Demonstration: Wireless Access Network Selection Enabled by Semantic Technologies

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ABSTRACT
Service oriented access in a multi-application, multi-access network environment is faced with the problem of cross-layer interoperability among technologies. In this demo, we present a knowledge base (KB) which contains local (user terminal specific) knowledge that enables pro-active network selection by translating technology specific parameters to higher-level, more abstract parameters. We implemented a prototype which makes use of semantic technology (namely ResearchCyc) for creating the elements of the KB and uses reasoning to determine the best access network. The system implements technology-specific parameter mapping according to the IEEE 802.21 draft standard recommendation.

Categories and Subject Descriptors
C.2.6 [**Computer Communication Networks**]: Network Architecture and Design – *Asynchronous Transfer Mode (ATM), Centralized network, Circuit-switching networks, Distributed networks, Frame relay networks, ISDN (Integrated Services Digital Network), Network communications, Network topology, Packet-switching networks, Store and forward networks, Wireless communication.*

General Terms
Design, Management, Standardization.

Keywords
Vertical handover, semantic technologies, service oriented, network selection.

1. INTRODUCTION
Mobile terminals such as notebooks, internet tablets, smart phones and, recently, netbooks [1] are dramatically increasing in numbers and already tend to replace desktop computers as the primary connectivity device. The problem with all these portable devices is that they have limited computing capacity. As a consequence, they are used for web browsing, email, multimedia consumption and generation, or simply connect to a virtual machine running somewhere in the computing cloud and performing more intensive computation. All these usage patterns require connectivity, especially wireless connectivity.

Although mobile terminals feature interfaces for at least two wireless technologies (i.e. UMTS, WiFi), connecting via the "best" access technology is still not possible. This freedom of choice is bounded by technological as well as business related constraints. Two major standards organizations, IEEE and 3GPP, are working on drafts (IEEE 802.21 and 3GPP UMA, GAN, VCC) to standardize handover between heterogeneous access networks, also called vertical handover [2].

By access network selection we refer to selecting a target network for (1) connecting to or (2) handing over to in a manner that allows consuming electronic services with high quality of experience. When applications running on the mobile terminal detect that the user might experience degradation in the quality of experience caused by the access segment (i.e. a change of context), a network selection for handover process starts. The optimum would be a transparent layer-3 handover which preserves the state (including IP address, port numbers and security associations) of the troubled connections [2].

A handover can be requested by the mobile terminal (mobile initiated handover) or by the network (network initiated handover). Vertical handovers have not yet become a standard feature, but there are several efforts under way in this direction as summarized in the following.

In this demo we show how semantic technologies can be used to solve the wireless technology interoperability problem. We extended the Cyc TinyKB with a domain specific ontology and rules for inter-technology parameter mapping. We used some of the mapping rules provided in the IEEE 802.21 draft standard [3]. As opposed to other similar work in the literature, our approach makes use of a KB (ontology + facts + rules + instances) where access interfaces publish specific technology dependent information, which can be queried by high layer entities. The KB handles all the parameter translations from low level technology dependent to high level, technology and platform independent ones. To the best of our knowledge, this is the first attempt to use a KB approach for network selection purposes in wireless.

This work can be further extended in a number of ways. Local contexts, having a semantic representation can be reported to servers which could make use of the information for network planning, location based services or other customized services. Having a model of a wider array of network technologies could also help dynamically composing transport services similar to the way web services are being composed [4].

2. SEMANTIC MAPPING OF QOS PARAMETERS
Provisioning users with desired application experience requires the network selection system to take into account quality of service (QoS) related parameters and their mapping between services at different layers of the protocol stack, particularly between IP QoS and link layer QoS.

ITU has specified five QoS parameters for IP transport of applications: transfer delay, delay variation, loss ratio, error rate and throughput. Based on these parameters, 6 classes of service for packet classification have been defined; these are numbered from 0 to 6 [5].

Early IEEE 802.11 (WiFi) specifications do not define any mechanisms for QoS support. However, changed starting with the IEEE 802.11e revision [3] and further extended by 802.11f and 802.11r [5]. Early IEEE 802.16 (WiMAX) defined four classes of service and the 802.16e amendment to this standard introduced the fifth. Finally, 3GPP defines 4 QoS classes, conversational, streaming, interactive and background.

There are three types of QoS-related information which can be shared among different technologies using the MIHF (Media Independent Hanover Function) [5]:

- Service classes
- QoS parameters (per service class)
- Network performance measurements (per service class).

In our implementation, we introduced in the KB concepts related to service classes, QoS parameters, relations between these, and rules for cross-standard mapping between IEEE 802.11, 802.16, 802.21 and UMTS. Figure 1 shows how MIH users can use the MIHF to query the local KB in which interface specific knowledge and parameters values are published.

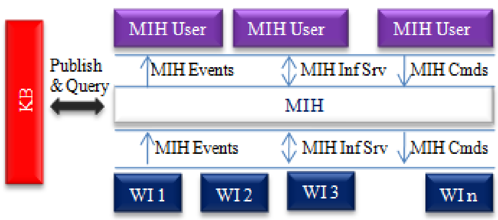

Figure 1 Local KB for service oriented network selection

3. MODELLING THE LOCAL KNOWLEDGE BASE

Two of the basic rules of ontology engineering refer to inserting concepts and to inserting predicates, functions and rules [6]. A concept in an ontology should be as specific as possible, so it should be inserted as low as possible in the taxonomy. Predicates, functions and rules, on the other hand, should be as general as possible, thus referring to as many concepts as possible while being consistent. In our approach, we tried to follow these rules as close as possible. However, since we are modeling domain specific knowledge in a microtheory, our rules are quite specific.

Two of the most relevant concepts we introduced in the KB are: *AccessNetwork* (as a specialization of the *ComputerNetwork* concept) and *ClassOfService*, some instances of protocols are *IEEE802dot11Protocol* and *IEEE802dot16Protocol*, *3GPPProtocol* and *IEEE802dot21Protocol*. Having concepts inserted in the ontology, we needed a mechanism to assert that an instance of *AccessNetwork*, e.g. *WiFi1*, implements the *IEEE802dot11Protocol* and specify the version of the implemented protocol (i.e. “a”, “g”, “b”, etc.). Predicates such as *networkImplementsProtocol* and *implementsVersionOfProtocol* can be used for this.

After inserting taxonomical information, the next step was to create rules for mapping IEEE 802.21 specific QoS parameters and classes of service to those corresponding to the underlying technologies according to the implemented protocol.

Finally, the result of extending the KB and creating instances, enables a MIH user to issue queries and receive correct answers. An example query expressed in CycL is presented in Figure 2 and can be translated in natural language to: “*Which are the published networks that have maximum packet transfer delay more than 0.1 seconds?*”.

```
(#$and
 (#$hasCoSMaxPacketTransferDelay-802dot21 ?X ?Y)
 (#$greaterThan ?Y
   (#$SecondsDuration 0.1)))
```

Figure 2 Example of a rule

4. DEMONSTRATION

In this demo, we demonstrate how access interfaces featured by an Asus EeePC 1000HA running Eeebuntu periodically publish their parameters (current context) in the local KB. Higher level entities such as applications and mobility protocols can query the KB to determine the interface that best fits their requirements (see Figure 1). We extract technology-specific parameters from Linux drivers and we focus mainly on WiFi, UMTS and 802.3 for the pro-active network selection as proposed in [7].

5. REFERENCES

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