

IYOUIT

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Abstract. We have implemented IYOUIT, a context-aware application for the mobile phone that promotes a digital lifestyle for people on the go. Within its essential building blocks, IYOUIT incorporates Semantic Web technology to abstract data about and around the user into meaningful interpretations of the user's digital trace in the real world. Quantitative data is mapped to qualitative context ontologies and combined with specialized domain knowledge to classify and assess the user's situation. Beyond the easy sharing of personal context and experiences within the IYOUIT mobile community, the application seamlessly connects to most popular services on the Web like Flickr, YouTube and Twitter. IYOUIT is available free of charge for all Nokia S60 phones.

1. IYOUIT Mobile Experience

IYOUIT¹ is a mobile application that aims at making it easy to automatically collect context data with a standard mobile phone and facilitates an instant and light-hearted sharing of personal experiences within online communities. In combining and aggregating various context sources, a rich portfolio of personal information is derived and can be made available to others on the Web and on the mobile. For selected data sources, qualitative statements about a user's given situation can be made through the transformation of quantitative sensor data into qualitative context information, e.g. by long-term observations of user positions via GPS and cellular information to identify qualitative places of interest. Subsequent classification processes then combine qualified context elements with formalized domain knowledge to derive meaningful complex conceptual descriptions of situations and events [1].

As a prototype from our labs, IYOUIT is freely available at no charge. In addition to a feature-rich mobile client that is currently offered for Nokia S60 phones, we have implemented a Web 2.0 portal providing an open API and integration with different 3rd party services, as detailed in Section 2. The mobile client (cf. Figure 1) is structured in tabs, where each tab either displays a certain type of context information (for instance local weather reports in the Weather tab) or accumulates various pieces of information in a contextual overview that helps in assessing the situation of a user at a given point in time:

Me is IYOUIT's home tab and standard entry point. It summarizes recently spotted information in the user's proximity and highlights his latest presence status. Clicking on one of the entries, a more detailed view is provided within the respective tab.

¹ <http://www.iyouit.eu>



Figure 1: IYOUIT Mobile Client

Buddy is the central place for the real-time context collection of all approved buddies, including their current whereabouts, latest activities, shared photos, amongst others. To easily find specific pieces of information or to simply have a look at newly gathered presence updates, different views on context, various sorting orders and context-dependent ad-hoc groups are in place. To better group and differentiate social contacts among each other, qualitative social relationships can be defined. Ontology-based reasoning maintains the consistency of social networks and allows for network completion.

Location informs the user about her current whereabouts in more details. Positioning is either by precise GPS coordinates or estimated based on the aggregated location data of the IYOUIT user community. Places of interest are determined over time by observing the user's movements. They are informed to the user and can be linked to basic context concepts, e.g. as "Home" or "Office". These concepts correspond to the underlying context ontologies and can later be used to further assess the current situation of the user through classification-based reasoning.

Events displays a timeline of recently observed significant changes in the user context. Here, entries to places of interest are listed together with social encounters, network information as well as activities observed by the accelerometer sensor of the phone. Proactive actions, e.g. switching of the phone profile from "Outdoor" to "Meeting", can be attached to places and activities such as "working" may be bound to nearby people. Semantic information as attached to context is reflected where possible, e.g. in the type of place of stay ("my own Office", "the Home of a friend") or the kind of buddy in proximity ("my best Friend", "a Colleague from work").

Weather exemplifies how local information can be used in IYOUIT to further assess the user's situation. In this tab, weather information in terms of the current weather

situation as well as a forecast is summarized according to the user's location. Qualitative abstractions along the lines of our own weather ontology are applied and help the user to understand that the weather is for instance "exceptionally pleasant for this season". This information is based on the history of meteo data and further visualized in colored forecast entries where color gradients represent semantic classifications.

Experience allows to set IM-compliant presence attributes like activity, mood or availability. This tab also accepts small text notes to be posted on Twitter² that are proactively complemented with personal context information.

Photo allows access to the phone camera. Newly added pictures are proactively tagged with available context data and can be uploaded to Flickr³. Beyond widely used machine tags such as a geographic information, IYOUIT photo tags may include semantic descriptions such as the current place, nearby people and the corresponding social relationships as well as a number of qualitative weather annotations. As a consequence, managing and sharing photos becomes more intuitive, for instance by being able to "find all family pictures taken around the holiday cottage on a sunny day" or "subscribe to photos captured by buddies on the university campus".

