Value-Added Internet: a Pragmatic TINA-Based Path to the Internet and PSTN Integration

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Abstract

This paper deals with the issue of integrating the Internet with the PSTN in order to devise an architecture encompassing the advantages of both networks. Key TINA concepts like the Session Concept and the Service Architecture computational model are used to provide the glue for such an integration. The result is the enhancement of the Internet with real-time packet delivery capability as well as advanced billing features that successfully exploit existing billing systems. A comparison with other approaches to quality of service over the Internet is provided. The prototype that is currently being developed within the SISTINA (Solutions for Integrated Services à la TINA) project to demonstrate the concepts outlined in the paper is described.

1. Introduction

In the current telecommunication scenario the provision of new services and the enrichment of existing services with value added features is becoming a key issue for the Public Network Operator (PNO) success. This is a very important objective for PNOs as the wide diffusion of Internet is endangering their position as network service providers potentially reducing their role to pure connectivity providers. The Internet phenomenon is causing a migration of network intelligence from the core network to the peripheral systems. Lost revenue for PNOs is the result.

Within the SISTINA (Solutions for Integrated Services a la TINA) project, Italtel and Siemens have jointly devised a TINA based solution capable of exploiting the advantages of two apparently contrasting worlds such as the Internet and the PSTN in order to provide value added services and to keep a share of network intelligence in a PNO's network.

Starting from the analysis of the state of the art as far as the Internet and telecommunication worlds are concerned, a new attractive service deployment architecture has been identified. The proposed architecture derives from the combination of the strengths of each world, which allows to overcome the weaknesses of the other.

The services offered by telecommunication service providers are usually characterized by a guaranteed quality of service and by the utilization of payment mechanisms based on a monthly bill. Capabilities like these, typical of the PNO world, are very attractive also to WWW application developers. However, these cannot be provided on the Internet without the cooperation of a telecommunication service provider who has a direct control on its network infrastructure.

On the other hand, the wide Internet acceptance and the large diffusion of WWW applications, does not allow to realistically envisage a network scenario in which advanced services are provided using a different paradigm. The simple and easy to use graphical user interface of Web applications has become mandatory for every type of service provided through the network. As a consequence, only an architecture capable of enhancing existing WWW applications with value added features can be envisaged. WWW applications have to be provided with new features in such a way that they do not need to be redesigned but they can simply take advantage of new APIs that enrich the set of supported capabilities. In this scenario TINA provides the enabling technologies and concepts that allow to successfully merge these two different worlds.

The result of the SISTINA project is a TINA-based distributed architecture. The TINA Service Architecture and the TINA Computing Architecture have provided the basis for the design of such a solution.

TINA Service Architecture concepts such as the session concept (in terms of access, service and communication session) are integrated in a service platform which can be used by all kinds of standard Internet applications. SISTINA enhances them through four key value added features:

1. Session control: to overcome the limitations of the stateless pure WWW approach
2. Guaranteed Quality of Service (QoS): when high bandwidth and/or real time communication is required within a service session, dedicated switched end to end connections are established between users and service providers, bypassing the Internet or at least its bottlenecks
3. Integrated billing, in terms of
   - flexible/reverse charging of the dedicated real-time connections
   - charging of online service usage and goods purchased through electronic commerce applications on the monthly telephone bill
4. Confidence

This outstanding bundle of value added features can give an answer to some of the major Internet open issues and provide a new central role for PNOs in the Internet era.

2. SISTINA Architecture

The architecture devised for the SISTINA project is depicted in Figure 1. This architecture involves some of the Business Roles identified by TINA, such as the Consumer (End User and Internet Application Provider), the Retailer and Connectivity Provider (SISTINA Retailer), and the 3rd Party Service Provider (Confidence Provider). The task of the SISTINA Retailer in this scenario is to add value to normal existing Internet applications, through features that only Public Network Operators can provide.

Network Operators can play an important role in providing these features as they have the required know how and the capability to control the telecommunication network. Existing TMN/IN Billing Systems can be used to support the billing mechanisms foreseen by SISTINA .

