A Novel Infrastructure Facilitating Access to, Charging, Ordering and Funding of Assistive Services

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Abstract. Given that, nowadays, access to ICT is required for almost any kind of education, employment and commerce form, and is increasingly required for travel, it is mandatory to focus on integrating groups of users with any type of disability at a personally and societally affordable cost. In this paper, we outline an ICT-enabled novel infrastructure that significantly facilitates user access to a large set of specialised assistive services and enables small ICT players (e.g. web entrepreneurs) to develop novel services "on user/user group demand" supported by crowd funding. Our vision is to create an infrastructure that can move ideas more quickly from conception to market and consumer availability, that can be more efficient by being better targeted to user needs, that can move users closer to researchers and developers to ensure that the full range of needs are better addressed and that can reduce both the development and operation cost of assistive services. The system we propose consists of the Assistance on Demand (AoD) service infrastructure which aims to be a gateway for accessing on demand diverse types of human and machine-based assistive services. This AoD is accompanied by a flexible payment infrastructure that aims at enabling, for all relevant stakeholders (end users, service providers, etc.), the easy, flexible and reliable handling of multiple bills for different services, while at the same time supporting crowd-funding, as necessary, for user-driven assistive technology (AT) or service development. In this paper, we present the state-of-the-art technologies and approaches that will serve as the basis for the design and development of the AoD and payment infrastructures and then we discuss the requirements that these intertwined systems have to fulfill and draw high-level design directions.

Keywords: Service platform, Assistance on Demand, micro-payments, service description and ranking, non-functional ranking, crowd-funding.

1 Introduction

As information and communication technologies invade our everyday life, they become indispensable for a blooming set of activities including education, employment, commerce, health services, transportation, or even daily independent living. This puts at risk those who cannot use ICT and services due to disability, low literacy, low digital-literacy or aging-related barriers. On the other hand, novel technologies can

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radically change the scene. For example, the development of digital service market-places have contributed to the decrease of service delivery costs. Similarly, the needs of many small groups can now be catered for in a better way through cloud technologies which allow significant sharing and more intense processing capabilities. The emergence of novel payment models, notably crowd-funding approaches, has contributed towards the creation of new applications and services by web entrepreneurs that fit better the needs of the crowds (individuals/groups) funding them. We argue that by applying the crowd-funding model, it is possible to better serve persons with disabilities, including the unaddressed (up to now) tails (i.e. "non mainstream" disabilities).

Exploiting the latest ICT developments, we design a novel open source Assistance on Demand (AoD) service infrastructure which intends to enable diverse stakeholders to easily set up ICT-supported AoD services catering for individual needs of persons with disabilities, where stakeholders include family members, friends and carers, as well as professionals (individuals and SMEs) offering all kinds of assistive services. This, in turn, enables persons with disabilities to access a wealth of different human- or device- or network-based services. The AoD services that will be built using our AoD infrastructure understands the user's assistance requests, responds to them by filtering the available solutions based on his/her preferences and suggests a possible matching. The AoD infrastructure also caters for different patterns of assistive services: continuous or interruptible, periodic or random and enables the use of different charging models (pay-per-use, pay-per-item, or any other) depending on the type of service and the charging model selected by its provider. The related charges may be of very limited value, they can even be context – dependent and by all means they have to be accountable and justifiable.

The AoD platform creates, in essence, a dynamic ecosystem which brings closer the users, the service providers and application developers, each of which has a set of distinctive requirements that cannot be covered by established e-commerce platforms and one-fits-all solutions. To support the above requirements, it is mandatory to design and implement a charging and payment system, interlinked with the AoD that a) provides smooth and reliable support of fine-grained payments, leveraging on emerging micropayments technologies b) provides reliable and flexible infrastructure that will cater for the charging and payment functionality in order to alleviate the service provider from these burdens and to support the consumer in a seamless way, c) supports the interactivity and the collaborative capabilities among the service providers and the consumers in an enhanced form of crowd-financing focused on accessibility features and d) allows for intelligent and parameterized notification of reaching or exceeding specific amounts.

