Standardized Localization Interface

Application-centric location information provisioning

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Motivation

- A variety of localization services exists:
  - Deployed in different environments (with overlaps).
- The aim should be seamless, accurate, and robust location information provisioning.
- Requirements for provisioning quality vary across applications;

Goals and contributions

- Goals:
  - **Seamless handover and fusion** of localization services;
  - **Straightforward addition** of new localization services;
  - In an **unified way** enabling portability of applications;

- We contribute with:
  - A middle-ware localization service architecture;
  - A proposal for standardized interaction (APIs);
  - A prototypical implementation of such an architecture;

Example of usage – WiFi horizontal handover

1. RSS decrease → an 'app' is triggered → the app requests location:

request_location('2D', '1m accuracy', '1s', 'movement')

request_context('map')

2. The user is still far from handover locations → but, the user is moving → request location again for the case the user moves for more than 3 m:

request_location(' '2D', '2m', '1s', 'on event – 3m', duration – 30sec)

3. The user is close to a handover location → request provisioning:

request location(' '2D', '1m', '0.5s', 'periodically', 'duration - 30sec')

4. The handover occurred → check if the user is progressing towards locations where no handover is needed:

request_location('movement')

5. Yes, s/he is! → we don't need location information for a while.

*Take home: heterogeneous requirements for location information (e.g. once/ periodically/on event, flexible accuracy/latency/duration, …)

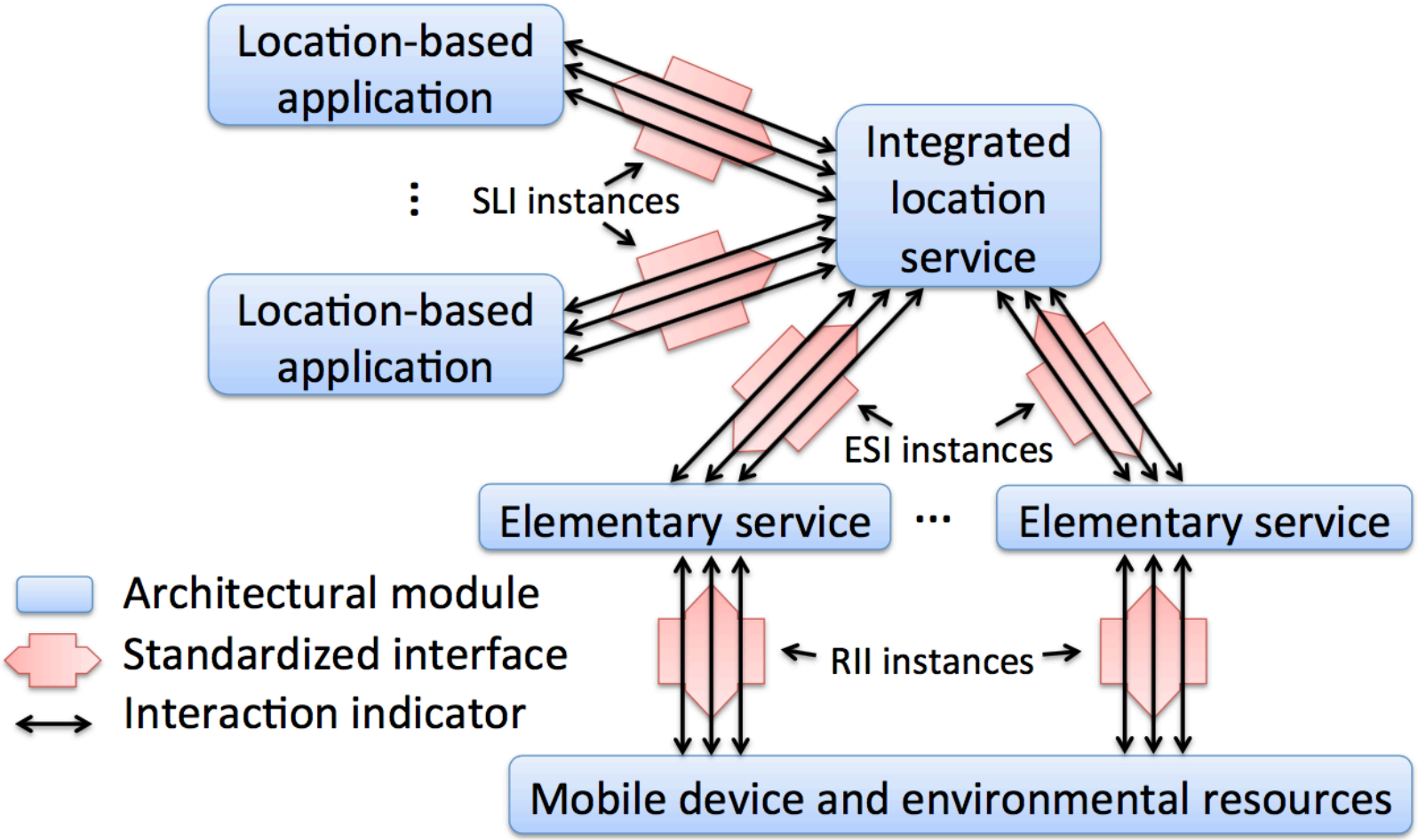
Standardized Localization Interface (SLI)

