Internet Accounting and Charging Standards & Methods (M31 – Market Managed Multiservice Internet, SUSIE, Diameter, etc.).

Georgios Telechas
A.M.: mis0405
Date: 30/12/2005

University of Macedonia
Master Information Systems
Networking Technologies
Professors: A.A. Economides & A. Pomportsis

<u>Η Λογιστική του Ίντερνετ , οι Κανόνες και οι Μέθοδοι Τιμολόγησης του (Μ31, Η Διοίκηση της Αγοράς “Πολύ-υπηρεσιών” του Ίντερνετ , SUSIE,Διάμετρος, κλπ.).</u>

Γεώργιος Τελεχάς
Α.Μ.: mis0405
Ημερομηνία: 30/12/2005

Πανεπιστήμιο Μακεδονίας

ΠΜΣ Πληροφοριακά Συστήματα

Τεχνολογίες Τηλεπικοινωνιών & Δικτύων

Καθηγητές: Α.Α. Οικονομίδης & Α. Πομπόρτσης

Contents:

Introduction

Today's basic Internet service offerings and future advanced services on the Internet lack a crucial component for businesses: adequate pricing and charging methods. Funding transport services with revenue from related services, such as content and entertainment offerings, and advertising is done to help cover network cost. However, cross-financing transport services is not transparent to businesses and does not scale to high-bandwidth offerings.

Although solutions for methods of charging and accounting single service class networks, such as the telephone network or Virtual Private Networks, exist and are applied successfully, Integrated Services Networks require a completely different approach. Charging and accounting for integrated services remain unsolved problems at the time being which is due to a variety of service characterizations by Quality-of-Service (QoS), advanced networking technologies, such as ATM (Asynchronous Transfer Mode), and an emerging Integrated Services Internet. In addition, new telecommunication services impose another degree of complexity to existing billing systems, including the demand to bill separately for content. This determines the need to integrate concepts for interoperable and standardized billing solutions between providers for inter-operator agreements which include content and transport services.

Besides its popularity, the Internet offers the important possibility of accessing usage information for many services at a single network layer, since most services will be transported by IP, independently of the underlying network technology. For commercial applications, this allows for very interesting product offerings, such as service bundling. Figure 1 shows the hourglass model which describes the relationship between network technology, Internet protocols, and value added services.

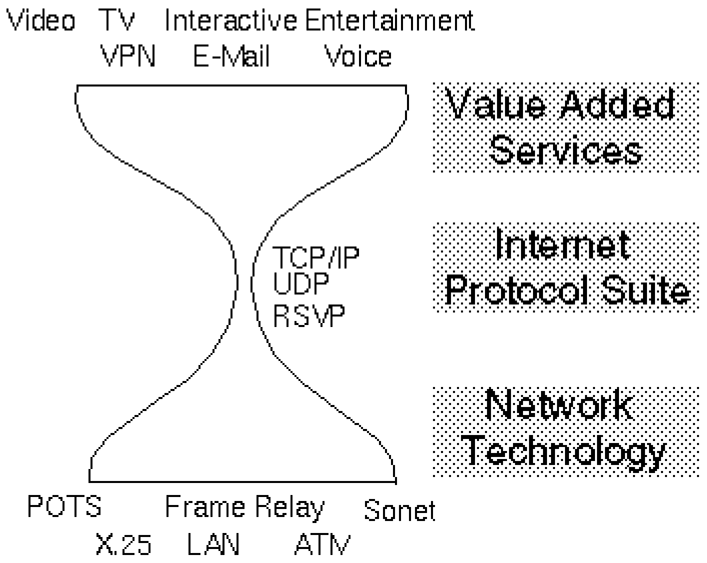

Figure 1: Hourglass-model of the Internet

Aside from communication protocol relevant issues, a particular problem area arises with electronic payments for various kinds of transport services, determining the clear necessity of pico- or micro-payments. As existing traditional and electronic payment systems are not well suited for this task, solutions have to be researched, including cryptographic protocols for secure transmission of payments. In addition, due to the highly competitive telecommunication service provider market, dynamic pricing schemes for integrated multiservice networks are required as well.

.

Internet Accounting [1]

Accounting determines the collection of information in relation to a customer's service utilization being expressed in resource usage or consumption. Thus, accounting defines a function from a particular resource usage into technical values. The information to be collected is determined by a parameter set included within an accounting record. This record depends on (1) the network infrastructure, which supports the service, e.g., Internet, N-ISDN, ATM, or Frame Relay and (2) the service provided. The content of an accounting record is of a technical nature, such as the duration of a phone call, the distance of a high-speed network link utilized, or the number of market transactions done. This accounting record forms the basis for charging and billing. To understand Internet accounting, it is important to answer questions like "what is being paid for" and "who is being paid." With respect to the question "what is being paid for" a distinction can be made between transport accounting and content accounting. Transport accounting is interesting since techniques like DiffServ enable the provision of different quality of service classes. Each class will be charged differently to avoid all users selecting the same top-level class.

Charging[1]

Charging determines the process of calculating the cost of a resource by using the price for a given accounting record which determines particular resource consumption. Thus, charging defines a function which translates technical values into monetary units. The monetary charging information is included in charging records. Prices already may be available for particular resources in the accounting record or any suitable resource combination depending on the network technology or the application.

Pricing[1]

Pricing is the process of setting a price on a service, a product, or content. This process is an integral and critical part of businesses and closely related to marketing. Prices can be calculated on a cost/profit basis or on the current market situation. In businesses selling telecommunication services, prices are set on predefined services, where the quantity used is measured, e.g., in units, time, distance, bandwidth, volume, or any combination thereof. These basic quantities to be priced are obtained from accounting devices and depend on the network type.
Tariffing is a special case of pricing, normally regulated by governmental and political economic impacts. It has been applied to the traditional telephone network.

Pricing models[1]

Components of Internet pricing include three basic elements (cf. Figure 2). First, an access fee is collected which is usually a monthly charge for using an access link to the network. The price depends on the capacity of that link. Secondly, a per-call or connection/reservation-setup-fee may be charged. In connection-oriented networks or connectionless networks with reservation mechanisms, setting up connections or reservations can be charged separately. Finally, a usage fee can be used to charge services on time-, volume-, or QoS (Quality of Service)-basis. This fee determines the actual resource usage customers consume based on economic principles of marginal cost and market mechanisms. For Internet services, network externalities play an important role. Independently of the basic transport service, a content-fee can be introduced. Depending on the application content, this fee may be omitted (e.g., telephony, fax, e-mail services where the "content" is provided by the customer himself or herself), billed separately (e.g., Wall Street Journal online edition), or integrated into the telecommunication charging system .

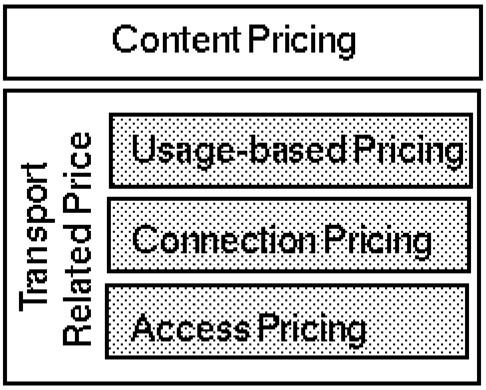

Figure 2: Components of Internet Pricing

These price components are reflected in pricing schemes fully or partially. For example, voice services have all three transport components, but an ISP usually charges only for access and optionally for usage on a connect-time basis **[2]**. For Internet services, the most important methods include flat-fee, usage-based, reservation-based, volume-based, service-class-based, and connect-time-based methods. These methods may be combined, such as class-based and volume-based.

Billing

The method of payment defines a well-defined scheme of how money between participants is exchanged, e.g., customers and retailers or service users and providers. In general, electronic payment systems or traditional systems as utilized for traditional payment transactions are applicable.

