AUTOMATED SLA NEGOTIATION FOR WIRELESS UBIQUITY

A Secure Approach

Les Green
Faculty of Information Technology, University of Technology, Sydney, P.O. Box 123, Broadway, NSW, Australia
lesgreen@it.uts.edu.au

Keywords: Billing, Ubiquity, Authentication, Speculation

Abstract: This document explores the financial system for automatically negotiated service level agreements. Focus is placed on billing and a solution is proposed based on autonomous, negotiating agents. Security, non-repudiation and authentication issues are addressed, along with the role of speculation and aggregation within the system.

1 INTRODUCTION

New Generation Networks attempt to offer additional benefits to both consumers and providers in the telecommunication value chain. They are designed to enhance End User Quality of Experience (QoE) by providing greater choice of services, breaking the traditional fixed service offerings and allowing the user to do what they want, when they want, where they want at a given price. Service Providers stand to benefit from these customised service offerings through the ability to gain additional income from the value added services.

Research has suggested [1] that the current cost of providing and maintaining a mobile network billing system may be anything up to 50% of the total infrastructure investment and annual turnover. Seamless, automated billing which can provide added value to the service delivery chain is therefore a large concern for current and new generation network operators.

This document discusses a billing framework to support the delivery of customised Service Level Agreements; addressing security, authenticity and validity of the different entities involved in the economic system.

This work is part of a greater project exploring service ubiquity through electronic negotiation, titled "Managing Quality of experience Delivery In New generation telecommunication networks with E-negotiation" (QDINE)[1].

[1] http://qdine.it.uts.edu.au

Section 2 discusses the problem background and the role of aggregators and speculators in a billing system, a solution is proposed in section 3, highlighting the interactions between actors in the system. Section 4 introduces future work.

2 THE PROBLEM

Within ubiquitous service availability, an end user is free to roam within the constraints of possible network connectivity. Consequently, application services utilized by end users may be delivered via any number of network service domains. The owner of each domain involved in the delivery path at any given point in time will want to be reimbursed for the services it has provided.

Previous work towards a Service Level Agreement (SLA) negotiation framework [2][3] provides a cascading model for user billing domains. A benefit of the cascaded service agreement model is that an end user need only be concerned with billing between itself and the domain to which it is directly connected. Additionally, only domains which offer end user connectivity need to support user billing.

Users desire simplicity and predictability [4]. In terms of billing, an end user will not want to pay individually each domain which has provided (a fraction of) a network service. This opens the way for billing aggregators and speculators. Billing aggregators package provided services into one bill whilst speculators speculate on future costs and so quote a fee for some future period. Say the next six months. Section 3.4 discusses the role of speculation in greater depth.

A player may be both an aggregator and a speculator, with end users appointing such a player to manage billing on their behalf. Given a larger buying power than a single end user, the speculator or aggregator, following referred to as a Billing Provider may negotiate for bulk rates from network providers. A billing provider may be a user's home network service provider or a third party billing provider.

Additional advantages for billing providers are also possible, such as the ability to offset loss and form strategic alliances. Such alliances may provide free partner traffic or other incentives, and may give greater marketing leverage to billing providers.

The way in which an end user is charged by, and pays the billing provider is tied directly to the marketing strategy chosen and therefore unspecified. However, ***the way in which a billing provider is charged from service providers for services used by an end user*** is the interesting research point that is addressed here.

With the increase of global wireless connectivity via a multitude of available access technologies, both in the licensed and unlicensed radio frequencies, it is not feasible for a billing provider to have pre-negotiated service agreements with every possible network access provider around the world into which an end user could roam. Ubiquitous service availability may require user connectivity from a domain with which a billing provider is unfamiliar. We are left with issue of establishing a valid billing path for a service.

3 A POSSIBLE SOLUTION

In consideration of the above requirements, a method is proposed whereby an end user, or more precisely a user agent is responsible for negotiating service contracts autonomously, and is supported by a means to verify its trust in an unknown network. Every user has an associated Billing Provider, whose status as a trusted and reliable player is generally known. The Billing Provider is responsible for authenticating the user agent to foreign networks as required.

Many business processes occur to deliver valid bills to end users for a particular service. The financial system in telecommunications networks can be broadly defined as the following path.

