Mobility Collector

ROYAL INSTITUTE OF TECHNOLOGY

Battery Conscious Mobile Tracking

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Outline

Location tracking

Spatial and temporal granularity in location-dependant data

Current technological status

Robust data

linking spatial with physical movement

Mobility Collector - a mobile tracking platform

Usability of **Mobility Collector**

Location Tracking

There is a need for location awareness:

a) Multi-user systems

- Studying behavior and movement
- Extrapolating information (prediction)

b) Single-user systems

- Ubiquitous (pervasive) computing
- Studying and understanding the user’s context
- Aiding the user in decision making

Tech status for location tracking

The industry's focus is on purpose-oriented apps

Research development is not a priority

The location listening service is acontextual

Temporal granularity has precedence over the spatial one

Multiple API's, different software implementation and ambiguous documentation

Mobility Collector

A highly configurable tracking platform for Android devices (Android 2.0 and higher)

Research oriented and open-source

Equidistant and equitime tracking options

Contextual battery preserving algorithm

Configurable point- and period-based annotations

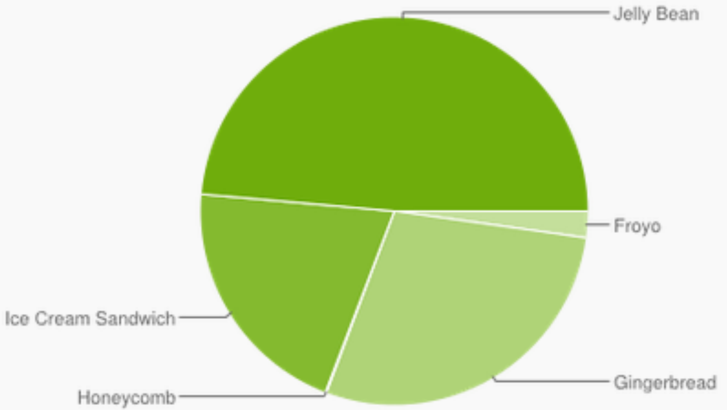
Why Android?

Open-source

Offers hardware and software diversity

Mobility Collector - minimum API 5

Version	Codename	API	Distribution
2.2	Froyo	8	2.2%
2.3.3 - 2.3.7	Gingerbread	10	28.5%
3.2	Honeycomb	13	0.1%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	20.6%
4.1.x	Jelly Bean	16	36.5%
4.2.x		17	10.6%
4.3		18	1.5%



Source: http://developer.android.com/about/dashboards/index.html

Tracking algorithms

Equitime and Equidistant tracking

Tracking parameters

Parameters

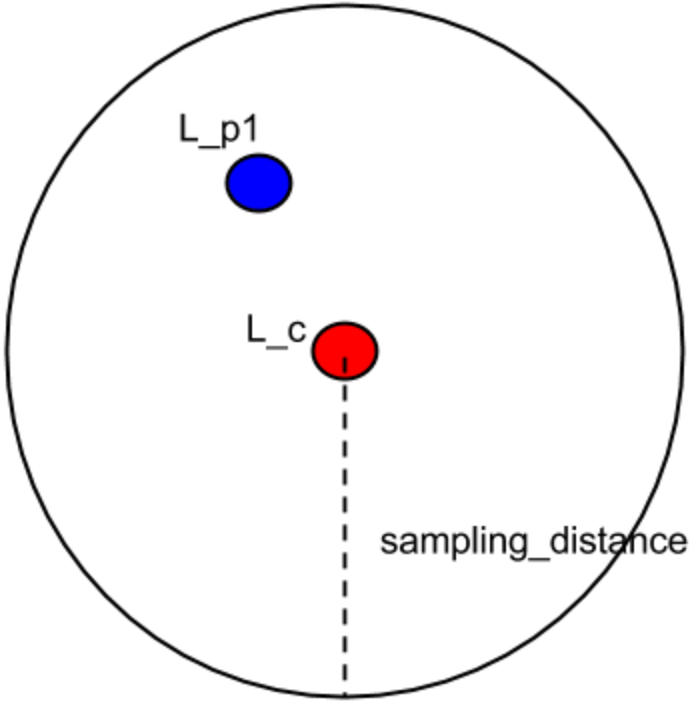
Sampling time - the frequency at which the location listener will try to obtain a fix

Sampling distance - the clustering constraint which prevents locations to be broadcasted if they are within a certain distance of the last fix