- Capturing the functionalities of the state of the art services;

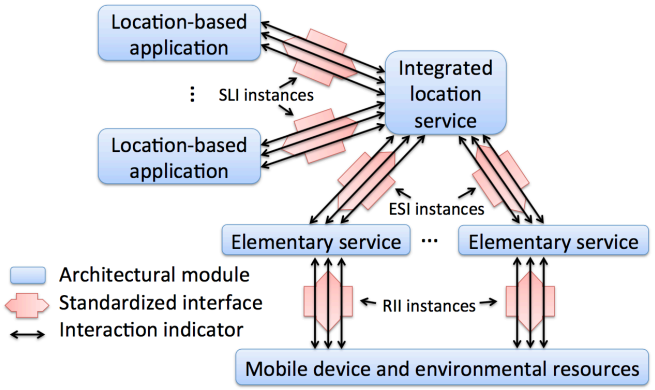
Action	Description	Direction
Specify policy	Specify trade-off policy	LA→IL
Request location	Request location information	LA→IL
Report location	Report location information	IL→LA
Request renewal	Request provisioning renewal	LA→IL
Request context	Request context of location information	LA→IL
Report context	Report context of location information	IL→LA

- Request location: **type, dimensionality, accuracy, period, on event, step, duration, movement**;
- Request context: **map (zero-point, map vs. physical sizes) or location types translation**;

