On Applications and Profiles for Policy-based Pricing of Ubiquitous Services

Sayan Kumar Ray
Faculty of Business and Information Technology
Manukau Institute of Technology
Auckland, New Zealand
Email: sayan.ray@manukau.ac.nz

Jairo A. Gutiérrez
School of Computer and Mathematical Sciences
Auckland University of Technology
Auckland, New Zealand
Email: jairo.gutierrez@aut.ac.nz

Abstract

Next-Generation Networks are increasingly ubiquitous and one of the challenges users face is the lack of a convenient mechanism and standards to access every day services. Dynamic pricing, which changes according to context and demand, and ad-hoc engagement with network services providers, are solutions in the right direction. This paper continues the exploration of a user-oriented pricing approach for next-generation networks where pricing for services will not be governed by long-term agreements but will be based on ad-hoc usage (policy-dependent), short-term agreements and spot-pricing (and payment). Based on the usage, the users will make decisions on what to pay and who to pay for the best service they require. These new approaches allows multiple competing access providers to dynamically determine prices for services, broadcasts those tariffs and automatically negotiate a spot contract with a software agent running on the user´s device. The paper also discusses our thoughts on the range of services and users´ profiles required to deploy a working prototype.

Keywords

Ad-hoc service contracts, user-centric services, users' profiles, policy-based management, policy-based pricing, dynamic pricing and service classes, 5G networks.

INTRODUCTION

With Next-Generation Networks users will expect to be offered different types of services (e.g., VoIP, high speed media streaming, Internet browsing, application usage, content-oriented access scenarios etc.) and they are expected to roam seamlessly and, for a particular service, they are expected to choose the best-possible connection (Bellavista et al, 2002; Louta and Bellavista, 2013). This connection would be the most affordable option which satisfies the user requirements at the time and place they are trying to connect from. One of the keys for the success of such ubiquitous services is the issue of assigning proper prices for those services.

Using the right pricing strategy, an operator will try to obtain the highest possible revenue while the users will try to get the service they require at the minimum possible price. Now there could be situations where potential users may not have any contractual agreements with all the different network operators involved when trying to access the required services through the best underlying network. How would the pricing and billing for such a scenario work? Also, there could be situations where multiple underlying networks are offering a particular service which meets the user requirements (including competitive rates). How would such rates be communicated to the potential customers, how would they choose among them and how would the customer commit to a particular provider? Is it possible for users to sign spot agreements or short-term agreements dynamically with different operators so that they can access different services as and when required at the best affordable rates? Although, the tendency of traditional "telcos" is to keep the pricing and billing structure as simple as possible, in future generation networks, where things are most likely to be user-controlled, such traditional long-term contracts with customers are likely to be challenged by other arrangements that offer more flexibility to the users. However, that flexibility and the requests from many potential customers means human operators cannot hope to cope with the updating of the several context information and rules needed to satisfy changing conditions.

This paper explores a user-oriented pricing approach where pricing for services won't be governed by long-term agreements but will be based on ad-hoc usage (based on certain policies), short-term agreements and spot-pricing (and payment; Beltran et. al., 2010). Users will choose the ideal option available for the required service, will decide on how long to use the service for (it could even be for a short period on an 'as and when required' basis) and will make decisions on what to pay, who to pay and even how to pay for the best service they require. This information will be pre-configured in a user's profile and a software agent sitting on the user's handheld device will execute the whole procedure automatically based on this information. This approach is now possible as a result of a range of evolved broadband wireless access standards and technologies, autonomic communications, new pricing schemes and policy-based management (PBM) techniques. This new landscape also allow multiple competing services providers to dynamically assign prices and poses new and interesting challenges to regulators.

In Gutierrez & Ray (2014) we discussed the dynamic characteristics of pricing network services and the policy-based techniques to price ubiquitous network services. We also explained how our proposed policy-based pricing scheme may work in a heterogeneous networking environment. In this paper we will explore the different types of applications and services that could be provided with such a platform, and we'll illustrate the operation we envision with a mini case based on a particular set of policies.

