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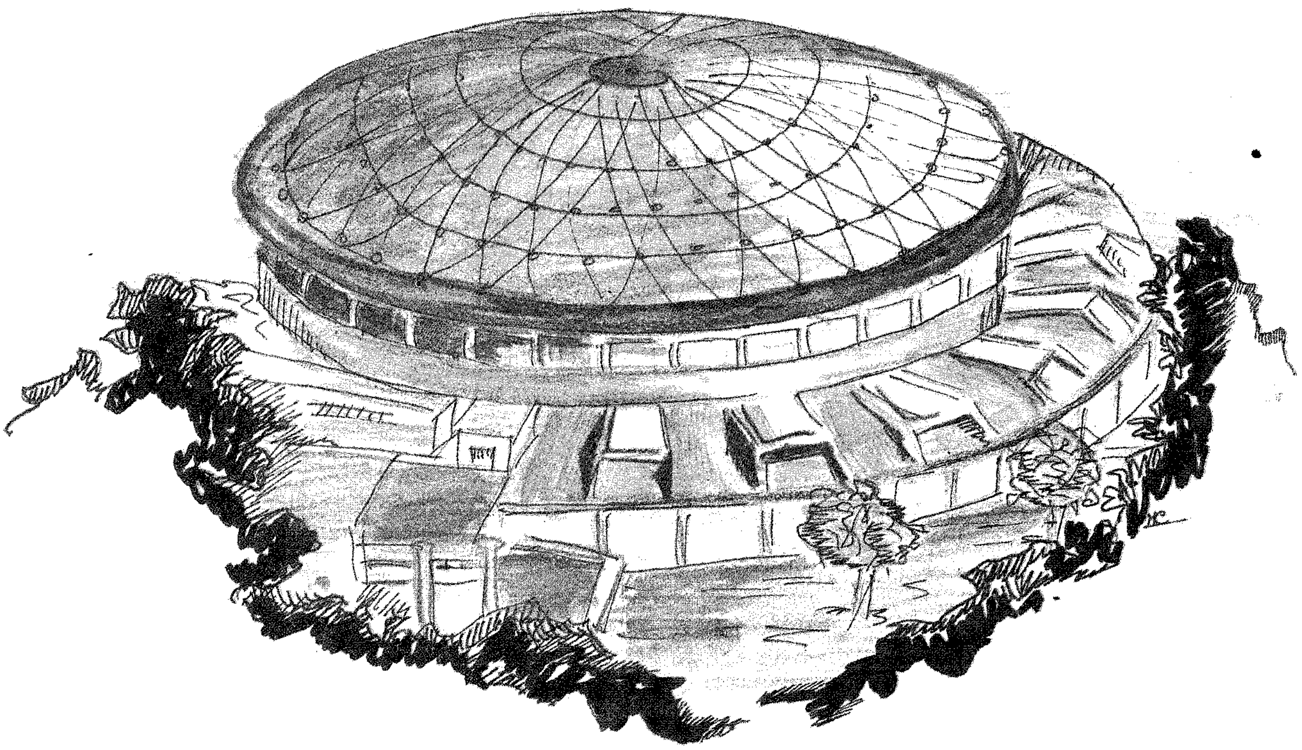

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A MODEL OF AN APPLICATION RELAY FOR FILE TRANSFER, ACCESS, AND MANAGEMENT

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Abstract - A relay at the application layer , allowing file access, transfer, and management between different computers belonging to different networks, is discussed from the system architecture point of view. After discussing different types of relays, it will be shown that a protocol conversion using the Virtual Filestore concept is able to realize a relay for file access and transfer, greatly reducing the complexity of the multiprotocol conversion problem. Some implementations of this model are briefly shown.

I. INTRODUCTION

At the beginning of 80's, several networks were set up either by homogeneous computers using a communication protocol produced by manufacturers or by etherogeneous computers using a home-made protocol. At that time, it was possible to put a computer on more than one network at the same time thereby allowing interconnections between different kinds of networks. At that time, international standards for remote terminal access were well defined, and the standard organizations were working in order to define electronic mail applications. The definition of the standard documents concerning file transfer, access, and management and remote job entry applications was at initial stage. Before the completion of the standard definitions, the scientific and academic community (in particular the High Energy Physics community) needed an interim solution to connect existing protocols for file transfer and access. For this purpose, the authors started a study of feasibility of a software gateway system.

