Standardized Localization Interface

Filip Lemic, Ivan Azcarate, Vlado Handziski, Anatolij Zubow, Adam Wolisz
Telecommunication Networks Group (TKN), Technische Universität Berlin, Germany
Email: {lemic,azcarate,handziski,zubow,wolisz}@tkn.tu-berlin.de

***Abstract*—Location-based applications are currently proprietary to service that is providing location information, hence they require significant modifications to be able to run with another localization service. To address this pitfall, a recently proposed middle-ware localization service architecture allows seamless provisioning of location information based on applications' requirements, irregardless of the underlying source of location information. A unified style of interaction between the application and the middle-ware service is supported by the Standardized Localization Interface (SLI). In this work, we first overview the main interaction primitives of the SLI. We follow by demonstrating its benefits using location-enhanced horizontal WiFi handover as an example application.**

I. Introduction

The availability of location information of mobile devices is a driver for a plethora of Location Based Services (LBSs) and a valuable source of context information in wireless networks. Development of reliable, fast, and accurate location information provisioning services is the subject of active research. Nevertheless, these provisioning services have limited applicability because they provide desirable performance only in certain environments. In addition, the provisioning services differ substantially in the way location information is delivered to the applications, i.e. in the interfaces for providing location information. To achieve seamless provisioning from the perspective of location-based applications, these applications should interact with several provisioning services. Hence, there is a need for dynamic addition and/or exchange of provisioning services, as well as fusion of their results.

We previously developed a standardized middle-ware localization service architecture that addresses the above mentioned interoperability and integration problems[1]. The core entity of the architecture, i.e. the integrated location service, allows for fine-tuning of the usual trade-offs between the accuracy, availability, latency, and power consumption of location information provisioning dependent on the requirements from the applications. A detailed description of the developed middleware localization service architecture is given in [1].

The architecture offers to the location-based applications a single interface, namely the SLI, that is independent from the used individual provisioning services and their possible fusion. This standardized interaction enables full portability of the applications, by design, across specific location information provisioning services. In this work, we overview the most relevant interaction capabilities of the Standardized Localization Interface (SLI). On an example of location-aided horizontal WiFi handover, we further demonstrate the benefits of the SLI in terms of usage simplicity and adaptability to the applications' requirements for location information.

[1]https://github.com/terraswarm/standardized_localization_service

II. Standardized Localization Interface

The SLI specifies the interaction primitives and respective parameters for enabling interfacing between the location-based application and the integrated location service of the middleware localization service. The full specification of the interface is given in [2], while in the following we overview only its most relevant primitives and parameters. A summary of the SLI's primitives, with an indication of their directionality, i.e. from the location-based application (LA) to the integrated location service (IL) and vice versa, is given in Table I. The SLI's primitives include requesting and reporting location information of desired features. These features are the location type and dimensionality (2D or 3D), the desired accuracy of location information, the latency of its provisioning, and the desired provisioning duration. The SLI also includes primitives for exchanging the relevant context of location information between the application and the integrated location service.

The application can request location information from the integrated location service using the *Request location* primitive. Similarly, the integrated location service can report the requested location information using the *Report location* primitive. Location information can be reported as a global, local or semantic location, which is defined with the *location type* parameter of the *Request location* primitive. The global location, comprised of a longitude, latitude, and altitude information, defines a location in the WGS 84 global coordinate system. The local location, represented in a (x, y, z) notation, is understood as a location in relation to some predefined location coordinate, i.e. zero-point, usually in indoor spaces. In addition to their 3D notations, both types are in practice also often used for 2D localization, so the application can also specify a request for 2D location information. The semantic location type is a string object used for expressing location as being inside of a space or in the proximity of an object. In addition to reporting location information, the integrated location service can report the *movement* parameter, which specifies the movement speed and orientation of a mobile device. The *duration* parameter of the *Request location* primitive defines a time interval for which the application requires location information updates. The *accuracy* and *period* parameters of the *Request location* primitive define the desired accuracy of location information and the period of its provisioning. The *on_event* parameter indicates that location information should be provided periodically, with the period specified with the *period* parameter. Alternatively, location information can be provided upon its changes from a preceding location information, with the size of change indicated by the *step* parameter of the primitive.