Scan collects technical observations in terms of scanned Bluetooth beacons and seen WLAN access points. Observed beacons can be associated with buddies while scanned WLAN access points are geo-tagged. Both can be associated with rules to trigger proactive actions such as setting the user's experience or automatically subscribing to WLAN network access in a certain place.

Complementary to the above, further application tabs exist for displaying local information on a map, for showing GPS details and statistical overviews of the personal context history, for scanning bar codes of books and products as well as sound and video recordings. Similar to the photo management, sounds and videos are automatically tagged with surrounding context information. Additionally, noise-level measures are applied to add further qualitative information, e.g. to detect a "loud" or "silent" environment.

2. IYOUIT on the Web

While the primary personal use of IYOUIT is on the mobile phone, the application also materializes on the Web in its own portal. To date, the IYOUIT service infrastructure consists of in total 32 distributed software components, developed by five people. Since IYOUIT's public release in June 2008 more than 600 users from 50 different countries have registered with the service. As a lively community, users are spread around the globe from the USA, Canada and Latin America, over Europe to Asia. To date, almost one million location measurements have been recorded, 6.000+ pictures have been tagged and uploaded and more than 15.000 weather forecasts have been requested. The average number of social connections among our users is 2.95, which indicates a relatively high degree of connectedness amongst the community

² <http://twitter.com>

³ <http://www.flickr.com/search/?q=iyouit>

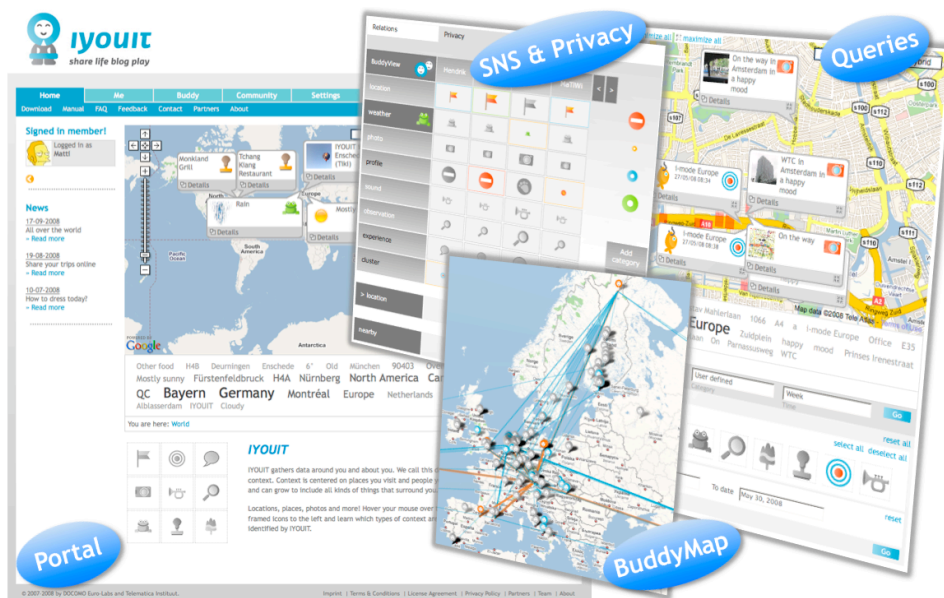


Figure 2: IYOUIT Web Portal

members. Monthly hits on the IYOUIT Web portal currently average 30.000+ requests. The features highlighted in Figure 2 are:

IYOUIT Web Portal: the Web portal offers everyone a glimpse at the IYOUIT user community. Latest observations and selected bits of collected context are displayed live together with hints on how the community is evolving. For registered users the following features are additionally available.

Context Queries: a special interface for context queries offers different ways to query the aggregated context information from the past. Searches in these context histories can be complex and along different dimensions, e.g. for selected context categories and attributes along a defined timeline or in correlation with special social settings. Search results are mapped into their geographic origin, summarized in contextual clouds that incorporate concept definitions and shown in a detailed result list.

Social Relationships & Privacy: user can conveniently define social relationships and personal privacy policies in a special place on the portal. In IYOUIT, each user may decide to whom and to which degree personal context information is disclosed. Those access control directives are bound to explicit users or social relationships and certain types of context information. This way, colleagues might only be granted access to little location information, whereas family members may have access to the entire record, up to the street level. Being application independent, access control directives automatically adapt to the changing service infrastructure and translate high-level user defined policies into concrete, service-specific rules.

