Case Study on Extending Internet of Services Techniques to Real-World Services

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Abstract: The Internet of Services promotes distributable, composable and tradeable services as first-class entities. Such services are assumed to encompass the full range from electronic web services to conventional business services. However, research and development of service models and platforms to realise the Internet of Services vision has largely been concentrating on pure technical services. In this case study, we have applied modelling and registration techniques to existing business services with none or few technical components. We outline the results of suitability and acceptance aspects and include an evaluation of the new Unified Service Description Language (USDL) compared to the Web Services Modelling Language (WSML) in the context of real-world service representation.

1 Background

Businesses involved with e-business activities struggle to find a balance between keeping trade secrets and exposing information about their products and services on the untrusted Internet [DL02]. On the contrary, any participation in value chains backed by distributed business processes requires a public, detailed and accurate description of goods and services. The Internet of Services (IoS) idea suggests that these services become tangible entities which can be traded and composed on marketplaces to ease the creation of value chains [Car09, CBSvD09]. However, techniques from this area still differ in how they apply to technical services compared to real-world services (RWS). While today most research prototypes focus on technical web services, it is expected that the service continuum handled by IoS service platforms be extended to conventional business services over time. According to the typical service lifecycle in the IoS [OBB+09], differences would most likely occur during the usage phase due to missing technical service execution, while the other phases would mostly remain the same. Therefore, we conducted a case study on the extent of reusability of Internet of Services ideas and techniques especially from the modelling, registration and offering processes to real-world services. The

offering phase scope of the work is hachured in the IoS service lifecycle in figure 1.
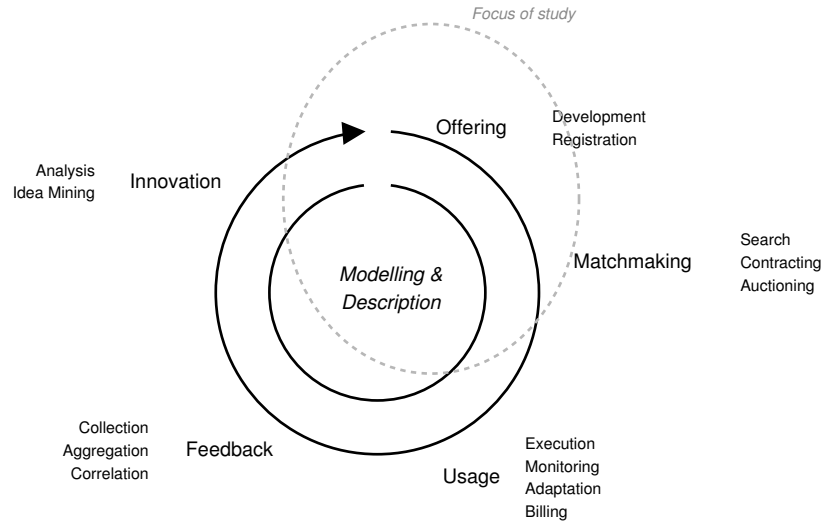

Figure 1: Scope of evaluating real-world service trading in the IoS lifecycle

Our first aim was to determine the technical suitability of modern declarative description languages for conventional business services or hybrid IT-supported services. Previous languages designed purely for web services such as WSDL and DAML-S have been criticised for not conveying enough information about the value and the content of RWS [BAG03]. Therefore, we wanted to find out which languages offer a spectral view from conventional to electronic services, thus making it possible for service providers to change the service implementation and delivery without having to change the description. Of particular interest has been a readiness comparison of the new language USDL specifically designed to describe tradeable business services with the established generic semantic web service language WSML.

Our second aim was to see to which extent companies accept the offering processes on service marketplaces. It implies a consideration of the willingness to expose descriptive service information in registries. To reach both aims, we performed an evaluation study called Real World Services in Dresden (RWSDD) with the additional goal of extrapolating its results to a general discussion on IoS concepts.