After a first phase, the following general principles of a gateway for file transfer and access were stated:

1. No changes of the applicative programs on the end-nodes in order to reduce the software support need and also to facilitate the end-users that require no special interface while accessing remote files through the gateway.

2. No "store and forward" feature on the gateway, but "on fly" conversion, allowing the user to control the whole transfer operation.

3. Software modifications on the gateway machine only at the application level, without changes of the involved protocols.

In the following a gateway model will be described using the OSI relay model at the application level. The OSI terminology will be used to define other general concepts that are common also to non-OSI network protocols. Different kinds of relays will be compared using the OSI File Protocol Machine model. It will be shown that a protocol conversion mediated by a Virtual Filestore is independent of the differences between the involved File Services. Two implementations of this model will be briefly discussed.

II. THE OSI REFERENCE MODEL AND FTAM ARCHITECTURE

Within the OSI reference model [1], the protocol architecture has a seven-layer structure. The active component within a layer N is termed an (N)-entity. An (N)-entity cooperates with

(N)-entities in other systems by means of an (N)-protocol, using the (N-1)-Service provided by the layer below, to provide an (N)-Service to (N+1)-entities, as shown in figure 1.

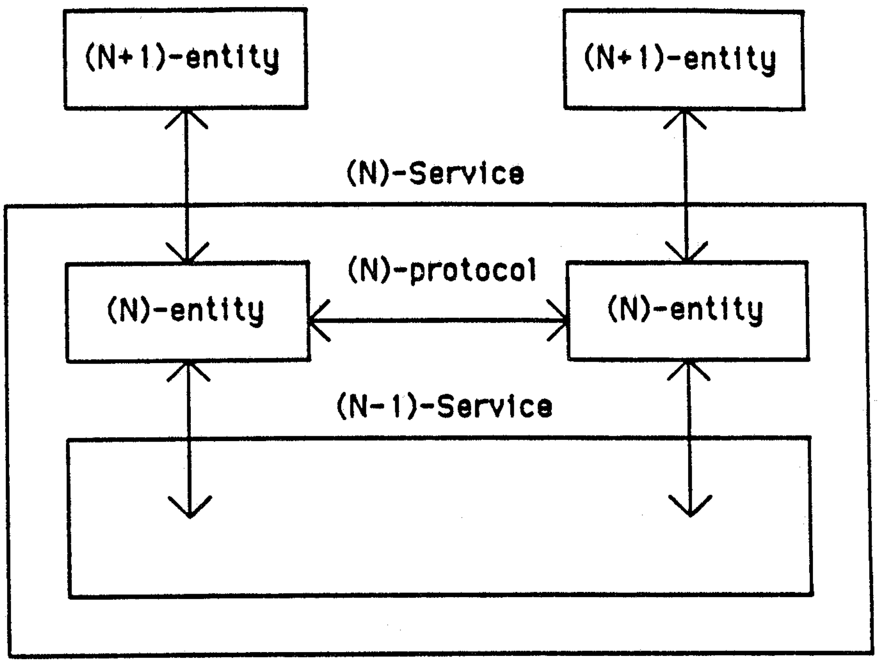

Figure 1. Entities, Protocols, and Services in OSI

A protocol entity utilizes the Service Primitives in order to communicate via the Service Provider [2]. A Service Primitive can be considered as an elementary interaction between a Service User and the Service Provider. During the Service Primitive activity, the values for the various parameters of the primitive are established and both user and provider can refer to them. Therefore the specification of a service can be expressed in terms of the possible orderings of Service Primitives and their parameter value dependencies [3].

The ISO 8571 documents [4] [5] [6] [7], defining the FTAM (File Transfer, Access, and Management) model, defines a File Service and specifies a file protocol available within the application layer of the OSI Reference Model. It provides sufficient facilities to support file transfer, and establishes a framework for file access and file management. It also defines several concepts, particularly the two File Service users, "initiator" (FSUI) and "responder" (FSUR), emphasing the asymmetry of the dialogue between them. The responder is an application entity with the ability to manage a Virtual Filestore (VFS). The VFS is "an abstract model for describing files and Filestores and the possible actions on them" [8].

