Semantic Service Delivery for Mobile Users (September 2006)

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Abstract—This paper addresses the business of semantic based service delivery of advanced services for the mobile user. Location is a key to mobile services, e.g. allowing points-of-interest guiding, route information and emergency help. The paper uses location service capabilities as an example for advanced service delivery.

Telecom networks provide voice and data connectivity in other countries, but advanced service roaming based on location is not yet in place. This paper analyses the current status of location roaming, and suggests service delivery based on semantic as a solution. It highlights the complexity of such services, indicates both technical and sociological challenges for this type of service, and uses WSMO based semantic annotations as an example of how to overcome existing limitations.

The paper shows how WSMO is applied to realize seamless access to the Orange and Telenor location services. Based on the experiences gained through the implementation of real life services the paper presents a business expectation of semantic web services for the mobile user.

Index Terms—**Semantic Web Service, Advanced Telecom Services, Telematics, Service Roaming, Location Based Service.**

I. Introduction

Basic telecommunication services like mobile telephony and SMS became popular, because customers do not have to configure the devices. The services are available everywhere due to seamless service setup and roaming agreements.

Future telecommunication services will need more than just connectivity. Positioning, tracking, and seamless service access to personalized services are already demonstrated in various environments [1]. Main focus is on adaptation towards the user terminal, which typically is the mobile phone. In the upcoming world of pervasive (ubiquitous) services the user will be surrounded by a variety of devices, e.g. smart tags, smart assistants, wearable communication equipments. These devices will communicate to the user and his personal devices, and will address basic network services and service capabilities.

With the evolution towards service oriented computing, seamless integration of heterogeneous external services become critical. This is especially true in the Telecom industry, where Telecom providers in cooperation with 3rd Party Service Providers, look for means of integrating their heterogeneous services. Roaming of connectivity for GSM, GPRS and UMTS is in place, but the current infrastructure does not support roaming of advanced services built on location services capabilities.

Semantic Web-based technologies are widely acknowledged to play an important role in solving the interoperability problem between applications; the usage of semantic description, in the context of advanced Telecom services, is expected to simplify the integration of services. Such formal and explicit descriptions do not only enable easy service integration, but also support service roaming across networks and countries. Based on the semantically enhanced service description of location based services, one will be able to deduct general service ontology for that type of service. This will especially enable interoperability between Telecom providers and other location service providers to offer various location services.

This paper aims to highlight the challenges in the roaming of advanced Telecom services, and proposes the adoption of semantic technologies as a solution to tackle those challenges. The rest of the paper is organized as follows: Section II states in more details the problem of roaming of advanced Telecom services, Section III uses location as an example of an advanced Telecom service and highlights the service roaming challenges in this context. Section IV discusses the benefits of semantic annotations in the context of the Orange and Telenor location services, Section V analyzes the business profitability of semantic based services and Section VI concludes the paper.

II. Pervasive Services in Telecom

Pervasive services in Telecom are context-aware communication services. GSM introduced pervasive mobile telephony services first in Europe. 3G was introduced to provide roaming on a worldwide base, and compatible standards as UMTS are currently rolled out in the whole world. Systems beyond 3G will provide personalized wireless broadband access, and will incorporate mobile and wireless access methods including e.g. Wifi, WiMAX [2]. Offering personalized broadband wireless services across networks, both national and international, will require new ways of service interconnectivity. GSM service roaming is based on bi-lateral agreements. Packet data roaming was successfully completed in November 2000 between Telenor (N) and Sonofon (DK), based on GSM roaming exchanges (GRX) [3]. The current set-up provides data connectivity, but end-to-end Quality of Service (QoS) is still limited (see fig. 1).

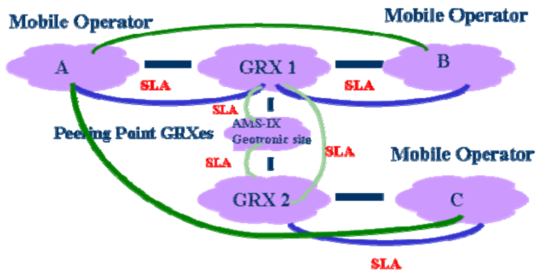

Fig. 1. Complexity of providing QoS in a roaming scenario

As QoS is an end-to-end measure, it needs service level agreements (SLA) between each mobile operator and the corresponding GRX, as well as SLAs between all GRX. The future service world will include requirements for QoS measures, but will also cover more complex services such as location of the user and services related to the user. Current roaming mechanisms are not appropriate to cover advanced services roaming, and adoption of other technologies, that specifically address interoperability of data and processes between services, is critical in this context. Location based on GSM is standardized through a ParlayX Web service, but more advanced location, e.g. through timing advance, assisted GPS, triangulation or indoor measurements gets a more complex description.