TABLE I: Summary of the Standardized Localization Interface

Action	Description	Direction	Parameters
Request location	Request location information	LA→IL	type, dimensionality, accuracy, period, on_event, step, duration, movement
Report location	Report location information	IL→LA	location information, movement
Request context	Request context of location information	LA→IL	context type, parameters
Report context	Report context of location information	IL→LA	map (zero-point, map vs. physical sizes) or location types translation

The SLI also defines a set primitives for requesting and reporting the context of reported location information. Two types of context information are envisioned, i.e. provisioning of the environmental map and translation from one location type to another. The *Request context* primitive is used by the application for requesting the context, while the *Report context* primitive provides the requested context. The *context type* parameter defines what type of context is requested. If the environmental map is requested, the integrated location service will report the utilized *map* together with the zero-point (i.e. the point used as a reference location) and the mapping between map sizes in its default resolution and physical sizes of an environment. If the translation between location types is requested, the additional *parameters* parameter has to be defined in the primitive, i.e. the input and output location types and input location information. The integrated location service responds with the *location types translation* parameter, i.e. location information of the requested output location type.

III. Example Usage

Current WiFi handover mechanisms rely on active probing of WiFi channels to detect the availability and configuration of Access Points (APs) surrounding the terminal. This results in increased scanning times, which translates to increased handover latencies and degraded communication service. Assuming that the profiling of radio characteristics, i.e. the Radio Environmental Map (REM), of a served environment is available, one option in reducing the scanning times is to ground handover decisions on location information of the mobile terminal in the served environment. In the following, we demonstrate the capabilities of the SLI on an example of location-enhanced horizontal WiFi handover.

Let us assume that the terminal is connected to an AP and the observed Received Signal Strengths (RSSs) from that AP start decreasing, which triggers the handover application. The application requests current location information of the terminal, as specified with the first primitive in Listing 1. More specifically, the application requests "local" type of location information in a 2D space with the average accuracy of 1 m to be reported once in the next 1 s. Additionally, the movement pattern of the terminal is requested as well with the parameter "movement". The application also requests the map of the served environment using the second primitive in Listing 1. Based on the received location and context information, the application is able to map the current location of the terminal to the respective location in the REM. Hence, the application can derive if the terminal is still far away from handover locations and let us assume that is the case in this example. Let us further assume that, by leveraging the "movement" parameter, the application derives that the terminal is moving towards locations where the handover should be performed.

Following that conclusion, the application requests provisioning on an event, i.e reporting of location information in case the current location changes from the initial one for more than 3 m. The requested location information has the same features as in the previous request and this type of provisioning is requested for the next 30 s, as specified with the third primitive in Listing 1. Let us assume that, before the expiry of the request, the application in notified that the terminal moved for more than 3 m. Moreover, let us assume the application derives that the terminal is at this point in the vicinity of some locations where a handover should occur. Hence, the application issues a request for fast and accurate periodic provisioning for the next one minute, as specified with the forth primitive in Listing 1.

The application then compares the periodically received location information with locations for the REM to check if the a handover should be triggered. Let us assume that, before the expiry of the latest request, a handover to another AP is triggered by the application. Following the handover, the application issues a request for "movement" parameter only to check if the terminal is still moving towards the locations where there is no need for a handover (fifth primitive in Listing 1). Let us assume that is the case in this example, so the application goes back to sleep mode.

LISTING 1: List of SLI primitives in a given example

```
1. request_location(type:local,dimensionality:2D,...
             ...accuracy:1m,period:1s,movement)
2. request_context(context_type:map)
3. request_location(local,2D,1m,1s,...
                  ...on_event:3m,duration:30sec)
4. request location(local,2D,0.5m,0.5s,...
                  ...periodically,duration:60sec)
5. request_location(movement)
```

IV. Conclusion

The provided example shows the adaptability of the SLI to different requirements for location information from the application. Furthermore, the application is independent from the underlying source of location information, which is abstracted by the middle-ware localization service. In conclusion, the SLI is an easy-to-use abstraction that supports a broad range of requirements that different applications could have.

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References

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[2] F. Lemic, V. Handziski, N. Mor, J. Rabaey, J. Wawrzynek, and A. Wolisz, "Toward Standardized Localization Service," in *Indoor Positioning and Indoor Navigation (IPIN'16)*, 2016.