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The Applications of a Toolkit for Virtual Network Creation and Management

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Abstract

This paper considers potential applications of a toolkit for the creation and management of virtual networks by their users. First, it shows the need for such a toolkit, and introduces the notion of *supranet* as the result that the application of the toolkit may yield. Then, it briefly examines the characteristics of the groups that may find the adoption of a supranet useful and convenient. Finally, it presents a complete supranet application scenario.

1. Introduction

In the past few years, there has been a rapid growth in the diffusion of telematic services within many types of organisations and, more in general, within society. One of the main factors that contributed to the introduction of telematic services in many aspects of people's everyday lives has been the wide availability and the popularity of Internet-based services, facilitated by their affordable costs and simple usage.

Today, a large number of business corporations, national and regional agencies, non-profit organisations, universities and many other types or forms of associations exploit telematic networks to collaborate, study, work, and retrieve on-line information in a practical and efficient way. It is important to note, however, that groups have different needs in terms of the communication infrastructures they use. For instance, some groups may require high levels of confidentiality for the messages being exchanged, or may need a high level of control over the network's topology, or, again, may need to keep the anonymity of their members.

The services offered by today's networks are essentially homogeneous and do not take into account the different needs of the many types of groups and organisations. In the future, we see the need to create, within large networks, collaborative environments that are private to a specific group or organisation. We refer to this service as a *virtual network service*, since it can be seen as equivalent to defining a virtual network on top of the physical one. This virtual network interconnects only the members of the group, and carries the group-related traffic being exchanged among them. A virtual network service allows each group to tailor the underlying network to its specific needs. For instance, each group may want to specify the desired level of security for the communications among members, define a convenient network topology and control the data traffic inside the network.

In a previous work [1], we argued that telematic networks should offer virtual network construction and management tools to all of their users, so that any user who wants to create a collaborative environment for a group will be able to do so; even though the tools can also be used by service providers to create virtual networks for their clients, we expressed the opinion that tools must be available to, and usable by, anybody, as frequent and unpredictable changes to the network's characteristics are to be made in many important applications. We also introduced and discussed the notion of *supranet*. Supranets are low-cost virtual networks - private to a group - that can be built on top of physical networks by any of their users. This paper focuses on the applications of a virtual network service such as the one offered by supranet tools, and shows that there are important applications in which virtual networks must be created and managed by users. Section 2 illustrates the main characteristics of a supranet; Section 3 describes the toolkit for supranet creation and management; Section 4 considers some groups and organisations, and discusses the potential benefits they may obtain from a virtual network service that allows users to manage the virtual network, while Section 5 presents a complete application scenario. Finally, Section 6 summarises the conclusions.

2. Supranets

A *supranet* is a virtual network created by one of its users on top of a physical network. Note that, even if we ignored the "created by users" condition, not all virtual networks would be supranets. Consider for instance the following characteristics of a collaborative environment:

1) membership is restricted; only "members" are allowed to access the network and to make use of the available services; admission of new members is controlled, e.g., by some network authority;
2) network topology can be defined and controlled; the paths (consisting of nodes and links) that connect members in the network may be explicitly designed and tailored to specific group needs;

3) resource capacity can be defined and controlled; it is possible for the network designer to define the capacity of the resources involved in the communications;
4) security mechanisms are available, e.g., to keep communications among members private, to guarantee the identity or anonymity of the interlocutors, to ensure data integrity and non-denial of service, and so on;
5) connectivity can be controlled: it is possible to forbid connections among some of the members; this allows the network authority to hide the presence of other members, e.g., for confidentiality reasons;
6) secure multicast may be used to send messages to a subgroup of the members in a secure manner, so that the messages cannot reach a member that is not included in the subgroup.

The first three characteristics in the previous list are the specifications that are needed to design any network, and they therefore belong to all virtual networks. We say that a virtual network is a supranet when, besides being built by tools available to all users of the physical network on which it exists, it has at least one of the last three characteristics. Therefore, supranets are virtual networks, but not all virtual networks are supranets (for example, the Mbone [2] is a virtual network but would not be a supranet, even if it could be built by normal users).

The designer of a supranet is called the "supranet creator". The creator (i) may be an individual as well as a team or committee of more individuals, (ii) determines the characteristics of the supranet, and (iii) is responsible for its actual construction, regulation and activation.

Supranets are low-cost and flexible. They provide not only the ability to control the network connectivity, topology, and resources capacity in a dynamic way, but also the ability to create and delete the whole environment in a very short time. In a physical network (such as a private one), to add a new link, node or host may be an expensive operation.