The "crowd-funding for accessibility support" feature of the payment infrastructure is one of the novel components of the proposed infrastructure because it is expected to contribute to the change of the legacy "service push" approach (from service developers/providers towards consumers) to the "service pull" approach, where users directly define the assistive service requirements and developers undertake the development under a crowd-funding scheme (i.e. a collective effort by consumers who network and pool their money together, usually online, in order to invest in and support efforts initiated by other people or organizations). The proposed system explores the frontier between crowd-funding and group-funding, also providing analytical tools to process useful statistics both for service providers and users and updated information upon request on the progress of the work and appropriate handling of the funds.

The rest of the paper is organized as follows: in sections 2 and 3 we discuss the state-of-the-art related to the design and development of the Assistance on Demand service infrastructure and the payment infrastructure respectively. Then, sections 4 and 5 describe the design of the proposed novel platforms and finally section 6 concludes this article. Both the AoD service infrastructure and the payment infrastructure will be designed and developed in the framework of the Prosperity4All project (FP7-710510) co-funded by the EC [1] that develops a wide set of tools targeting societal groups in the risk of exclusion.

2 State-of-the-Art Technologies for the AoD Platform

To achieve its goals, the proposed Assistance on Demand service infrastructure will capitalize on leading edge Cloud technologies as well as on semantic web service description and web service ranking solutions based on non-functional properties (such as QoS, safety, price).

2.1 Semantic Web Service Description

Web services have evolved through multiple progressive steps since 1990 (when electronic documents in HTML format were first published and linked). XML (eXtensive Markup Language) allowed information produced by any entity to use the same description format and thus enabled structured information collection. The next step was to abstract and describe in a uniform manner the web services to extend their capabilities in the direction of dynamic interoperability, and in particular to address the need for interoperability in the face of heterogeneous standards for representing content communicated between distributed components. There are many situations where systems developed using web services will need to overcome interoperability limitations arising from their inability to agree in advance on the syntax and semantics of interactions and this is the case in Prosperity4All, which targets to bring together and even prioritise diverse service suppliers offering AoD. Users and software agents should be able to discover, invoke, compose, and monitor web resources offering particular services and having particular properties, and should be able to do so with a high degree of automation if desired.

There exists a plethora of service description efforts that can be grouped into different strands with each strand having its own motivation and representation needs for capturing service information. The individual efforts may differ in terms of scope (e.g. capturing IT or business aspects of services or the whole service system), or purpose (e.g. automate a specific task, or offer a reference model), or the ability of the approach to capture business network relationships between services and last but not least in terms of use of standards.

W3 consortium (W3C) has been very active in this area (along with OASIS, OMG and Open Group) and has delivered a set of service description standards. W3C defined Web Service Description Language (WSDL) (already in 2001) which is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. WSDL is extensible to allow description of endpoints and their messages regardless of what message formats or network protocols are used to communicate. However, the only bindings described in version 1.1 document describe how to use WSDL in conjunction with SOAP 1.1, HTTP GET/POST, and MIME.

The Semantic Web came to enable greater access to services on the web enabling the dynamic linking and sharing of ontologies contributing to the notions of orchestration, choreography and mediation, since different communities may not always share ontologies directly. Interoperability improves substantially through ontology mappings enabling semantic translation between different representations of concepts based on different ontologies. OWL-S (formerly DAML-S) is an ontology of services that makes these functionalities possible while Web Service Modeling Ontology (WSMO) appeared in 2005 and provides an ontology based framework, which supports the deployment and interoperability of Semantic Web Services.

Semantic Annotations for WSDL and XML Schema (SAWSDL) extended the Web Services Description Language and XML Schema definition language that allows description of additional semantics of WSDL components. The specification defines how semantic annotation is accomplished using references to semantic models, e.g. ontologies. SAWSDL provides mechanisms by which concepts from the semantic models, typically defined outside the WSDL document, can be referenced from within WSDL and XML Schema components using annotations.

