A PROGRAMMABLE APPROACH TO RESOURCE CHARGING IN MULTI-SERVICE NETWORKS.

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Abstract: *A dynamic market is arising for telecommunication services, brought on by advances in technology and the growth of the Internet. This market is characterised by competition and innovation as service providers seek to differentiate themselves from their opposition. Network support systems will need to support this dynamic environment by allowing new services and business policies to be easily introduced. This paper argues for an active network or programmable, policy based approach to network charging in order to provide the support and flexibility which will be required. A policy based execution environment , PEACH, is described which allows charging polices to be located and executed in network elements and allows accounting and charging to be performed where needed in the network.*

1 INTRODUCTION

A dynamic marketplace for the provision of public Internet connectivity has sprung up worldwide in the last five years. Service providers need to be able to quickly introduce new services and to easily change existing services to gain the best economic advantage. Flexibility in the provisioning and support systems, including the charging and billing systems is crucial to support both rapid service introduction and adjustment of pricing models.

This paper proposes an active network approach to the provision of charging support in service provider networks. Charging policy is specified as a set of high level programs or rules deployed in a variety of network nodes including routers and other traffic handling network elements. New charging services and capabilities can easily be introduced in this way.

The next section of the paper discusses the role of pricing in networks and examines some contributions to the field. The paper then reviews the capabilities that charging systems must exhibit to deal with the demands of future networks and services and argues for a programmable approach. A model for resource based charging is then presented. This is followed by a description of a Policy Execution environment for Charging and Accounting (PEACH) which is a platform for policy formulation and execution. A test bed to validate the work is next presented and a comparison with other research is then made before the paper concludes.

2 PRICING IN NETWORKS

Network pricing serves primarily to allow an operator to recover costs and generate a profit. However the fundamental nature of packet networks allows for pricing to play a wider role including resource management and congestion control [1].

The statistical multiplexing capability of the Internet sometimes results in congestion and, when this occurs, some control mechanism has to be employed to allocate resources amongst competing users. In the field of economics pricing is the principal such mechanism and number of proposals have been made on the application of pricing to allocation of network resources at times of congestion[2]. Application of these ideas suggests a situation *of dynamic pricing* for Internet services i.e. the pricing of the service depends on the load in the network and will vary over time.

Pricing is also used to regulate network usage in a multi-service network. A multi-service network means that some packets will be given preferential treatment over others. For this reason it is not incentive compatible to charge all users the same. Otherwise everyone will benefit by declaring his/her packets to be the highest priority. Some form price discrimination must apply in order to gain the benefits from an integrated services network [3].

The emergence of e-commerce technologies makes it possible to dramatically alter the market for telecommunications services [4]. Trading protocols, intelligent agents and micro-payment techniques allows for a dynamic relationship between service purchaser and service provider, even for fixed users, and creates the possibility for new business and pricing models for service purchase. The ability to charge and pay in real time removes the need for generation and storage of call detail records [5]. Scenarios can easily be envisaged in which a service user conducts a 'reverse auction' with a number of suppliers (or consortia) to purchase a telecommunication session [4].

3 REQUIREMENTS ON CHARGING SYSTEMS

3.1 The need for flexibility

Network pricing is a wide subject area with a number of distinct sub-fields. Next generation charging systems face a wide range of demands. These systems must be able to charge for a broad array of services and resources using a variety of pricing models and charging schemes. They must flexibly be able to allocate costs to either sender or receiver and do so if necessary in real time. They must be able to interwork with both customer and other service providers charging systems. As well as being used for cost recovery they may interwork with the traffic control system to manage congestion in the network.

In order to be able to meet all these possible demands network charging systems will above all else be required to exhibit a high degree of adaptability and flexibility. These systems must be designed with change built in. It is our belief that a programmable approach to the provision of charging functionality is the best way to meet these demands.

3.2 A policy based approach

Pricing models associated with services reflect the business goals or *policies* of the service provider. In a dynamic marketplace these policies may be subject to change very often. Policies may also be customised or adapted to meet the needs of selected customer segments or even individual customers. A charging system must allow for the rapid introduction, modification and deployment of business policies.

Broadly speaking policy determines the conditions under which a service or resource should be accessed or used. Policy is often expressed using rule based formalisms. Rule based formalisms allows for business policy to be captured in small chunks and to be easily and quickly introduced into running systems. Rule based tables have long been used in the telephony network to express routing, charging and other policies ,[6] and interpreted rule based system are now being used in the Internet to express policies about QoS [7].

