

Towards Context-Aware Service Discovery: A Case Study for a new Advice of Charge Service

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Abstract — It is already possible to discover and consume numerous network-based services with different kinds of devices. However, selecting the most favorable service among a set of appropriate services to solve a specific task can become complex and time-consuming for the user. In such situations, interaction between the user and the device should be minimal for the sake of user convenience. Here, context-aware service discovery can support the selection process through automated filtering based on the actual context. To demonstrate the feasibility of such kind of service discovery, this article describes our case study for a new kind of Advice of Charge (AoC) in the domain of mobile telecommunication. In contrast to existing AoC solutions, we investigate how context information can be used to automatically choose the most appropriate network operator prior to placing a call (AoC-P).

Index Terms — Advice of Charge, Roaming, Context-Aware Service Discovery

I. INTRODUCTION

IN service-oriented environments, prior to actually using a service, a *service discovery* has to take place. Service discovery is the task to obtain descriptions for a desired service. These descriptions can then be taken to determine whether an offered service is chosen or not – either manually, i.e., through user interactions, or automatically.

In this connection, *service discovery protocols* have been developed that apply different description models, e.g., Java service interfaces (Jini) or XML (in particular, UDDI). However, there is still the task to evaluate the obtained descriptions and decide which of the relevant services offers the most favorable solution. As there is currently no support in this regard by the available service discovery protocols, it is up to the application or even the user to perform this task.

To overcome this, service discovery can make use of the *current user's situation* (or: *user context*¹) to determine which

actions to take next, e.g., in order to select a specific offered service. Thus, (user) context information becomes an implicit part of the service discovery protocol. In the area of *context-aware service discovery* there are already some published approaches, e.g., Cooltown², the context toolkit [2], and CB-SeC [3]. Moreover, the need for a semantically well-defined common vocabulary, i.e., an ontology [4], to unambiguously communicate context information among service requesters and providers has been identified. The use of ontologies in context-aware service discovery has already been demonstrated in [5], resulting in a higher quality of the retrieved results.

In this article, we focus on a particular kind of context-aware service discovery in the application area of *Advice of Charge*. Advice of Charge (AoC) is already an established service in the area of telecommunication networks [6]. AoC is understood as a supplementary service that informs the caller about usage-based charging information. This information depends on the actual context of the user (location, time, etc.). However, note that AoC is not meant to replace the charge metering inside the network, which is considered to be correct in all cases.

The currently specified categories of AoC do not provide the information prior to the service set-up time. Hence they are not suitable to support service discovery. Users have a great interest in corresponding information prior to the actual connection, e.g., when roaming in a foreign country. Therefore, this article describes our prototype implementation that demonstrates how a new category of AoC can be employed as a supplementary context-aware service in the domain of mobile telecommunication.

The remainder of this article is structured as follows. In Section II, we give an overview of AoC categories and further motivate our approach. Section III describes our case study. Section IV closes with a conclusion and an outlook on future work.

II. ADVICE OF CHARGE APPLICATIONS

Currently specified AoC services comprise one or more of the following cases [6]:

1. *Charging information at the end of the call* (AoC-E). The AoC-E supplementary service enables a user to receive in-

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¹ We here derive the notion of *user context* from the more general term *context* in the sense of “any information that can be used to characterize the situation of an entity, where an entity can be a person, place, or physical or computational object” [1].

² <http://www.cooltown.com>

formation on the recorded charges for a call when the call is terminated.

2. *Charging information during a call (AoC-D).* The AoC-D supplementary service enables a user to receive information on the recorded charges for a call during the active phase of the call.
3. *Charging information at call set-up time (AoC-S).* The AoC-S supplementary service enables a user to receive information about the charging rates at call set-up time. In addition, further information can be received during the call if there is a change of charging rates. Many providers do currently not provide this information and only a few number of mobile devices are able to show it.

Currently such information can be retrieved in telecommunication networks but not in other wireless networks. Also the information is not based on real prices, but on tariff units. For each unit a special signal is sent and the device has to calculate the price based on price-per-unit information stored in the device. The price is then for information purposes only and not, e.g., to automatically select the cheapest among a number of available services. What we are aiming at is a fourth application of AoC:

4. *Charging information prior to a call (AoC-P).* The AoC-P supplementary service enables a user to receive information about the charging rates prior to the set-up of a service in a mobile network.

The price information for a service in mobile telecom networks is of course available before using a service, but acquiring this information is not an easy task. For instance, to acquire information about the costs for a call with a mobile phone from a foreign country, one has to look up the web-sites of the respective mobile network operator(s), find the tariff tables, and then extract the relevant information from these tables. Unfortunately, this is a time-consuming and rather cumbersome task.