DIFFERENT APPLICATIONS AND SERVICES

The next-generation of networks (e.g., Fifth Generation or 5G) will have to support an increasingly diverse set of services, applications and users, all with extremely diverging requirements for work and life. The different applications and services could be broadly classified under the following classes:

- Real-time: delay intolerant "live" feed; usually based on the UDP protocol.
- Streaming video: buffering and playback features
- Non-real time: delay tolerant services; usually competitively priced.
- High-speed multimedia/gaming: interactive, delay intolerant, high Quality of Experience expected.

Additionally, the following types of services are common among Internet users:

- *Watching video on demand*: These services are generally bandwidth hungry and consume significant amounts of battery power; they could be expensive to run and require uninterrupted connectivity.
- *Browsing the internet*: Basic service with minimum demands on speed and bandwidth requirements.
- *Making a Skype call or other telephony and video telephony application:* These services are generally Constant Bit Rate (CBR) with moderate bandwidth and high availability requirements.
- *Playing online games:* These services are generally Variable Bit Rate (VBR) and bandwidth hungry. They consume significant amounts of battery power; they could be expensive to run and require uninterrupted connectivity.
- *Writing emails:* Basic service with minimum demands on speed and bandwidth requirements.
- *Reading online:* Basic service with minimum demands on speed and bandwidth requirements.
- *Listening to music online:* These services require moderate bandwidth and reliable connectivity.

WORKING WITH PROFILES

For each service, a user may have different profiles set up in his/her smartphone for ease of access. Depending on the service, the profiles may feature the following primary interests (profile preferences) and an associated set of corresponding quality levels.

- *Type of profile*: What type of service is the profile defining? This is in reference to the services outlined in section II.
- *Level of Quality of Service (QoS) expected for the service:* What should be the level of quality of service which is expected from the underlying networks for a particular profile?
- *Distinctive (QoS) features for the particular service:* Which QoS features expected in terms of availability of bandwidth, traffic load, congestion, delay, and jitter?
- *Affordable Tariffs*: What is the limit to the maximum price that the customer is willing to pay for a particular service?
- *Ways of Charging:* How would the customer prefer to get charged for the service bought? The different types of charging could be:

- *Flat rate charging:* a fixed amount of charge irrespective of the usage;
- *Metered charging:* the charge would vary in proportion to the usage depending on either the bandwidth usage or the period of usage;
- *Flat up to a cap then metered:* the user should not exceed the usage over a predetermined limit and will be charged at a flat rate for that usage; any excess 3tilization will be charged at a premium;
- *Paris Metro Pricing (PMP):* PMP adds the concept of traffic classes in order to provide different qualities of service. This mechanism was developed by Odlyzko (1997, 1999). The main idea is to divide the available capacity among several logical networks which are then assigned different prices. Users pay higher prices when they deem it necessary, and thus automatically classify the traffic among the several available networks (Gutierrez, 2008).
- *Priority pricing*: The key to these systems (Shenker et al., 1993; Gupta et al., 1997) is the use of priorities when requesting services. The charges are calculated according to those priorities. With this type of scheme, it is crucial to have an effective price strategy, because otherwise users are tempted to label most traffic with the highest priority possible. One of the great advantages of this scheme is that IP has been equipped to deal with priorities since its early days: Version 4 of the protocol has a priority field for each packet transmitted; the use of that field has been included in all the important QoS frameworks proposed by the Internet community.

- *A preferred underlying technology/operator:* What would be the user's preference in terms of a favourite service provider? However, this is an optional feature since it is not necessary for the proposed dynamic pricing scheme to work.
- *Location of the user device:* What is the current location of the device in relation with the underlying networking infrastructure? For instance: closeness to a 3G-4G/WiMAX base station, or a WiFi access point. The value stored will indicate the level of transmission energy consumed by the device's battery and details about the received signal strength (and quality).
- *Remaining battery life (to support power utilization efficiency):* How much battery power would be consumed if the underlying base station or router of choice is located far away from the device? Are there any other options to connect if the device is running low on battery? Additionally, if the underlying base station (or router) is congested, the device's battery may drain more quickly if connected to that station.