3.3 Distributed Policy Environment.

A policy based approach to providing network charging capabilities is in essence a programmable approach. A service provider prepares policy ‘programs’ which reflect the business goals he wishes to achieve and deploys that policy in his network in order to implement those goals. It will be necessary to place and execute policy in the most appropriate points in the network in order to meet varying application and network requirements. Some functions which will benefit from a dynamic distribution of policy include

- Dynamic charging and pricing
- On line electronic payment
- Charging for resources in multiple nodes
- Customer specific rating rules or discounts e.g. ‘Family and Friends’.
- Billing Fraud control

Possible distribution points include policy servers, routers, gateways and even customer equipment e.g. for customer specific rating rule evaluation.

3.4 Benefits

A programmable, policy based, approach offers many benefits. Firstly the system allows rapid introduction, or modification, of new policies to reflect changing market conditions. Secondly the system is open ended and can be adapted to new, and as yet unforeseen, business models or charging schemes. A programmable approach also allows for ease of interwork with third party charging , billing and payment systems.

Distributing policy elements in different nodes is a step forward from the existing client-sever or Intelligent Network (IN) approach and allows many possibilities which are difficult to achieve with traditional approaches. Dynamically deploying charging in different nodes allows a service provider to obtain an optimum tradeoff between service manageability and network performance. New capabilities and features may be introduced at points where they are needed. Customised services may be introduced on a selective basis. Different charging treatment may be accorded to similar flows based on the policies applied e.g. a flow which is part of a bundled service may be free while attracting a charge if used by itself. Locating policy in network nodes can also reduce the amount of signaling in the network e.g. when used for calculation of real time charges or in conjunction with network auctions where a user may install a policy to handle bids for resource access.

4 AN APPROACH TO RESOURCE BASED CHARGING

Resource usage charging is most suited to the use of services which require high levels of QoS and in particular to dynamically provisioned services.

A service which is charged for is said to have a *pricing model* which determines what is to be charged for and how charging is to be made. A *charging scheme* is the manifestation of a pricing model in the charging support environment. A charging scheme indicates a list of resources whose usage may be charged for in the course of usage of a particular service. Each resource so indicated has an associated set of *charging parameters* which define the quantities which are used to asses usage of this resource. A charging parameter has an associated set of *tariffs* which determine the rate at which a charge is accumulated. Each parameter also has a designated *meter* which is used to measure the parameter usage. Finally a charging *function* specifies a formula which combines parameter usage and tariff to determine a charge

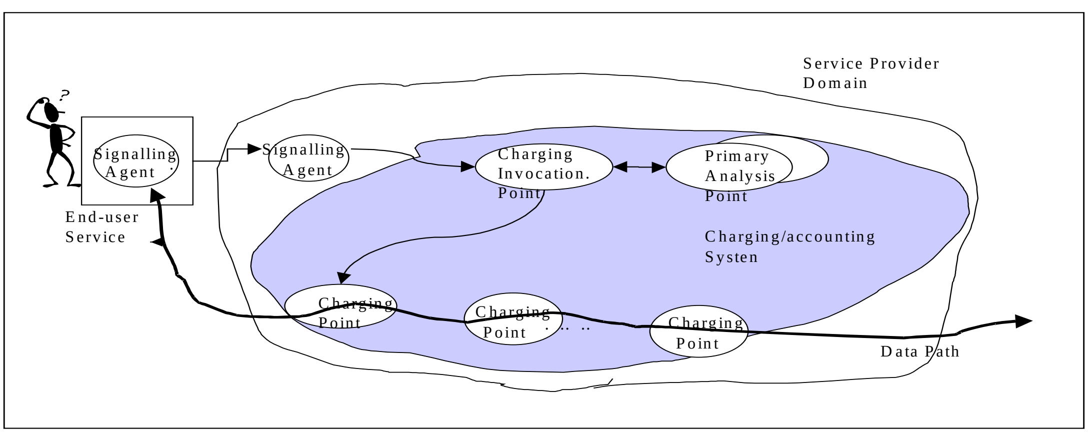
A resource based scheme is always associated with a flow and most often this will be the only resource to be charged. The definition of 'flow' can be made general enough to encompass many types of data stream. [10] proposes a general methodology which categorises flows based on a number of parameters:

directionality, one-sided vs. two sided, endpoint granularity, and functional layer. This approach allows both connection oriented and connectionless flows at different aggregation levels to be handled in a single, parameterisable, approach for charging, traffic measurement and other purposes.