III. LOCATION SERVICES

In this section we use location to address the challenges when it comes to service roaming of advanced Telecom services. We uses location from the Orange network in Poland and the Telenor network in Norway in order to establish ways for location roaming [10].

Semantic annotation of information has reached the business market, and allows information exchange across companies. We suggest extending the semantic annotations and use them for the exchange of advanced telecom services.

Mobile Location information

Advanced Telecom service delivery has moved from vertical to horizontal service architectures. Telenor’s Innovation lab PATS (fig. 2) is an example of a lab working on such horizontal service architectures. The lab consists of Engineering and development/execution platforms as well as service delivery platforms [4].

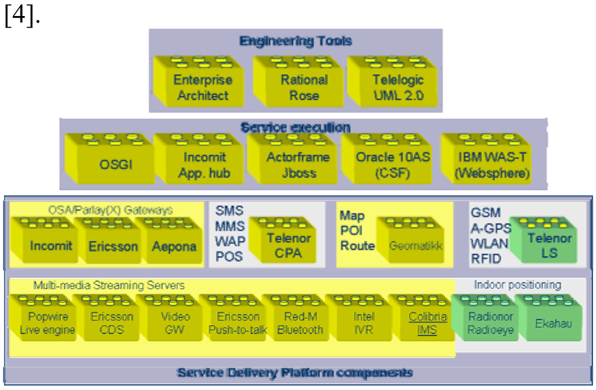

Fig. 2. Location information achievable from Telenor’s PATS lab

In the PATS lab, Telenor has four different measures providing user location to service providers:

- Mobile positioning (POS) using the GSM/UMTS positioning in Telenor Mobil’s network [5].
- Advanced GSM positioning combining GSM location techniques with assisted GPS (A-GPS) provided by Telenor R&D.
- WLAN positioning from Telenor R&D, Radionor or Ekahau.
- Touch-based location systems using RFID or Near Field Communications (NFC).

A multitude of location information sources increases the complexity of location provisioning and even more the complexity of getting location exchange across networks, countries, and operators.

The location information used in the Orange network in Poland and Telenor network in Norway are semantically expressing the same information, i.e. the location of the phone, but uses different formats. When including WLAN or RFID based location (see fig. 2), information will be represented through yet another format, making it difficult to provide reliable exchange across operators.

Challenges in location roaming

Technically, roaming of location information is the provision of a location parameter, and might include the information about the accuracy and the time of the measurements. The main challenge for a roaming exchange is in the heterogeneity of the Web service interfaces and data formats. The following chapters concentrate on the challenge to handle heterogeneous descriptions of location.

IV. SEMANTIC ANNOTATIONS

In this section we highlight the potential of semantic annotations in the mediation between advanced Telecom services and present a real case study (i.e. the Orange and Telenor location services) on how WSMO [6] semantic annotations are added in order to potentially enable interoperability between Telecom providers.

Role of Semantic Mediation

On the semantic Web, data is annotated using ontologies: concepts, relations, instances, and axioms in ontologies give meaning to data on the Web. Because ontologies are shared specifications, the same ontologies can be used for the annotation of multiple data sources, not only limited to Web pages, but also collections of XML documents, relational databases, etc. Because of their shared terminology, ontologies already enable a certain degree of inter-operation between these data sources. However, it would be unrealistic and it cannot be expected that all individuals and organizations on the semantic Web will ever agree on using one common terminology or ontology. It can be expected that many different ontologies will appear and, in order to enable inter-operation, differences between these ontologies have to be reconciled - this reconciliation of these differences is usually called ontology mediation.

The most important thing in this context is that ontology mediation enables reuse of data across applications on the semantic Web and, in general, cooperation between different organizations.