The latest W3C work is on the definition of the Unified Service Description Language (USDL) for describing general and generic parts of technical and business services to allow them to become tradable and consumable. USDL builds on the standards for the technical IT description efforts for services such as WSDL, adding business and operational information on top. USDL defines normative UML modules for capturing the "master data" of a service i.e., class models for pricing, legal, functional, participants, interaction and Service Level Agreement aspects. Therefore, both manual and IT services can be described with USDL. Both W3C SAWSDL and W3C SA-REST are designed to be agnostic of any service description schema. Similar holds for W3C SML.

Another interesting and lightweight service model is Minimal Service Model (MSM) [2] which has been adopted by iServe for publishing services and querying them in expressive and extensible manner. iServe intends to be the place on the Web where linked data meets services. The Minimal Service Model, driven by Semantic Web best practices, builds upon existing vocabularies, namely SAWSDL, [3] WSMO-Lite and hRESTS [4]. In a nutshell, MSM is a simple RDFS integration ontology based on the principle of minimal ontological commitment; it captures the maximum common denominator between existing conceptual models for services. Thus, MSM is an integration model at the intersection of existing formalisms (namely, WSMO and OWL-S), able to capture the core semantics of both Web services and

Web APIs in a common model, homogeneously supporting publication, discovery and invocation. Still, MSM is devised so that framework-specific extensions can remain attached, to the benefit of clients able to comprehend and exploit those formalisms.

2.2 Service Selection and Prioritization Based on Non-functional Properties

Service selection and prioritization can turn out to be a very complex and challenging task, especially when more than one services have equivalent/similar functionality and the decision is made upon a variety of different non-functional properties. Non functional properties include information about location, optimal transmission format and protocols, applicable user or system policies (e.g. price), QoS and security policies [5]. The fundamental issues of service selection and prioritization are a) specifying requestor's service requirements, b) evaluation of the service offerings, and c) aggregating the evaluation results into a comparable unit. Of course the requestor's requirements and the service offerings have both functional and complex non-functional aspects, which need to be expressed for evaluation matched against each other.

Before we attempt to match the requestor's requirements to the service offerings, a model to describe the service's non-functional properties. Due to the versatility of non-functional properties (and the fact that new ones might be required at any time) in combination to the fact that the non-functional criteria depend also on the domain, the extensibility and flexibility of the service description scheme are stringent and mandatory requirements. WSDL-S [6] and OWL-S have been proposed to be used to describe the non-functional properties while other researchers decided to build extensions on UDDI repositories to allow expression of non-functional properties [7]. Both are viable approaches, the former might prove more flexible and expandable in the long run, the latter are certainly more immediately applicable as they are based on widely deployed repository technologies. At all cases, in selecting its semantic service description approach, Prosperity4All will have to take into account a variety of non-functional service properties.

To evaluate the service offerings, approaches based on policies [8] have been proposed while others that rely on reports from other users (or even server providers) and previous experiences [9] (reputation based) have also been explored. The policy based approaches rely on policy languages that traditionally only allow expressing a small number of non-functional properties. Given the diversity of AoD services that Prosperity4All aims at enabling, including human and device- based services, it is very likely that different evaluation approaches may need to be supported.

Ranking and selection based on non-functional properties is inherently a multi-criteria decision-making problem due to the presence of multiple parameters that cannot be directly compared to one another. The relative importance of parameters such as price and reliability, thus, varies for different clients and situations. To capture the relevance of the selection criteria, graph and ontologies-based approaches on one hand and context-aware service selection approaches on the other have been proposed [10]. In the latter, the requestor's context is modeled using OWL/RDF which is transformed to be part of the constraint values of the category based and domain specific non-functional service selection criteria. While the initial setup of the weights for the preferences is left to users, the system can modify the values automatically to deal with emergent behaviour (e.g. an emergency status).

To reach a final service selection, the scores related to different non-functional properties need to be combined and compared. While numerical or keyword values have been explored [11], the ontological representation with the help of logical expressions allows semantic ranking to provide more accurate results. The value of a non-functional property of a service may depend on the concrete request data from the client: the service NFP description includes logical expressions that compute concrete NFP values at run-time. For example, given a description of the expected service demand, the NFP expressions can compute the actual price and the expected reliability of the service.