In understanding the aim of OSI, it is important to distinguish between standard definitions and their real hardware/software implementations. Two enviroments are identified by this distinction:

1. Open System Interconnection Enviroment (OSIE) : the set of definitions of the standardized services and protocols and data structures enabling interconnection of systems. Within the OSI FTAM model, the operation of the protocol is modelled by the interaction of two File Protocol Machines (FPMs). The FPMs communicate by means of the services available at their lower boundary, in such a way as to provide the services required at their upper boundary (figure 2).

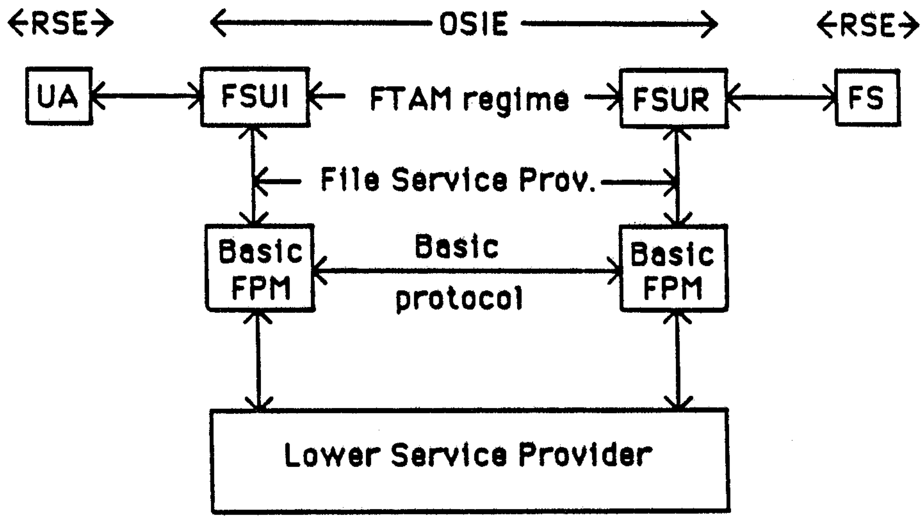

Figure 2. FTAM and File Protocol Machine models

2. Real System Enviroment (RSE): it concerns the implementative aspects, in terms of the real facilities and resources supporting an application process within a real system. Within the FTAM model, this enviroment implements the mapping of the parameters of the File Service Provider into the Real Filestore.

III. THE CONCEPTS OF GATEWAY AND RELAY

A gateway is generally defined as the "collection of hardware and software required to effect the interconnection of two or more data networks enabling the passage of user data from one to another" [9] [10]. For layered network protocols, if the conversion is realized at level N, it is usually said that the two networks are interconnected by the gateway at level N, or that this gateway is a level N gateway. In the OSI environment a gateway at level N is termed an (N)-relay system, and contains an (N)-relay to forward data from one (N)-entity to another, as shown in figure 3.