An important application area for ontology mediation is that of Semantic Web Services. In general, it cannot be assumed that the requester and the provider of a service use the same ontology to annotate their data and thus mediation is required in order to enable communication between heterogeneous business partners. We exemplify this type of heterogeneity in the following section by describing the data and location based services for two Telecom providers: Orange and Telenor.

WSMO representation of location information

Our implementation of a semantic annotation for location as an advanced Telecom service is based on the following steps:

1. Provision of the location services as a Web service
2. Establish a Service Ontology, here specific for the use case scenario.
3. Describe the web service elements in the service ontology, including concepts, types and the relations between the types
4. Specification of non-functional parameters, which are handled by the semantic web services platform
5. Bring the service into the platform, including the mapping from service ontology to platform ontology

We assume that the location service is available as a Web service, thus start with step 2, the service ontology. The service ontology is required for a semantic service specification and can be derived from the domain model containing data types used by the interface definition of the services or by defining own data types. The types used in this paper are represented by concepts in the domain ontology developed specifically for use cases from the Adaptive Services Grid (ASG) project [7]. The ASG project developed a prototypical implementation of a semantic service platform, and integrated existing Telecom services into the platform. A collection and analysis of available information and specifications on telecommunications domain was performed prior to the development of the vertical service domain, process ontologies and the semantic framework. With respect to the Shared Information Data (SID) of the Telecom Management Forum [8] we have established a definition of domain specific concepts:

concept *phoneNumber*
 number ***ofType*** *_string ( )*
concept *coordinates*
 longitude ofType _float
 latitude ofType _float

In addition, the ontology also defines a full description of the relations between types. Having defined the domain ontology, we need to define the location service ontology. This ontology may be represented with following declarations:

webService
http://195.116.60.7:8080/LocateService/services/LocateService

Our ASG platform handles non-functional parameters, e.g. name, supplier, and a privacy statement, here:

nfp
 dc#title ***hasValue*** *"OrangeLocateService"*
 dc#publisher ***hasValue*** *"Orange"*
 dc#serviceType ***hasValue*** *EducationOnly*
endnfp

The domain ontology describes the capabilities of the services, and define pre- and post-conditions. A pre-condition may be that a supplied phone number is valid "Service Choreography" is a composition of the component (atomic) services in a chain. "Grounding" stores information about the location of message types, mapping between ontology object and parameters of a Web Service:

```
interface OrangeLocateServiceInterface
  choreography OrangeLocateServiceChoreography
    stateSignature
      in dO#phoneNumber withGrounding
ssWSDL#wsdl.interfaceMessageReference(OrangeLocateServicePortType/phoneLocation/In)
      out dO#location withGrounding
ssWSDL#wsdl.interfaceMessageReference(OrangeLocateServicePortType/phoneLocation/Out)
```

The final step is the declaration of the meaning of the service, here the provision of location information for all provided phone numbers:

```
transitionRules
  forAll{?P} with (?P memberOf dO#phoneNumber) do
      add(?L memberOf dO#location and
      dO#hasLocation(?P,?L))
  endForall
```

The following example shows the implementation of the service, using the ASG domain ontology:

```
concept phoneNumber
  nonFunctionalProperties
      dc#description hasValue "concept of a phone
      number"
  endNonFunctionalProperties
  countryCode ofType _string
  areaCode ofType _string
  number ofType _string
```

Having performed the steps for both the Orange and the Telenor location service, we have established service roaming for advanced Telecom services. Platform prototyping is ongoing [9], and will finally allow a demonstration of the service roaming.

Advanced Service Roaming

The description of a location service, based on one of the four potential methods presented earlier, is too complex to allow reliable advanced service roaming as required for location services.

Our approach is to annotate the Web Service descriptions with Semantic information simplifying the exchange of service information. Location information has a functional property, the position, and non-functional properties such as supplier and privacy information. Non-functional parameters might also address the accuracy or the time of last recording for the phone position.

We have selected WSMO for the representation of these functional and nonfunctional properties. Through the same annotation of the services, i.e. a Domain Ontology for Advanced Services and Service Ontologies for the location, a direct exchange of location information can be performed in a GRX. Similar to GPRS roaming, we assume that a service level agreement between the location providers is in place, and we also assume that the customer agrees on being located.

The current implementation is performed in the ASG project [7], and uses WSMO for the annotation of the services

V. Business Considerations

Location information is the key to advanced Telematics services, as finding attractions in the vicinity, providing a route to a destination, and giving guidance in an emergency situation. The following section provides business considerations, based on the steps necessary to establish semantic web services.

