Charging and Accounting Technology for the Internet

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SPP ICS Electronic Commerce Projects, "CAPIV – Charging and Accounting Protocols in the Internet and in Virtual Private Networks" No. 5003-54559/1 and "MEDeB – Management, Evaluation, Demonstrators, and Business Models" No. 5003-54560/1

1. Project Objectives

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 Business Models), include the design, implementation, and evaluation of charging and accounting mechanisms for Internet services and Virtual Private Networks (VPN). They develop the enabling technology support for open, Internet-based Electronic Commerce platforms. Their main components encompass usage-based transport service charging methods of high-quality Internet transport services as well as methods for advanced and flexible configurations of VPNs. To complete a real-world applicable solution, security-relevant and trust-related issues in charging, accounting, and billing processes are integrated. Furthermore, the investigation and development of pricing and cost models for Internet services is performed to obtain practical experiences in incentive-compatible dynamic pricing models. This work is complemented by important application scenarios, such as an Internet telephony application as well as an Electronic Commerce scenario, in order to demonstrate the applicability and efficiency of the developed approaches.

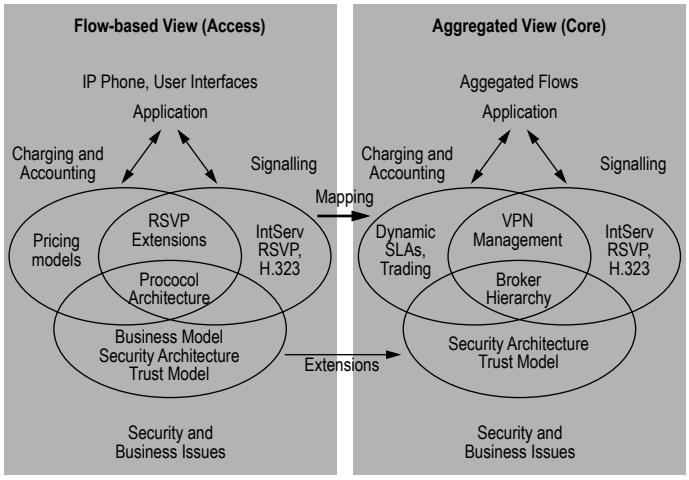

Fig. 1: Technical Structure of CATI

2. Problem Overview

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. While starting with an approach based on the Integrated Services Architecture (IntServ), the project has laid recently a stronger focus on the Differentiated Services Architecture (DiffServ) as well. The IntServ approach utilizes known signalling protocols, such as the Resource Reservation Protocol RSVP, whose extension to carry charging relevant data within the networks on a per-flow basis is adequate. For the DiffServ approach an appropriate signalling approach is under development, which considers the DiffServ Bandwidth Brokers as well as Service Level Agreements (SLA) as important components for a charging solution. In addition the DiffServ/IntServ interoperability is envisioned to be able to support multi-provider scenarios in a much stronger focus. The development of a common technical concept has been performed, in which all project tasks are integrated, where the design and implementation of VPN management functions consider many DiffServ-related issues as prerequisites for future systems.

In due course, besides these important technological developments, business cases are considered jointly. They include the basics of packet-based networks, where the Internet determines the most prominent example, and are currently focussed on a flow-based approach of selling communication services. One of the major factors allowing the selling of these services is a set of appropriate pricing models. Finally, business views are backed by a security and trust model, which currently allows for the description of basic roles and relationships between participants in an e-commerce scenario and relate it to the technical networking environment.

3. Technical Areas

Within the CATI project, a number of intermediate results have been achieved. The basic CATI scenario and architecture have been described, delimiting an overall framework for detailed design and implementation issues. They cover the role of Quality-of-Service (QoS) provisioning and that of VPN usage by introducing the roles of customers, Internet Service Providers (ISP), and financial institutions. Signaling issues for IntServ, DiffServ, and their combination are integrated, which is demonstrated by an IP - telephony application as well as in an e-commerce scenario. The aspects of multiprovider models have been taken care of explicitly by the description of SLAs, their negotiation, their trading, and their scopes. A general graphical user interface for Internet applications utilizing the charging extensions has been implemented. It covers to a great extent services and QoS requirement specifications as well as payment system-related informations. An overview of the combined technical areas of CATI is depicted in Figure 1.