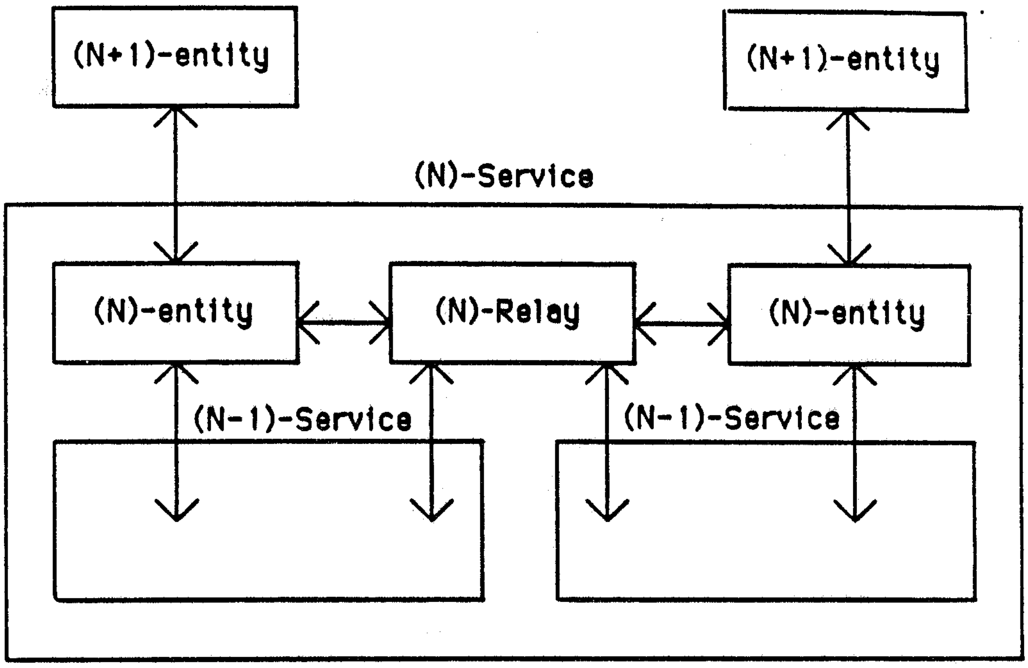

Figure 3. (N)-Relay in OSI

When computers belonging to different networks are interconnected, in order to achieve host-level interoperability it is necessary to have the same protocol functionality from the highest level down to the level where a conversion or relay occurs. The best solution to maintain the end-to-end conditions seems to be a conversion at each level, above the relay level. Apart from the complexity of this kind of conversion [11], it is not easy to decide at which level the relay will be defined. A solution for a relay between TCP and OSI protocols is proposed by Groenbaek [12] where the relay is defined at TCP transport level, equivalent to the ISO/OSI transport and session levels (figure 4). He proposes the same software on each end-machine for higher layers, conserving the original lower layers. An extended finite-state machine with descriptions of transitions and actions for each of the 654 state/event possible combinations is used in order to specify the relay protocol.

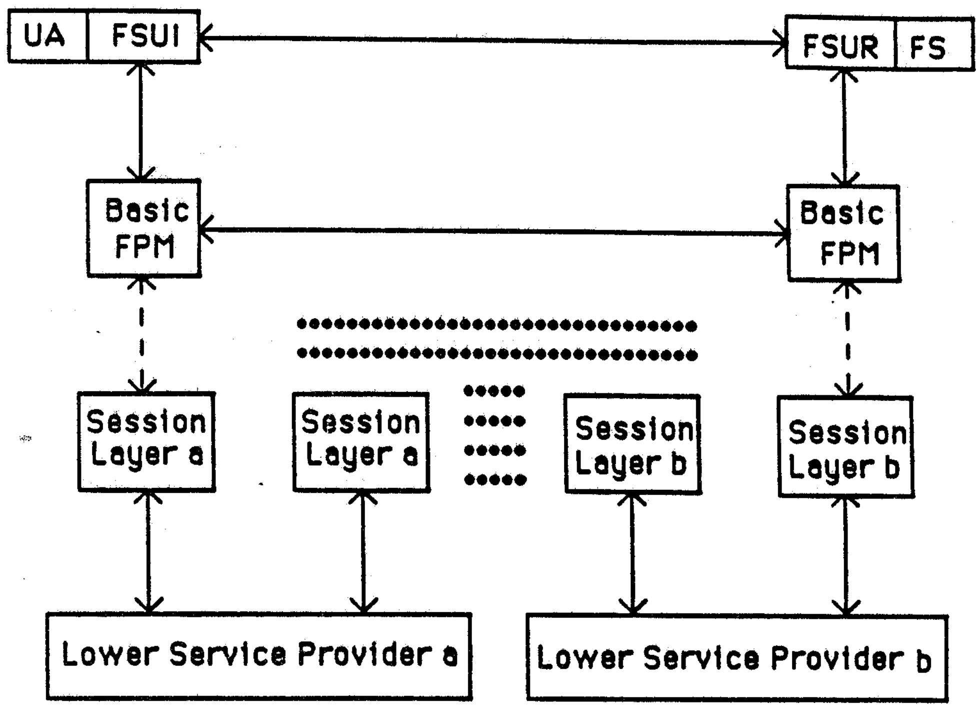

Figure 4. Relay at Session level

The approach of solving the problem of relay at a level that is lower than application layer (fig. 4) has a great limit: the need to use in each end-node two different software interfaces, one to access to its own network machines and the other to access to other machines connected through the relay.

In the last years, few papers about formal description of the protocol converters have been published [13] [14]. In the Ohara paper three different kinds of conversion methods are defined: Protocol Interface Conversion, Service Interface Conversion, and Hybrid Conversion. The Protocol Interface Converter between two layered protocols appears as a set of different protocol converters, one for each layer. This implies that any layer in one of the involved protocols must correspond exactly with one other layer of the second protocol. In a Service Interface Converter the (N)-layer services of one protocol are converted into the (M)-layer services of the other protocol. The Hybrid Converter involves a Protocol Interface Converter starting from a given layer, the protocols on the lower layers remaining unchanged.