3 State-of-the-Art Technologies for the Payment Infrastructure

While micropayments are not a new idea, the micropayment system together with the proposed AoD will put the user in the driving seat, considering an extensive set of micropayments methods and allowing for dynamic selection depending on the context (and the user preferences – in case they are explicitly expressed). Such methods include the following:

- Electronic check: The electronic check is a digital token that lets a service provider withdraw money from the end user's account at a later date. It is the digital equivalence of a physical bank check while the end user's account can be in a real or virtual bank (main example the Paypal system).
- User – initiated transfers: In this type of payment solution both the user and the service provider have accounts and the end user asks his bank to transfer money to the SP's bank. The banks can be real or virtual.
- Service providers – initiated transfer: This is similar with the previous case with the difference that the user's involvement is not required when making a payment, as long as the SP has the user's account information. The user provides the necessary information. The more typical example in this case is the usage of credit cards. In such a case the account number is replaced by the credit card number (which is typically associated with a bank account).
- Prepaid SP account: In this type of payment solution the user pays money to the SP upfront, who maintains an account on behalf of the user. The account is deducted every time the user makes a purchase or utilizes a service from the SP. This may decrease overhead cost associated with payments.
- Prepaid SP voucher: The SP creates payment codes valid for the specific SP. Instead of using accounts to keep track of how much each user has deposited, the SP sells payment codes to users. The payment codes can then be used at a later date to make purchases.
- Invoicing: The user is invoiced for his purchases at a later date. The specifics of invoicing vary, for example once per month or after a certain debt threshold has been reached.

In addition to the above, the support of crowd-funding is mandatory for the realization of the AoD collaborative vision. Crowd-funding is a collective effort by consumers who network and pool their money together, usually online, in order to invest in and support efforts initiated by other people or organizations. The basic idea of crowd-funding is for an entrepreneur to raise external finance from a large audience, where each individual provides a very small amount, instead of soliciting a small group of sophisticated investors.

4 Assistance on Demand Service Infrastructure Design and Challenges

The target of the presented Assistance on Demand service infrastructure is to enable the rapid deployment of innovative machine/human assistance services on demand by allowing individuals to seek assistance in an organized fashion from a set of predefined sources based on the need, the desired quality of service and other personal preferences.

4.1 AoD Infrastructure Design Considerations

The Prosperity4All AoD infrastructure is designed to offer unique features including the support of:

- Diverse target user groups: This diversity concerns the role they play (service suppliers, service developers, service consumers, consumer relatives and other interested individuals), the targeted application domain (safety, daily leaving, education, entertainment), the socio-economic status/background, other characteristics such as mental, cognitive, emotional, educational, IT-literacy of the individual/group user. To maximize adoption, the AoD infrastructure will support user interfaces that support multimodal interaction and flexible interface configuration with minimal technical knowledge requirements and will provide technical support as a service offered in flexible, possibly collaborative, yet efficient and reliable, way.
- Different types of assistance services including human/machine/crowd-based services: To offer all these services on demand, we need to define a common service description language and employ semantic service annotations to facilitate flexible classification/organization and fast search according to multiple attributes. The AoD infrastructure will enable the creation of "dashboards" of assistance services, customizable (per person or community/group) and supporting a wide set of service selection criteria (e.g. service type, price, developer, presentation, quality and security level) while offering zero/default configuration options for efficiently supporting non professional disabled users.
- (Machine-based) Services created from different developers (companies/ individuals/ organizations/ communities): A mechanism to communicate the service characteristics and infrastructure requirements of each service/application is needed, so as to guarantee proper reservation of resources, given that the proposed AoD

infrastructure aims to offer a dynamic set of services/applications. This mandates the design of a relevant interface between AoD infrastructure and developers' infrastructure. Both Infrastructure-as-a-Service and Platform-as-a-Service paradigms will be pursued to ensure that the AoD infrastructure will be scalable, robust and future proof.