Pricing → Accounting → Charging → Billing → Payment

Pricing is the process in which a concrete pricing model instance for the use of a particular service is defined. Accounting involves recording use of a particular service. Charging is concerned with generating costs based on the pricing model and service accounting data. Billing is the process of delivering those costs to the consumer of the service or resource. Finally the consumer must pay the provider for a given service.

This paper discusses the pricing and billing components of this chain. The accounting, charging and payment components are also important but are not discussed here due to space constraints.

3.1 Billing Security

An electronic bill for some good or service is worth no more than the cyber space it occupies, unless all parties concerned can be sure of the bill's authenticity. To ensure an accurate and valid billing process, many requirements must be met to produce and deliver authentic bills.

1. All parties must be Authenticated
2. The Agreements must be valid and binding
3. The charges must be verifiable
4. When required, communication must be secure and Non-Repudiable.

Accordingly, the billing framework is designed with security, authentication and verification as a primary influence.

3.2 User Authentication

Borrowing from Internet Single Sign On (SSO) technologies[5][6], the following User Agent authentication model is proposed, based on asymmetric encryption[7][8]. Refer to Figure 1 for a diagram of the below points.

1. The user generates a public and private key pair and registers the public key with the Billing Provider. This step only happens once and may be performed manually by the user via a web interface on the billing provider's website or by any other means.

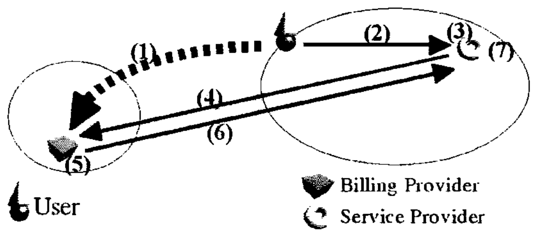

Figure 1: User Authentication

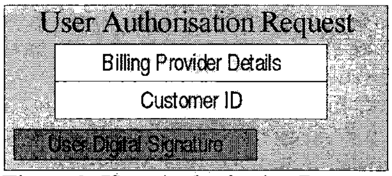

Figure 2: User Authorisation Request

User public keys remain valid throughout a specific time period. All entities in the negotiation environment should have synchronised clocks within a broad tolerance to ensure correct authentication. This requirement is easily satisfiable using the existing and widely used network time protocol [9].

2. When a user agent wants authorisation to request services from a provider, it creates a User Authorisation Request (Figure 2) comprised of its billing provider details and customer identifier and sends it to the service provider.
3. At this point, the Authorisation request may be rejected by the service provider for any reason such as a banned billing provider or maybe because the service provider is simply too busy.
4. The service provider then builds a User Authentication Request (Figure 3) from the original signed User Authorisation Request and includes a request for the Billing Provider's Identity Credentials (Digital Certificate) if the identity of the billing provider is not known in advance. The Authentication Request is then sent to the billing provider.
5. The billing provider checks the User Authentication Request by validating the signature on the enclosed User Authorisation Message against the stored public key on the customer record.
6. If user authentication is successful, the Billing Provider returns a Success Message (Figure 4) bundled with the user's public key and a Service Provider Billing Authorisation which authorises the Service Provider to issue bills for the supplied public key. The Billing Provider's credentials are also supplied if initially requested, to certify the billing provider's identity.

The billing provider must, for each customer, maintain a list of Service Providers which have been authorised as billers for the particular customer's public key. This is to ensure that if for some reason the customer's purchasing rights are revoked, or the secrecy of the private key associated with the public key has been breached, the Billing Provider can contact each Service Provider to revoke the public key.

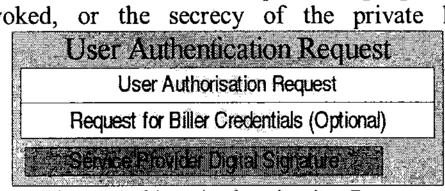

Figure 3: User Authentication Request

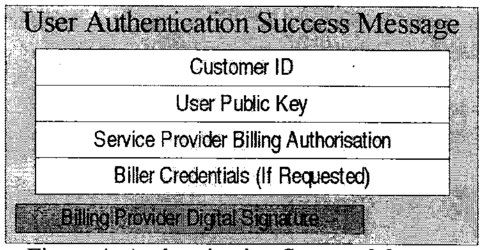

Figure 4: Authentication Success Message

The Billing Provider must receive proof from each Service Provider it has registered as an authorised biller that it has acknowledged the revocation of the public key. One appropriate means of non-repudiation is through the use of digitally signed messages in concert with valid Digital Certificates. A Billing Provider cannot claim it did not have a particular service provider registered as a recipient of a key because the User Authorisation Success Message provides a digitally signed proof that a service provider was given authorisation to send the billing provider bills signed by a particular public key.