Example

A typical scenario encompasses an accounting applied to the number of outgoing data on a special link or on content included in a file. The accounting record contains, e.g., the duration of a data transfer, the obtained QoS (Quality of Service) characteristics (such as bandwidth consumed, delay encountered, and error rates experienced), and additional resource and device usage (such as a video camera). The content may be indicated by different video clips sent. These accounting records are fed into the charging which happens, e.g., in an administrative domain of the video clip provider. Pricing has been defined by the network operator, based on QoS characteristics of the particular communication service, and it has been defined by the content provider of video clips. All charges are calculated and collected in charging records from the centralized billing system of the video clip provider. A number of charging records for a certain period of time are accumulated and billed to the customer. Finally, he may decide at this point in time or in a predefined manner how the bill gets paid for, applying traditional or electronic systems, e.g., by credit card payments applying Secure Electronic Transactions (SET).

What is being paid for?[3]

A first thing to recognize is that Internet accounting can be divided into *transport accounting* and *content accounting*. The goal of transport accounting is to charge users for the transfer of packets or bytes over the Internet. The goal of content accounting is to charge users for the content or services that are delivered over the Internet. The second thing to understand is that charging can be *flat-rate* as well as *usage-based*.

Who is being paid?[3]

Another important question is whether the bill will be issued by the Internet provider or by the organization who owns the content stored on servers at the remote side of the network. The term *provider-based* accounting will be used to denote the first case; the term *server-based* accounting will be used for the second. Since the transfer of information is generally charged for by the Internet provider, transport accounting usually falls into the category of provider-based accounting. It is also possible, however, that the Internet provider charges for the content, which in turn is provided by others. This case, which is similar to 900 numbers in in plain old telephony service (POTS) is considered to be important for Internet providers and is the subject of various research projects.

How are payments made?[3]

The question "how are payments made" has two possible answers: *inband* or *outband*. Outband payment is still the dominant form of payment and can be implemented by means of credit cards, bank transfers, checks, and so on. Outband payment can be used with provider as well as server-based accounting. Inband payment is relatively new and can be implemented in terms of cybercash. Although this form of payment will become especially useful for server-based accounting, it may also be interesting for roaming users who connect to multiple Internet providers.

Is Internet accounting needed?[3]

To answer the question of whether accounting is needed in the Internet, it is important to distinguish between *content accounting* and *transport accounting*. There is a general agreement that content accounting is actually needed. In fact, some people even claim that content accounting will eventually make transport accounting superfluous, since the costs to transport the content can be added to the price of the content. This reasoning does not hold, however, for free content. In fact, the assumption that the price of the content can take into account all the transport costs has as its final implication that Internet providers should have complete control over all content providers. This assumption is not realistic, and it is therefore likely that transport accounting, in one form or another, will remain necessary. Which form of transport accounting should remain is still an issue of debate. In fact there are three possibilities: flat-rate, usage-based, or a combination of both. Although flat-rate is currently the prevailing form of transport accounting, several researchers believe that usage-based charging will be introduced soon.

Accounting Protocols[3]

There were several possible candidates to choose from, including Simple Network Management Protocol (SNMP), COPS, RADIUS/RADIUS++, TACACS/TACACS+, and Diameter. To make a choice, last summer the AAA WG followed a stepwise selection process. First the problems of roaming, mobile IP, NASs, and Code-Division Multiple Accesses (CDMA 2000) were investigated to find all the criteria an AAA protocol should satisfy. Then the members of the AAA WG were invited to submit proposals for their favored protocols; each proposal should clearly explain how the requirements mentioned above were satisfied. As a result, four protocols remained in the race: SNMP, COPS, RADIUS, and Diameter. The four proposals were investigated by a panel of seven persons. These persons were only allowed to judge on the basis of what was written down in the proposals; other information was not taken into account. The conclusion of the panel was to select Diameter. COPS would have been an alternative, but the impression of the panel was that Diameter was further advanced than COPS. This is somewhat interesting, since Diameter relies on the new SCTP transport protocol, which has still a long way to go. RADIUS dropped out of the contest because it missed many features, and the result of adding these features would be something similar to Diameter. SNMP was not selected because there was disagreement on whether it could satisfy the requirements of authentication and authorization. Although there was general agreement that SNMP would be suitable for accounting, it was not selected because the intention of the AAA WG was to choose one single protocol for authentication, authorization, and accounting. Despite this formal position, it may still be expected that SNMP will continue to play a role in accounting

Provider-based Accounting [3][14]

An interesting question concerns the architecture providers should choose to account for transport and content. The issue of content accounting on behalf of others is particularly challenging, since good solutions in this area will allow Internet providers to obtain additional income; the amount of money involved in this can easily exceed the

income from the traditional transport business. Because of this importance, and because the IETF and IRTF are not (yet) working on this, the research project Internet Next Generation has developed a new architecture for provider based accounting. The parameters of the accounting request message are:

• *Server information*, including a readable string identifying the owner of the server, an authentication key, and the server's IP/DNS address.

• *Price,* which may be a single value or, with multiple components, a chain of values. The currency should also be specified, as well as a timestamp to allow determination of the exact exchange rate to cover cases where the client wants to pay, for example, in euros, but the server wants to receive dollars. The timestamp is also needed to ensure that information cannot be reused (replay protection).

• *Content type*, which may take the value streaming or atomic. In case of streaming, the price is actually a price per unit, and can be expressed in megabytes or minutes. Other differences between these types of content are explained later.

• *Accounting server information*, which includes the authentication key as well as the IP/DNS address of the accounting server within the server's Internet provider.

In case the client agrees to receive charged content, it forwards the information within the accounting request message to the accounting server of its own Internet provider. To guarantee that no one can change the information, protection is needed via message authentication codes. Such codes can be generated using algorithms like MD5 or SHA1. If the client has paid all previous bills, the accounting server within the client's provider stores the information for future billing purposes and forwards the *accounting accepted message* to the server's provider. If this Internet provider is also willing to participate in the accounting process, it stores the information too and forwards the message to the content server. In case of streaming, the client's costs can depend on the amount of data the client has received. The price is therefore actually a price per unit, and the unit may be, for example, 1000 Packets or 1 Mbyte. Alternatively, the price may depend on the amount of time the transmission lasted: in this case a unit may be 1 minute. In both cases the client should periodically send acknowledgments to indicate that it is prepared to pay for the next unit of data or time. In fact, these acknowledgments take the same route and contain the same information as the original accounting accepted message. This message and the subsequent acknowledgments in fact play a similar role to coins in a public telephone booth: if the client does not pay additional coins (acknowledgments), the service stops. Instead of using acknowledgments, it would theoretically also be possible to introduce an *end of accounting message*. This message should be issued by the client if the client does not want to receive further content. This approach has the disadvantage, however, that the client continues to pay until the server has received the end of accounting message. If the client forgets to issue such a message, or the client's system crashes, or the message gets lost in the network, the client will still be charged. To avoid such problems, acknowledgments were introduced in the design. To keep the traffic generated by the acknowledgments at a reasonable level, it is important to choose a realistic unit size. A unit of 1 minute, for example, is reasonable, but a unit of 1 mini second is unreasonable, since 1000 acknowledgments may overload the accounting system. Atomic content, such as a piece of software, is only useful if it is complete. If the last byte is not received, the content is useless and the client will not be prepared to pay. The all or nothing nature of atomic content makes the use of periodic acknowledgments superfluous. Instead, the client should send an acknowledgment after reception of the last byte; only then will the client have to pay. The problem with this approach is that the client may deny reception of the last byte in an attempt to get away with not paying. For that purpose it is important to have no repudiation mechanisms. The actual payments involve three steps:

- The client pays its own Internet provider. This step may be implemented via inband or outband payments. In case of outband payment, the Internet provider may combine the costs of multiple transactions onto a single bill and issue this bill on a periodic basis.
- The Internet provider of the client pays the Internet provider to which the server is connected. Because of the large number of possible trust relationships between Internet providers, it may be necessary to introduce a Trusted Third Party (TTP). Such a TTP, which may be a bank, takes care of the financial balance between all associated Internet providers.
- Finally, the server gets paid by its own Internet provider. In that case the accounting servers should configure the access routers such that the amount of traffic flowing between both users will be measured.

