VIRTUAL ACTIVE IP NODE FOR COLLABORATIVE ENVIRONMENTS

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Abstract: The present document describes the VAIN architecture (Virtual Active IP Node), which enables users to deploy new network services based on virtual active networks, and how it solves the challenge of segmenting the incoming traffic that crosses nodes towards the services, conserving the original objective of independence of the protocol (Tennenhouse,1996). Our solution is based on using network expressions that use all the semantic contained in each incoming packet, which does not need to know the inner structure of the protocols. VAIN architecture has been development to response to challenges outlined by electronic commerce, specifically those regarding to collaborative environments and marketplaces. To achieve this objective we have considered the following goals: first, a three layer conceptualization; second, a transparent implantation and its integration with existing infrastructures; and third, a strategy of network traffic distribution based in all the information within the input packets, which is named "expressions based distribution".

1 INTRODUCTION

Since its proposal (Tennenhouse,1996), active networks (networks formed by programmable devices which are able to perform tasks on demand over the traffic that crosses them) have turned into a special research area with excellent works and projects. Its success within the research community is probably due to the fact that all involved researchers understand this technology as a step forward, opposite to traditional networks, since nowadays active networks are able to perform processes than traditional networks can not.
Traditional networks make a special emphasis in the network structure and guarantee the information delivery to the application which it serves in a suitable time. Each intermediate device which constitute these networks are specialized in receiving packets of information, performing a minimum set of tasks (typically over protocol headers and therefore they are limited to the structural aspects of communications ignoring its meaning, that is, the packet content), computing next hop or output's interface and delivering packets towards the wire. These networks are data exchanged systems in which compute capacity relay on the final elements of the network (client and server on C/S architecture, for example).
Therefore, nowadays we say the semantics of the communication is responsibility of the final elements. Actually, communication does not add meaning to the applications of which it is formed.
Active networks allow communications to be an essential part of the application's total meaning, being able to focus on the solution, that is, the application, instead of on the transmission part of the logic. The fact that between two distant points exist one or more intermediate nodes with the capacity of sharing logic have a direct consequence: The data sender or receiver can share logic without need to become a central server or a transmitter of the information.

1.1 The needs of a virtual architecture

Within active networks research virtual active networks (VANs) are a special area (Gong Su,2001). VANs are semantic networks which emphasize in the abstraction of the communications, looking for new architectures. These VANs have a clear advantage over no-virtual active networks: they are flexible and independent of the physical infrastructure that supports them. However, any change in the physical infrastructure, for example in traditional networks, will remarkably affect its

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design, due to the fact that the design will be highly depending on addressing, naming and devices. Hence, in this paper we will go a step forward, asserting that the existence of a virtual layer, which contents part of the meaning, not only make the design more flexible regarding the changes on its lower structure, but also it allows new ways to think about communications.

1.2 Active networks and collaborative commerce

From its beginning, electronic commerce has evolved from the old EDI to the recent frameworks like ebXML. The on-line collaboration has enriched the old ideas giving rise to new concepts, like collaborative commerce and distributed marketplaces.
On the other hand, the technologies that give support to these new forms of on-line work/commerce are based in the well known concepts of the client/server architecture through the interchange of messages. In any case the present solutions only consider the syntax of the communication, in which the final nodes interpret the messages. That is, the semantic of the communication – its meaning – is handled at the final nodes of the communication, between the different implied organizations.
We can define the collaborative commerce as the commercial relations between organizations which define common objectives and work in a collaborative way, participating jointly in processes of business previously decided (Puentes,2003). Between the tasks to carry out in this context we can mention the planning and estimations, the management of the inventory, the management of the supplying chain, the product design and development, the manufacture, the logistics and support to final clients.
We can divide these tasks in two categories: those that compose the value chain (and therefore susceptible to be managed by means of outsourcing - justified via the theory of the integration cost) and those that serve as support of the communication with competitors, clients and suppliers (these two last ones comprising of the supplying chain). The solutions to automate the first of these categories are the family of technologies associated with the collaborative work, the second with e-marketplaces. The collaboration in this last one is also susceptible to be reached through technologies that are applied to the first one (Tennenhouse,1996).
Current solutions to these needs are solved through an external organization, the integration intermediary, which manages, control and order the interactions between its users. This highly centralized approach is consequence of the conceptualization of the solutions under a C/S scheme. Active networks have the suitable features to support new ways of on-line working and thus to allow new forms of collaborative work. Virtual active networks provide the necessary level of abstraction to give an independent solution from the lower platform and to allow the designer to focus specifically in the business logic. We have implanted VAIN (Virtual Active IP Network) architecture, which proposes a virtual design specially thought for the on-line collaboration with the aim of implanting virtual collaboration processes as marketplaces.
More specifically, active networks have a set of features that make them appropriate to implant the semantic of the business layer under a single