Standardized modular localization service



Standardized modular localization service

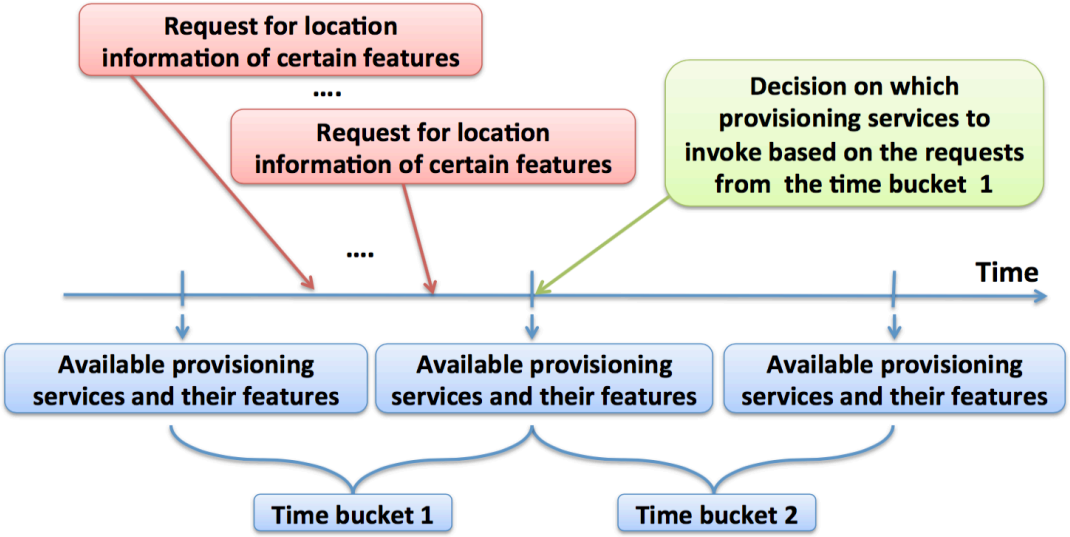


- Integrated location service:
  - Supplies and requests location information;
  - Manages the selection of services to be invoked;
  - A setting for fusion and caching of location information;
  - A setting for calculating location-context parameters;

- Interfaces:
  - Standardized Localization Interface (SLI);
  - Elementary Service Interface (ESI);
  - Resource Interaction Interface (RII);

Dynamic vs. time-bucketed operation

- Dynamic vs. bucketed selection decision?
  - High dynamicity that will further increase → frequent need for a new decision;
  - Dynamic selection has to be fast → algorithms have to be simple → not optimal for optimization;
- Time-bucketing is therefore selected:



Algorithms for selection of provisioning services

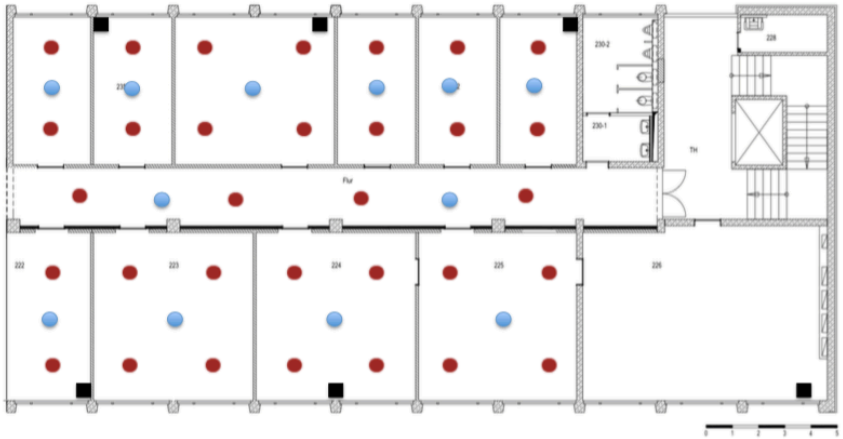
- Input:
  - Requests (accuracy, latency requirements) from the applications;
  - Provisioning features (accuracy, latency, power consumption);
- Objective:
  - Decision on which provisioning services to invoke;
- Subject to:
  - Fulfilling the latency (and subsequently accuracy) requirements from the applications, while:
    - PRSA → per-request minimizing power consumption;
    - PTSA → per time-bucket minimizing power consumption;

GDP-based implementation

- The GDP (Global Data Plane):
  - Natively supports a **single-writer log**-based messaging;
  - Provides a **publish/subscribe and REST** interfaces;
  - Logs are encrypted ensuring **data privacy and security**;
- Integrated Location Service:
  - Python 2.7-based multi-threaded daemon service;
- Publicly available on GitHub → **SLSR: Standardized Localization Service;**