Charging and Accounting for Integrated Internet Services

Today's information society bears a stringent need for advanced communication services and content. Although solutions for methods of charging and accounting of single-service networks exist and are applied successfully, integrated-services networks require a completely different approach. Charging and accounting for the future Internet remain unsolved problems for the time being. This is due to a variety of service characterizations by quality of service (QoS) and the fact that the shape of the integrated-services Internet is still not fully defined. In addition, a highly competitive telecommunication service provider market requires dynamic pricing schemes for integrated multiservice networks in order to deal with basic bandwidth allocation and advanced QoS services. Based on basic terminology and general economic models, an investigation of best-effort and integrated-services Internet characteristics in terms of suitable, applicable, or existent solutions and approaches for charging and accounting methods is provided. Using these ideas being developed in research trends are sketched for the upcoming third and fourth phase of Internet development which will be strongly influenced by economic elements.

Integrated Internet Services

This section discusses state of the art in research in the area of charging and accounting for the Integrated Services Internet model **[1]**. The integrated services architecture is currently adopted by major telecommunications equipment manufacturers **[4][5]** and is expected to be deployed in the next years in most developed countries. Proposed charging and accounting approaches are divided into three categories:

1. Best-effort charging and accounting, usually a measurement-based approach;

2. Flow- or reservation-based charging and accounting in integrated services (intserv), including flow aggregation; and

3. Charging and accounting of differentiated services (diffserv).

Since the integrated services approach still maintains the traditional best-effort service class, it is discussed here with respect to charging and accounting. Accounting for datagrams in a connectionless network imposes a high processing overhead on Internet routers. To measure volumes and account them to address-port pairs was studied in the RTFM working group, and practical experience was collected in New Zealand where the only Internet link is a satellite connection and usage-based accounting was necessary **[6].** The seminal work of Varian and MacKie first mentioned the application of economic pricing models to Internet traffic **[7]**. Their first auction-based approach was never implemented and is still considered too costly. Nevertheless, a recent proposal for an experimental high-speed router based on multiple processors aims at integrating auctions on packet level. Other approaches use hardware to speed up accounting **[8]**

The integrated services model is based on service class discrimination. New services encompass controlled-load and guaranteed services which are signaled by a newly introduced Resource Reservation Protocol (RSVP). With this new integrated services description, it was time to review charging and accounting issues. With bandwidth reservation and support for QoS, new models and architectures for charging and accounting surfaced. The auction-based approach was revisited by MacKie and applied to flows on the integrated services architecture. Mackie gives a solution for network optimization based on economic principles (Generalized Vickrey Auctions). This work is still in progress and its feasibility has yet to be proved.

Using a high-speed integrated services test-platform, this work shows the feasibility of measuring large numbers of flows in real-time. Since the granularity is no longer a packet but a flow-state, less overhead is generated and the burden of charging and accounting can be put on recent router hardware. Recent work on flow aggregation promises to solve the backbone scaling problem associated with a purely reservation-based approach. Such an approach allows protocols like RSVP at the end-systems to

be kept and eliminates the need for per-flow state at high-speed routers. This approach could be combined with the reservation-based charging scheme described in using zone-based charging for each provider at ingress and egress routers **[9].**
Work on differentiated services is performed within the integrated services working group of the IETF. It is primarily based on the observation that per-flow state in routers as it is needed for reservation protocols such as RSVP can become a bottleneck in the Internet. Therefore, proposals have been made to provide lightweight reservations or priority schemes **[10].** No agreement on a possible introduction or standardization has been reached, and work on charging and accounting options for such protocols is only starting slowly. For example, a proposal by Clark and Fang describes a zone-based charging scheme that is based on packet tagging and dropping (in/out profile tagging). The proposal supports different service classes and has the nice property that charging is performed at the edge and at interconnection points of the network only. In this context, other proposals introduced assured a premium service for prioritized service classes. However, such proposals do not describe concrete methods of how money is collected and they do not study economic implications of charging for integrated network services. **[10]**
The recently initiated differentiated services models have not spawned much work in the field of pricing models yet. Focuses on diffserv mechanisms and experimental approaches to zone and QoS-based pricing schemes, while SIMA focuses on charging and accounting at the edge of the network. **[10]**

Charging and accounting in ATM networks

As charging and accounting is per se not a completely new area, related issues are of significance. This is due to, e.g., a long-lasting experience in the telephone network. However, the main difference compared to the Internet is visible in the set of fixed QoS characteristics per telephone connection. Therefore, the style of packet-based networks shows major technical differences and requires different handling of charging and accounting tasks. In addition, recently started work on charging and accounting in the ATM environment shows some commonalties, but is still significantly different due to at least the virtual connection principle applied.
For ATM-based B-ISDN (Broadband Integrated Services Networks), the tasks of accounting, charging, and billing are required to complete the offer of integrated services. ATM accounting may be expected to serve as embracing network functionality capable of supporting the needs of service providers, retail customers, value added service providers, and other businesses. Virtual Private Networks (VPN) offer a possibility to satisfy special enterprise needs on closed networking environment, where an ATM-based solution is highly qualified to obtain high bandwidths and guaranteed QoS. The "Broadband Network Infrastructure for the Swiss Federal Administration" (KOMBV) determines a Swiss example for a VPN based on the Swisscom ATM network. It guarantees a maximum flexibility for a variety of different applications requiring multimedia services; it eases management overhead; and it reduces costs to operate the VPN. However, ATM-based intranets are only affordable for medium and larger enterprises, because tariffing structures slightly favor high-volume customers[**11].**
The telecommunications view of the terms accounting, charging, and billing has been preliminarily defined in. The basic charging for ATM is called "three tier charging", where the set-up fee, the total of all duration fees, and the total of volume fees are included. In contrast, two basic components of ATM tariffs are commonly identified. The charges of an access component are typically fixed per installation and they are constant over billing periods. This charging does not require any online

measurements. However, it should allow for compensating providers for required facilities for a service subscriber to access a service or services, e.g., those facilities specifically provided to that service subscriber. In addition, they are independent of the utilization and related mainly to the type of access, such as capacity provided, maintenance, or redundancy. Charges of the utilization component should be in accordance with the service requested by the service subscriber. In principle, these charges should be determined on the basis of network resources and additional functions required, providing the service to the service subscriber. The measurement of the utilization component usually has to be carried out online. Most current utilization charging schemes are based on saving parameters received through the ATM signalling, e.g., including traffic contract, source and destination addresses, counting ATM cells during the ongoing call, and saving the set-up time and duration of the call. Current research is being done by several ACTS projects, such as CA$HMAN (Charging and Accounting Schemes in Multi-Service ATM Networks) and CANCAN (Contract Negotiation and Charging in ATM Networks) as well as a small Swiss project **[12].**

As ATM technology in the WAN environment used to be controlled by PTTs (Post Telephone Telegraph) formerly, tariffing schemes defined initial approaches for public ATM networks. These changes today due to private companies offering ATM services and pricing schemes. However, legacy ATM networks still rely on conventional tariff models as applied to telephone services. Current implementations on ATM pricing models are based either on a flat rate, as for legacy leased line tariffs, or on a two-part pricing scheme which is a monthly access and usage-based fee, as for legacy switched circuits tariffs. However, new proposals in recent research suggest different ATM pricing models to take into account various service classes offered by ATM. However, as ATM provides different service classes, it is not appropriate, e.g., to charge for a constant bit rate traffic a volume charge. As the result obtained shows, various traffic types require different pricing approaches to make their special characteristics visible in economic incentives **[12].**

Charging and Accounting Technology for the Internet (CATI) [13]

The objectives of the CATI project (Charging and Accounting Technology for the Internet), consisting of CAPIV (Charging and Accounting Protocols in the Internet and in Virtual Private Networks) and MEDeB (Management, Evaluation, Demonstrators, and eBusiness Models), include the design, implementation, and evaluation of charging and accounting mechanisms for Internet services and Virtual Private Networks (VPN).