The following shows some of the potential profile configurations that a user may create and store in the smartphone/device. These configurations would be matched against the tariffs broadcast by the providers, as detailed in Gutierrez & Ray (2014), and a suitable connection would be automatically selected and accepted by the software agent running on the device.

1. *Video on Demand:*
   - High bandwidth required,
   - Low cost connection required (this may also include a maximum tariff that the user wishes to state for the particular service),
   - Less loaded connection required for uninterrupted QoS (i.e., network reliability should also be taken into account),
   - Connection should be present locally in order to consume less battery power
   - Charging should be usage-based, i.e., metered charging
2. *Browsing the Internet:*
   - Connection that offers lowest tariff is required,
   - Any free connection is fine (may be free hotspots are available)
   - Flat up to a Cap charging
3. *Skype call or Video Telephony:*
   - High or moderate bandwidth with Constant Bit Rate (CBR) characteristics,
   - Less loaded connection for uninterrupted call (i.e., should be a reliable network),
   - A good QoS required for the call,
   - Connection should be present locally to consume less battery power
   - Charging should be usage-based, i.e., metered charging
4. *Playing online games:*

- High bandwidth with Variable Bit Rate (VBR) characteristics
- Less loaded connections that could provide a fast and uninterrupted service (i.e., should be a reliable network)
- Metered charging based on usage

5. *Writing emails / Reading online:*
   - Just wants the lowest tariff on offer
   - Free connections better if available
   - Flat rate or Flat up to a Cap charging
6. *Listening to online music:*
   - Lowest tariff,
   - Moderate bandwidth is required
   - Flat rate or Flat up to a Cap charging

WORKING WITH POLICIES

Policies have been used as a means of implementing flexible and adaptive systems for the management of Internet services, distributed and security systems (Sloman, 1994; Verma, 2002). This approach may be used in our pricing context problem. In fact, a user may have configured policies to drive her access to the network services, whereas different service providers may also have different pricing policies to promote the use of their respective resources: in this case to publish the tariffs associated with the services offered. These are some of the probable user-side policies based on the proposed concept of User Profiles:

- ***If*** *guaranteed_bit_rate and UDP service* ***then*** *max_tariff ≤ limit and metering = usage-based*
- ***If*** *guaranteed_bit_rate and UDP service* ***then*** *operator_choice = operator_rating (priority)*
- ***If*** *non-GBR and TCP service* ***then*** *tariff_offered = nil or tariff_offered = minimum*
- ***If*** *non-GBR and TCP service* ***then*** *tariff_offered = minimum and metering = max_limit*

The next set shows some of the probable user-based policies using QoS information as a criteria for selection:

- ***If*** *guaranteed_bit_rate and UDP service* ***then*** *bandwidth_availability ≥ threshold*
- ***If*** *guaranteed_bit_rate and UDP service* ***then*** *battery_consumption ≤ threshold*

Finally, these are some probable operator-side policies within the context of service provider's tariffs:

- *If less_users and users_steady* ***then*** *decrease_tariff_slow*
- *If more_users and users_steady* ***then*** *keep_tariff_steady*
- *If less_users and users_decreasing* ***then*** *decrease_tariff_fast*
- *If more_users and users_increasing* ***then*** *increase_tariff_slow*
- *If returning_user* ***then*** *offer_discuounted_tariff*
- *If more_users and guaranteed_bit-rate_service_preferred* ***then*** *increase_GBRtariff_fast*

Apart from these we can have more policies for new users (perhaps in terms of single- payment, i.e. one off, accounts or based on the type of service the users requires).