More concretely, charging information is typically needed just prior to a phone call, e.g., when calling back home from a foreign country. With this information, it is possible to select the most favorable (i.e., the cheapest) from the set of network operators, or – in terms of service discovery – selecting the most favorable service from the list of offered services.

As a consequence, mobile users abroad can always be confident to make phone calls with their mobile phones at the best available rate. The MNO can offer this value-added service to all of his customers either for free or with an additional charge. In general, the motivation for any network provider to offer AoC-P is to make (roaming) tariffs more transparent for their customers, resulting in more user confidence and – last but not least – increasing use of the services themselves.

For AoC-P, we are mainly interested in the following two use cases:

1. *Finding the cheapest service supporting the current needs among a number of available services.* In some situations it might be possible for a nomadic user that a desired service is available from different service providers, maybe even via different networks. In this case it has to be calculated which alternative is the most favorable (i.e., the cheapest). This calculation has to respect that, e.g., communication performance will be different for different networks. So it is possible that a connection offered with a cheaper price per minute will in the end become more expensive than another because of a lower bandwidth.
2. *Download of DRM protected multimedia content.* This use case is part of a more complex mobile Digital Rights Management (DRM) approach addressed in [7]. The corresponding AoC service provides overall costs for downloading a file, i.e., the costs for downloading the protected digital content. The cost may be based on the time needed for download (considering the bandwidth of the connection) or based on the amount of data to be transferred. Note that this is an important information, as this is an additional cost w.r.t. the (potentially separate) *right* to consume the downloaded protected.

In the following section we will only address the first kind of usage. For the second use case, we still have to first complete our DRM infrastructure that is based upon the latest OMA DRM v2.0 Specification [8].

III. ADVICE OF CHARGE FOR ROAMING USERS

Many people travel abroad and make phone calls to their home country with their mobile phone, but they don't really know how much these calls will cost them. There are various Mobile Network Operators (MNOs) in each country, each of them offering variable prices that are hard to compare.

One AoC-P service discovery solution could be that an application in the mobile phone contacts all available to retrieve charging information, the MNOs send back their offers, and the application computes the most favorable MNO for the planned phone call. However, there are a number of technical challenges for such an approach. Firstly, all MNOs would have to offer an according service, using an ontology that makes the replies processable by the device in an unambiguous manner. Secondly, the whole service discovery process might take a comparatively long time due to the number of messages sent and received. Thirdly, the computation to determine the most favorable MNO has to take place in the device, which might also take significant time due to its limited computing power. Moreover, comparing different rates with potentially different policies is an inherently complex task.

We therefore propose a different solution using a centralized entity, i.e., the homebound MNO, which takes over the computing tasks. Fig. 1 shows the use case for AoC in such an approach.

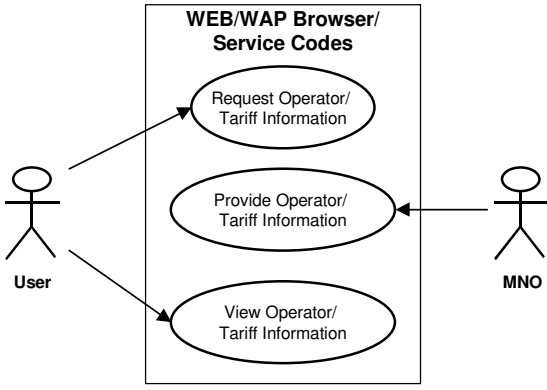


Fig. 1. Use Case Diagram for Roaming Users

A. Use Case Description

A mobile user sends a request to his MNO together with parameters describing the planned phone call, among which there is the source and destination country of the planned phone call. Most of these parameters can be automatically determined from the actual context of the user. The MNO then sends the request to a so-called Rating and Charging Engine (RCE), where all roaming partner MNO rates are kept. Given the information provided together with the request, the RCE calculates the most favorable price and sends a corresponding reply back to the requesting user via the MNO.

Fig. 2 shows the corresponding sequence diagram. Thus, the *homebound MNO* offers a service that allows mobile users to look up the most favorable price and MNO for a planned phone call. The MNO has to keep the RCE updated with the current tariff prices of roaming partners worldwide. Then the RCE is able to calculate locally the best tariff from all available MNOs in the user's context, which in this case refers to the source country provided with the request. As a consequence, mobile users abroad can always be confident to make phone calls with their mobile phones at the best available rate.

For the request/reply AoC protocol in our case study, the following parameters are required for the tariff calculation:

1. *Source country*, i.e., the country from which the requester wants to make the phone call. Note that this parameter can be automatically determined from the network.