Instantiation and evaluation setup

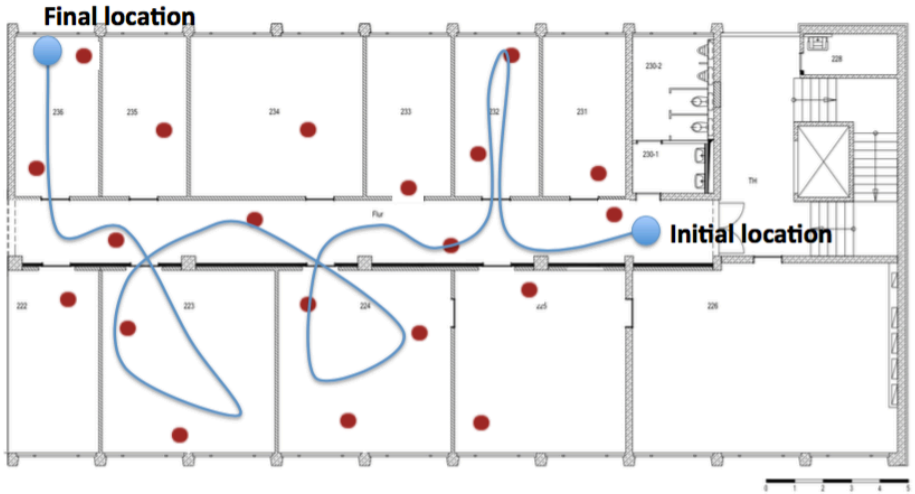
- Instantiation of a set of fingerprinting-based services;
- Localization scenario → to derive the expected performance of the instantiated provisioning services;



Provisioning service	Accuracy	Room accuracy	Latency	Power consumption
Euclidean small	3.14 m	52.5 %	0.66 s	2.0
Quantile small	3.05 m	55.0 %	0.72 s	2.0
Euclidean medium	2.41 m	62.5 %	0.86 s	2.0
Quantile medium	2.22 m	65.0 %	0.91 s	2.0
Euclidean large	1.96 m	75.0 %	1.05 s	2.0
Euclidean semantic	/	52.5 %	0.66 s	1.0
Quantile semantic	/	55.0 %	0.72 s	1.0

Evaluation

- Tracking scenario:
  - To demonstrate the benefits of different functional components;



#	Accuracy	Latency	Provisioning type	Location type
1	1.5 m	2.0 s	periodic	local
2	100 %	1.5 s	periodic	semantic
3	100 %	5.0 s	periodic	semantic
4	100 %/1.5 m	3.0 s	periodic / on event (1 m)	semantic / local
5	1.0 m	1.0 s	periodic	local
6	1.5 m	1.0 s	periodic / on event (3 m)	local
7	2.0 m	1.5 s	on event (1 m)	local

Evaluation results

- Basic – basic functionalities of the integrated location service;
- Caching & mapping – caching/mapping functionalities introduced;
- Long-term interpretation – pushing the intelligence to the ILS;
- Dynamic – "God-view" on provisioning features;

Type	Total number of requirements	Accuracy satisfaction	Latency satisfaction	Both requirements satisfaction	Consumed power
Per-Request Satisfaction Algorithm (PRSA)					
Basic	659	141	388	113	2021
Caching & mapping	659	352	504	303	1201
Long-term interpretation	659	361	531	313	1167
Dynamic	659	451	528	347	1387
Per-Time-Bucket Satisfaction Algorithm (PTSA)					
Basic	659	98	388	68	1510
Caching & mapping	659	331	504	281	854
Long-term interpretation	659	341	531	294	833
Dynamic	659	433	528	339	1041

Results

- Global optimization consumes ~25% less power;
- Accuracy satisfaction of global optimization is ~25% smaller;
- Mapping and caching capabilities reduce total consumed power and benefit both accuracy and latency;
- Pushing “the intelligence” to the ILS benefits latency and accuracy;
- “God-view” improves accuracy satisfaction;

Conclusions

- Each of the defined functional components benefits the overall performance of the SLSR.
- In tracking scenarios, there is a dependence between accuracy and latency.
- Satisfaction of requirements from the applications is more important than “provisioning on steroids”;
- Standardization is needed.

The end…

Thank you!

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