BuddyMap: complementary to the dedicated definition of social relationships as described above, BuddyMap allows users to explore their surroundings for nearby users and new buddy invitations. Here, all IYOUIT users are anonymously shown in

their location on a map. Existing social networks are highlighted and users are classified according to their status and key contextual features. Subsequently, invites to new buddies can be issued that will be pending until the receiving party accepts. Further to the above, the IYOUIT portal hosts pages that allow for a convenient configuration of all settings of the mobile client as well as the personal IYOUIT Web presence. Users can decide whether they want to share their personal context with others through the Web 2.0 services Flickr, Twitter, Dopplr or YouTube. The sharing experience can be instant, by posting single data items, or through the potentially lifelong aggregation of contextual data in online sites. The IYOUIT portal also implements selected features from our research lab. In an experimental blogging engine users are, for instance, invited to configure personal context blogging or automatic profiling. The latter allows for the automatic aggregation of significant context items over time into profiles that indicate the most prevalent context elements and concepts as well as to visualize trends in contextual change. Blogs can be used to highlight special contextual traces, like trips to unusual places, as online blogs.

3. IYOUIT Buildings Blocks

IYOUIT operates on its own component framework, the so-called Context Management Framework (CMF) [6]. Together with context ontologies and principal data abstraction paradigms, CMF components represent the central building blocks of our system. Semantic Web technology is used in several places to implement key features and to seamlessly connect the application to different services on the Web. The distributed nature of the CMF allows for realizing a system with diverse ownerships. Trusted parties might provide sensitive management components, while others might add additional 3rd party services.

3.1 Context Ontologies

To enable ontology-based reasoning mechanisms in IYOUIT, we have designed a set of ontologies for distinct application domains including social relationships, location records and weather conditions. A total number of twelve interrelated component ontologies define more than 300 concepts, 200 properties and 300 individuals. Due to the near real-time requirements of IYOUIT, where for instance the situation of a user shall be instantly classified, we concentrated on the modeling of highly efficient yet expressive ontologies rather than utilizing already existing and widely used ontologies such as DOLCE⁴. All IYOUIT context ontologies are thus formalized within the decidable fragment of the Web Ontology Language (OWL) [2].

As one of the core components of CMF, the *Ontology Manager* provides a gateway to simplify the access to OWL ontologies. Given an ontology, it allocates a reasoning resource and instructs it to retrieve the corresponding set of axioms. The parsing of the concrete OWL syntax and the interfacing with various DL reasoners (at the time of writing we use Pellet⁵, FaCT++⁶ and RacerPro⁷) is delegated to a semantic middle-

⁴ <http://www.loa-cnr.it/DOLCE.html>

⁵ <http://pellet.owldl.com>

ware (in our case the OWL API⁸). Among the supported queries are requests to retrieve (parts of) the concept and property hierarchy, the (direct) types of individuals, the (direct) individuals of concepts and the relations that hold between two individuals. Each of those requests might refer to implicit knowledge, which is why a reasoner has to be involved to ensure the completeness of the returned results.

3.2 Data Aggregation

In IYOUIT, ontologies are used to represent high-level concepts of user context. We purposely restrict their use to high-level representations to keep the ontology size controlled and the reasoning fast [3]. Aggregation of low-level context information is needed to transform quantitatively gathered data into qualitative context concepts.

We present two examples for data aggregation in CMF. The first is the *Location Provider*, which has the main tasks of turning estimated user positions into actual address records, to store location traces and to deduce frequently visited places. It implements its own positioning framework in tracing information from the cellular network and observed GPS annotations. To abstract from exact positions to conceptual places, the Location Provider identifies significant location records of a user by applying profound statistical learning and clustering methods to historic location data [4]. Once established, a place is presented to the user. It can be named and linked to ontology concepts including common place concepts like “Office”, “Home” or “Business Place”. Subsequently, IYOUIT will note about visits to known places resulting in qualitative location traces that can be used elsewhere in the application.