Analyzing the business of providing advanced services for the mobile user is based on the following steps [10]:

(1) Create a service overview, addressing services for the mobile user, including location information, routing, points-of-interest (POI) and booking of a service.

(2) Identify real world services, here the location services from Telenor and Orange and make them available as Web services.

(3) Establish the methodology to convert the existing Web services to semantic web services, and make them available in an application. Our methodology is based on the three areas:

1. Semantic Service Creation, including semantic description of the service, service testing and registration at the service platform.
2. Domain Ontology development, required for defining the service landscape semantically.
3. End-user Application, which is the interface for real users to address the services.

Addressing the life time of a product means analyzing the costs/effort to establish a service, to maintain the service and to modify/upgrade a service. Our analysis aims in comparing conventional services with semantic web services. The efforts in person days (pd) per step are estimated efforts based on the experiences from the implementation of semantic based location services. The usage of semantics for services incorporates the following changes:

- Service creation: We assume that services are available as Web services, and thus the main effort is to establish a semantic service description.
- Service testing is easier in a semantic web service environment, as a testing suite has to be written only once, and can be used for all testing of all services.
- Service registration is of similar effort for conventional and semantically based services.
- Domain ontology development is only needed for SWS, and is a clear cost driver.
- Application development is not considered now, but is subject to further work.

We define the creation of semantic service description S, service testing T, service registration R, Domain ontology development D, and service update U. For one service provider, the semantic service description costs S in person days [pd] for n services are calculated as

$$S_{1tot} = S_{10} + nS_1, \qquad (1)$$

with S_{10} being the costs for understanding the semantic description of the service, and S1 the costs for describing each service. The respective costs for another provider will be S_{20} and S_2, and will be identical for all further subscribers. They can base their semantic service description on the service provided by provider 1.

Table 1 Deducted efforts for semantic service provision compared to conventional service provision

Description	Provider A		Provider B		Conv. Serv.
	Serv. p [pd]	Serv. q [pd]	Serv. p [pd]	Serv. q [pd]	
Svc – Semantic description	20	4	5	2	0
Svc – testing	3	0	1	0	4
Svc – registration	3	2	1	1	2
Dmn – creation/update	30	3	4	1	0
App – not considered	-	-	-	-	-

Considering m service providers with similar services will yield to a total cost of semantic service creation of

$$S_{tot} = S_{1tot} + (m-1)S_{2tot} = S_{10} + nS_1 + (m-1)S_{20} + n(m-1)S_2. \qquad (2)$$

Provisioning of conventional services would not need a semantic description, thus $S_{conv} = 0$.

Similar relationships exist for service testing T, service registration R, Domain ontology development D, and service update U. Domain ontology description is not needed for conventional services, thus only a cost factor for semantic service delivery. Service testing T and service update U will profit most from a semantic description. A test suite has to be written only once, and can be used without modifications for all service components. For conventional services, each service has to have an own test suite. While service upgrade for conventional services typically means a rewrite of the whole service interface, an update of the semantic description is the only necessary step for SWS. The effort for service registration is comparable between the conventional and the semantic service provision.

The total costs of service delivery can thus be calculated as

$$\begin{aligned} S_{tot} &= S_{10} + nS_1 + (m-1)S_{20} + n(m-1)S_2, \\ T_{tot} &= T_{10} + (m-1)S_{20}, \\ R_{tot} &= R_{10} + nR_1 + (m-1)R_{20} + n(m-1)R_2, \\ D_{tot} &= D_{10} + nD_1 + (m-1)D_{20} + n(m-1)D_2, \\ U_{tot} &= U_{10} + nU_1 + (m-1)U_{20} + n(m-1)U_2. \end{aligned} \qquad (3)$$

Conventional service discovery will see the following costs

$$\begin{aligned} &S_{conv} = 0, D_{conv} = 0, \\ &T_{conv} = nmT_{conv0}, R_{conv} = nmR_{conv0}, \\ &U_{conv} = nmU_{conv0}. \end{aligned} \qquad (4)$$