We designate the charged flow the *primary* resource. We distinguish between *primary* and *secondary* charging. Primary charging involves charging for the call or flow at or near the edge of the network in a designated *primary charging centre*. This is considered to be the general case and apply to the majority of charged service sessions. Secondary charging entails charging for resources other than the primary resource. These resources may be located in the same or other network elements. Distributed charging of this kind can be enabled by embedding a charging specific marker in the signaling information for the flow and passing this marker to local charging modules in the network elements. When an active charging node reads an incoming policy element it will invoke the appropriate policy ruleset. The node will maintain a table of installed policy rulesets and will dynamically download new rulesets not already installed.

Policies may be invoked on a per signaled flow or for a service class aggregate. They can be triggered by instruction in the data plane or by request from the management plane. They can also be triggered via timeouts.

Policies are installed, activated and removed from active charging nodes on instruction from a policy management centre. Policies are identified by a policy class and number. They may be grouped into policy sets for management purposes. Policies are typically managed in a group of policy nodes by multicasting instructions to a policy node group. The application of these ideas to a signaled flow is shown in the diagram below :



Resource based charging for a Service session

In this picture the user on the left has requested a flow with a certain QoS level. The request is conveyed to the primary analysis point (PAP) where a decision is made about how to proceed. If charging should occur the primary charging point is configured with the necessary details (in the diagram the charging point nearest the user). If secondary charging is indicated a policy element is injected into the signaling protocol and conveyed thereafter to the secondary charging nodes

The Charge Invocation Point (CIP) is really a service access point , ('well known address') or API which a signaling or management agent can use to access the charging system functionality. The PAP is a charging policy server which contains policies relating to how services should be charged. The PAP is always invoked by the CIP from the network edge..

The charging point contains functionality to measure and record usage data and optionally to charge for such usage. It maintains state for each flow it charges for the lifetimes of that flow. For each flow there will exist one or more *Meters* which measure parameter usage. The meter encapsulates all resource specific functionality and provides a generic interface to the charging system. Each meter must be configured to indicate what is to be measured when the session is set up. Some charging parameters have dynamic tariffs which may change during the course of a session. The charging point will contain *Tariff* policies and Policy Components for these tariffs. Usage data is output (logged) each time the tariff changes or , for real time billing, charges are updated.

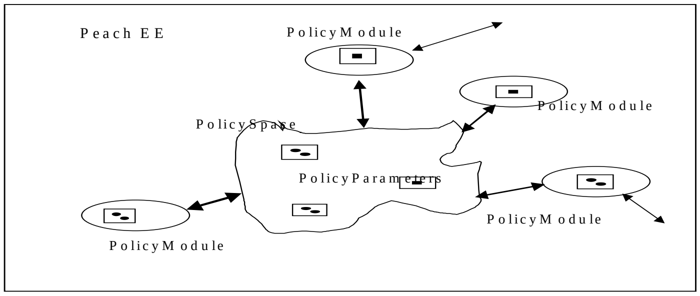
A charging architecture based the above functional entities enables the earlier benefits of a distributed policy based approach to charging to be fully realised.

5 PEACH – A POLICY EE FOR ACCOUNTING AND CHARGING

Active Network research [11], [12] points the way to find a general and flexible programming model to formulate and execute policies in the active charging nodes. Active network environments are described by execution engines (EE) which define a programming interface or virtual machine that allows users to control the active network. One of the primary concerns of active networks is how to enable *service composition* i.e. how software components can be bound together to enable compound services [11],[12].

Much activity in an active charging approach is concerned with data analysis and comparison. Matching the diversity of new services and flexibility in business choices, a wide variety of data types and sources can be anticipated in active charging nodes. Equally a wide variety of action types can be envisaged. A data driven approach therefore provides the best framework service composition in active charging nodes. A data based approach decouples service components from each other. This makes them relatively independent of each other and promotes reuse of existing modules in new services. Further it firmly places the business logic in the policy ruleset where it belongs and may be easily changed.

PEACH is a proposed EE for formulating and executing policy in active charging nodes. It is based on a *shared data control* [11] or *data driven* [13] approach to service composition. Data driven coordination models provide an service composition metaphor through the idea of a *Shared Dataspace* or *blackboard*. A shared data space is a common data structure to which all components in the computation have access. The diagram below gives a conceptual view of this idea in a PEACH EE in an active charging node.



Shared Data Space concept in a PEACH active charging node

The data space , *PolicySpace*, contains a set of shared parameters (*PolicyParameters*) which are read and written to by service components, *PolicyModules*. An incoming message or query to the active charging node causes an appropriate policy program to be invoked and this policy program acts as the composition program which invokes various policy modules as described above.