For enabling high-quality Internet transport by economic incentives for e-commerce scenarios, a set of charging, accounting, and management mechanisms for value-added Internet services are required. They are in the progress of being implemented within CATI or have been finished prototypically already. These demonstrators are based on basic architectural work and concept definitions, such as the definition of an integrated CATI scenario and architecture for Integrated Services/Differentiated Services (IntServ/DiffServ) models in support of charging, accounting, and Virtual Private Network (VPN) management mechanisms which is complemented by a security, a trust, and a business model. Design and implementation of charging and accounting extensions in reservations, which are demonstrated by a sample IP telephony application and an adequate graphical user interface. The IP telephony application currently utilizes Microsoft’s Netmeeting product and the ITU-T H.323 signaling protocol in addition. The prototypical demonstrator consists of at least three PCs running NetBSD (Linux in the future for routers) and the Crossbow IntServ architecture implementation, where in the case of the demonstrator two end-systems are interconnected by a router. Microsoft's Netmeeting – an IP telephony application – is running on both end-systems and utilizes an H.323 proxy for signaling purposes between them in addition to the extended interface of RSVP (Resource Reservation Protocol). During the IP telephony usage charging information are calculated within the router depending on its pricing model applied. This information are exchanged and distributed to connected end - systems and presented through their graphical user interfaces to the IP phone user. Therefore, the user is always aware of the current costs of his communication, he has to pay for. Design and implementation of VPN service management based on a hierarchy of brokers which is demonstrated by a Web-based VPN configuration user interface. For all VPN management tasks, the QoS-enabled, secure, and Internet-based VPN management system's design has been implemented currently for a single-provider case, even though designed for the multi-provider case. The current implementation provides charging and accounting between customers and peer providers as well as automatic service negotiation, establishment, and maintenance based on a service configuration interface for customers. A Web-based configuration interface allows for the seamless integration of underlying technology such as the generalized Bandwidth Broker hierarchy of the DiffServ architecture. The demonstrator utilizes end-systems interconnected by IOS-driven Cisco routers as well as Linux-based router extensions for experimentation purposes. A Linux-based VPN router has been implemented based on a freely available IP Security package for Linux and a DiffServ implementation from another project being performed at IAM. In addition, the transport of video or audio flows between sub-networks, utilizing the RSVP/DiffServ-Gateway implementation, has been demonstrated. Design and simulation of pricing model behaviors for dynamic market prices by a dedicated and specialized implementation of a simulation program for the newly developed approach called CHiPS. CHiPS applies the smart market paradigm on flow charging and solves the problem of synchronization issues of auctions between multiple ISPs in multi-provider scenarios. Design and simulation of (i) bandwidth broker signaling in DiffServ networks and of (ii) Service Level Agreement (SLA) trading.

First, a set of detailed signaling simulations investigate control scenarios for various inter-broker communication schemes, e.g., adaptive or fine-grained notifications. These simulations determine the trade-off between establishing end-to-end QoS guarantees and the control's scalability. Secondly, a specialized simulation has been implemented to study statistical resource guarantees in a DiffServ environment. Since SLAs include essential information on inter-provider service provisioning, they may be used to describe individual flows or aggregates. The simulation includes SLA traders which operate on flow aggregates, performing on a slower time-scale signaling than per-flow signaling. Initial simulation results show that profit-driven routing decisions for traffic described by SLAs can be suitable for DiffServ core networks. Application and development of an accounting and flow detection tool. Communication service user affiliations have often expressed their intention to charge individual users or organizational units such as departments or institutes for the volume of network traffic generated. So far, the technical and administrative complexity involved with this has prevented them from doing so. Therefore, tools through which individual users can inform themselves about their amount of network usage have been utilized. Heuristics have been developed to aggregate flow accounting data generated by routers into categories suitable for charging.

CATI was the first project within Switzerland to address the problems of charging and accounting of packet-based networks, in particular the Internet. Since traditional work in the area of charging for communication services was based on connection-oriented services, such as the telephone network or an Asynchronous Transfer Mode (ATM)

network, the loss of state information within the network, or only its dedicated storage for certain classes of applications, had to be dealt by. CATI developed a charging approach for reservation-based services, assuming that best-effort type of services will be available for a flat fee or for free today and in the future. However, the supporting protocols for a type of guaranteed service utilize resources within the network in a dedicated fashion. Therefore, this explicit usage should be charged for. The pricing model developed within CATI took advantage of well-known auctions, but extended these so-called Vickrey auctions to delta auctions, being capable of over-time calculation of an auction result, integrating its results in Resource Reservation Protocol, and investigating on the remaining incentive-compatibility of synchronized auction results in a multi-provider scenario. The simulation of trading Service Level Agreements between providers in an automated fashion resulted in insights on certain strategies for Internet Service Providers in a competitive market. Only two European and American projects (the ACTS project SUSIE and the Berkeley project INDEX) have been working on these areas of research in the early times of CATI. The Virtual Private Network configuration approach has not been looked at in the Swiss networking community as well as the international one. The central goal comprised the provisioning of a design and implementation of a QoS-enabling, secure, and Internet-based VPN management system including charging and accounting between customers and peer providers. This included other advanced features not existing in today concepts and their implementations: automatic service negotiation, establishment, Web-based maintenance based on a service configuration interface for customers. In addition, the research worked on the mapping of fine-grained IntServ mechanisms onto DiffServ and provided an IntServ/DiffServ Gateway.
Finally, the simulation of bandwidth broker signaling in DiffServ networks provided basic insights into future DiffServ networks. These tasks were complemented by the inherent view of security-related aspects, such as a trust model for providers and customers, secure micro-payment schemes, and security support for business transactions. Business models and demonstrators showed that the concepts developed are possible to exist in the real world. CATI took over a large number of these challenges and resulted in a number of very interesting results, which have been published in a large number of scientific publications, which may be obtained from the CATI web page: http://www.tik.ee.ethz.ch/~cati.

M3I - Market Managed Multiservice Internet. [14]

M3I is a European Union project in the 5th Framework of the IST-Program that started in 2000. The partners of this project are HP European Laboratories, Athens University of Economics and Business, Darmstadt University of Technology, BT Research, Swiss Federal Institute of Technology and Telenor Research. We note that, the term accounting was used in this project to denote the data collecting and storing function. This function receives and merges transformed metering data from mediation systems, stores this data and provides it to the charging function when requested.
The M3I project aimed "to design, implement and trial a next-generation system that will enable Internet resource management through market forces, specifically by enabling differential charging for multiple levels of service." This system would allow customers to increase the QoS by accepting different charging rates, to receive real-time feedback and to acknowledge charging information. ISPs would be able to change the prices and to communicate them to the customers, to maintain current QoS levels in case of congestion by changing prices, and to be able to charge for different QoS levels or multicast.

The main results of the M3I project are:
• The development of a pricing framework for price setting, communication and reaction.
• The design and implementation of a charging and accounting system.
• The presentation of new business models for ISPs in a set of scenarios.
• The performing of technical experiments and evaluating customer experience.

Internet Accounting VS Telephony Accounting [14]

It is interesting to investigate whether providers of POTS, who have many years of experience in telephony accounting, can reuse this knowledge for Internet accounting. To answer this question, it is important to distinguish between billing and metering. Billing for Internet services will be comparable to billing for POTS. As a consequence, experiences in this area can be reused. Metering, the process of measuring the parameters within the network related to the customer's service usage, is rather different, however. Take, for example, the parameters to measure. In POTS it is common to measure call duration, time of day, and destination of the call (local, national, or international). Since the Internet is connectionless, it is principally impossible to measure call duration. Instead, some providers measure how long users are connected via their local access line to the Internet. Although this is somewhat comparable to measuring call duration, more and more users get permanent connections to the Internet (xDSL, cable, UMTS). As a result it becomes less feasible to use access duration for accounting purposes.