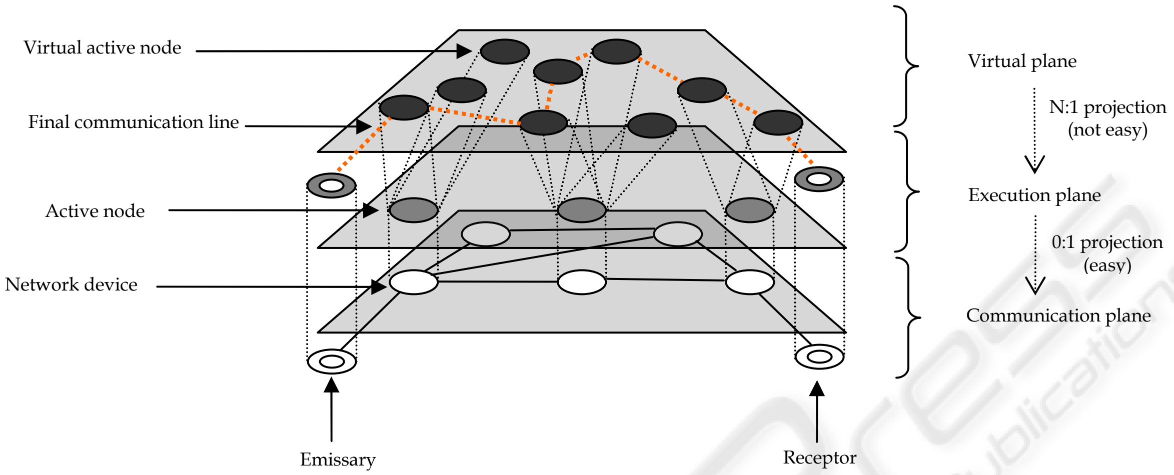

Figure 1: Relations between planes

solution: The nodes of an active network have the features of flexibility and abstraction regarding their behavior as elements of a communication network. This necessity from adaptability to its environment turns active nodes in a highly programmable element since its behavior is susceptible to be modified voluntarily; and abstraction, since the processes or services are not known a priori will render to the network to which it belongs.

On the other hand the forms to conceive the business planes are directly related to the semantics of the application in particular, which makes difficult to elaborate a common technology for all casuistry. The adaptation of the solution to the particular semantics in each case, although viable, is not optimal. Thanks to it the active networks can support the implantation of solutions that have into account not only the syntax of the logic of businesses, but also their semantics on the own network, providing different strategies and new and powerful designs.

1.3 Routing in active nodes

Active nodes are network devices that are able to process packets of data crossing them. This capacity of processing is dynamic, in such a form that the incoming traffic can contain the code that the node has to execute for a certain subgroup of packets that it handles.

A very important stage of the routing in the traditional devices is the selection of the following jump which is done taking into account the characteristics of the packet and the state of the same device, which usually changes little between packet and packet. We will talk in this document about this selection as the distribution of the incoming traffic in information flows, formed by individual packets that fulfil a same criterion.

Basically, the proposed solutions until now presents the feature of distributing the guest code data by means of its inclusion in the processed traffic (capsules, active packets) or by means of a dynamic programming of the node (programmable nodes). The execution of guest code (the semantic) in execution environments makes the services. The design of the node allows selecting what packet must go towards a specific service.

One of the initial objectives of the active networks research group (Tennenhouse,1996) has been to design networks with capacity of fine re-programming so that they can allow new protocols in a transparent way. Therefore, a good design of an active node does not have to circumscribe to a specific protocol. In fact, it will allow the node to manage new protocols.

Until now the proposed solutions have a basic problem: how to segment the incoming traffic and to distribute it towards its active services. It is necessary a criterion in each individual packet to allow selecting a specific target execution environment. A first approach to solve this question could be to use the origin and target address as a selection criteria, with the main disadvantage of not allowing to distinct more than a flow for each pair (sender, receptor). Other way to solve this question, which is the most used solution, is to use the field "*port*" of the transport protocols to distribute the traffic, nevertheless these causes that this traffic has necessary a TCP or UDP layer (in the case of IP networks) and therefore it is committed to use these protocols., besides loosing the necessary flexibility.