Initial values, as deducted from the development and implementation of the location service at Telenor and TP/Orange and experiences from the domain experts are

$$\begin{aligned} &S_{10} = 16, S_1 = 4, S_{20} = 3, S_2 = 2 \\ &T_{10} = 3, T_{20} = 1, T_{conv0} = 4 \\ &R_{10} = 1, R_1 = 2, R_{20} = 0, R_2 = 1, R_{conv0} = 2 \\ &D_{10} = 27, D_1 = 3, D_{20} = 3, D_2 = 1, D_{conv0} = 0 \\ &U_{10} = 0, U_1 = 1, U_{20} = 0, U_2 = 1, U_{conv0} = 4 \end{aligned} \qquad (5)$$

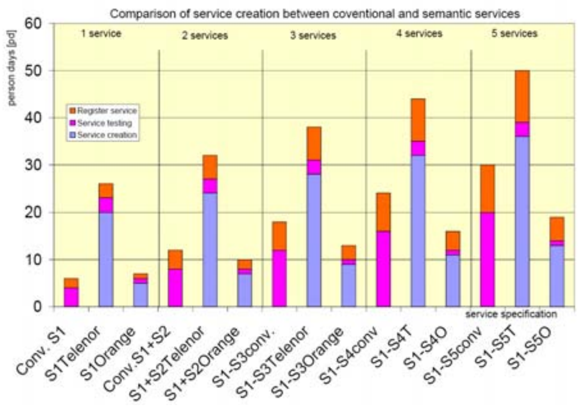

Figure 3 - Comparison of service creation costs between SWS and conventional service provision

Using the deducted effort for semantic service delivery (see table 1), and apply them to two service providers with up to 5 services each results in the effort presented in fig. 3. The following conclusions can be drawn. The initial semantic service description for semantic web services (SWS) drives the costs. For one service provider the advantages of using SWS are in the easier testing and upgrade of services, but required efforts in semantic service creation and domain ontology development drive the costs.

If we include the domain ontology development and update, we receive the results of fig. 4. It shows that the development of the semantic service description and the domain ontology are the cost driver for the first provider. A second provider will only see incremental costs for the domain ontology adaptation. He will already see cost benefits when providing 5 services.

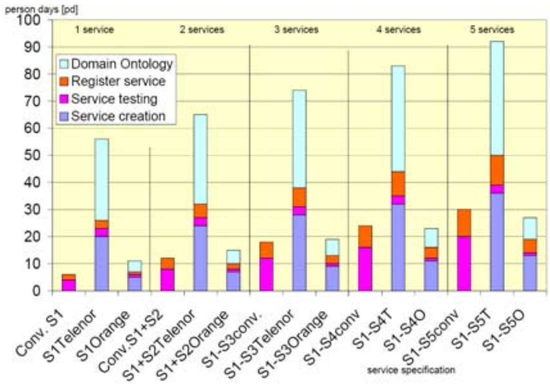

Figure 4 - Cost of service creation, registration, testing and ontology creation

Figure 5 shows the cost split-up for semantic service creation, and the total costs compared to conventional service delivery. It shows (left fig.) that semantic service description is the main cost driver. When calculating just service related costs between conventional and SWS delivery, a break even point would be achieved for 3 providers with 5 services, or 5 providers with 3 services. However, including domain ontology will move the break-even point to higher values (right fig.) with 15 services provided from 5 different providers.

When including the update of service, the break-even point will be reached for substantially lower number of providers or services. Thus, service maintenance and service upgrade are the items which make SWS delivery advantageous as compared to conventional service delivery.

VI. CONCLUSIONS

This paper addressed business aspects of semantic service delivery, based on services for the mobile user. Location service is selected as initial service, as it is the basis for advanced services such as points-of-interest, routing and emergency help.

Location services points out the complexity of mobile, GPS, WLAN or touch-based location. Current roaming mechanisms are not appropriate to cover advanced service roaming, as they are based on static interface definitions to Web Services. To tackle the challenges we proposed WSMO-based annotations of location services.

Based on existing location services from Orange in Poland and Telenor in Norway we showed how the services are modeled with WSMO. Having the semantic representation in place, a service exchange center can base the roaming on these representation rather than static service interfaces. Global service roaming will be based on heterogeneous service descriptions and ontologies.

The paper presented initial business considerations for SWS delivery, showing that the initial costs for developing semantic services are due to the semantic service description and the ontology development. SWS delivery profits from lower maintenance and upgrade costs, and is superior when implementing services from multiple providers.