It is also questionable whether the destination address will be a useful parameter for Internet accounting. As opposed to POTS, where subscriber numbers include a country and city code, early IP addresses do not contain any form of geographical information. Recent IP addresses that follow the rules defined by the Classless Inter Domain Routing (CIDR) standard do have some notion of location, but this information is less detailed than the geographical information contained in telephone addresses. Also, Domain Name Service (DNS) names, which as well do not really contain geographical information, are difficult to use for accounting purposes. One of the problems of using DNS names for accounting is that a single IP address may be related to multiple DNS names, each registered in a different top-level domain. If the price depends on the DNS name, the problem arises of which DNS name to choose. Although it may be difficult to charge different prices for local, national, and international traffic, it may be quite feasible to charge differently for interoperator and intra-operator traffic. To implement this, the operator should use the information within its routing tables to determine which customers are connected to its network and which are not. Charging differently for intra- and interoperator traffic may be interesting for providers to attract customers and save on peering agreements. Because of its complexity, it can be expected that usage-based accounting in the Internet will be based on a relatively small number of parameters.

Examples of possible parameters are traffic volume (transmitted, received), traffic class (in situations where DiffServ is applied), time of day, and probably the question of whether or not the destination is connected to the same provider as the sender. These parameters can already be difficult to use. Consider, for example, the case of a congested network that drops packets. The user may still have to pay for these packets, and the interesting case occurs that a provider of a congested network will charge more than a provider of a well designed network.

Research and standards[14]

Although Internet accounting appears to be different from accounting in the traditional telephone world, researchers and organizations from the telephone world showed interest in Internet accounting at an earlier stage than the developers of the traditional Internet protocols. This difference in appreciation can be understood from the fact that accounting has always played an important role in the telephony world. This world is completely different from the world of traditional Internet researchers, who often come from noncommercial organizations like universities. It is not surprising, therefore, to see that the Advanced Communication Technologies and Services (ACTS) program of the European Commission [**15],** in which the telecom industry and operators played an important role, already subsidized accounting projects in the mid-'90s. Originally, these projects focused on asynchronous transfer mode (ATM) accounting; examples are the Contract Negotiation and Charging in ATM Networks (CANCAN) and Charging and Accounting Schemes in Multiservice ATM Networks (CASIMAN) projects. As more and more people understood that ATM would never play the role originally envisaged, the ACTS accounting projects started to investigate Internet accounting problems too. A good example of such a project is the SUSIE project, which integrated ATM, IP, and TINA concepts to study charging of premium IP services. Current projects within the European 5th framework Information Society Technologies (IST) program do not pay attention anymore to ATM, but focus on Internet accounting. An example is the Market Managed Multiservice Internet (M3I) project, which investigates differential charging to provide multiple QoS levels [**16].**

The IETF [15][16]

It is already nearly 10 years since the first RFC appeared on Internet accounting (RFC 1272). This first RFC, which was based on the ideas and terminology of OSI, inspired the Real-Time Traffic Flow Measurement (RTFM) group to define the so-called Meter management information base (MIB). This MIB allows the gathering of usage data from the network and may be important for accounting, performance, configuration, as well as security purposes. Other IETF groups did not pay much attention to accounting, and interest in the subject seemed to disappear.

MICRO PAYMENT GATEWAYS

Agree on an existing payment system

The first alternative is that PSOs and users agree on one existing payment system, which will then be introduced world-wide. This alternative, however, will be difficult to realize. The first obstacle is that the payment system operators do no want to give up their market position in favor of another system **[17].** They already operate proprietary systems, which meet local (national) needs and regulations (e.g., Micromoney in Germany, w-HA in France, Minitix in The Netherlands, Quick in Austria, Nochex in the United Kingdom). The existing systems operate cost-efficient on a national scale or in broader geographical regions, so any alternative system will have serious competitors **[18].** The second obstacle is that this approach violates the free market rules, which encourage competition between PSOs and their systems. The third obstacle is the legislative and regulatory differences, which are likely to occur when a single electronic payment system is being introduced in multiple countries. The fourth obstacle is those customers who may already trust and find convenient their current payment system(s). This trust and convenience may ALTERNATIVE

SOLUTIONS seriously decrease the customers' willingness to switch over to an alternative system. Customers must therefore be persuaded to adopt the new system, which leads to substantial introduction costs. Hence, the idea of selecting a single payment system has a significant chance of failure. This is also shown by history: many payment systems aimed at global acceptance and domination,but none of them succeeded.

Create a new electronic payment system

The second alternative is to create a new payment system and introduce it world wide. The first step in this process is to define a new standard for electronic payments. In addition to the difficulties listed for the previous alternative, new obstacles arise. One of these is the standardization process. In case of technical standards, like those of the IETF, the standardization process can easily take four to six years. Standards for payment systems, however, also require involvement from financial and legal authorities. This involvement will likely further delay the development of the standard. Additionally, it is not even sure that all legal and regulatory issues can be solved due to the different laws and rules imposed by the financial authorities. For example, there is no common view on whether a payment system operator (e.g., PayPal) needs in every country a banking license or not. There is no agreement either on the type of organizations that are allowed to issue electronic money, e.g., in the Netherlands e-money is exclusively issued by credit institutions or banks, while in Denmark non-banks are allowed to issue multi-purpose smart cards under special conditions **[19].**

Payment Gateway

The third alternative is to keep current payment systems in place and make them interoperate by introducing a *Payment Gateway* (PG), which interconnects the various payment systems. In this way, instead of one payment, a chain of payments will be performed. The new system that comprises the PG and existing payment systems is called *Hybrid Payment System*. This third alternative does not suffer from the problems of the previous ones, and is therefore more likely to succeed **[20].**

Internet Open Trading Protocol (IOTP) WG

The IOTP WG **[21]** was chartered in 1998 to continue the engineering work of the IOTP protocol started by the Open Trading Protocol (OTP) Consortium. The results of the IOTP WG are a framework for trading of products on the Internet (RFC 2801, **[22])** and the Electronic Commerce Modelling Language (RFC 3106, **[23]).** The developers of this framework tried to provide an online trading model, which resembles the every day's trading and which supports current and future mechanisms. The trading process includes the accounting for products (as defined in Section 2.1) and delivery of products. The products are delivered over other channels than the Internet, however. In the IOTP framework the following roles are identified: customer, merchant, customer care provider (for taking care of disputes with customer), a payment system operator and a delivery provider. The protocol is optimized for the case when the customer and merchant do not have prior relations. Multiple roles can be played by a single organization (e.g., a merchant can also be a customer). If we assume that no disputes take place (so the customer care provider can be omitted), the following interactions take place. First, a customer selects the product (s) from a merchant. The accounting system of the merchant executes the accounting functions, and presents the bill to the customer. To pay the bill, the merchant offers one or more electronic payment systems provided by a payment system operator. The customer selects one system and initiates a STANDARDIZATION ORGANIZATIONS AND ACTIVITIES payment, which is processed by the payment system. Usually, these payments have large values (e.g., above €5). After the payment, the delivery provider delivers the selected and paid product(s).

Although, IOTP is an open standard, not many merchants use it. A major reason for this is that there are no incentives to adopt this standard. One problem with IOTP is the inefficient and inconvenient payment message exchange, which is tunneled through the IOTP protocol. Another problem is that the protocol was designed completely generic and brand-independent, which made it inflexible towards existing and emerging payment systems (e.g., systems that support person-to-person payments). The generic and brand-independent characteristics of standards usually make them powerful, but in this case, it might be a disadvantage. Another problem emerges from the behavior of merchants: they need payment systems to be integrated into their web shops as soon as possible within a given budget and given time constraints. Payment system developers create proprietary systems for a particular environment and customer group, and are less interested in generic standards **[24].** At the time of writing, an improved version of IOTP (IOTP v2.0) was under development. The Electronic Commerce Modeling Language (ECML) defines a standard set of information fields. The aim of this standard is to ease the process of filling in various fields with customer information on the web sites of merchants. In this way, customers will be less confused by the varying web sites of merchants. For instance, the customer information needed to make payments can be filled in automatically in a standard manner for every merchant from which the customer buys content. ECML may be used with any payment system. At the time of writing, version 2 of ECML is under development.