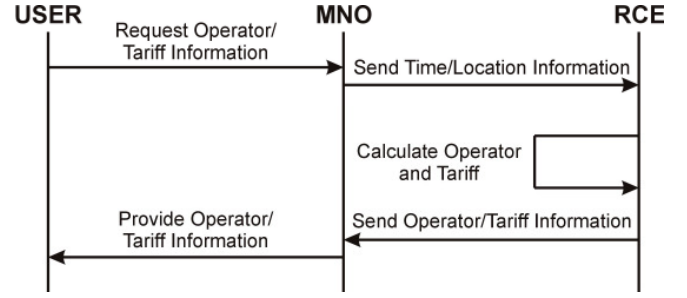


Fig. 2. Sequence Diagram: AoC-P for Roaming Users

2. *Destination country*, i.e., the country in which the callee is positioned.
3. *The day of the week*; this is due to the fact that there are usually different tariffs available for weekdays and week-ends.
4. *The time of the day*; again, this is due to the fact that different tariffs for the different times of the day are available.
5. *The expected duration*, if known. If not provided with the request, the RCE selects the best tariff according to a base unit (e.g., one minute).

Note here that most of the parameters can automatically be extracted considering a user profile and according preferences.

The reply of the RCE contains either the calculated expected price for the planned call and partner MNO name (if the expected call duration has been provided) or the best offer w.r.t. the assumed base unit.

Finally, note that access to such a kind of service is not limited to mobile networks as described here. Similar applications are, e.g., AoC services for connecting to wired or wireless networks with a PC, laptop, or PDA.

B. System Architecture

The stakeholders of the system are client devices and their homebound MNO each hosting an RCE. The deployment diagram in Fig. 3 illustrates this setting. The MNO offers the AoC service for roaming users by means of an offered interface (indicated by a circle named *I_AoC*).

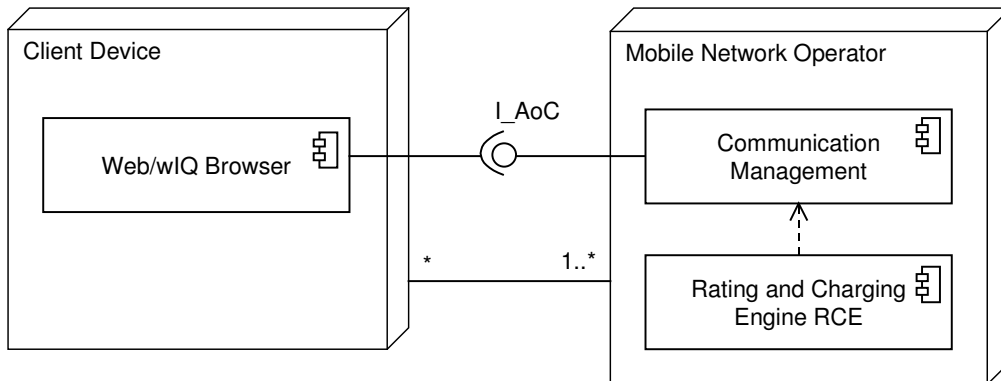


Fig. 3. AoC-P for Roaming Users, System Architecture



Fig. 4. AoC-P – Roaming Request

C. Prototype Implementation

We implemented a prototype for the described use case. Fig. 4 shows screenshots taken from different (mobile) devices requesting AoC-P service. The request can be sent either via the Internet or a cellular network. Fig. 5 shows the corresponding replies sent back to the devices. Client devices have as component a browser enabling to send AoC-P request commands. On the other hand, the MNO provides access (e.g., via HTTP, WAP, or USSD) and forwards requests to the Rating and Charging Engine that calculates all arising expenses

depending on the provided information.

Regarding the request via a mobile phone, the AoC-P service is realized in our approach by means of the *Unstructured Supplementary Services Data* (USSD) channel of the GSM network via USSD-Browsing. USSD is a means of transmitting information or commands over a GSM network. It uses the GSM network's signaling path and is session-oriented. This means, when a USSD service is accessed, a session is established and the radio connection stays open until the user or application or a time out releases it.



Fig. 5. AoC-P – Retrieving Roaming Price Information

In the context of our USSD-based AoC-P service, we make use of the following advantages of USSD:

- USSD is available in virtually every GSM network today.
- Mobile phones do not have to fulfill any special requirements to make use of USSD; even mobile phones of earlier generations are able to make use of USSD.
- USSD can be up to seven times faster than SMS, as SMS is a store and forward service, whereas USSD is session-oriented.
- USSD services can be free of charge. Note here that roaming use of USSD is never charged, but the services associated with a USSD command could be charged depending on the policy of the homebound MNO.