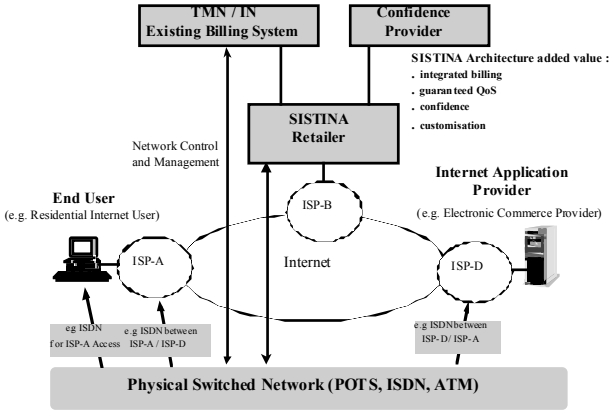

Figure 1: SISTINA architecture

Figure 1 shows the normal Internet business roles: the End User, the Internet Application Providers (IAPs) and the Internet Service Providers (ISPs) that provide the Internet Access. The End User uses a standard CPE to access the Internet (e.g. a PC). The ISPs may or may not operate an own subnetwork and are interconnected via the global Internet.

With respect to this scenario a new additional role is played by the SISTINA Retailer. The SISTINA Retailer provides service independent Session Management capabilities in support of the interactions between an End User and one or more Internet Application Providers. In the context of such a session the value added features of the SISTINA Retailer can be used by the participants. By establishing a session, which includes authentication and authorization of all participants, and by providing a subscription mechanism, the SISTINA Retailer acts as a "Retailer" in the TINA sense, as it mediates between End Users and Providers of Internet Applications. All the functionality of the SISTINA Retailer is independent of the services offered by the various Internet Application Providers which can range from Video Shopping, to Electronic Malls or simple HTML pages.

In order to provide a guaranteed Quality of Service it is required that the owner of the SISTINA Retailer has control over a telecommunication network and that the possibility exists to provide a "direct" (i.e. switched) communication path between an End User and an Internet Application Provider. In this role the owner of the SISTINA Retailer also acts as "Connectivity Provider", in the TINA sense.

The overall architecture makes extensive use of TINA Computing Architecture and Service Architecture principles and concepts (e.g. DPE, Session Concept, …).

Two major phases during a service session can be distinguished: the Access Phase where the session is established and the Usage Phase where the End User transparently interacts with the Internet Application

Provider. For both phases, TINA-DPE communication via the Internet is used. For this purpose the normal Internet End User Application and Internet Applications must be made TINA-DPE capable. During the usage phase, if required, dedicated end-to-end connections between End Users and Internet Application Providers can be established.

In the SISTINA scenario five major stakeholders are identified:

- End User
- SISTINA Retailer
- Internet Application Provider
- Confidence Provider
- Billing Provider

2.1 The End User

The End User is a classical Internet user (in a private or business environment). To enable the End User to enjoy the added value provided by the SISTINA Retailer it is necessary to download additional Java software in order to make his browser TINA capable. This software incorporates a Java CORBA client, for functional interaction. In brief, the SISTINA software executed in the user's browser environment supports:

- the IIOP communication with the SISTINA server;
- the invocation of remote methods on the SISTINA server objects interfaces as a consequence of the users actions on the SISTINA applet GUI in order to realize session management, integrated billing and connectivity control related operations;
- the support for the remote invocation, addressed by the SISTINA server, of operations related to session management, integrated billing and connectivity control that influence the user application.

The goal is to minimize specific requirements for the hardware and software of the End User's CPE in order to widen the base of SISTINA suitable terminals.

2.2 The SISTINA Retailer

The SISTINA Retailer acts both as a TINA Retailer as well as a TINA Connectivity Provider. As a Retailer it provides generic service independent features like access session capabilities (authentication, authorization, billing), service session capabilities (service session control) and communication session features (connection control). As a Connectivity Provider it provides access to the resources of the physical switched network.