- Multiple cost models: To alleviate affordability issues which are even more acute this decade, the AoD will support multiple charging/profitability paradigms. These are expected to lower the usage cost of assistance services. We anticipate that facilitating access to a wealth of assistance services, both paid and free, their utilization will significantly improve and in the end will result in lower cost. To realize this vision, the AoD service infrastructure is responsible for monitoring the access/usage of the offered services and for communicating with the payment infrastructure which is responsible for charging. Different charging models have to be supported (for example, software download or human-offered AoD may follow a one-off payment model, while AoD translation services may follow different charging models depending on expected quality), implying that the AoD Service infrastructure needs to monitor different access/use characteristics per offered service.
- Quality of Service Differentiation: Given that usually higher QoS comes at significantly higher price and that the Quality of Service depends on different factors for the variety of supported AoD services, the proposed AoD will enable an intelligent multi-criteria QoS improvement scheme that realizes a "try harder" cascade chain and enables flexible Quality of Service- charge trade-offs. A default quality will be offered at start-up and the user will be asked whether she desires to update the QoS possibly at a slightly higher tariff. Such an approach has to be accompanied by the use of scalable Quality-of-service monitoring tools (machine and human-enabled) to enable flexible and sophisticated billing in cooperation with the payment infrastructure.
- Generic open source infrastructure that meets the current and emerging needs of stakeholders interested in easily setting up AoD services.

The AoD infrastructure will include a "readily available" marketplace for service developers/suppliers. Offering collections of assistance services on demand brings services closer to the users and contributes both to cost reduction for the users and profit creation for the suppliers. This AoD infrastructure will be a meeting point facilitating collaboration among service developers/suppliers, interested users (expert or not, disabled or not, belonging to different mental, societal or other groups), volunteers and persons interested in employment.

4.2 AoD Development Aspects

To cope with all these challenges and offer Assistance on Demand services with unprecedented flexibility, a generic AoD service infrastructure placing emphasis on modularity and specifying the core functionality and interfaces to its subcomponents can be designed. To support different application domain and/or target groups, different instantiation of the generic AoD infrastructure will be possible with more sophisticated implementation of certain modules optimizing different functional and performance aspects. The core of this infrastructure will be based on the semantic annotation of the supported services extending well established vocabularies and annotation techniques to support the wide range of supported services. This will enable fast semantics-based service lookup and composition, service execution and monitoring, and real-time service selection/prioritisation based on customer needs. For the discovery of services, the AoD service infrastructure will interface the developers' infrastructure, while for the support of physical networks of human assistance a different interface will be realized. For the development of the proposed AoD, a semantic service description approach that supports the wide variety of services to be offered and allows for fast service discovery and invocation based on multiple criteria will be designed. For this reason, we will choose widely adopted semantic service description approaches and will extend them to support/describe human-offered Assistance on Demand services and to describe all attributes of interest for the diverse target groups (quality of service, price, input/output interface supported etc.). With respect to service discovery mechanisms, we will adopt state-of-the-art discovery mechanisms (such as Universal Description Discovery and Integration (UDDI) or WS-Discovery) and modify them to support the extended semantic service description approach that will be designed within Prosperity4All.

We will capitalize on existing nonfunctional properties description and ranking approaches and will extend them in order to define generic evaluation and ranking methods that differentiate the property filtering according to coarse criteria such as application domain characteristics. Observing that sophisticated service ranking may introduce significant delay before service starts to be offered, flexible lightweight yet efficient ranking mechanisms will be designed.

5 The Payment Infrastructure Design and Challenges

To complement the functionality of the envisaged AoD platform, the design and development of a payment infrastructure that enables the on-line payment of (multiple) services offered by different suppliers following different charging models on behalf of the end-users and –equally importantly– allowing crowd-sourced financing of R&D, supporting micropayments and bids is necessary. The aim is to alleviate the need for each service supplier to create and maintain her own charging and payment infrastructure. Similarly, for the user the aim is to simplify the process so that, instead of receiving multiple bills from the different suppliers, she will be charged per usage in a way that micro-charges per customer and per service supplier are accumulated in the charging and payment system and billing is made when amounts reach a specified threshold or on a regular basis. The system will operate transparently and accumulate charges on the user's periodic bill without an explicit confirmation for every click (unless otherwise opted by the user), without requiring credential insertion each time it is used. Special focus will be put on usability and simplicity.