International Telecommunication Union (ITU-T)

The International Telegraph Union was established by 20 founding members in Paris in 1865. The Union's name was changed into International Telecommunication Union in 1932 to reflect the Union's responsibilities concerning wireline and wireless communication **[25].** Some of the accounting standards were defined by the ITU-T in the M.3000 series and others, the X.700 series were adopted from the OSI standards. The mapping between the accounting related ISO and ITU-T standards is presented in [26]. The term TMN is introduced by the ITU-T as an abbreviation for "Telecommunications Management Network". According to the M.3010 standard, "a TMN is conceptually a separate network that interfaces a telecommunications network at several different points" **[27].**

Accounting management is one of the management areas supported by a TMN and it is defined as a "set of functions, which enable the use of network services to be measured and the costs for such use to be determined and rendered" [50]. The accounting management in TMN and OSI does not differ much because of the adoption of some OSI standards as a framework for the TMN. The usage metering, collecting metering records, creating charging records and billing are very similar functions. The tariffing function specifies a set of data that is used to determine the prices for the used services **[28].**

Charging for Premium IP Services in the European Information Infrastructures & Services Pilot (SUSIE) [29]

The SUSIE project started in 1999 and was funded by the European Commission under the ACTS programme. The participants of this project were Teltec Ireland, Eurecom, Fraunhofer Institute FOKUS, Martel, Silicon Graphics, Flextel and Waterford Institute of Technology. The main objectives of this project were the usage-based charging of Premium IP services and the integration and validation of accountable IP-based services. Premium IP services are those IP-based services that are enhanced with Quality of Service. We note that, the term accounting was used in this project to denote the process of pulling together raw metering information and creating accounting information, which can then be used to calculate the charges. This is actually a synonym for the data collecting and storing function. In this project a reference model for the charging and data collecting and storing functions was developed **[30].**

The developed reference model can also be used in a multi-provider billing environment. In this case, an IP flow crosses multiple ISP domains, and each ISP may charge adjacent ISPs for the used network resources. ISPs will charge the flow sending and/or receiving users directly. Adjacent ISPs may only exchange bills with each other: it is not needed to exchange charging information as well. Accounting over multiple service providers (i.e., federated accounting) was considered because this project focused on Premium IP services and these services are delivered within a multi-service provider context. For this, architecture of the Trade Accounting System was developed **[30].** This system may become useful if DiffServ will be deployed on the Internet, and DiffServ providers will compete with each other. In this project, a TINA-based accounting system for Premium IP was developed as well [**30].**

TINA is a proposed architecture of the Telecommunications Information Networking Architecture Consortium. TINA provides a framework for billing control and management of dynamic service provisioning platforms. We note that, within TINA, the term accounting denotes the process of "receiving data from a service and calculating charges using prices". This definition is a synonym for both the data collecting and storing, and charging functions. The advantage of the developed TINA-based accounting system is that it can handle both ATM and IP-based accounting. This means that this system can receive metering data from a Premium IP meter reader and charging data from an ATM accounting system, and creates converged charging information. Hence, this system calculates IP-based charges based on metering information and combines them with related ATM charging information. SUSIE contributed to the work of the AAA WG and to the NA 8 Working Group of the European Telecommunications Standards Institute. The developed reference model became the basis of the policy-based accounting work of the AAAarch RG**[31].**

Commercial products and platforms

A large number of accounting related commercial products and platforms were developed and deployed. These products and platforms implement different accounting functions or provide a complete accounting solution. For instance, the metering function is implemented in NetFlow, XACCTusage, LFAP; the billing and payment function is implemented in iBill, NetToll, PayTrust; complete accounting services are provided by iMode, Teleknowledge's Totale Platform. The commercial products and platforms discussed in this section were selected because they introduced innovative ideas and solutions in the field of accounting, or have a significant market share. Because this thesis mainly focuses on the payment function within accounting, electronic payment systems that are used on the Internet are separately discussed in Chapter 3. The following products and platforms are presented in this section:

NetFlow, XACCTusage, iBill, iMode, NetToll. Descriptions of several other products and platforms can be found in [73].

Net Flow[32]

Net Flow is proprietary metering software developed by Cisco Systems, Inc. NetFlow is part of the Cisco IOS software package and provides the metering function for traffic accounting. The metering data can also be used for network monitoring and planning, application monitoring, Denial of Service monitoring, etc. The metering can be performed for customers, merchants, or ISPs. The data export format of version 9 of this product has been chosen by the IETF as basis for the IPFIX standard. NetFlow uses the concept of network flow, i.e., a unidirectional sequence of packets between given source and endpoints. During metering only the first packet of a flow needs to be fully processed, the subsequent packets are recognized as being part of the same flow. The quantities of flows that NetFlow can meter are for instance, IP addresses, packet and byte counts, time stamps, Type of Service and application port numbers.

XACCTusage[33]

XACCTusage is a commercial software product developed by XACCT Technologies. This product can meter the network resource consumption of customers in several network elements such as routers, switches, and firewalls; it can collect this data and transform it subsequently into charging and billing information. Therefore, network service providers or ISPs can use XACCTusage for transport accounting. XACCTusage can also be used for network monitoring, and can be connected to any standards-based network management system. XACCTusage uses the concept of gatherers, i.e., agents that implement the data collecting and storing function. Gatherers collect and store metering data from one or more network elements. Data is stored in relational databases such as Oracle, Microsoft SQL Server and Sybase SQL Server. Gatherers also aggregate and filter the collected data. This data can also be used for traffic engineering, fraud prevention, etc.

iBill[34]

iBill is a billing and payment platform developed by the Internet Billing Company, Ltd. This platform provides the billing and payment function to merchants who sell content, products and services on the Internet. Merchants need to have an iBill account and provide the charging information to iBill; the billing and payment function is outsourced to iBill. iBill can handle one-time billing or recurring (e.g., monthly) billing of customers. The payment systems that can be used to pay a bill are credit card systems, electronic check systems. After a payment transaction was successfully completed, iBill sends a receipt to the customer and notifies the merchant to deliver the paid products.

NetToll

NetToll is a platform developed by Enition, which stopped its activities. Merchants define the price of their content and charge their customers, while the billing and payment function is outsourced to NetToll. The innovative idea of NetToll was that it also allowed ISPs of the customers to pay for the content received by these customers.

This could be done by placing tokens (i.e., a type of electronic money) in the IP-packets. These tokens could be obtained by a NetToll server. Later the ISPs could aggregate the payments made on behalf of a customer, and present them on the monthly bill. For this, the ISP creates so-called toll detail records, which contain the identification information of a customer, value of payment, piece of content being paid, etc.

iMode[35]

iMode is a platform that provides wireless Internet access and services. iMode is developed by NTT DoCoMo, which is a major Japanese telephone operator and ISP. Nowadays, iMode is also available in many European countries. iMode has a very large customer base and many merchants. The ISP provides a content accounting system to affiliated merchants that publish chargeable content. The ISP charges customers for their network traffic based on subscriptions and per-packet-fees. A central billing relationship exists among the ISP, merchants and customers. According to this relationship, content related payments are collected by the ISP and distributed to merchants. This means that the ISP performs transport accounting for customers, and provides content accounting for merchants. It also aggregates traffic and content related charges of the same customer into a single bill. The ISP pays only 91% of the content related payments to the appropriate merchants, because 9% of the content sales are the fee for providing content accounting.

Characteristics of electronic payment systems

Electronic payment systems can be evaluated based on a number of different criteria. In related literature these systems are classified based on various characteristics such as security, ease of joining and use, pervasiveness, integrity, speed, anonymity, privacy, efficiency, reliability, account-based, token-based, etc**.[36].**
In this thesis, however, another approach is taken since other criteria are of interest. The next sections define a characterization model for electronic payment systems. First, the business roles that need to be paid in an electronic payment system (e.g., issuer, acquirer) are identified. Second, the functional characteristics (e.g., pre-paid, payment initiations and acknowledgements, supported payment values) are identified.