When calculating just service related costs between conventional and SWS delivery, a break even point would be achieved for 3 providers with 5 services, or 5 providers with 3 services. However, including domain ontology will move the breakeven point to higher values with 15 services provided from 5 different providers.

When including the update of service, the break-even point will be reached for substantially lower number of providers or services. Thus, service maintenance and service upgrade are the items which make SWS delivery advantageous as compared to conventional service delivery.

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REFERENCES

[1] P.Y. Danet, ePerSpace: A European Project for the Seamless and Personalised Digital Communicating Home of the Future, *European VPN Services Forum conference,* 15-17.6.2006 London.

[2] W. Kellerer, R. Hirschfeld, M.Wagner, and J. Noll, Systems beyond 3G Operators vision, *WWRF #7,* 3.-4.12.2002, Eindhoven (NL)

[3] K. Bruheim, GRX roll-out case study, EF-telecoms, London, 22-23.01.2002

[4] J. Floch, R. Sanders and R. Brk: Challenges and Results of Establishing the Teleservice Laboratory at NTNU. NIK 2003, Oslo, Norway, Nov. 2003

[5] 3rd Generation Partnership Project, Stage 2 functional specification of User Equipment (UE) positioning in UTRAN, 3GPP TS 25.305, Release 5, Sept 2003

[6] D. Roman, U. Keller, H. Lausen, J. de Bruijn, R. Lara, M. Stollberg, A. Polleres, C. Feier, C. Bussler, and D. Fensel: Web Service Modeling Ontology, Applied Ontology, 1(1): 77 - 106, 2005.

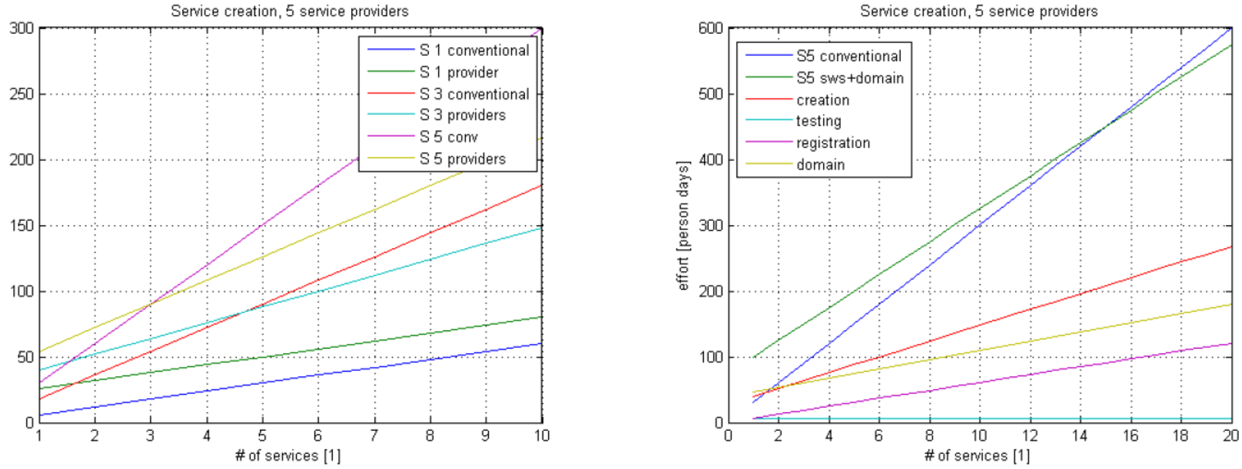

Figure 5 - Break-even analysis for SWS versus conventional service delivery

[7] J. Noll, E. Lillevold, Applying Semantic Web Technologies for mobile communications", *Proc. of WWRF #15*, Paris, 8.-9.12.2005

[8] Shared Information/Data (SID) Model, NGOSS rel. 6.0, Telemanagement Forum, http://www.tmforum.org/browse.asp?catID=2646&linkID=31157

[9] J. Noll, E. Lillevold, Roadmap to ASG based Semantic Web Services , *Proc. of The International Conference on Internet & Web Applications and Services 2006 ICIW*, 23-25.Feb 2006.

[10] V. Törmälä, et. al., Business Analysis, deployment strategy and evaluation of ASG based services, *EU IST ASG project deliverable D7.IV*, Sept. 2006