The SISTINA Retailer offers to the End User and to the Internet Application Providers the following service features:

1. Connectivity Control for a guaranteed QoS
2. Integrated Billing
3. Confidence
4. Service Customization

The Connectivity Control service feature allows for the establishment of dedicated switched connections with guaranteed QoS between two points in the path between CPEs and Internet Application providers, bypassing Internet bottlenecks. This feature is described in more detail in the section 5.

The Integrated Billing service feature offers the possibility of integrating the SISTINA payment system with the public network operator charging and billing system. This integration can be exploited both for:

2a. the payment of goods purchased on an Electronic Commerce platform or of on-line services offered by a generic IAP;

2b. the payment of connectivity resources (e.g. connections) used to have a guaranteed quality of service.

The Confidence service feature plays an important role in the business relationships between users and IAPs. It allows the SISTINA Retailer to provide a second level of authorization that is applied to both users and IAPs service requests. For example, a IAP can know he has a business relationship with a paying user and vice versa the user knows he can trust the IAP. The SISTINA Retailer makes use of the Confidence 3rd pty service provider to provide this service feature.

Finally, the Customization service feature allows the IAP to customize the services on the basis of the knowledge of the user's identity.

2.3 The Internet Application Provider

The Internet Application Provider can be any kind of provider of existing WWW-based applications (e.g. an Electronic Mall) or simply a set of HTML pages. After having signed a contract with the SISTINA Retailer, the Internet Application Provider becomes a SISTINA affiliated IAP.

Interactions between server applications and the SISTINA Retailer are CORBA based. Internet server applications require only minor enhancements in order to allow for their exploitation of the added value features provided by the SISTINA Retailer.

Basically, this can be achieved in two ways:

1. In a scenario where the traditional Web technology is used, the best solution is to install on the Web server a SISTINA software package which is in charge both of supporting the IIOP based communication with the SISTINA server and of providing a very simple high level API, that can be used by Web application designers to enrich their services with new functionality. Methods can be called inside CGI BINs executed upon HTTP requests. This package completely hides the details of the SISTINA environment from developers and allows designers to continue utilizing the Web technology they are familiar with.
2. In a more advanced Internet scenario in which the utilization of IIOP is already foreseen, Web application designers can directly implement a SISTINA enhanced Web service as a distributed service using the CORBA and Java technology. In any case, the effort for the support of the interaction between the Web server and the SISTINA server could be minimized by delegating these operations to a SISTINA software package installed in the Web server.

From an high level point of view, the SISTINA software package installed on the IAP Web server mainly supports:

- the IIOP communication with the SISTINA server;
- the invocation of remote methods on the SISTINA server objects interfaces in relation with the operation defined by the API;
- the retrieval of information related to the Web server involvement in the SISTINA services provision;
- the discrimination between Internet users having an active service session with a SISTINA IAP and normal Internet user.

2.4 The Confidence Provider

The Confidence Provider is an independent organization in charge of evaluating the reliability of both end users and Internet Application Providers. For example End Users can be considered to be reliable if they have always paid their bills, while IAPs can be evaluated on the basis of the quality of their service (in terms of both the quality of their goods and the quality of their shipping service, in cases where this applies). Unreliable end users and IAPs are inhibited from logging in.

2.5 The Billing Provider

As far as billing and charging is concerned, existing TMN/Billing systems can be integrated in the overall architecture. In this scenario the Billing Provider role can be played by the PNO, who takes care of both the charging of the dedicated real-time connections and the payments of goods/on-line services. For those PNOs who are not willing to take care of payments of goods and on-line services, a scenario in which the SISTINA Retailer also interfaces with different stakeholders such as banks/credit card companies has been devised.

3. SISTINA service scenario: user's point of view

The user can start his navigation as a "classical" Internet user on the Web Pages of a SISTINA affiliated Internet Application Provider (a Service Provider who has signed a contract with a SISTINA Retailer).