Evolution and classification of electronic payment systems,
Evolution of payment systems[37]

The first generation of Internet payment systems started in 1992 . Credit cards were mostly used for making payments online. At that time, payments that contained credit card numbers were transferred through communication channels without any security measures. In parallel, great efforts had started to develop, implement and deploy new electronic payment systems for use on the Internet. These efforts were driven by a number of factors such as the potential of micro payment systems to support online, electronic payments of low values, the necessity of making anonymous payments, and the need for more secure payment systems for high value payments. Commercial organizations, the banking sector, universities, and research institutes were involved in this work. In 1998 began the decline of the first generation of payment systems. Their success was very limited, some were only theoretically defined, others were implemented and tested in pilot schemes, many initiatives failed, and some became standards (e.g., SET for credit card payments). Examples of failed initiatives are First Virtual, DigiCash, IBM’s Micro pay, Compaq’s Millicent. Many attempts failed due

to the lack of standards for payment systems, being unable to reach a critical mass (i.e., wide penetration among users or reaching a large number of users and transactions), creating merchant specific currencies, or because of difficulties with subscribing and using the system, or due to high transaction costs and low speed .
The second generation of Internet payment systems started in 1999. These systems include characteristics such as pre-paid accounts, virtual accounts for person-to-person or business-to-person payments, email payments. Mobile payment systems started to appear in the same period. These systems use other communication networks (e.g., GSM) than the Internet. Mobile payment systems allow payments in both real and virtual worlds, and overlap with the new generation of Internet payment systems. Mobile payment systems could become serious competitors to the current electronic payment systems on the Internet, especially in Western Europe .

Classification of electronic payment systems[35]

In literature, different classifications of electronic payment systems can be found. Such classifications are based on the type of e-money, type of payment instruments and value of payments. A classification distinguishes e-cash and account-based systems. The e-cash systems are split into smart card systems (e.g., Mondex, Chipknip) and online cash systems (e.g., Net Cash, ECash). The account based systems are split into generic systems (e.g., NetBill, PayPal), specialized systems, and credit and debit systems (e.g., MasterCard, Visa, Cirrus). A second classification distinguishes token-based and account-based systems . The first group contains direct cash systems such as ECash, MagicMoney and PayMe. The second group is further divided into direct account systems such as CyberCoin, FSTC and NetBill; credit card systems such as SET, VeriFone and First Virtual; and push account systems such as AIMP, CheckFree and NetFare. Other classifications presented in are based on the value of payments (i.e., macro payment, small payment and micropayment systems) and on the payment validation method (i.e., online, semi-online and offline systems).
A third classification makes distinction between credit card, e-check, e-cash and micropayment systems. In the group of credit card systems are included the SET standard, First Virtual, Visa and MasterCard. Examples of echeck systems are NetCheck, ECheck and NetBill. Examples of e-cash systems are ECash, NetCash and CyberCoin. Micropayment systems are, for instance, Wallie, Click&buy, Way2Pay and Bitpass.

Minitix[38]

Minitix is a pre-paid account-based micropayment system introduced in the Netherlands by the RaboBank. Minitix includes a brand organization, an identification and authorization service provider and acts as a payment proxy on behalf of consumers. Consumers are required to register and provide personal information (e.g., name, address, birthday, gender, identity certificate, email address, etc.) and banking information. All provided information should be correct, otherwise the registration is cancelled. During the registration they also set a user name and password, which will be used later to access the payment system. Consumers also need to agree with the usage terms and conditions. After that, Minitix creates a pre-paid account for consumers who need to deposit money (maximum €100) before they can initiate payments. Consumers can access their accounts by opening a session. During a session they can acknowledge previously initiated payments, review the list of payments, manage their information provided at the registration, or initiate money transfers into their accounts. Consumers can only acknowledge payments if the balance of their account allows those payments. Each completed payment is immediately confirmed to consumers, who will also get a daily email with an overview of their completed payments for that day. Consumers can request the payment system to terminate the service. In this case Minitix transfers back the unspent amount of money if this is bigger than €1. Consumers that do not use Minitix for more than 3 months will receive back the unspent money and their account will be suspended. The risk of losing money is borne by consumers. Providers need to register for using Minitix as well. After that they need to set up their web sites to be able to provide payment information to the consumers. Each completed payment is indicated to the appropriate provider, which provides then the paid product. Minitix pays out monthly the providers. At the same time they receive a detailed list of payments. Providers do not run the risk of losing money because Minitix is a pre-paid system. They need to pay a one time entree fee of €180 and then a per transaction fee, which varies between €0,05 and €0,65.

Click&buy[39]

Firstgate AG introduced a post-paid, account-based micro payment system called Click&buy, which is actually a product accounting system in our view. In the beginning the system functioned only in Germany, then it was deployed in several other European countries (e.g., Austria, the Netherlands, France, Spain, Switzerland, UK) and in the USA. Click&buy incorporates a brand organization, an identification and authorization service provider, a payment proxy and a product access control service provider. Consumers are required to register and provide personal and banking information (e.g., credit card number). All provided information should be correct, otherwise the registration is cancelled. In return, a post-paid account is created for each of them. Consumers can access their accounts by opening a session (i.e., log into the system using a user name-password combination set during the registration). During a session they can acknowledge initiated payments, view their payments, check the balance of the account, and change the information provided at the registration. Consumers can also acknowledge payments to pay for subscriptions. In this case payments will be performed periodically and automatically. Consumers receive periodically (e.g., monthly) an indication that a money transfer took place, which restored the balance of their account. The money transfer is initiated by Click&buy using the banking information provided at the registration. The period can be changed depending on the number and volume of the acknowledged payments. Consumers can end using the system. Before that, however, the balance of their account is restored. Using Click&buy is free for consumers. Providers also need to register and pay a one time subscription fee for using Click&buy. During the registration the access path (or link), description, price and availability of the product (measured in time) is provided to Click&buy. Then they need to set up their web sites on which they offer products. Because Click&buy is an accounting system, providers need to register their products, and then protect those products such that only Click&buy will have access to it. In return, the providers receive a premium links for each registered product. These links will be added to their web pages. Products can only be sold in individual units, which means that consumers cannot select multiple products and pay in once. The prices of products vary between €0,05 and €5 because these are the minimum and maximum payment values supported. Providers will be able to see the completed payments in a management environment provided by Click&buy. Click&buy will further handle the payments, retrieve the paid product from the providers and deliver it to the paying consumers. Hence, providers do not receive indications of the successfully completed payments. The money received from consumers is paid out monthly to the providers that also receive a detailed list of completed payments. Because providers need to pay for the payment service, the commission will be deducted from the total amount to be transferred.

Bitpass[40]

Bitpass is a pre-paid account-based micropayment system developed in 2002 at Stanford University. Bitpass incorporates an issuer of "virtual debit cards" and an acquirer, a brand organization, an identification and authorization service provider, a payment proxy and a software provider. Consumers need to buy a "virtual debit card" with a specific denomination (e.g., US$3, US$5, US$10). After that they register in order to open a "spender" account. Consumers can register to Bitpass directly from the web site of providers that are already registered to Bitpass. During registration they need to provide information such as email address and the bought card's number.
Consumers also need to agree with the usage terms and conditions. The created account will be accessible using the correct email address and password combination set during the registration. Later, consumers are able to use this registration to pay other merchants. Consumers can log into the payment system, acknowledge initiated payments, review the history of their payments, buy more virtual cards and assign them to their account, or change their registration information. Consumers do not pay for using Bitpass. Providers also need to register first to receive an "earner account", which can be accessed the way consumers access their accounts. Providers also need to agree with the usage terms and conditions. Providers using Bitpass need to follow a set-up procedure and product registration similar to the one described for Click&buy. Then they will add the resulting premium links to their web sites. Bitpass provides them gateway software, which will receive payment confirmations from Bitpass and will control the product access of paying consumers. Providers are paid out periodically, but they are also allowed requesting a pay-out under certain conditions. Providers will pay Bitpass transaction fees up to 15% of the payment's value. There is no setup or monthly fees.