7. Upon receiving a success message, the service provider validates the billing provider's credentials. The returned user's public key is used to validate the signature from the initial User Authorisation Request received from the User Agent. On successfully passing authorisation, a billing path for future services is established, and the user can proceed to request services from the provider.

Users' public keys are stored by service providers for use in validating future Service Level Agreement (SLA) requests. In this way, the service provider need not validate with the billing provider for each SLA provisioned.

3.3 Pricing

Pricing is concerned with generating the instantiated values to be used within a charging model.

Pricing of service level agreements in the QDINE framework is not limited to one specific pricing mechanism. The pricing mechanism for any particular SLA instance is encapsulated within prices quoted on the SLA.

The actual mechanisms used to generate individual prices to be used in an SLA offer are implementation specific. The QDINE project has developed an intelligent pricing mechanism based on limited supply and the pre-emptive capability of differentiated service networks[10] for use in testing the billing framework. The pricing mechanism adopted by a service provider will be based around that service provider's business model. The billing framework is designed to be independent of any specific pricing mechanism.

3.4 Speculation

Speculation can play a major part in pricing of any good or service. To understand the role speculation may play in the QDINE project, existing telecommunication trading is examined.

Beginning around 1998, bandwidth commodity markets such as Band-X [11], Arbinet [12] and Bandwidth Market Ltd [13] have emerged, trading point to point bandwidth as a commodity on an open market.

Unlike the majority of traded commodities such as gold or electricity, spot bandwidth is a temporal, non storable commodity [14]. As such, it cannot be purchased today, stored and released back onto the market at a later time. If it is not used when purchased, it is lost.

Financial market speculation involves buying, holding and selling a financial asset to benefit from fluctuations in price. Due to its non-storable nature, financial bandwidth speculation does not lend its self to spot markets, but to derivative markets such as futures and options.

Using futures and options, a speculator can manage risk in a market place by purchasing SLAs for future time periods, or purchasing the option to buy or sell predefined SLAs in the future at a predetermined price.

Success of bandwidth markets and exchanges has been limited for a number of reasons. Firstly, network operators do not want their main source of income, i.e. Bandwidth, to be devalued and sold as a simple commodity with no product differentiation. Additionally, lack of standardised contracts and negotiation protocols for bandwidth trading has been a problem, along with long provisioning cycles once trades have occurred [15].

The QDINE service negotiation framework does not aim to commoditise network bandwidth. However, services will be specified in a common format. It can be assumed that within a distributed, open, well defined SLA trading environment such as the QDINE framework, speculation over network services will occur.

Three types of speculation are identified.

1. If an asset is to be purchased and held for a period of time, speculation is made on the value of that asset for the duration of the ownership.
2. If an asset is purchased to be divided into smaller lots for resale, there is speculation on the future value and demand of the divided lots.
3. "Pure" financial market speculation, involving the purchase, holding and selling of a financial asset to benefit from fluctuations in price.

Below are the speculative activities carried out by a billing provider in the QDINE project.

3.4.1 Customer Side Biller Speculation

The billing provider (BP) speculates on service use by a customer over a future period and offers an agreement for some future service period to one or more of its customers. A simple scenario of customer side speculation is outlined below.

- Billing provider proposes a deal to a customer - "You can get 30 hours of grade 1 video conference per month from any of {Optus, Telstra, Vodaphone} during the next month for $30.
- If the customer accepts, the User Agent then knows it will cost $1 per hour for the first 30 hours from the specified providers for grade 1 video service.
- The User Agent negotiates as normal for services, receiving quotes for current market prices for requested services. The User Agent knows however, that within its first 30 hours for the month for grade 1 video calls prom participating providers, no matter what the actual price negotiated is, the cost charged to the User Agent from the billing provider will be $30 for that month.
- When requesting a service, the User Agent must rationalise, based on many factors, possibly including average monthly use and current price whether or not to choose one of the alliance service providers from the pre-arranged deal to deliver the service. Possibly at some times, the User Agent will have no available alternative but to use an alliance Service Provider. Therefore even though the current price may be only 80¢ per hour, the user will be charged $1 per hour for that period.