OPERATION OF THE PROPOSED PRICING SCHEME

In the future 5G networks, the user devices will have simultaneous access to different wireless technologies and the device will make the final choice among different wireless/mobile access network providers for a given service (Javaid, 2013). For our user-oriented pricing scheme to work, one of the important criteria are operators publishing the distinct services/application profiles on offer with their associated features at different QoS levels. Along with that, it is important for the operators to also publish the corresponding cost of accessing those services (Louta, 2013). The software agent looking for accessing one or more of those published services, on behalf of the user, and in the context of the 'as and when required' connectivity vision, can then choose from multiple options based on the user requirements as specified in their profiles. Figure 1 illustrates the envisioned operation: the software agent sitting on the user device chooses the best service provider (out of multiple option) for the selected user's profile, keeps track of the usage period and initiates payment once the service is complete.

This procedure enables the software-enabled device to quickly engage with multiple providers and, in the time scale of a few seconds, achieve the best connectivity available for the selected user profile. Possible scenarios include the arrival of a traveller to an airport which is being serviced by two or three network providers and

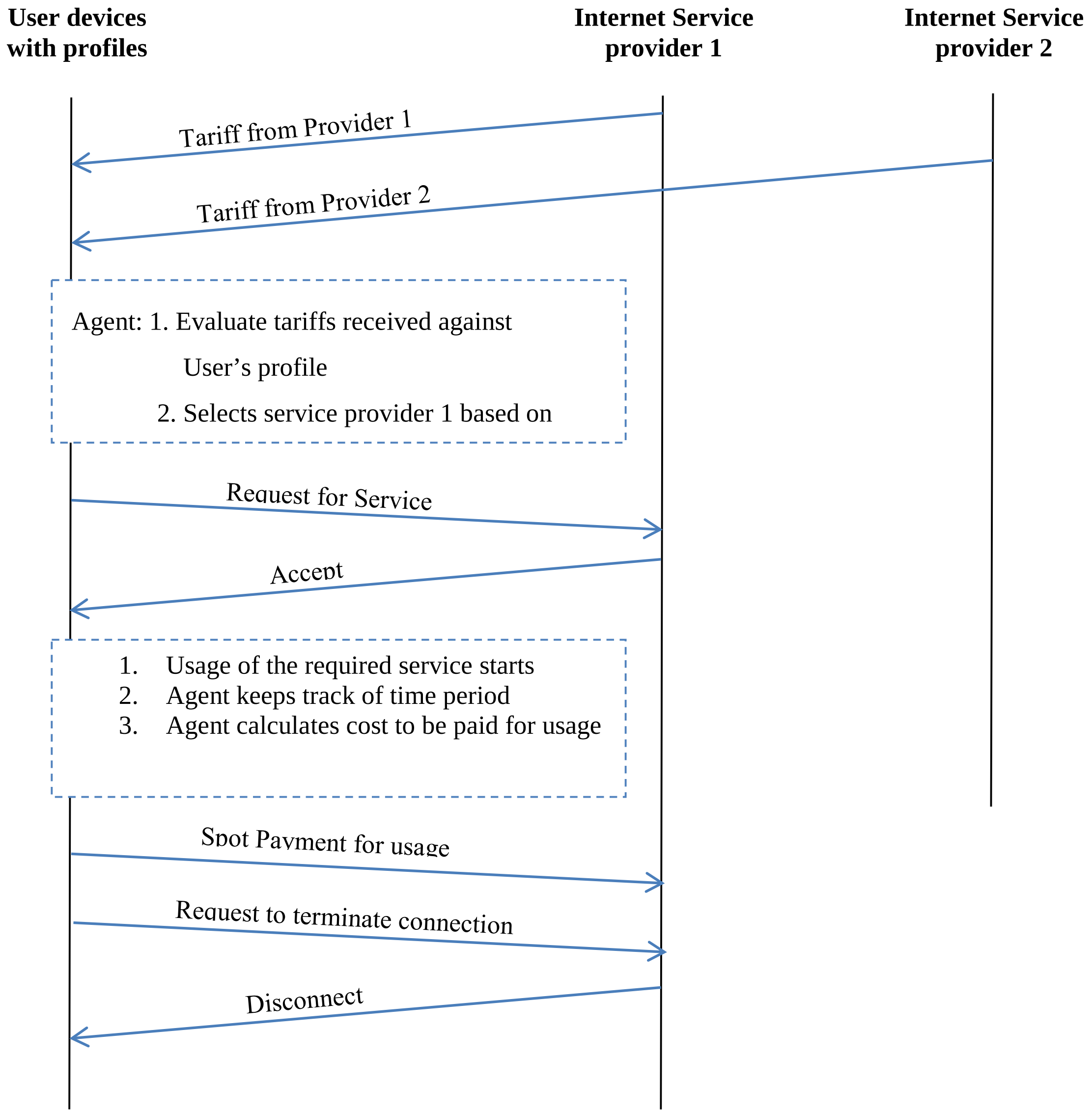

Figure 1: Operation of the proposed pricing scheme

rather than manually spending a significant amount of time comparing the services available and their tariffs, our proposed dynamic, policy-based pricing scheme facilitates the ad-hoc connection and accelerates the moment when the user can start to use the service.

A key requirement in this context is how the users will come to know of the different services and their corresponding tariffs that operators are offering. We assume that the different base stations and access points governed by different operators periodically broadcast the individual services and their corresponding tariffs to inform potential customers. This could be particularly useful for urban and suburban