3.1 Internet Access Domain

The IntServ model of the Internet Engineering Task Force (IETF) based on RFC 1633 has been extended with charging and accounting mechanisms by defining new RSVP (RFCs 2205/2206) objects and performing first implementation steps. At this point the close cooperation with the SNF MicPay project needs to be stated, where an electronic micro-payment scheme has been developed and its requirements have been designed and partly implemented by new RSVP objects within the same CATI implementation.

3.2 Internet Core Domain

For the VPN management tasks, the QoS-enabled, secure, and Internet-based VPN management system's design has been implemented. It encompasses for QoS mechanisms the DiffServ model (RFCs 2474/5 and 2597/8) and maps fine-grained IntServ

mechanisms onto Differentiated Services. These areas determine success issues for VPN provisioning in todays Internet services market, since VPNs determine a cost-sensitive alternative for leased lines or frame relay networks. While supporting a multi-provider scenario, the following tasks are provided: 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 RSVP/DiffServ-Gateway. This goal is achieved by a generalization of the Bandwidth Broker concept of DiffServ, introducing a broker hierarchy of services. The services implemented for CATI encompass QoS and VPN support.

3.3 Pricing Internet Services

The design of Internet services pricing models and its evaluation are in progress. The design is based on the classification of related work and an identified set of dimensions, such as service categories, pricing components, and charging parameters. A newly developed approach CHiPS (Connection-Holder-is-Preferred Scheme) proposes an auction model for dynamic price determinations in an incentive-compatible fashion. CHiPS solves the problem of synchronization issues of auctions between multiple ISPs, which originally is due to characteristics of the Delta Auction for continuously performing auctions. Therefore, the smart market approach is applicable to Internet packet flows, e.g., determined by explicitly reserved flows via RSVP. Furthermore, investigations on the optimality problem of prices for dynamic volume-based multi-class traffic prices are in progress. The ISP's point of view on pricing models in practice has been documented as well as a discussion on cost recovery schemes in a business environment.

3.4 Trust and Security Model

Since the transfer of charging information in an open Internet requires securing actions, a security model as well as a trust model have been developed. The trust model is applicable in a generalized e-Commerce scenario, where end-users, ISPs, payment providers, and a Public Key Infrastructure (PKI) determine the roles. Appropriate trust relationships between these roles are defined, taking into account common business practices and available protocols. Afterwards, this general model is directly applied to the IP telephony application scenario, which in turn cooperates with the MicPay project for the development of a micro-payment scheme. Work in the security domain considers, amongst others, the IP Security approach (RFC 2401-12) as well. The developed security architecture distinguishes between data flows and control flows and formulates three views. The reservation view involves the end-user (customer) and the closest ISP (access ISP). The service view determines an end-to-end relation between two customers and the intermediate ISPs. Finally, the clearing view encompasses the information exchange between the payee and the payer (either of the above defined roles), which depends on the payment scheme utilized. All of these views are based on the designed phases in the business model.

3.5 Business Model

Based on the technical necessity of roles and relationships, similar to the trust model assumptions, business roles have been defined. They encompass the end-customer and a customer premises network as well as two types of ISPs, access ISPs and core ISPs. Depending on these roles, the semantics of an SLA is interpreted and its content may vary. The business model itself introduces additionally the role of an e-commerce provider, offering services or goods in general. The business process as described in the model consists of four phases, each of which involving the determined roles and the utilized communication protocols. (1) The contracting phase sets up business conditions between business partners. (2) The reservation phase is applied to IntServ and establishes the service conditions and follows the reservation view as stated in Section 3.4. (3) The service phase corresponds to the service view and includes the actual performing of the negotiated service. Finally, (4) the clearing phase contains, dependent on the payment scheme negotiated, the payment and the billing process.