In any case, in order to exploit the SISTINA value added service features, the user must enter the SISTINA world, that is he must give his username and password. On-line subscription to SISTINA is foreseen. After the authentication procedure the user knows he will enjoy all the value added features he has subscribed to.

The Internet Application Provider can decide to propose the user to enter the SISTINA world:

- at the beginning of his navigation, if the IAP is providing a customized service (and therefore needs to know about the identity of the user in order to provide him with a customized navigation), or
- just before the utilization of a particular value added service feature, if the IAP is providing a service which makes only use of the connectivity control and/or integrated billing SISTINA Service Features.

The decision about when proposing the user to enter the SISTINA world depends upon the type of service the Web application developer has designed. At that point the user is presented with a choice between continuing the navigation as a normal user or accepting to enter SISTINA world to enjoy some enhanced features. It means that the user has to explicitly accept to identify himself in order to be recognized as a SISTINA subscriber and consequently to have access to something more. Once the user has accepted to access the SISTINA world and he has been authenticated and authorized, he can take advantage of a single SISTINA value-added service feature or of any their combination. For example, the user can be asked to provide his username and password:

- before entering a payment phase that allows the charging of the purchased items on the telephone bill or
- before starting a high quality video conference on a dedicated connection with a sales person, paid by an Electronic Commerce Application Provider or
- before initiating the navigation on a Web server that is able to personalize the content of the pages for

SISTINA users. The cost of any purchase is added to the user telephone bill without requesting him a new identification but only the acceptance of the operation.

In this approach, the logic of the service being provided resides within the Web application, while the SISTINA value added service features are service independent capabilities implemented in the SISTINA Retailer.

After the user has enjoyed the SISTINA value added service features foreseen by the service offered by a first IAP, he can be invited in following links that point to new SISTINA affiliated IAPs. The interaction between the user and the new SP can occur in the context of the same access session (i.e. the access session between the user and the SISTINA Retailer is maintained): the user does not need to log in again.

It is also possible that the SISTINA Retailer has a Web site and acts as an IAP. Such a site can be used to advertise all SISTINA services and IAPs. The SISTINA Retailer Web pages allow a SISTINA subscriber to enter the SISTINA world as a named user or to subscribe SISTINA services.

4. SISTINA computational model

The SISTINA service features, described in section 2.2, can be provided by one or more stakeholders. The scenario devised by the SISTINA project foresees the involvement of two different stakeholders:

- the SISTINA Retailer: it offers service features 1, 2 and 4;
- the Confidence Provider: it offers service feature 3;

Service features 2a and 2b can be split, and the scenario can be easily extended with the involvement of a third stakeholder (e.g. a bank or a credit card company) taking care for the payment of goods.

In the SISTINA target architecture, depicted in figure 1, both the End User and the Internet Application Provider play the Consumer role in the TINA sense, since they access and use services provided by the SISTINA Retailer. The Consumer and the SISTINA Retailer are in a "User to Provider" relationship.

The SISTINA Retailer plays both the Retailer role, since it provides the Consumer with access to services and uses other providers to support the provision of services to Consumer, and the Connectivity Provider role, as it has to control network resources to provide an end-to-end quality of service. In this sense, the other provider, the Confidence Provider, plays the Third Party Service Provider role, in the TINA sense. The SISTINA Retailer and the other Service Providers are in a "User to Provider" relationship.

The SISTINA Retailer is the only "point of contact" of both the End User and the IAP. It interacts with the Confidence Provider to check authorization rights of the End User and of the IAP (parties), while it interacts with the legacy billing systems when the cost of a purchased good or the cost of a dedicated connection has to be added to the consumer's telephone bill .

The TINA-based SISTINA computational model is depicted in figure 2.