environments where users can have multiple different options to choose from for a specific service requirement. Another possible scenario has the user sitting on a café on a busy urban street wanting to log in to Skype for an urgent video chat. As far as the tariff goes for that service, there could be multiple different options (3G, LTE, WiMAX, WiFi etc.) to choose from offered by different service providers. Based on the selected profile (for instance profile 3 or Skype Call as described in the Working with Profiles section above), the software agent sitting on the user's handheld device can quickly scan the environment around (i.e., the broadcasted signals from different base stations and access points), select the best option to connect to and then connect automatically. The user can then utilize the service as per his/her requirements. The agent keeps track of the usage and calculates the payment value that needs to be settled on the spot (spot payment) or afterwards depending on the preferred payment options. Figure 2 illustrates the envisioned operation.

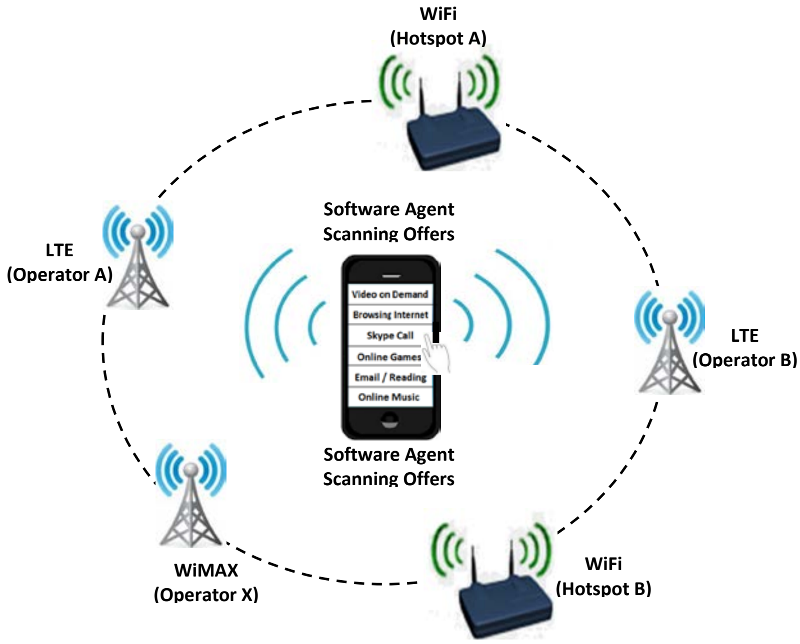

Figure 2: User Agent Selecting the Best Offer for a Profile

CONCLUSIONS AND FUTURE WORK

Our continuing investigation into the application of Policy-based Management ideas on the domain of dynamic pricing of pervasive network services shows that the PBM techniques we have adapted are flexible and capable enough to satisfy the requirements we envision for ad-hoc engagement using Next-Generation Networks; especially when dealing with a constantly changing and distributed context, not only in terms of the number of potential providers and users' devices but also in the environment diversity. Clearly, it is not possible to rely on users' intervention to update changes in the bulk of policies used in order to adapt to new services or devices connected to the network, or to be able to cope with any potential policy conflict. Therefore, it is mandatory to make use of mechanisms for automatic policy generation and refinement as well as for policy conflict detection and resolution. Some of those mechanisms have already been used in the context of network management but need to be adapted for a multi-provider, multi-technology pricing environment.

