The money for DFN-operation should be acquired on a basis, that the originator of costs should pay.

b) All (or almost all) services should be charged on a use-oriented basis.

This general policy has to be realized in a very complex and heterogenous user community with federal structure and very different budgeting policies.

In order to elaborate a budget plan for DFN-operation based on the technical and organisational requirements, a general model for DFN communication has to be defined. This model should reflect all those different issues. In order to develop the model several categories of costs have been identified:

a) costs for transfer of data (PTT-services,

b) costs for use of remote (computer) resources,

c) costs for central DFN-infrastructure (e.g. protocol testlab) and

d) costs for decentral DFN-infrastructure (e.g. reference machines).

Cost categories a) and b) are regulated in contracts between DFN-users and ***non-DFN*** *service providers (i.e. PTT and computing centres). The costs are charged in the line of the general DFN-policy - they are charged on a originator- and use-oriented basis. Because these costs are basically fixed in bilateral contracts between a*

DFN-user and a non-DF[illegible] organisation, the term "bilateral form of communication" summarizes the responsability for that part of the "overall" DFN-operation-budget. This form of ***decentral*** *DFN-operation is adequate to the heterogenous organisation of the German scientific community.*

Cost category c) cannot be easily charged on the above mentioned general basis for some technical (accounting) reasons. Therefore this part of the budget has to be financed on a basis of a general contribution of DFN-users to the DFN-association (see below).

Charging for cost category d), which is the bulk of finance for DFN-operation, will be again done based on the DFN-principles: It will be done on an installation basis.

3. Organisational Issues

In order to define the engineering principles of the DFN-project and [illegible] DFN-developments, a central project management group [illegible] established. Another part of this staff has the task to define the conditions for DFN-operation and (at a later time) to organise the [illegible]. For those two reasons it was necessary to create a special organizational form; an association (DFN-Verein) has been established in the beginning of 1984. The members of this association are future users and (so far) computer manufacturers. The management body is the membership assembly, which elects a board of directors for three years. The project management group reports to that board.

The main research institutions in Germany and nearly all universities together with approximately 15 industrial partners are now member in t[illegible]N-Verein. This is a good basis for the starting phase of DFN.