Finally, as in human societies groups and associations are governed by a number of rules, the operations of a supranet are governed by rules dictated by its creator. Rules are concerned with admission, access rights, use of supranet resources, relationships among members, etiquette, and so on. Compliance of members with these rules will be monitored, and sanctions for disobeying them will be decided by the creator or by a committee set up by the group for this purpose.

3. The Supranet Toolkit

The supranet toolkit allows the "supranet creator" to establish, manage, and tear down a supranet. The toolkit is designed so that it can be used at different levels, thus accommodating the needs of beginner, intermediate, and expert creators. In the following, we distinguish between *creation/teardown* functions and *management* functions.

The toolkit facilitates the creation phase by providing help in several steps. In a preliminary phase of the construction, it collects general information on the supranet to be built. This knowledge will be used later on either to suggest alternatives to the creator when appropriate or to automatically take decisions in those cases in which the creator wishes to delegate the design of some aspects of the supranet to the system. Such information may include, for instance, type and number of users (both the initial and maximum number are to be specified), their class and the corresponding privileges, and such other information as user admission criteria.

In the second step, the toolkit facilitates the definition of the supranet topology. The topology may be entirely defined by the creator or automatically generated by the toolkit, or, again, the creator may want to define the main structure (e.g., the backbone of the virtual network) and let the toolkit complete the design. In this phase, all feasible paths that connect supranet nodes are established. The toolkit automatically generates appropriate routing tables

that reflect the creator's decisions on the topology. Note that, within a supranet, routes are fixed, i.e., they never change during the whole supranet lifetime.

The third step is dedicated to the construction of multicast groups. The creator has to provide information on the type and number of these groups. The toolkit will then generate the supranet address space based on the maximum number of users and the maximum number of multicast groups that the creator has requested. Each supranet may have an address space of different size. Supranet addresses are intended to be meaningful only when used in the context of the supranet. Appropriate functions are created that map supranet addresses to the addresses of the underlying physical network (e.g., to IP addresses).

At this point, the creator is requested to express his or her requirements in terms of overall security of the supranet. Several different options are available: the creator will choose whether to restrict security measures to some specific cases or to define a common security level for all the communications that take place within the environment. In those cases where the creator leaves freedom, the users are allowed to decide if and when to use additional security mechanisms.

Finally, the toolkit allows the creator to express the rules that will govern the communications over the supranet. Such rules correspond to a behaviour code that must be observed by all users. This is not strictly enforced by the system, though, and it is in general possible for the users to break the law. However, supranets provide the means to detect users misbehaviour, and the creator may apply appropriate sanctions whenever such events are detected.

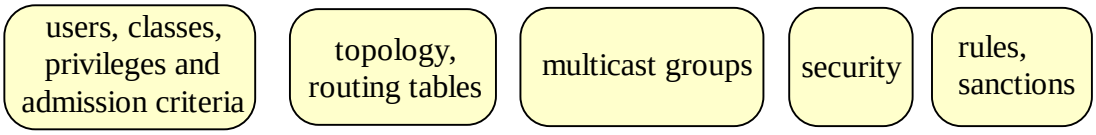

Figure 1: Supranet construction phases

The management functions of the toolkit allow for modifications during the supranet lifetime, like adding or removing nodes, updating the routing tables, detecting rule violations, and so on.

4. Groups

In this section, we consider some groups that may potentially benefit from a supranet-creating virtual network toolkit. Note that these examples are relative to only some of the many areas of applications that can be identified.

- Small organisations or groups of individuals cannot in general afford to build their own private physical networks. Instead, they may find it convenient to build a supranet or to have it built by a provider, and then manage it by themselves. Even large organisations with greater investment power are normally interested in cost-effective solutions to the problems related to their communications infrastructure. Supranets are easy to create and delete, and they can be tailored to the organisations' needs.
- Many groups or associations have a very short lifetime, often determined by the occurrence of a certain event. For example, the group of the buyers and sellers involved in an auction sale usually breaks up when the event terminates. Another example is that of project-oriented virtual companies. In these cases, it would be impractical or inconvenient to physically build a collaborative environment; a virtual network service offers the possibility to quickly create a low-cost, sufficiently secure environment to support their activities. Once the event is over, the environment can be rapidly dismantled.
- The network-related characteristics of many groups change frequently and unpredictably, and it is desirable that the group's virtual network be up-to-date and running as soon as possible after the occurrence of each change. Examples are groups that are built

incrementally and rather slowly, such as many special interest groups and organising committees, which are greatly helped by the existence of their own network well before all the available slots are filled; the so-called “extranets”, which connect a corporation to its suppliers and/or its customers, whose lists are in constant flux; and groups in which appointments, elections, promotions, resignations, retirements, hiring, and so on continuously modify the membership and the roles members play within the group.