This type of customer side speculation is common in today's service offerings, such as 100 hour free weekend talk time or such.

3.4.2 Provider Side Biller Speculation

The billing provider speculates on how much of a particular service type its customers will use for a future period, and may pre-purchase such a service from Network Service Providers.

A particular Billing Provider may decide to pre purchase 10,000 hours of grade 1 video conference from service provider "A" at a price of $1 per hour to be used over the next month by its subscribers.

Depending on the billing method adopted by the service provider, the pre-negotiated cost could be specified by the service provider on the bill sent to the Billing Provider, along with the signed SLAs, or the Billing Provider could be responsible for applying the speculated costing on reconciliation of the bill.

3.5 SLA Request Process

As described above in section 3.2, previous to requesting an SLA, the user agent has been authorised by the service provider as a customer of a particular billing provider. This allows any SLA signed by the user agent to be authorised immediately by the Service Provider without needing to contact the billing provider.

If a user's public key has changed between authorisation and an SLA request, the cached public key will not validate against the SLA request signature. The user authentication procedure must be repeated to establish user identity.

As outlined in the negotiation mechanism from [2], negotiations towards an acceptable SLA including pricing is performed.

During the negotiations, once a user agent accepts an SLA offer, it signs the SLA and returns it to the Service Provider. If the Service Provider agrees with the parameters on the signed SLA, it stores the SLA and activates the service.

3.6 Billing

The billing process allows new foreign network Service Providers to form billing relationships with unknown billing providers associated with roaming users. To establish a trusting financial relationship, billing providers and service providers should be certain of each others identity and must agree on other billing details such as invoicing frequency and payment method employed. Discounting specifics and other pricing related details may also be included in a billing method.

Payment methods adopted may be be a bank routing and account number, credit card number or any other of the numerous payment systems available. Payments are not addressed further in this project. It is sufficient to say that at Biller/Service Provider negotiation time, the payment method to be used should be defined. ISO 20022[2], IFX[3] and Rosettanet[4] all offer tools to mark up payment information.

Authentication of Billing Providers to Service Providers is done during User Authentication, however other specifics of the billing method adopted between service provider and billing provider should not be limited to a single implementation, ultimately they should be based on individual provider requirements. However, a basic process for establishing or "bootstrapping" the billing process needs to be common amongst participants and is specified below.

The Bootstrap Mechanism. The mechanism used to establish a billing method between the service provider and billing provider is built around the process of each party aiming to fulfil its own requirements for the final billing method specification. The mechanism to establishing the billing method occurs in three stages.

1. Initially, each party informs the other of a list of ontologies which it can understand, and in which the billing method may be specified.
2. In the second stage, the service provider informs the billing provider of the information it requires to bill for services. The billing provider then constructs a billing method template including components satisfying the informational requirements of the service provider, and components satisfying its own requirements of a billing method. The billing method template constructed is composed of ontological elements common to both sets of ontologies specified in step 1.
3. The third stage in establishing a billing method is forming an agreement on the concrete values to be used in the billing method. This stage follows an offer / counter offer / final offer argumentation strategy at which point either the negotiation succeeds and the outcome is a concrete billing method instance, or the negotiation fails and the service provider may not provide services to the billing provider's customers. A Service Negotiation Protocol (SrNP)[16] has been proposed by the TEQUILA[17] and MESCAL[18] projects and is well suited to this argumentation component.

A billing provider may also be a network service provider – and hence at some point may act as a

[2] http://www.iso20022.org/

[3] http://www.ifxforum.org/

[4] http://www.rosettanet.org/payment

Service Provider to the foreign Service Provider's home customers. Both parties have something to gain by establishing an optimal agreement.