The remainder of this paper is structured as follows: First, we present our applied multi-phase evaluation methodology including the selection of target companies and services and the steps required to bring them into the IoS. Then, we explain our findings regarding the suitability of selected service description technologies and acceptance of our chosen approach regarding the survey, modelling and registration of commercial RWS. The methodology and the findings are compared to similar studies. Finally, the paper is concluded with remarks on the prospective value of the IoS for real-world services.

2 Evaluation Methodology

The starting point for the case study is a local setting of companies offering services within the city of Dresden in Saxony, Germany. The economical-structural characteristic of having mostly small, often tiny, and only some medium-sized companies poses a challenge regarding the ease of use of Internet of Services techniques. The criteria for the evaluation of suitability and acceptance aspects in applying IoS techniques to RWS have been chosen accordingly. They encompass *service identification* to isolate services from the overall offering of the companies, *adequate tooling* to express the service concepts and constraints appropriately without overhead or under-specification, and *self-empowerment* to let companies model, manage and register the descriptions by themselves.

We prepared a four-phase methodology which included an identification of a decent number of various service companies, and subsequent reduction of quantity, hence gaining quality, by filtering with a questionnaire, active modelling of service descriptions and registration of the services at an internal and a public service portal. We also planned a selective implementation of web services leading to hybrid conventional-electronic service offerings although eventually decided to postpone this activity. The resulting methodology is visualised in figure 2. The timeframe for this evaluation was limited to three months from February to May 2010. It was mainly conducted by a student by e-mail in multiple feedback rounds. The following paragraphs describe all evaluation phases in detail.
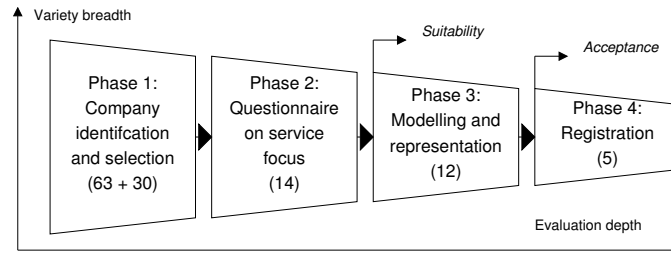
Figure 2: Overall methodology of real-world service selection and integration into the IoS in multiple phases, including number of participating companies in each phase

2.1 Identification of Service-Centric Companies

We limited our study on 63 individually identified local companies from all industry domains and in addition through an industry association (IHK) to 30 companies from the tourism sector.

The first set of companies included mostly small and tiny companies which according to their own estimations offer 95% services and 5% products. Represented industries were mainly event agencies, design studios, translation and correction

of documents, consulting and delivery services. Target customers were a mix of consumers, businesses and the public sector.

The second set of companies included mostly branch offices of larger tourism companies which are characterised by a higher level of IT-supported operations. In contrast, decisions about IoS integration are less likely taken directly by the local companies. The chosen tourism companies offer travel planning and booking services, sightseeing tours as well as lodging and catering for tourists.

All selected companies were sent background information on the Internet of Services and a questionnaire about their service offering and procurement habits. The tourism companies received an industry association statement about the importance of Internet innovations as additional incentive.

2.2 Inventory of Existing Service Offering and Usage

Only 14 companies completed the questionnaire, while some filled the forms only partially. Missing key data such as company names even made it impossible to identify duplicates, therefore we dropped all incomplete questionnaires. The response rate was higher with smaller companies compared to medium-sized ones.

Of note are some statistics about the companies' previous usage of Internet and World Wide Web facilities according to the results of the questionnaire. 100% are advertising on a dedicated website. 71% make use of online business registries, while only 36% are paying for inclusion in printed industry registries. Regarding the descriptions of offered services, 100% found the company name and website required attributes, compared to 64% for both the offering details and telephone contacts. Physical address information was deemed important in 29% of all cases, either as text or as geographical location on a map. Electronic services are offered by half of the companies. The statistical information served as input for the service identification criterion.

2.3 Service Modelling

Among all companies which completed the questionnaire, 12 indicated that they be interested in having their service offering modelled in a modern declarative service description language, and the remaining 2 were undecided. We started modelling with the Unified Service Description Language (USDL), while in parallel evaluating concepts from the Web Services Modelling Ontology (WSMO).