Our approach is oriented to guarantee flexibility, creating a design of active nodes that does not fit its traffic to a particular protocol and thus allowing using anyone, even without knowing it *a priori*, but preserving the capacity to segment the traffic in a powerful and individual way.

VAIN architecture has been thought to be used over IP protocol, nevertheless this is not a limitation, since it is possible to extend its operation to other existing protocols or designs. VAIN does not force at any moment to use a specific network protocol, although it recognizes the traditional ones by means of his declaration in the "network scheme". This scheme can be completed *in-band* or *out-band* with new designs without the need of re-programming the node entirely or affecting other flows of information. The following sections will show the VAIN architecture describing its fundamental components: The description of the model as three layer architecture, the internal architecture of the node, its implantation and the deployment stages for using it.

2 VAIN - VIRTUAL ACTIVE IP NODE

As we have already said, VAIN has been designed for marketplaces and collaborative commerce. This goal is reached through an abstraction layer that enables complex designs that look for the collaboration between final entities. These entities only need to agree in the operations of their business since the architecture hides the peculiarities of the network. At the same time this abstraction allows independence between the virtual design and the infrastructures of the communication supplier.

2.1 Three layers virtual active networks

Our solution is addressed to support collaborative commerce on Internet and is based on conceptualizing the active nodes as devices of three layers: (1) Communications layer: where the communication between active nodes and other devices assures the network connectivity. (2) Execution layer: its goal is to control the execution of the Execution Environments (EE) and to guarantee the right security and concurrence rules. (3) Virtual layer: This one is the result of the semantic of the guest code (the result of its execution in an active node).

The sum of the layers of each one of the network elements in an active network makes planes [figure 1]: (1) The communication plane includes the traditional network on which is based the infrastructure of active network. It has an own addressing. The responsibility of this structure falls into the transmission of packets between units of commutation throughout all the plane (or sub plane). (2) The execution plane is where the active nodes give the required functionalities to equip the network with the programming features. (3) And the virtual plane establishes the lines, hosts, nodes and other entities of the communication. It is projected over the lower plane so that a given design is independent of the lower ones (communications and execution). As its name indicates, its semantic will change depending on the services that implant it. This plane organizes the partial semantics of the solution, that is, the partial interaction of its elements in a tree way, having as root the host leader and as terminals the virtual active nodes called "*meeting points*".

The virtual active nodes correspond with EE of physical nodes so that, although the design implies more of a virtual node, it is executed in the same physical node if the circumstances and restrictions allow it. The communication lines establish the directions and the starting and final points of the flows of data between hosts and virtual nodes. They do not correspond, necessary, with traditional communication lines between network devices, since they can be communications into the node. Hosts can be source or target of these communication lines and can be specialized.

2.2 Notation of a virtual plane

The different elements from the virtual plane are integrated in the following notation [figure 2]: the entities can have associated labels of diverse nature, final hosts can take their name and direction; the active nodes virtual labels do mention not only to its address, but also to the requirements that must fulfil (owner, features, modules, etc); meeting points