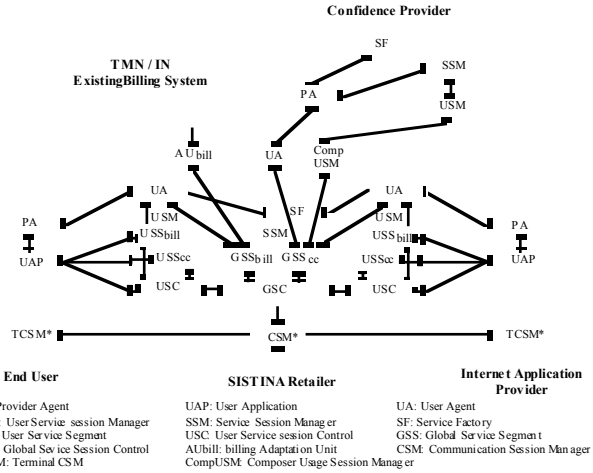

Figure 2 - SISTINA computational model

The SISTINA Retailer USM comprises the service-specific and generic session control segments of a provider domain user service session. It is composed by one common service component, the USC, and by one or more service components specific for the supported service features, the USSbill and the USScc.

The SISTINA Retailer SSM comprises the service-specific and generic session control segments of a provider service session. It is composed by one common service component, the GSC, and by one or more service components specific for the supported service features, the GSSbill and the GSScc. The last two service components are in charge of interacting respectively with the AUbill and the CSM* to request the actuation of the billing and connectivity control functionality. Both the AUbill and the CSM* are in charge of translating SISTINA requests respectively of integrated billing and connectivity control into operations supported by existing billing systems and existing communication systems.

5. Provision of additional QoS by means of the SISTINA architecture

The SISTINA service architecture aims at providing added value to pure INTERNET-based services, such as

the capability to offer the users a "on demand" better Quality of Service. Typical examples of services which can take advantage of increased QoS provisioning are:

- download of big files such as pictures and videos
- real-time audio or audio/video interaction (depending on the CPE's capabilities) between customer and sales people/customer support people
- real time provision of multimedia contents
- upload of a file to a printing or CD burning shop
- deferred access to the service at reduced cost using network load information (i.e. downloading copies during night time or updating proxies during night time)

Thanks to the existence of the service session maintained by the SISTINA Retailer dedicated switched connections can be established between users and service providers, taking advantage of different transport technologies.

On the basis of the knowledge of CPEs capabilities, in terms of type of access to the Public Network (POTS / ISDN and ATM/ADSL), of service provider capabilities and of the characteristics of the network deployed between users and service providers, the SISTINA service platform is capable of selecting the most appropriate transport technology and of establishing the dedicated connection required in order to achieve the desired QoS. Service providers can be expected to have multiple different connections to several kinds of Public Networks, to cater for the different types of user terminals.

The SISTINA Retailer is the stakeholder in charge of instructing the network elements involved in the service session on the way to establish the additional connection, to cut off Internet bottlenecks.

Different technical realization can be envisaged. One promising possibility is the utilization of third party call control mechanisms. Other possible alternatives are currently under investigation (i.e. connections established by terminals or by other network elements).

In figure 3 a general scenario is illustrated. Two transmission paths are indicated: C1 is a transmission path from the Client towards the Server through the Internet , C2 is the dedicated connection established on the basis of a request coming from the SISTINA Retailer in order to offer increased QoS to the Client.

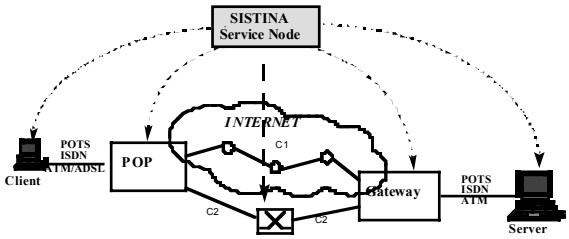

Figure 3: A general scenario for guaranteed QoS provision

This feature not only provides IAPs with the possibility to reach Internet users through Quality of Service-guaranteed connections, but it also gives the possibility to integrate at the service level Internet and traditional connection-oriented transport mechanism.