The results of this phase determine the suitability of IoS service description languages and are thus presented in detail in the next section.

2.4 Service Registration

After creating the service descriptions, we submitted them for a brief review to the companies and offered them to have them registered publicly on a service marketplace, not registered at all, or registered with pseudonymisation techniques applied so that the real-world business could not easily be found out from the service description.

The results of this phase determine the acceptance of IoS marketplace concepts and are thus presented in detail in the next section.

2.5 Further phases

The questionnaire results indicated that similar to the modelling needs, 9 companies would be interested in a web service implementation regarding parts of their business services, with the remaining 5 being undecided. Our study did not cover the actual realisation of web services or any post-registration activities like search for offered services, service usage contract establishment or feedback submission.

3 Findings

Our study concentrated on two main aspects: Suitability of current service description and registration techniques, as well as acceptance of offering services at IoS marketplaces among the participating companies. We give a detailed explanation about possibilities and weaknesses of modelling RWS with USDL and WSML to determine the suitability, and we analyse the responses of companies to our realisation to determine the acceptance. We draw conclusions mostly from the 3rd and 4th phase of our evaluation. It should be noted that due to the low number of services considered in the late phases, the results are not representative. However, given the lack of similar studies, they help to understand the challenges of bringing real-world services into the IoS and to identify problems early in the process.

3.1 Suitability of USDL

USDL is a very recent service description language which has so far not yet been used on public service marketplaces [CWV09]. It presents a simplified syntactic XML representation of a hierarchically modular service ontology based on OWL [OBB+09]. Major modules encompass a foundation and core description, service level objectives, pricing, functional descriptions and interaction, as shown in figure 3. The syntax is kept synchronised with an Ecore model so that Ecore-based trans-

formations can be used in addition to XML transformations, which is popular with Java tool developers [ETV06] and hence stimulates the refinement and extension through domain-specific modules and vocabulary. At the time of the evaluation study, not all modules of version 3 (USDLv3) were completed. Especially the legal module has only been created as a stub, and the service level module was work in progress. This limitation, combined with an exclusion of syntax intended to represent features of technical services, restricted our study to functional and pricing aspects. The USDL editor, while not yet easy to use, can be considered adequate for expressing all language features. A further limitation, restraining the self-empowerment criterion, was the missing unrestricted availability of the editor to companies. We worked closely together with some of the USDL authors and tooling creators to ensure that our feedback could help to avoid some of the early issues we found. The progress on USDL development can be tracked on an Internet of Services commercial community site[1].
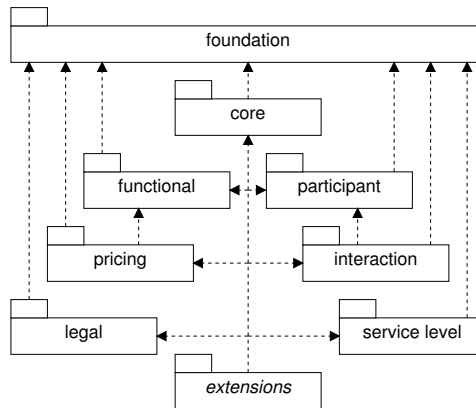

Figure 3: Modular structure of USDL version 3

In general, USDL can be seen as the first major description language which is suitable for RWS and web services alike. The example 1, which is an excerpt from one of the RWS modelled by us during the study, demonstrates how to represent an actual certified consulting service without explicit pricing information in compact USDLv3 pseudo-notation which omits syntax elements for better readability.