At initial Biller-Service Provider relationship establishment, for instance when a customer of a Billing Provider wanders into a unknown Service Provider's zone and wishes to use its services, the Service Provider and Billing Provider have a requirement to establish ***some sort*** of agreement ***before*** the user can use the services. This may be relatively urgent. The Service Provider may have a "base" pricing scheme which is used when it has accumulated little or no information on the Billing Provider or User. The Billing Provider is left in a take-it-or-leave-it situation with the service provider until a stronger relationship can be formed.

In contrast, adjustments to the billing method formed between a service provider and billing provider are infrequent, may have no strict time requirements for convergence, and presumably happen over high speed network links. A more complex and optimal negotiation strategy can therefore be employed.

4 CONCLUSION AND FUTURE WORK

This work has explored the need for a comprehensive and open billing solution, required for ubiquitous service delivery to mobile and fixed users. Service billing is examined in a broad context with focus placed on managing secure and binding relationships between involved entities.

A billing solution based on negotiating electronic agents is presented, describing the process used for authenticating and authorising involved entities. Further discussion of the key components in a comprehensive billing solution is also made.

An interesting component of this research is the consideration of speculators and aggregators in the billing process. The introduction of a Billing Provider to promote security and encapsulate much of the speculation is an innovative component with respect to current state of the art.

Work has been done in developing a communication set based on open protocols and a shared ontology. A framework has been previously designed for SLA negotiations. Future work will see the integration of this ubiquitous billing work into the SLA negotiation framework towards a seamless, open, service delivery platform. During this implementation, the scalability of the approach will be examined.

This research is performed as part of an Australian Research Council Linkage Grant, LP0560935 between Alcatel and the University of Technology, Sydney. It extends work already performed on the Negotiation of Service Level Agreements for New Generation Networks, performed as part of the Alcatel Research Partnership Program (ARPP).

REFERENCES

[1] Cushnie, J., Hutchinson, D., Oliver, H., 2000, *Evolution of Charging and Billing Models for GSM and Future Mobile Internet Services*, QofIS '00: Proceedings of the First COST 263 International Workshop on Quality of Future Internet Services, London, UK

[2] Green, L., 2004, *Auto Negotiation of Service Levels for NGNs - T2D2 - System Architecture*, University of Technology, Sydney

[3] CADENUS - Creation and Deployment of End-User Services in Premium IP Networks, *Source:* http://www.cadenus.fokus.fraunhofer.de/, *Accessed:* 26 November 2004

[4] Nielsen, J., 2000, *Designing Web Usability: The Practice of Simplicity*, New Riders Publishing, Indianapolis

[5] Josephson, W., Sirer, E., Schneider, F., 2004, *Peer-to-Peer Authentication With a Distributed Single Sign-On Service*, Peer-to-Peer Systems III, Third International Workshop IPTPS 2204, San Diego, CA

[6] The Java Open Single Sign-On Project, *Source:* http://www.josso.org/

[7] Hellman, M., 2002, *An overview of public key cryptography*, IEEE Communications Magazine, *vol.* 40, *num.* 5, *pp.* 42 - 49

[8] Kaliski, B., 1993, *A Survey of Encryption Standards*, IEEE Micro, *vol.* 13, *num.* 6, *pp.* 74-81

[9] Mills, D., 1992, *RFC 1305 - Network Time Protocol (Version 3)*, University of Delaware

[10] Debenham, J., 2004, *Auto-Negotion of Service Level Agreements*, University of Technology Sydney,

[11] Band-X, *Source:* http://www.band-x.com/en/

[12] Arbinet, *Source:* http://arbinet.com/

[13] Bandwidth Market, *Source:* http://www.bandwidthmarket.com/

[14] Chiu, S., Crametz, J., 1999, *Taking Advantage of The Emerging Bandwidth Exchange Market*, Oncept Inc.

[15] Borthick, S., 2001, *Bandwidth Trading: What's In It For You?*, Business Communications Review, *pp. 26-30*

[16] *MESCAL Deliverable 1.2, Source: http://www.mescal.org/deliverables/MESCAL-D12-public-final.pdf*

[17] TEQUILA - *Traffic Engineering for Quality of Service in the Internet, at Large Scale, Source:* http://www.ist-tequila.org

[18] MESCAL - Management of End-to-end Quality of Service Across the Internet at Large, Source: http://www.mescal.org