In this sensitive AoD region, we consider important to apply the innovative (in this domain and for software-as-a-service cases) concept of charging per use, to allow assistive technologies to be sold as a service (rented) rather than purchased, supporting pay-per-use schemes and dynamic changing tariffs. In typical e-commerce scenarios, charges are calculated according to the types and the quantity of the purchased items/services, either human-, software- or hardware-based. But this is not our case, and one of the main drawbacks of such scheme has been that they psychologically discourage the users from using the service. The flexible support of pay-for-use will offer the possibility to those needing assistance to get it at lower cost by paying for use only instead of paying for purchase. On the other hand, service providers can get higher profits by approaching larger customer groups.

This functionality leads to the following set of design requirements:

- Both machine (software) and human-based services charging should be made through a single infrastructure;
- Multiple charging models from product purchase to product rental on a pay-for-use basis, with highly dynamic tariffs that may change on service/supplier/user/country/time basis.
- Support reliable and fair charging scheme primarily based on the "pay as you go", allowing for the selection of flat charging (if selected by the user).
- Provide detailed logging and accounting information describing the charging and the usage of the services upon requests.
- Allow for intelligent and parameterized notification of reaching or exceeding specific amounts.
- Allow for transfer of charging schemes among users and / or consumers, in the context of the trusted and collaborative community.
- Donation and user bidding schemes for promoting service pulling tilt and crowd-sourced R&D financing.
- Personal data privacy and scalability.
- Support of different monetary systems and legislations while flexibility can be further enhanced supporting dynamic price adaptation, either on periodical basis or on demand-response basis (e.g. getting a taxi may be more expensive after a special sport event or physical disaster).

To efficiently support this rich payment system functionality, two discrete subsystems will be defined: the micropayment subsystem and the user bid subsystem, leaving the core charging and payment system of this activity to focus on all other aspects and having the subsystems taking care of a concrete sub set of payment functionality.

For those services, associated with pay-for-use charging models, the micropayment infrastructure will communicate with the AoD infrastructure and the micro charges will be accumulated and classified per user and provider so that payments are done either on regular basis or when the charges reach a predefined threshold to avoid excessive transactions. In the end, customers are charged for all the services they have used and a similar approach for the service providers will be followed.

Micropayment support is considered mandatory for allowing public access points (such as libraries) to make the full range of assistive technologies available to their patrons but only pay for those that the patrons actually use. This will allow many organizations to offer the full range of access solutions to their patrons at reasonable cost.

Central to micropayment functionality is the personal data and privacy management. These issues affect:

- The identification, authentication and authorization mechanisms. There are three mechanisms of authentication, i.e. whether the authentication is based on something the user knows (e.g. username, password), possesses (e.g. token) or is (e.g. biometrics).
- The security of the data: It is important that the service provider convinces the user that the provided information is treated confidentially and the integrity of the data is protected.
- Accountability and logging: The very nature of the micropayment functionality presupposes reliable logging of activities which can guarantee accountability.

With respect to the crowd-funding approach, the large AoD infrastructure customer database will be used to disseminate the initiation of a certain service creation, so that potentially interested users can contribute. Prosperity4All exploits the fact that the AoD platform brings together service suppliers, solution developers and customers to make crowd sourced financing of R&D a reality. Service developers/suppliers will also be notified and will be prompted to declare whether they intend to create the service. In case more than one is interested, they will be asked by the system to prepare an offer, i.e. specify the service one intends to create and possibly set a payment threshold, while volunteering and rewarding will also be supported. A predefined deadline for offers for service creation will be defined to allow for comparing the submitted proposals and trigger the service creation.

6 Conclusions

The proposed Assistance on Demand service and payment infrastructures aims to achieve unprecedented flexibility and high quality experience for any user, to increase the "pull" marketing tilt of the ecosystem and to facilitate successful financing of components, features, and other solutions. This way, market/community/citizen’s needs trigger directly the service creation. Leveraging on the current state-of-the-art technologies, the vision of the AoD and micropayment infrastructures will become a reality and will offer a colorful palette of advantages to the most sensitive parts of our society. Our future work will certainly focus on the detailed design, implementation and demonstration of the proposed infrastructures to illustrate the advantages that ICT technologies can bring to our society.

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