Listing 1: USDL representation of consulting service

```
core:Service {
 guid "urn:Consulting Mueller Services"
 nature "Human"
 naturalPersons {
  firstName "Gustav"
  lastName "Mueller"
```

---

[1]USDL community: `http://internet-of-services.com`

```
  contactProfiles {
   virtualAddress "+49 (351) 0000000"
}}
organizations {
 guid "urn:Consulting Mueller Company"
 representatives "//@naturalPersons.0"
 certifications {
  certificate "DIN ISO 9001"
 }
 contactProfiles {
  physicalAddress {
   street "Dienstboulevard"
   city "Dresden"
}}}
serviceLevelElements {
 availabilityAttribute {
  type "Telefonische Erreichbarkeit"
  timeZone "CEST"
  timeRanges {
   Mo-Fr: 9:30 - 16:00
 }}
}
paymentTerms {}
pricePlans {
 name "Standardstundensatz"
 currency "EUR"
 planComponents {
  componentFloor "70"
 }
 taxes {}
}
capabilities {
 name "Unternehmensberatung"
}}
```

Several interesting USDL features map real-world situations to service description fragments. For example, the modelling of roles can map a restaurant, an associated delivery service and a training with the chef as services with corresponding opening or operating times. Compared to printed business registries, these structures already present an immense advantage when looking for a service to cover specific needs.

Yet, a number of weaknesses result from precisely this broad scope. Additional weaknesses were found in the realisation of certain XML language constructs and in the presentation within the Eclipse-based standalone USDL editor of version 0.5. A subset of ostensive weaknesses found by us will be briefly mentioned here, while a full report on the suitability of modelling particular real-world services in USDL can be found in an online report [Kur10].

- While industry-specific perspectives are planned, they are currently not part of the public specification. Therefore, modelling always exposes the entire structure which is often not desired, especially for services in the creativity domain like marketing or event management.

- Composite services in the real world can be extremely complex. For instance, a food delivery service may have separate product shopping cart and delivery options. USDL offers limited support for composite services.

- The pricing module of USDL is very powerful by allowing a great degree of granular price decomposition. However, this leads to difficult price evaluation at runtime. A possible solution would be to add non-normative simple pricing information to each full specification, e.g., a service *starting at 99 EUR*. This enhancement would reflect imprecise price statements often seen in RWS advertisements.

- Availability as a temporal and spatial concept is not used to its full potential. This is a key metric to distinguish functionally identical or similar services and filter out services which are out of the question due to their unreachability.

- USDL service descriptions are likely used in user-friendly portals. However, USDL lacks unified graphical elements such as provider and service logos, banners and similar visual hints.

- The service-level module is very basic. It does not support ranges or dependency specifications between objectives. Legally valid contractual rights and obligations of RWS providers and consumers requires an expressive syntax if the aim is to replace currently used paper contracts with machine-readable documents.

- Legally required information such as tax numbers are not yet part of the language. For the completion of the Legal module, such real-world requirements need to be taken into account.

- The editor refuses to work properly with Unicode data and mandates to use XML encoding for non-ASCII characters, resulting in larger and harder to read documents.

We expect that the upcoming standardisation attempt will reduce the number and impact of the identified weaknesses and therefore increase the suitability of describing tradeable services in USDL.

3.2 Suitability of WSML

The Web Service Modelling Language (WSML) is a format for representing concepts from the corresponding service ontology WSMO [FRP+05]. Given that

WSML is popular among existing SOA and semantic web service research and that several reasoners, registries and discovery components exist, we were interested to see if a new language like USDL was really necessary or if WSML could be used to model the relevant artefacts instead.

Compared to USDL, WSML is a rather computational low-level language which provides rich syntactical constructs for describing capabilities, mediators, properties and domains of services. The language is based on extended first-order logic and rule language foundations such as terms, predicates and logical expressions [CPPT08]. WSML furthermore provides extensive annotation support which is very useful when processing descriptions at service marketplaces, as well as mappings to RDF and XML exchange syntaxes and to OWL ontologies. Similar to how OWL-S defines concepts specific to web services, the WSML semantics provide means to express web service ontologies, but could equally be used for RWS. Some language concepts like real-world effects specifications already extend the scope.