To give a successful application example of USSD, we refer to *wireless Information Query*³ (wiQ), a system which – amongst other features – provides a gateway functionality to convert USSD service requests into corresponding HTTP commands and transfer retrieved HTML content into USSD messages. The content of the services is based on HTML and can thus be created and maintained using standard Internet tools. Furthermore, all data is conveniently hosted on a Web server.

Note that this service can easily be made accessible via SMS or WAP, too. But in these cases the service will already cause roaming costs when used.

IV. CONCLUSION AND OUTLOOK

In this article we present an AoC service that conveniently informs users about the most favorable MNO for a planned phone call, taking into account the current context like location, time, etc. We see this case study as a first step towards delegated service selection in ubiquitous environments. The vision of ubiquitous computing is that computers will be everywhere, but no longer recognized as computers [9]. They will be embedded within various objects, smoothly integrated into the environment, and intermittently connected to each other through wireless connections. As a future work towards ubiquitous computing, we aim at taking profile information to enable automatic acquisition of appropriate context information, in particular by means of user profiles stored on mobile devices.

In our case study, we used a centralized computing entity, i.e., the user's homebound MNO and a corresponding RCE, although in general other solutions are of course also applicable. Here, delegation is due to the fact that the information necessary to compute the most favorable service – in this case the currently charged phone call rates – is not locally available in the user device, such that another entity has to be contacted to determine the most favorable service provider. Moreover, we can benefit from the computing power of the MNO's server, making use of an already existing, comparable fast communication technology (USSD), which can even be provided free of charge.

Our case study shows the feasibility of applying context-aware service discovery for automatic filtering of available services. Such a filtering is essential in ubiquitous environments when a huge amount of services is available anywhere at any time. Our centralized approach so far avoids a common vocabulary for the MNO rates and cost models – rates are manually extracted from the different MNOs and stored in the RCE. For automated processing there is the need to unambiguously express charging information. The next step in this respect is therefore to define an according ontology.

Moreover, we are currently developing an enhanced Digital Rights Management solution applicable to ubiquitous environments. The SIM card in mobile phones is employed as secure hardware keeping the digital rights that allow to consume protected content. Only certified consumer applications (potentially running on different devices) are able to obtain the decryption keys. A corresponding secure protocol has been defined in [7]. Within that approach, the AoC-P service described in this article is adapted to inform users about the overall costs for downloading protected content via different networks, i.e., the price of the content and the estimated connection fees. We see this as an essential service for the user acceptance of such systems.

REFERENCES

- [1] A. K. Dey, G. D. Abowd, and D. Salber. *A Context-Based Infrastructure for Smart Environments*. In Proceedings of the First International Workshop on Managing Interactions in Smart Environments (MANSE '99), Dublin, Ireland, December 1999.
- [2] A. K. Dey. *Context Toolkit*, 2004. <http://www.cs.berkeley.edu/~dey/context.html>
- [3] S. Kouadri Mostéfaoui, A. Tafat-Bouazid, and B. Hirsbrunner. *Using Context Information for Service Discovery and Composition*. In Proceedings of the Fifth Conference on Information Integration and Web-based Applications & Services (IIWAS'2003), Jakarta, Indonesia, September 2003, pp.129-138.
- [4] D. Fensel. *Ontologies: A Silver Bullet for Knowledge Management and Electronic Commerce*, August 2000. Springer.
- [5] T. Broens, S. Pokraev, M. van Sinderen, J. Koolwaaij, and P. Dockhorn Costa. *Context-aware, ontology-based, service discovery*. In Proceedings of Ambient Intelligence: Second European Symposium (EUSAI 2004), Eindhoven, The Netherlands, November 2004. LNCS 3295, pp. 72–81, Springer.
- [6] European Telecommunications Standards Institute. *ETSI ES 201 296 V1.1.2 (1998-09): Integrated Services Digital Network (ISDN); Signalling System No.7; ISDN User Part (ISUP); Signalling aspects of charging*. 1998.
- [7] S. Flake, M. Runowski, J. Tacke. *Mobiles DRM in ubiquitären Umgebungen*. In Proceedings of the 9th BSI IT-Sicherheitskongress, Bonn-Bad Godesberg, Germany, May 2005. (in German)
- [8] Open Mobile Alliance. *OMA Digital Rights Management V2.0 Specification, Candidate Enabler Release Documents*, December 2004. http://www.openmobilealliance.org/release_program/drm_v20.html
- [9] M. Weiser. The computer for the 21st century. *Scientific American*, 265(3), pp. 94–104, 1991.

³ <http://www.orga-systems.com>