This feature can be combined with flexible charging policies in order to offer the End User an homogeneous view of the services he is accessing.

For example an additional connection established to achieve better Quality of Service could be paid by the IAP in case of electronic commerce applications, implementing a sort of Internet-based multimedia freephone service to advertise products. This is allowed by the existence of a single complex telecommunication session, which involves one or more service providers and at least one network provider, which detains all the information related to the service provisioning, including that related to network connectivity provision and to billing.

6. Comparison with other approaches

Mulimedia applications typically require two different kinds of communication mechanisms:

- Control messages, that are best conveyed on a datagram-based network, in that they do not require a continuous data flow between a source and a destination, but only the rapid delivery of small chunks of information;
- Video/audio streams, that are best conveyed by connection oriented networks as the concept of flow is inherently tied to the concept of resource allocation over a (statically or dynamically) defined path.

In any of these cases a strict delay requirement exists: delays in multimedia services like videoconferencing, tele-education, networked games, and in general in all interactive services, is a major factor of perceived quality.

The SISTINA approach is that of integrating, at the service level, PSTN with the Internet, trying to use each network to convey the type of traffic it is best suited for.

Routed datagram networks are very cost-effective in transporting small chunks of information, and that is the purpose they are used for within SISTINA. Traditional switched networks have proven to be very efficient in conveying real-time, fixed bandwidth, traffic, therefore whenever the provision of a stream-oriented data flow is required, a real-time switched connection is transparently established end-to-end, cutting off bottlenecks. QOS is provided on-demand, whenever really needed and whenever there's someone willing to pay for it.

The recent overwhelming success of datagram-based networks, such as the Internet, has proven their ability to provide multimedia-like services at a fraction of the cost required to provide the same services on a traditional connection oriented telecommunication network. The huge success of the Internet has pushed researchers to investigate the possibility to effectively convey stream-oriented traffic with strict bandwidth and delay requirements on it.

A number of different approaches have been devised and new protocols, among which RTP and RSVP have been defined.

This section will highlight the advantages of the SISTINA approach with respect to such protocols.

6.1 RTP

RTP is a protocol suite made up of two components:

- a protocol for the actual transmission of real-time data (called itself RTP)
- a control component (RTP Control Protocol, RTCP) to transmit QoS information and session control information to all participants to a RTP session

Despite its name, RTP doesn't really provide any guarantee of delay in the packet delivery: only because of its being UDP and not TCP-based, packets with high delay can be simply discarded and no retransmission of lost or corrupted packets is supported (it would simply be pointless in most of real time applications).

RTCP provides information, in the form of control packets, to all participants to the audio/video session. From the QOS point of view, the most important data it conveys is a feedback on the quality of data distribution. This feedback reports help in controlling congestion which is one of the biggest causes of delay [1] In other words, RTP simply warns the applications when something went wrong, but cannot (and doesn't want to) do anything to remedy the problems [2].

In any case, even if technology is quickly progressing, IP routing still tends to introduce higher delays than traditional switching within connection-oriented networks. Even if and when routers with pass-trough delays comparable or inferior to those of traditional switches will be available, it will take years before they will be ubiquitously deployed. SISTINA, on the other hand, by exploiting the huge installed base of telecommunication switches, is realistically capable of meeting strict delay requirements without any revolution of the installed base of equipment.

6.2 RSVP

RSVP is an attempt to provide a signalling-like protocol to reserve resources on the links connecting sources and destinations of a data flow.

RSVP has a number of major flaws:

- There is no guarantee the data packets for which resources have been allocated will actually follow the route where the allocation has been performed: in case of route oscillations, data packets will be routed in a different way PATH messages have been routed [2]. Some work on protocol behaviors [3] show that route oscillations are not a seldom event in the Internet.
- Soft states put inherently at risk the allocation of resources: in the case where several successive RESV messages are lost, some useful resources could be freed leading to disruption in the communications
- It will take years before all routers will be RSVP compliant. In the meanwhile, if a data flow encounters a non-RSVP compliant island, there's no guarantee of QOS. As RSVP does not influence routing, no mechanisms are defined to try to at least circumnavigate such islands.