While WSML is highly modular, a definition of modules is outside of the scope of the language. Therefore, concepts such as provider addresses and pricing information need to be captured in application-specific and site-specific WSML base ontologies as shown in figure 4. Additional functional domain ontologies like *Consulting*, *Hotel booking* or *Translation*, optionally divided into subdomains such as *Book translation* and *Translation into Japanese*, can be instantiated and the instances combined with instances of the non-functional properties and service concepts from the base ontologies to achieve rich descriptions and multiple discovery methods including multi-faceted browsing and goal or intent resolution.
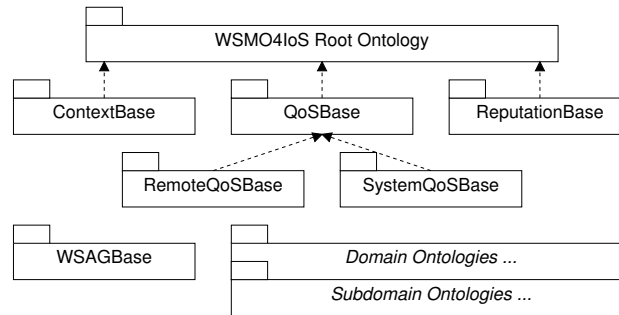

Figure 4: WSML base ontologies required for IoS platforms

The hypothetic base ontology set WSMO4IoS as designed in the figure has partially been realised by us to experiment with our findings. It contains definitions for non-functional properties such as local monitorable parameters (CPU load, memory consumption), remote monitorable parameters both on the service level (availability) and the invocation level (response time, success), and non-monitorable properties like a service's location, usage context and reputation. For the registration of RWS, machine-monitorable properties are of no concern. Especially with smaller

companies, connecting real-world data sensors such as RFID tags to software sensors used by IoS platform monitors seems to be not feasible, although technically possible for larger companies to automatically supervise properties such as shipping times. In contrast to this limitation, location and reputation information are highly important to the providers of RWS, especially due to the physically imposed geographic boundaries on some services. WSML provides syntax to describe *post-conditions* and *effects* which could translate to real-world effects. However, we decided to stay with the simple property syntax and instantiate concepts from the ContextBase ontology. Optional base ontologies are included for further processing, e.g., WSAGBase to derive WS-Agreement SLA templates for contract-bound service usage. The listing 2 shows an excerpt from the WSML description of the consulting service.

Listing 2: WSML representation of consulting service using WSMO4IoS

```
instance providerMueller memberOf {wsag#Provider,wsag#
   ServiceInfo}
  wsag#providerName hasValue "Consulting Mueller Company"
  wsag#providerStreet hasValue "Dienstboulevard"
  wsag#providerCity hasValue "Dresden"
  wsag#providerPhone hasValue "+49 (351) 0000000"
  wsag#providerPersonName hasValue "Gustav Mueller"
  wsag#providerCertificates hasValue {isocert}

instance consultingservice memberOf {wsag#Service,wsag#
   ServiceInfo}
  wsag#serviceKey hasValue "Unternehmensberatung"
  wsag#serviceType hasValue wsag#HumanAtomic

instance isocert memberOf {reputation#Certificates,qos#
   ServiceSpec}
  qos#value hasValue "DIN ISO 9001"
  qos#unit hasValue ""
```

The nature of WSML supports modelling complex characteristics of a service without necessarily providing prior specification in schemas or base ontologies. For instance, in listing 3 a delivery service restricts its orders to EU countries and gives a rebate of 2% for recurring orders. Compared to USDL, the flexible syntax can be seen as advantage, however it also requires higher processing and reasoning resources.

Listing 3: WSML advanced service definition

```
capability
  sharedVariables ?customer
  precondition
    annotations
      dc#description "Only delivering to European Union."
```

```
      endAnnotations
      definedBy
        ?customer memberOf Customer
          and ?customer[hasResidence hasValue ontomediator#
              eucountry].
    effect
      annotations
        dc#description "Any delivery turns customer into patron."
      endAnnotations
      definedBy
        ?customer memberOf Customer
          and ?customer[isPatron hasValue xsd#boolean("true")].

nfp
  RebatePrice hasValue ?price
  annotations
    dc#description "Patrons get a 2% rebate."
  endAnnotations
  definedBy
    ?customer[isPatron hasValue xsd#boolean("true")] memberOf
        Customer
    implies ?price[hasAmount hasValue ?amount, hasCurrency
        hasValue "EUR"] memberOf Price and numericMultiply(?
        amount, 0.98).
```