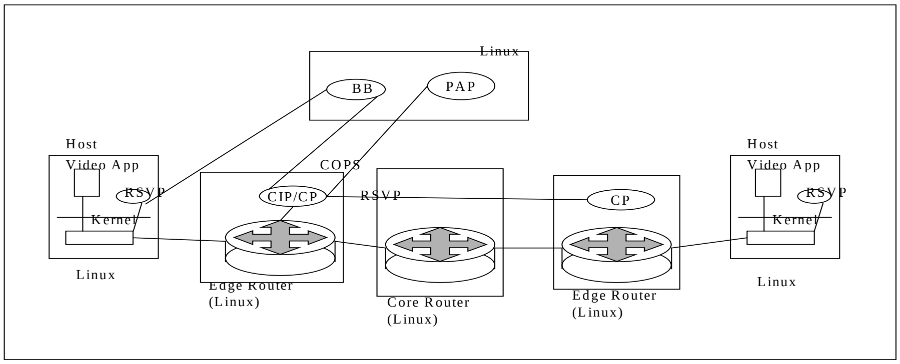
To meet the needs for new service introduction extensibility to PEACH is provided in two ways:

- Users may extend the policy space by defining their own policy parameters. This allows for analysis of a wide range of service types.
- Users may define their own policy modules allowing them to hook in arbitrary data sources(e.g. LDAP directories, databases) and to provide formalisms other than rule sets for analysis. PEACH will provide a 'pluggable' framework which supports addition and inclusion of policy modules at runtime.

PEACH is implemented in Java. It provides a data driven execution engine which will facilitate the introduction of flexible, extensible based charging schemes.

6 VALIDATION

The ideas described above are currently being tested on a Diffserv based testbed shown below. This represents a single network provider domain with two stub networks (i.e. the edge routers connected by a transit network (i.e. the core router).



Charging Architecture Test Bed

The test apparatus enables us to validate the applicability of an active approach to network charging in a variety of scenarios including:

- Sender or receiver based charging
- Dynamic pricing schemes
- Real-time charge display and payment
- Bundled services charging

The validation scenarios are chosen to prove that PECAH can address a wide variety of charging situations and to allow major changes to the charging schemes to be introduced quickly. A variety of charging architecture configurations will be used. The configuration shown in the picture above is for ‘sender based charging’.

In the picture Charge Invocation Point (CIP) is combined with the Charging Point (CP). The CIP is accessed by the Bandwidth Broker (BB) using a CIP API library which in turn uses a sockets interface to communicate with the CIP. COPS is used as the protocol to connect the CIP and the Primary Analysis Point (PAP). In this case the CIP is acting as Policy Enforcement Point or PEP [14]. RSVP is used to signal between the host and the BB.

7 RELATED WORK

A number of proposals for charging and accounting have been published which address the same area as PEACH.

SUSIE is an ACTS project which aims to investigate the ‘convergence’ of IP multimedia charging in the context of a usage charged ATM network.The application of the model to Internet services is explored in [9]. SUSIE proposes a policy based architecture which is based on a data collection and processing approach to charging, in contrast to the active approach of PEACH.

Arrow, [8], is a charging and accounting system suggested for an Integrated services Internet.. Arrow features a layered architecture which includes a policy layer in which different logic modules may be placed to implement various pricing schemes. Arrow shares the same goals as PEACH i.e. the need to have a flexible and adaptable charging system.

AIACE [15] describes a framework which allows charging logic to be flexibly deployed between network nodes and accounting servers. It features an accounting co-processor which resides in routers and other network elements. Accounting ‘plug-ins’ are used to perform accounting tasks on behalf of accounting servers and may be dynamically loaded. AIACE aims to create a more efficient , flexible and open accounting system. PEACH is similar in many aspects to AIACE but features a more programmable approach and has a more specific focus i.e. rapid modification of charging logic to reflect changes in business policies.

[16] proposes a radical and novel approach to network charging by deploying the accounting and charging functionality on customers systems. PEACH shares the same goals of creating a flexible and customisable charging environment but can be considered a more evolutionary step.

8 CONCLUSION

Packet based multi-service networks introduce a lot of complexity into network charging both because of features of the underlying technology and the diversity of services which they make possible. Charging systems in multi-service networks must be flexible and adaptable in order to introduce new pricing models and reconfigure existing ones. We have introduced an active network based policy architecture which allows for the rapid deployment of policy to network nodes and allows for easy configuration and customisation of associated pricing models.

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