IV. APPLICATION RELAY FOR FILE TRANSFER AND FILE ACCESS

Using the relay model by Groenbaek to describe an application level relay for file transfer and access (fig. 5) connecting two File Protocol Machines, according to the Ohara's model an Hybrid Converter is obtained. The extended finite-state machine could be very complex because of the great number of state/event combinations.

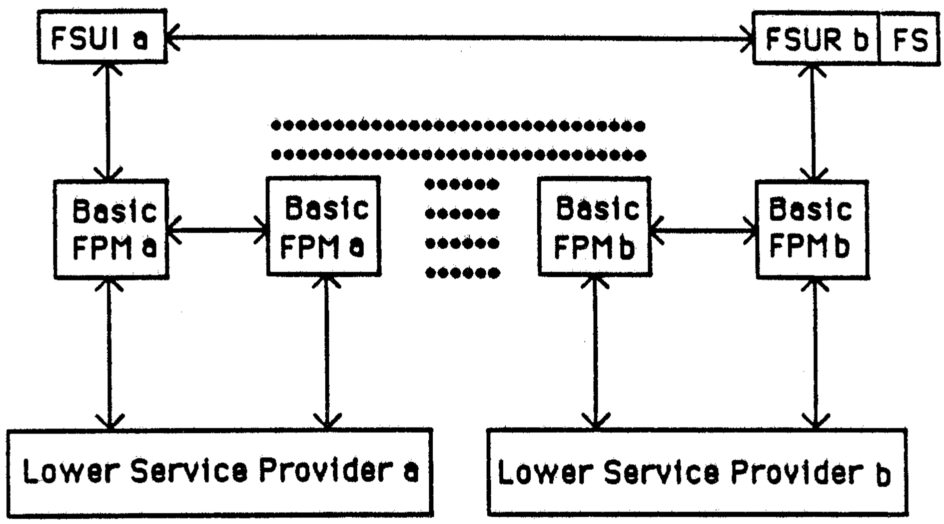

Figure 5. The application relay model at File Protocol Machine level

An alternative application level relay model, based on the concept of Virtual Filestore, is proposed by the authors (fig.6).

Within the OSI File Server model, a common model, the Virtual Filestore, is defined describing files and their attributes. The Virtual Filestore definition is very powerful because it allows the differences in style and specification to be absorbed into a local mapping function, and any particular system can then interwork with other different systems in terms which can be mutually understood.

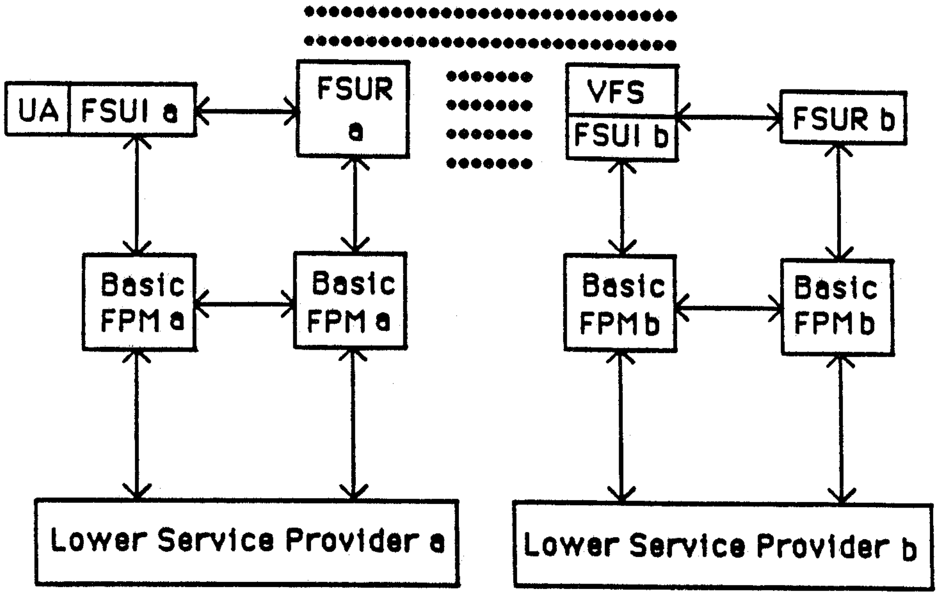

Figure 6. The application relay model at Virtual Filestore level

An operating system implementing this Virtual Filestore model that supplies the user a unique interface in order to access both local and remote files, could be very interesting. This could be realized by supplying the primitives allowing the user to access directly the Virtual Filestore and by mapping between the Virtual filestore and the File Service User Initiator primitives.