WSMO4IoS would have to be completed in order to draw a final conclusion about the suitability of the language. A major gap towards a description of RWS is the absence of a predefined pricing ontology. Hence, one could assume that in the Internet of Services, description syntax is less important than standardised and widely utilised base ontologies. Still, we assume that the computational power of WSML will be of great benefit over purely syntactical approaches when complex service bundles and compositions become commonplace, provided that service platforms can interpret the additional information. The language would be even more suitable if custom XML Schema datatypes could be used from both web services and information systems relating to RWS.

As a next step, we intend to explore additional WSML modules and apply them to our samples. The conversion and sharing of base ontologies between various service description approaches could mean an interesting challenge. The ongoing work can be tracked at a dedicated website[2]. For further exploitation of WSML in the context of the IoS, we also recommend the creation of a global collaborative catalogue of base ontologies. The catalogue will help to reduce duplication and enable the integration with service discovery, service level agreement transformation and other runtime tasks, as well as design-time tools such as WSMO Studio.

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[2]WSMO4IoS page: http://serviceplatform.org/wiki/WSMO4IoS

3.3 Acceptance of IoS concepts among companies

Out of the 12 companies whose services we modelled, 5 indicated to us that they would like to immediately see the service descriptions being used on a public service marketplace independently from whether or not the companies would get direct access to modify the registry entries if needed. The remaining 7 were unsure. Therefore, we measured the acceptance of modelling and registration techniques in the IoS with 5 RWS providers. Acceptance is an important competitive metric which directly affects the quantity of turning potential into actual users [Kol01].

Service descriptions approved for public registration were registered into an instance of the ConQo semantic service registry [SBSB08]. Its service model mandates a domain-dependent WSML file with an arbitrary number of attached documents and hyperlinks, including USDL or WSDL files. For a preference-driven search and discovery over the service offering, USDL information would have to be transformed into WSML constructs to become visible to the ConQo reasoner. However, since search was not a goal of this study, we only considered few attributes such as service name, description and ownership specification. A service catalogue within a social network of users, communities and companies has been produced which reflects the contents of the service registry. The resulting service catalogue can be found online[3].

We perceived a general reluctance to specify prices and conditions upfront. Therefore, we suggest to include negotiation capabilities into the service description languages. Service providers would specify which input parameters affect the price on a mandatory or optional level. While SLA negotiation including QoS and pricing conditions is an established topic among SOA researchers, specifying negotiation metadata for a prior meta-negotiation about which properties are negotiable in which situation is a relatively new topic [BVMB08].

USDL in particular offers specification fields for employee roles and birth dates. The usage of these fields will depend on trading employee privacy and company protection versus customer needs and curiosity. If all service description fields are public, crawlers could be created to exploit this information in non-intended ways. We expect this to become a major area of interest for privacy research along with the establishment and rising popularity of the IoS.

We also experienced that companies would need much easier-to-use guided tools and editors to bring their services in the IoS. Both the USDL editor and WSMO Studio are exclusively targeting technical users. Easy applications or web-based wizards could help to parallelise the collection of registration data from companies. The presence of a large number of service descriptions is one of the key success factors for service marketplaces due to the network effect [SV98].

Regarding the registration, our plan to let companies register the descriptions by themselves had to be put on hold despite the availability of a step-by-step documentation. We perceived both a problem of understanding the resulting declarative

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[3]RWSDD service catalogue: `http://crowdserving.com/real-world-services-in-dresden`

service descriptions and an incentive problem of what the benefits of registering the files would be. Therefore, we as marketplace operators performed the registration on behalf of the companies, which will obviously not scale. We recommend the standardisation of service package publishing interfaces and the inclusion of publishing functionality into modelling tools to streamline this process. We also suggest that service description ownership and dynamic content adaption (e.g., provider address updates) within service platforms be treated explicitly to convey the advantage of roaming between different hosters without losing information. Our discussion with the affected companies strengthened this view.