The next phase in this research deals with the ratification of policies and the final testing of our proof-of-concept. These are the remaining steps we have planned:

- Policy ratification (priorities, conflict checks, coverage, conflict resolution, policy refinement)
- Validation and deployment
- Testing, feedback loop

Deploying ubiquitous services requires that users and providers collaborate in order to assign prices to these services. The key factor in the pricing mechanisms in the context of such services is the dynamic adaptation to the environment (context awareness; Baladrón et. al., 2013; Gutierrez, 2008) and henceforth their temporal evolution as a function of the context. Finally, our pricing platform must consider the mechanisms that can be used to make users aware of the evolution of the current prices.

COPYRIGHT

REFERENCES

Baladrón, C., Aguiar, J.M., Carro, B., and Calavia, L. (2012).“Framework for Intelligent Service Adaptation to User's Context in Next Generation Networks”, *IEEE Communication Magazine*, March, pp 18-25.

Bellavista, P. Corradi, A. and Vecchi, S. (2002), “Mobile Agents for Usage-based Accounting in Wireless Ubiquitous Environments”, Retrieved on 17th March 2014 from http://lia.deis.unibo.it/Staff/PaoloBellavista/papers/woa02.pdf

Beltran, F., Gutierrez, J.A. and Melus, J.L. (2010). “Technology and market conditions towards a new competitive landscape in the wireless access market". *IEEE Communications Magazine*, Vol. 48, June, pp 46-52.

Gupta, A., Stahl, D., & Whinston, A. (1997). Priority pricing of integrated services networks. Internet Economics, 1997, pp 323-352, ISBN: 0-262-13336-9.

Gutierrez, J.A. (2008). “Policy-based Network Management as a platform for the pricing of ubiquitous network services”, *Proceedings of the 2008 IEEE International Conference on Intelligent Pervasive Computing (IPC 08)*, Sydney, Australia, December, pp 439-443.

Gutierrez, J. A. and Ray, S.K. (2014). “Policy-based Pricing for Pervasive Services in Future Heterogeneous Wireless Access Networks”. *Proceedings of the 28th International Conference on Information Networking*, Phuket, Thailand, February.

Javaid, M. A. (2013). “5G Technologies: Fundamental Shift in Mobile Networking Philosophy”. Available at SSRN: http://ssrn.com/abstract=2387193.

Louta, M. and Bellavista, P. (2013). “Bringing always best connectivity vision a step closer: Challenges and Perspectives”. *IEEE Communications Magazine*, Vol. 51, February, pp 158-166.

Odlyzko, A. (1997). “A modest proposal for preventing Internet congestion”. Technical Report, 1997. Retrieved from http://www.research.att.com/~amo/doc/modest.proposal.ps

Odlyzko, A. (1999). “Paris metro pricing for the Internet”. *Proceedings of the first ACM Conference on Electronic Commerce*, Denver, Colorado, pp 140-147.

Podobnik, V., Trzec, K., Jezic,G. (2009). “Context-Aware Service Provisioning in Next-Generation Networks: An Agent Approach”. Information Science Reference, pp 19-38.

Shenker, S., Cocci, R., Estrin, D., & Zhang, L. (1993). Pricing in computer networks: Motivation, formulation and example. *ACM/IEEE Transactions on Networking,1*, pp 614-627.

Sloman, M. (1994). “Policy Driven Management for Distributed Systems”. *Journal of Network and Systems Management*, pp 2-33.

Verma, D. C. (2002). “Simplifying Network Administration Using Policy-Based Management”. *IEEE Network*, March/April, pp 20-26.

Wireless World Research Forum (2009). “User Profiles, Personalization and Privacy”, May.