The SISTINA approach has an answer to all these RSVP open points. QOS in SISTINA is guaranteed in that fixed bandwidth switched connections are used to convey stream oriented traffic. SISTINA makes use of hard states, as resources are allocated by means of traditional signalling mechanisms. Last but not least SISTINA relies on those switched telecommunication networks that have been proving QOS for years. Again, no revolution is needed: the installed base of an equipment that has been proving for years to provide those features we are looking for, can be successfully exploited.

7. SISTINA integrated billing

Billing systems are something very valuable in the context of an on-line service business scenario. The combination of electronic commerce servers with advanced billing systems and capillary billing organizations such as those run by PNOs, can represent a very powerful business machine.

Within SISTINA it is possible for the IAP:

1. to pay for the cost of the additional connection(s) established in order to increase the QOS, or at least for part of it
2. to take over the cost of the telephone call from the customer to his ISP, for the duration of a SISTINA session
3. to offer discounts on the End User's telephone bill (e.g. in case the customer purchases goods for a certain amount of money).
4. to ask the PNO to charge the cost of the goods purchased through the Electronic Commerce application, or the cost of the services enjoyed by the consumer, on his monthly telephone bill

In order to achieve these goals, the SISTINA Retailer has the capability to:

- flexibly split the charge of the additional connection(s), established in order to increase the QOS, between the End User and the IAP. A particular case within this framework is that of the Application Provider paying for the entire cost of the connection.
- charge the cost of a connection the End User is using at that particular moment, such as the connection to the Internet POP, on a third party.
- decrease the End user's telephone bill, independently of the cost of the connections he is using at that particular moment
- charge on the End User's telephone bill, or on a separate document which can be shipped together with the telephone bill, the cost of the goods purchased through the Internet Application, or the on-line services enjoyed by the customer

In order to safeguard SISTINA Retailers against insolvent consumers an expense limit is supported (Retailers could always decide not to use this feature).

Within this context it is possible to perform an on-line agreement between End User and SISTINA Retailer on the monthly expenditure ceiling (off-line procedures can follow: for example the SISTINA Retailer could ask for a deposit to be paid by consumers). The amount of the monthly expenditure ceiling can be later re-negotiated (again, off-line procedures can follow)

It is possible for End users to check their monthly expenses. The difference between their current expense and the monthly expenditure ceiling is explicitly stated. The on-line visualization of personal data related to the consumer (e.g. the monthly telephone bill, the log of outgoing PSTN calls etc.) could represent an interesting enhancement of this feature

The SISTINA Retailer checks the expenditure ceiling before authorizing 3pty service provider to sell goods or services.

8. Conclusions

The SISTINA network architecture adds value to the existing WWW Internet applications by interworking with the standard connection-oriented PSTN services. Key TINA concepts like the session concept or parts of the business model have been exploited.

For a PNO a SISTINA-based solution results in the ability to generate extra revenue and to provide Internet users with advanced features like quality of service and accounting.

The possibility of charging the cost of goods electronically purchased on the monthly telephone bill can be regarded as a major value added feature, in that not only it easily solves the problem of payments over the Internet, but it also decreases the cost of transactions, giving way to a whole new range of goods and services to be purchased on the Internet (e.g. low cost goods and services).

The possibility to apply flexible billing to the additional connections established to increase the QoS, to reverse the charge, or to apply discounts on connections in case they lead to successful business transactions, can overcome the well-known Internet user unwillingness to pay for whatsoever services or goods.

The same extremely successful business paradigm exploited by PSTN freephone numbers applies here, where the stakeholder asking for the service (the additional connection) is different from the one paying for it, and the latter is willing to pay as the service itself can increase his revenues.

We believe that this is one of the very pragmatic approaches which makes use of the TINA principles in the Internet context.

The Siemens/Italtel team is developing a prototype for the SISTINA architecture.

9. References

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