Finally, the acceptance of post-registration processes like service usage and rating needs to be taken into account. While we don't cover these aspects in our current work, we intend to explore it later through complex service scenarios. For example, an RWS provider needs to offer a composed service which includes a web service interaction, and the web service shall be dynamically replaceable under the constraint that it won't ever cost more than a certain limited amount of money.

4 Related Work

This evaluation study is mainly related to different service description approaches and to surveys on the acceptance of service provisioning approaches on marketplaces.

Literature coverage of industry-driven electronic service description (e.g., WSDL, SAWSDL, WADL) and brokering (e.g., UDDI, ebXML) is quite complete. Surprisingly, while product taxonomies and declarative product descriptions also exist in standardised formats, only few publications focus on comprehensive machine-processable descriptions of business services to make them comparable, composable and tradeable through marketplaces. An abstract meta-model to combine aspects from several approaches is given in [BF09]. Its authors further developed a concrete realisation as EMF meta-model with graphical representation and editor tooling. While USDL and WSMO4IoS are primarily subdivided into modules and base ontologies, both extensible with domain-specific concepts, the meta-model primarily considers the four service system dimensions component, resource, product and process. Both the meta-model and USDL have a fixed set of non-functional service properties, while WSMO-based description ontologies allow for dynamic sets of arbitrary properties. The resource model of the meta-model, which is not considered by USDL or WSMO4, is comparable to resource clauses in special web service and component description languages like CQML+. An apparent limitation of the meta-model approach and others is the lack of public syntax specifications and tools. Without these, service platform integration as well as suitability and acceptance studies cannot be performed.

Measuring the acceptance of service provisioning on marketplaces relates to similar work in the area of e-commerce. A dual perspective on buyers' and sellers' accep-

tance of trading good on marketplaces has been examined empirically in [Kol01]. Acceptance problems found by the study centre around a mismatch between supply and demand in certain configurations, for instance, consumers expecting better quality in one domain and more choice in another. Solving the mismatch requires thorough specification and processing of non-functional properties during matchmaking, which is provided by most advanced service description concepts. It also requires means to discover under-supply and subsequently techniques to describe and offer competitive offerings to close the gaps, which is outside the scope of service descriptions and needs to be provided by service platforms and marketplaces. The study omits service-specific arguments. Nevertheless, the findings resulting from the mismatch especially under the network effect equally apply to our work. Measuring a broad-scale acceptance of IoS service offering concepts will only become possible once IoS marketplaces will become more widely used in commercial environments.

On a minor scale, this study also relates to alternative combined handling of RWS and web services. Few approaches focus on a spectral view for describing and trading both conventional and electronic services as well as hybrid IT-supported conventional services. Related work on this aspect can be found in [CWV09].

5 Conclusion and Future Work

In the spectrum from fully electronic services to IT-independent business services, current Internet of Services approaches and platforms mostly concentrate on electronic or at least IT-supported services. However, we were able to demonstrate in the case study RWSDD that central service offering tasks such as modelling and registration of service descriptions have become more feasible and inclusive than with previous conventional SOA techniques. While the study criteria are only partially fulfilled, the expanded view on practical service trading helps to refine research results in the IoS.

Major barriers to wide adoption of the techniques can still be found in service description languages like USDL and WSML. They require a further evolution, especially in terms of standardised base vocabulary for expressing service properties, and improved user-friendly tooling for entering into an economy of scale by reaching a critical mass of self-empowered IoS participants.

Further crucial factors for durable acceptance of IoS ideas will be the availability of permanent service marketplace installations with guided service provisioning processes, the long-term manageability of service portfolios and the inclusion of user feedback into the service evolution. Future studies about RWS are expected to yield more concrete results about the post-registration usage phases. We expect such studies to be performed once the IoS infrastructures are completely developed and actively used.

Acknowledgement

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