Way2Pay[41]

Way2Pay is a pre-paid account-based payment system developed and introduced by the ING Bank in The Netherlands. Way2Pay includes a brand organization, an identification and authorization service provider and acts as a payment proxy on behalf of consumers. Consumers are required to register for using Way2Pay. During the registration they need to provide personal, email, and banking information. After that they can open session by logging into the system using their email address and a previously set password. After registration they also need to transfer some money into their account. Consumers are then allowed to acknowledge previously initiated payments, send and request money from other Way2Pay consumers or third parties (who may not be registered at Way2Pay). In other words, Way2Pay supports person-to-person (P2P) payments as well. Once a payment has been acknowledged, consumers are not allowed to cancel it. Consumers can also change their registration information and review the status of their accounts.
Providers also need to register. Unlike in the case of Click&buy and Bitpass, the providers need only a short set-up of their web sites to allow consumers to pay with Way2Pay. For each piece of product they add information such as the name of the provider, a description of product, a product identifier, price of product (expressed in euros), and two URLs in case the payment is successful or rejected. This information will be provided to Way2Pay in a payment initiation. Providers do not receive

payment confirmations or rejections directly from Way2Pay, paying consumers provide them the confirmations or rejections. Based on these indications the providers will provide or not the product to the consumers. Providers can review the history of payments and are allowed to refund consumers.

Peppercoin[42]

Peppercoin is a post-paid, account-based micropayment system developed by R.L. Rivest and S. Micali, two professors at MIT. A spin-off company with the same name was founded in 2001 and it is expected to make its commercial debut in late 2003. The name of the system originated from the word "peppercorn", which is defined in the English law as "the smallest amount of money that can be paid in a contract". Peppercoin incorporates a brand organization, an identification and authorization service provider, a payment proxy, a product access control service provider and a software provider. Providers are required to register for using Peppercoin. Then they need to download an application called PepperMill to create so-called pepperboxes. Pepperboxes are files that contain individual pieces of encrypted products together with product information (e.g., provider, product description, product type, price). Consumers can download these files, but cannot open them. If providers receive payment information from consumers, they will send this information to Peppercoin and a decryption key to the consumers. Providers are periodically paid out. Providers pay per transaction fees for using Peppercoin. Consumers are also required to register. They need then to download and install an application called PepperPanel. This application will store authorizations from Peppercoin that the consumers are eligible to pay providers. This application is used to open pepperboxes and pay for them. PepperPanel reads the product information stored in the file and allows consumers to send the payment information to the appropriate providers. After that, the consumers receive the decryption keys to be able to extract and use the products. Consumers receive every now and then a list of completed payments and the total amount spent on products is deducted from their credit card account provided during the registration. Consumers use Peppercoin for free.

References

[1] R. Braden, D. D. Clark, S. Shenker: Integrated Services in the Internet Architecture: An Overview; Request for Comments, Internet Engineering Task Force, June 1994.

[2] C. Gadecki: Usage Bills: Easier Said Than Done; tele.com Magazine, November 1997.

[3] Internet Next Generation project: http://ing.ctit.utwente.nl/WU5

[4] Networks: The Case for IPv6; White Paper, http://www.baynetworks.com/Products/Routers/Protocols/2789.pdf, July 1997.

[5] Cisco, Inc.: Internet Protocol Version 6; White Paper, September 1996.

[6] N. Brownlee: New Zealand Experiences with Network Traffic Charging; ConneXions, Vol. 8, No. 12, December 1994.

[7] J. MacKie-Mason, H. Varian: Some FAQs about Usage-Based Pricing; University of Michigan, August 1994.

[8] R. J. Edell, N. McKeown, P. P. Variya: Billing Users and Pricing for TCP; IEEE Journal on Selected Areas in Communications, Vol. 13, No. 7, 1995, pp. 1162-1175.

[9] G. Fankhauser, B. Stiller, B. Plattner: Reservation-based Charging in an Integrated Services Network; 4th INFORMS TCOM Conference, Boca Raton, Florida, U.S.A., March 1998.

[10] . Clark and J. Wroclawski: An Approach to Service Allocation in the Internet; Internet Draft, draft-clark-diff-svc-alloc-00.txt, July 1997.

[11] Bundesamt für Informatik: KOMBV - Broadband Network Infrastructure for the Swiss Federal Administration; http://www. admin.ch/g7/projects/p2/kombv.html, 1997.

[12] A. Kuiper: Charging Methodologies for ATM: An Introduction; Cap Gemini, The Netherlands, August 1997.

[13] www.tik.ee.ethz.ch/~cati/deliv/CATI-final-report.pdf

[14]www.comp.lancs.ac.uk/computing/users/cushniej/jc_phd_resource.html

[15] European ACTS (Advanced Communication Technologies and Services) program:http://www.cordis.lu/and http://www.uk.infowin.org/

[16]] Euro. IST Program: http://www.cordis.lu/ist/projects.htm
M3I: Market Managed Multiservice Internet project:
http://www.m3i.org

[17] Böhle, K. et al., Electronic payment systems - Strategic and technical issues, Background paper No. 1 of the Electronic Payment Systems Observatory, December 2000.

[18] Abrazhevich, D. et al., Classification and characteristics of electronic payment systems, In Proceedings of the Electronic Commerce and Web Technologies Conference, Springer-Verlag Berlin Heidelberg, 2001.

[19] Hille, S., Legal and regulatory requirements on accounting, billing and payment, Deliverable 1.4 of the GigaABP project of the Telematics Institute, Enschede, November 2000.

[20] Barclaycard Merchant Services, http://www.epdq.co.uk/

[21] IOTP WG, http://www.ietf.org/html.charters/trade-charter.html

[22] Burdett, D., Internet Open Trading Protocol Version 1.0, RFC 2801, IETF, April 2000.

[23] Eastlake, D. and Goldstein, T., ECML v1.1: Field Specifications for Ecommerce, RFC 3106, IETF, April 2001.
[24] Böhle, K., Integration of electronic payment systems into B2C Internet commerce, Background paper nr. 8, Electronic payment systems observatory, April 2002.
[25] International Telecommunication Union, http://www.itu.int/home/
[26] Pras, A., Network Management Architectures, Ph.D. Thesis, University of Twente, 1995.
[27] ITU-T, Recommendation M.3010: Principles for a Telecommunication Management Network, Geneva, 1992.
[28] ITU-T, Recommendation M.3400, TMN management functions, Geneva, 1992.
[29]http://www.fokus.gmd.de/research/cc/glone/projects/susie/content.html.
[30]Carle, G. et al., Premium IP services, Deliverable AC320/SUSIE/WP2/N/R/004/B1 of the SUSIE Project, April 1999.
[31] Zseby, T. et al., Policy-based Accounting, RFC 3334, IRTF, October 2002.
[32] Cisco NetFlow, http://www.cisco.com/warp/public/732/Tech/nmp/netflow/index.shtml.
[33] XACCTusage, http://www.xacct.com/PRODUCTS/xacctusage/
[34] iBill, http://www.ibill.com/services/ibillcomplete/default.cfm
[35] iMode, http://www.nttdocomo.co.jp/english/p_s/imode/
[36]] Abrazhevich, D., Electronic payment systems - A user-centered perspective and interaction design, Ph.D. Thesis, Technical University of Eindhoven, April 2004 Faber, E. et al., Current innovation in commerce-enabling services, Deliverable 1.1.2 of the BITA Project, Telematics Institute, Enschede, October 2002 Weber, R., Chablis - Market Analysis of Digital Payment Systems, Technical Report TUM-I9819, Technical University of Munich, Munich, August 1998.
[37]] Kniberg, H., What makes a micropayment solution succeed, Master thesis, Kungliga Tekniska Högskolan, Stockholm, November 2002.
[38] Minitix, http://www.minitix.nl
[39] Firstgate Click&buy, http://www.firstgate.com
[40] Bitpass, http://www.bitpass.com
[41] Way2Pay, http://www.way2pay.nl
[42] Peppercoin, http://www.peppercoin.com