- A supranet may be built to connect companies that use different information systems. This may be the case of virtual corporations, i.e. groups composed of various independent firms that decide to become business partners. Usually, the partners already have their private networks, so the supranet may be built on top of several private networks (as long as they are connected by an internetwork) and grant secure communications.

Supranets may be used in a number of other scenarios such as schools, non-profit organisations and so on. In summary, groups that may benefit from a supranet-based solution normally have the following characteristics: group membership is restricted and admission to the group is controlled; the group is not interested in building a private network because of different reasons: for instance, it expects to have a brief duration, or it may need (or desire) to build a communication network with a low financial effort; also, the group may have a strong need for security mechanisms (i.e. confidentiality, authentication,..), or need to set up and tear down the communication network in a very short time.

5. The Auction Sale Scenario

This section presents a possible scenario, in which an auction agency exploits supranet features to support its activities.

An auction agency decides to build a supranet to connect people interested in its sales. Members of the supranet are buyers and sellers, but also experts for the goods that are to be sold, offices of the agency and places where the auctions are to be held. Clients and sellers may have contacts with the experts linked to the supranet in order to have some advice and valuations on the goods that will be sold by the auction agency. Each member may have contacts with the agency offices, from which he can get information about the auctions. By using a supranet, the agency may improve the quality of the services it offers to its clients, and acquire new clients allowing people to participate to its auctions even if they cannot reach the places where the auctions are held.

Besides, the agency may personalise its services on the basis of the clients' needs. For instance, it may classify the buyers on the basis of their interests, and use multicasting to send them catalogues of the objects for their area of interest (jewellery, old cars, carpets, ...).

Inside the network, the members always use their supranet addresses (and not their real addresses); the agency allows them to conceal their identity, if they wish to keep anonymity. Admission to the network is strictly controlled, and so the agency always knows who participates in the sales. To protect its business, the agency will forbid direct connections between sellers and buyers.

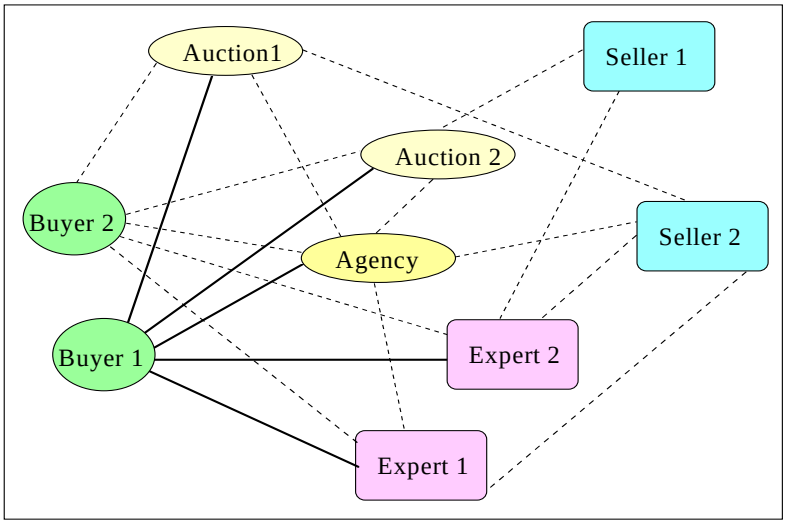

Figure 2: Buyer 1 can have contacts with the agency offices, the experts and the places where the auctions are held.

Some virtual visits to the exhibitions of the objects (which usually take place before the auctions) may be organised for prospective buyers. Our design applies also to multimedia and real-time applications on integrated-services internetworks [3].

The whole environment is protected from external intrusions by the supranet security mechanisms. During the auctions, buyers receive images of the objects, and can send their bids electronically; of course, all bids are authenticated (i.e., the supranet addresses are authenticated). Each bid is advertised to all the buyers. On demand, a buyer can get a receipt to assure him that his bid has been received by the agency. The sellers may be informed in real time about the bids for the objects that they entrusted to the auction agency to be sold. This is a typical case in which a private network cannot be considered a practical alternative, as each audience is too short-lived and too dynamic (unexpected bidders can "arrive" at any time during the sale and it is in the interest of the agency and the sellers to let them in) for a solution suitable for static, long-term applications.

6. Conclusions

In the future, we see the need for offering virtual network services over physical networks. A possible approach to this problem, based on a toolkit available to all users, has been presented in a previous work [1]. In this paper, we focused on the potential applications of this service, and we identified some groups of users that can potentially benefit from this service. Section 5 included the presentation of a complete application scenario based on an auction sale.

7. Bibliography

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