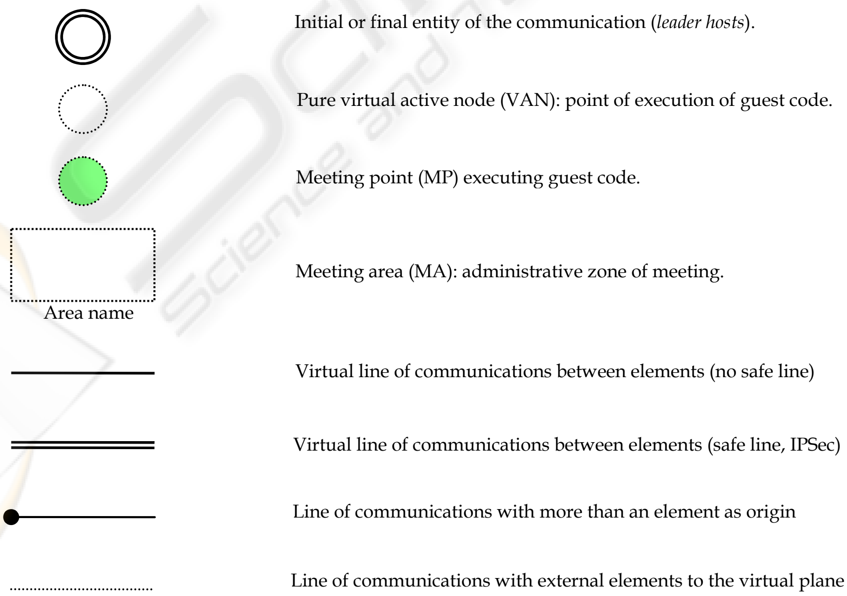

Figure 2: Elements of the virtual plane

(MP), like nodes of special purpose, inherit labels of the pure virtual active nodes (VAN); meeting areas (MA) have their administrative address and/or its name; finally, the lines of communications can be labeled with the name of the protocol – or protocols – that they will support, in addition to the restrictions in the ends, relative to the number of maximum connections allowed. The [figure 2] details the graphical elements associated with the conceptual elements.
Two last graph lock up the semantics related respectively to communications between an indeterminate number of entities and communications with entities outside the virtual plane. First one adds to the design the notation to show than an indeterminate number of elements (the black point) will communicate with the related entity. This graph will have, at the end of the well-known organization, a label that indicates the maximum number of simultaneous connections, as well as the used protocol. An end of this line will connect with a node whereas the other with a server or service. A typical graph will represent a VAN requesting guest code or necessary data for its execution to an external server. Both graphs can be represented by double lines to indicate a safe communication.

3 THE VIRTUAL ACTIVE IP NODE (VAIN) ARCHITECTURE

The technology that we have developed for the construction of VAIN architecture is based on a distribution process sufficiently rich and complex to allow segmenting the incoming traffic using any criterion, but conserving the flexibility of not fitting the solution to a protocol or set of certain protocols.
The exposition has been "to make the distribution of the incoming traffic using an expression that uses all the possible semantics at the moment in which a packet enters into the node". Our solution has been to have as the criterion of segmentation of traffic to flow, not only a concrete field of the head of packet with a known protocol, but also a complex expression that relates any value of this packet without needing to know anything about the used protocol.
As objective, this expression must recognize the ownership of a certain packet and deliver a concrete data flow to its corresponding service.

3.1 Stages of the distribution

There are two stages in the distribution: The creation of the packet dictionary and the selection of the target service.
The creation of the packet map, which is the application of a network scheme that allows recognizing the atomic units of information that the packet contains, is carried out when the packet enters in the node. The packet dictionary is created at the same time that the map is outlined and intends to define a set of pairs (field, value) that agglutinates all the semantics recognized by the scheme of network for that specific packet.
Finally, the selection process uses the dictionary generated in the previous stage to evaluate the network expressions and therefore to discover the target services of the packet.
I/O Modules have two goals (1) To isolate node engine from the special features of the data capture and of the injection on the wire; (2) To allow isolating the different net address formats. Although VAIN have been created to run over IP, it is so easy extending it to IPX, ATM or any other format that fulfil requirements of an OSI net layer (or even link layer).

3.2 The network scheme

The network expressions combine operands and operators (logical, arithmetic, relational and bit level) forming a complex expression. The operators can be constant or references, the latter are solved by using the packet dictionary created in the first stage of the distribution.
Basically the network scheme indicates all structural possibilities of a packet. Its declaration is made in the node dictionary (its repository of information) in XML format, and in memory, like a directed graph (and at the same time like a list doubly connected).
The scheme can be public (one per node) or private (one or more per service). The services can incorporate entries (in runtime and in XML format) so that the process recognizes private network schemes. The packet dictionary is the result of the creation its map. It is used as repository of information in the resolution of the network expressions, where references to the fields are solved as they are needed.

4 IMPLANTATION AND CURRENT STATE

In this document we have shown an architecture which allows us to increase the semantic of a communication, stating that logic can be shared between participants without the need of a central point that coordinates them. Mainly, VAIN allow each participant to design their own virtual active network and extend it along Internet allowing "points of presence" (services) which interact with others one from others users.

Expressions based delivery is a powerful and flexible tool to deliver input traffic into services, allowing these to be able to be used smartly, adapting itself to any situation, present and future. The advantage of this strategy with respect to others is clear: the independence of the native code of the node regarding the traffic that crosses it. In addition it allows the implantation of a node without knowing the protocols that will handle those of network level and link beforehand.

However the proposed solution presents a clear drawback: efficiency. Inside the implantation of the node finding and measuring bottle necks are fundamental. In our architecture we have basically two: the distribution of packets and the processing of these in the services.

The design of the virtual plane that we have proposed tries to link under a single implantation the solutions to the collaboration challenges and marketplaces, reached under different technological solutions until now. The virtual plane joins the partial semantics of the solution; our challenge from now on is to add its complete, enriching the notation and implanting gateway services to other technological solutions. In addition to this the transparency of the implantation must be maintained in order to avoid reaching a point of critical mass, which will cause the architecture to be a construction sufficiently ineffective so that it avoids its growth.

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