Our second example for data aggregation is the *CMF Weather Provider*. It enriches a given user location with prevalent meteorological data such as the actual temperature or wind speed. Two types of automatic abstractions that link qualitative to quantitative information are applied: simple static mappings assign values within certain intervals to the corresponding abstract descriptions, e.g. “light air” or “gentle breeze”, that are in turn further characterized within the weather ontology. To categorize quantitative temperature values meaningfully, more complex mappings are needed that take additional historic context into account, e.g. to avoid a temperature mapping of 5°C to “cool”, even though it might have been recorded on an exceptionally warm day. To this end, historical weather records that provide monthly minimal and maximal mean temperatures and precipitation values are used. Location and time are taken into account in mapping large sets of meteo data to qualitative abstractions to derive a rational categorization of the actual qualitative values such as “low”, “moderate”, “warm”, etc. Furthermore, we defined categories for “bad”, “fair”, “good” and “splendid” weather conditions based on the ratings for individual weather attributes like temperature, wind, pressure or precipitation and a qualitative health index. This health index is itself derived by classification and expresses to what extent the current weather situation may cause aches and pains. For instance, an axiom formalizes that weather conditions with low pressure, the passage of a warm front, high temperatures and humidity often cause migraines.

⁶ <http://owl.man.ac.uk/factplusplus>

⁷ <http://www.racer-systems.com>

⁸ <http://owlapi.sourceforge.net>

3.3 Social Reasoning

All of IYOUIT's community services rely on social networking. Users can establish defined relationships amongst each other, e.g. "friend", "colleague" or "husband", to build social networks and share context data through them. We, for instance, support the concept of buddy lists that allow users to instantly look up what their friends are doing. Social networking is implemented through the CMF *Relation Manager* that manages all defined social networks. The Relation Manager is also essential for implementing privacy protection in IYOUIT as access to personal context is defined along social networks and relationships: not only is an established relationship between users essentially required to share data, privacy policies can also be defined along relationships to determine the level of access to personal context. Such access policies can be specified for individuals ("my friend Robert sees my full address") or types of individuals ("all my friends can see my home city") and are naturally bound to the underlying social network. Our social ontologies currently holds more than 50 relationships and again makes use of ontology-based reasoning to combine explicit, user-defined facts about social relationships with the world knowledge encoded for network completion.

3.4 Situational Reasoning

Assessing the personal situation of a user at a given point in time is a key feature in IYOUIT. We develop situational reasoning methods that make in particular use of situational descriptions at the qualitative level of our context ontologies.

As a core CMF component the *Situation Provider* computes an abstract characterization of a user's situation by applying DL classification on detected high-level context elements gathered [5]. Abstract situation concepts like "Business Meeting" are formulated based on principal concepts representing such as the place (e.g., "Office"), the time of day (e.g., "Afternoon") and people in proximity (e.g., "Colleagues"). Finally, the classification result given by the computed direct individual types is established as a new (derived) context.

At the basic level, reasoning within the Situation Provider to classify user context can be seen as temporally static as it observes the situation of a user only for one given point in time. To reason about complete context histories over longer periods, specialized reasoning is used beyond DL-based classifications to detect the line of key situations over time [6]. The EventProvider computes spatio-temporal events like "leaving home" or "returning from vacation" indicating a qualitative spatio-temporal change in the user's state or situation. Events may naturally depend on each other and can be organized hierarchically. In the model we further distinguish between events as being homogeneous, complex and high-level to allow for the flexible design of large knowledge bases and their reuse in different application domains.

4. Conclusion

We have implemented IYOUIT, a mobile application that corresponds to latest trends in mobile services and the Web to enrich the digital life of people on the go. As a

prototype from our labs, IYOUIT is currently non-profit and available through our Web site free of charge. Commercial exploitations are thinkable towards smart mobile services that connect to the Web 2.0, like photo sharing and social networking. A comparison with competing applications that partially follow similar aims like Zone-Tag⁹ or Shozu¹⁰ is discussed elsewhere [6]. To the best of our knowledge, no applications currently exist that try to leverage Semantic Web technology in similar ways in the mobile domain.

Its underlying service infrastructure has been designed as a distributed, extensible component framework to deal with context information on various abstraction layers. Low-level data gathered from sensors is aggregated and consequently being mapped to qualitative concepts represented within formal ontologies. This twofold process of context aggregation and the subsequent semantic mapping allows for keeping ontologies lightweight and their application reasonable.

IYOUIT building blocks leverage Semantic Web technology in various ways, in particular for qualitative context abstraction and reasoning [1]. We have thus put special effort in optimizing our OWL ontologies and focused on efficiently integrating inference techniques based on results gained from extensive studies [3].

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⁹ <http://zonetag.research.yahoo.com>

¹⁰ <http://www.shozu.com>