This Virtual Filestore implementation model has been used by the authors to define a relay for file transfer, access, and management. Beginning from the formal representation of the several components of the proposed relay model and from their interaction, it could be possible to compare the relay model with a Service Interface Converter formally described using a Protocol Converter Machine as proposed by Ohara. The comparison of the complexity of this two models will be studied in the future.

Moreover, this model of the Virtual Filestore implementation allows the definition of a multiprotocol converter model. The complexity of this converter goes as N, N being the number of protocols to be converted. For each protocol both the mapping between File Service User Responder and Virtual Filestore, and the mapping between Virtual Filestore and File Service User Initiator must be realized. Viceversa, the realization of the multiprotocol converter defining a Protocol Converter Machine for each pair of protocols involved presents a complexity that goes as N(N-1)/2.

This theoretical model of an application relay has been implemented. The implementation of the relay between two networks has been realized on a PDP [15] [16] running the operating system RSX, interconnecting INFNET (the INFN network based on DECnet, the network protocol by DEC) and CERNET (the CERN network, based on a home-made network protocol). The multiprotocol-gateway (fig.7) has been implemented on a MicroVAX II running the VMS operating system (GIFT project, General Internetwork File Transfer) [17] [18]. At present time, it is able to interface the following protocols: CERNET, Coulored Books, DECnet, RHF, and TCP/IP. For the GIFT implementation, it was decided to create one dispatcher and one different module for each network protocol. Each module consists of a common kernel (i.d. the Virtual Filestore) and of a mapping part that is specific for each network protocol involved . In order to simplify the relay management, this solution was preferred instead of implementing a dispatcher inside a unique Virtual Filestore.

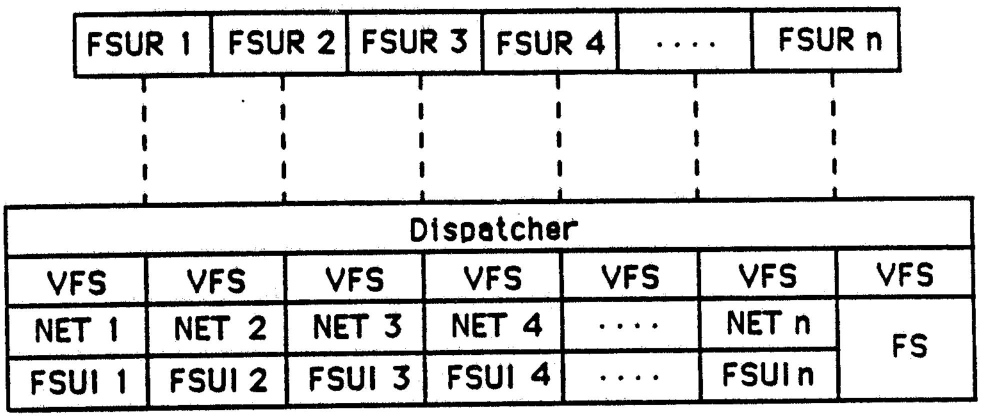

Figure 7. The Virtual Filestore conversion (multigateway)

In the scientific and academic community, a large number of network protocols are used with different facilities for file transfer, access, and management. Most of them are committed to migrate to the OSI architecture and there is a particular effort to adopt the OSI FTAM model. Within 1988, the OSI FTAM model will be completely defined by the standard organizations. However even when commercial products will be available, the substitution of the present tools and of the existing protocols will be slow. So the need of relays between OSI FTAM and other kinds of protocols for file transfer and file access will be fundamental in this transition phase when presumably the existing protocols will be widely used.

V. CONCLUSIONS

A theoretical model for an application level relay, based on a Virtual Filestore concept has been described and its validity demonstrated by showing two of its implementations that were and are widely used in High Energy Physics community. This theoretical model also allows the coexistence of different protocols for file transfer with OSI FTAM. The authors are working on a formal description in LOTOS of the multiprotocol converter presented in this paper.

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