3.6 Demonstrators

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 signalling 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 signalling purposes between them in addition to the extended interface of RSVP (Resource Reservation Protocol). During the IP telephony usage charging informations are calculated within the router depending on its pricing model applied. These informations 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 the 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. In addition, the transport of video or audio flows between subnetworks, 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 signalling in DiffServ networks and of (ii) Service Level Agreement (SLA) trading. First, a set of detailed signalling 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 signalling than per-flow signalling. 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.

3.7 Key Achievements

The work in CATI and its proposed solutions is compliant as far as possible with a number of standards and quasi standard products as mentioned above. The proof-of-concept for a valid usage-sensitive pricing scheme as well as a suitable and efficient charging and accounting implementation has been performed by means of an IP telephony as a sample application. In particular, CATI has achieved up to now the following four key issues, ranging from important conceptual work and evaluations, including its documentation, to prototypical implementations:
- Definition of an integrated CATI scenario and architecture for IntServ/DiffServ models in support of charging, accounting, and VPN management mechanisms which is complemented by a security, a trust, and a business model.
- Development and evaluation of pricing and cost models for the Internet.
- Design and implementation of charging and accounting extensions in reservations which are demonstrated by a sample IP telephony application and a graphical user interface.
- Design and implementation of VPN service management based on a hierarchy of brokers which is demonstrated by a Web-based VPN configuration user interface.

4. Know-how and Technology Transfer

The IntServ model for the future Internet has been extended with charging and accounting mechanisms by defining new RSVP objects and performing first implementation steps. The close cooperation with the SNF MicPay project resulted in a demonstrator for the MicPay project which includes the trust model developed for CATI and MicPay jointly.

Besides these important technological developments, business cases are considered as well. They are concerned with the basics of packet-based networks, the Internet in particular, and are currently focussed on a flow-based approach of selling communication services. One of the major factors allowing the selling of these services is a set of pricing models, whose applicability and changes as well as extensions, in turn, are part of the CATI project.

These investigations are closely performed with the CATI project partner SWITCH, determining an Internet Service Provider in a university-driven market situation.

The architectural discussions of moving towards a DiffServ-based Internet environment are of importance to our industrial partner IBM. Therefore, the integration work of IntServ and DiffServ, its signaling tasks and mapping problems, SLA topics and handling mechanisms, and the integration of charging and accounting tasks is transferred.

Some upcoming SNF projects, such as ANAISOFT, INVENT, and StreamCom, will utilize some of the solutions developed within CATI and will combine mobile agent technology, workflow applications, and charged VPN services. Furthermore, a future European research project in the 5th framework program called M3I exploits the charging-relevant topics of CATI to allow for the investigation of market-managed multi-service Internet mechanisms and scenarios.

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An Electronic Market of Workflows

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Objective

Managing processes is crucial for efficient organizations. Groupware tools like Workflow Management Systems (WFMS) can provide a support by enabling explicit design of processes and automated tracking during execution. But more and more, processes span organizations boundaries, for instance when services are outsourced (e.g. development of a web site or shipping of products). How to coordinate internal and external resources in such cases? How to ensure that the selected service's provider will execute his part of the process in the expected cost and time and will match the needed quality?

The goal of ACE-flow prototype is to demonstrate that an electronic market of workflows can enable such support. Any companies, industry associations, trade associations, etc. that would see their cases demonstrated in ACE-flow project, can contact the authors of the project.

Outsourcing of services and inter-organizational process management

The outsourced service can be considered as a sub-part of a process initiated in the customer's organization. This process is composed of a set of tasks, one of them being the outsourced service. The outsourced task will produce a result that will be used by the customer's organization in order to complete its process. Thus, the whole process could be considered as an inter-organizational workflow that should be defined and managed in order to ensure that it produces the desired level of quality in time and budget.

Market-based management of workflows

In order to ensure that the outsourced task will meet customer's demand, services can be accessed through an electronic market managed by a third party. The customer's organization can look up for types of services that correspond to its need and place orders