Equitime tracking

Time: T_c + 30 seconds

L_p(1) gets broadcasted



L_p - potential location

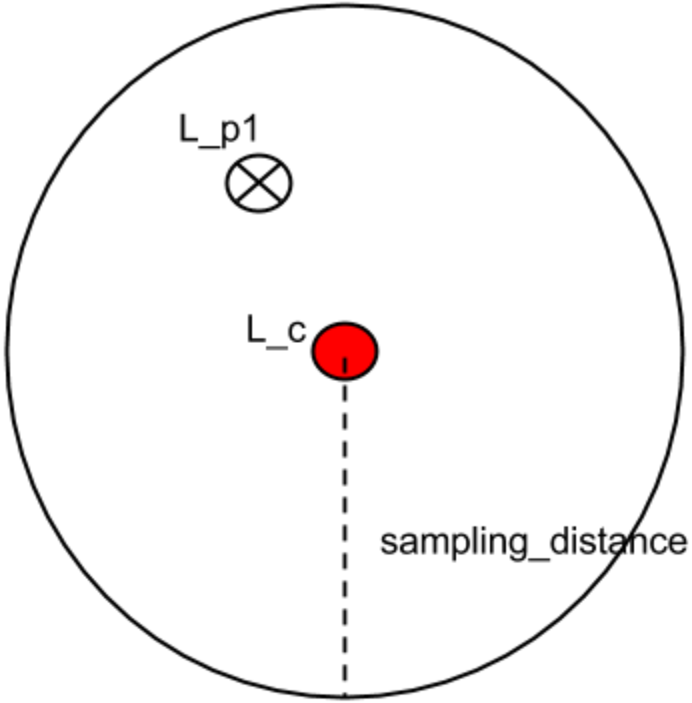
L_c - current location

Equitime tracking

Time: T_c + 30 seconds

L_p(1) gets broadcasted

L_p(1) **fails** the clustering filter



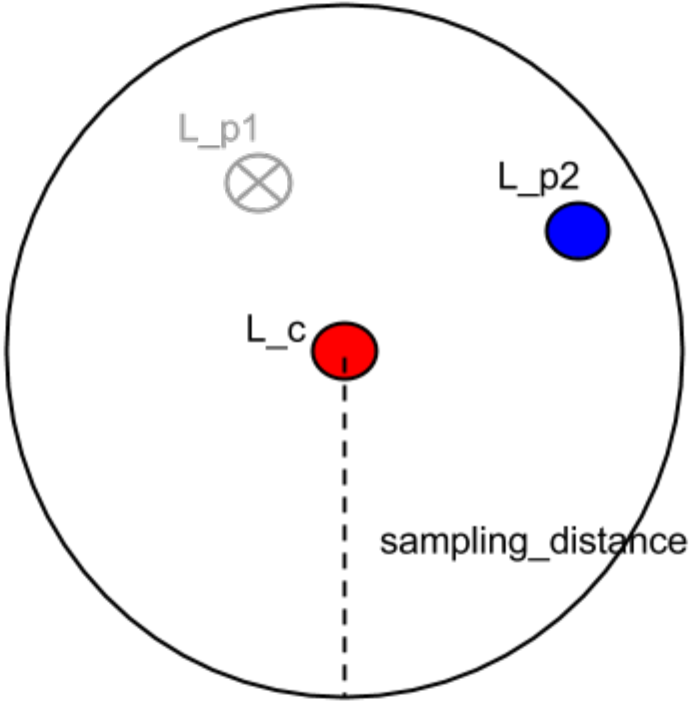
L_p - potential location

L_c - current location

Equitime tracking

Time: T_c + 1 min

L_p(2) gets broadcasted



L_p - potential location

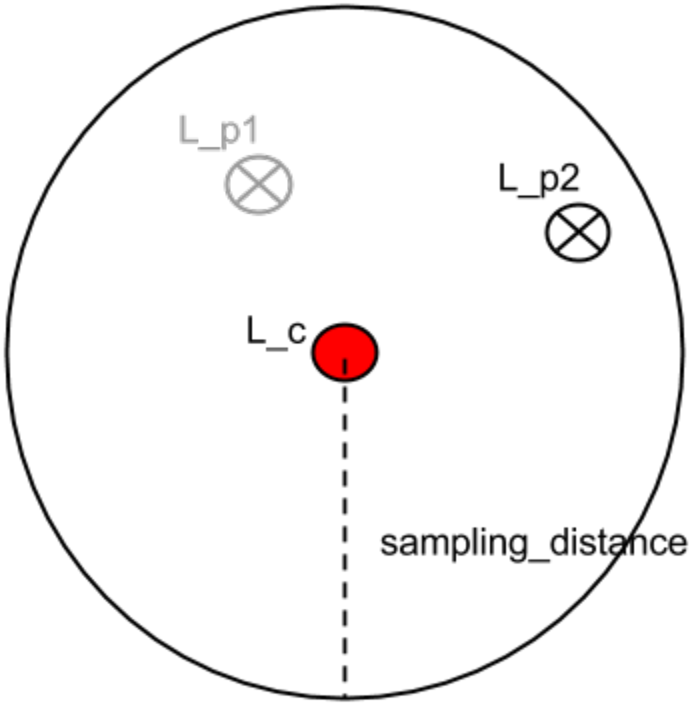
L_c - current location

Equitime tracking

Time: T_c + 1 min

L_p(2) gets broadcasted

L_p(2) **fails** the clustering filter



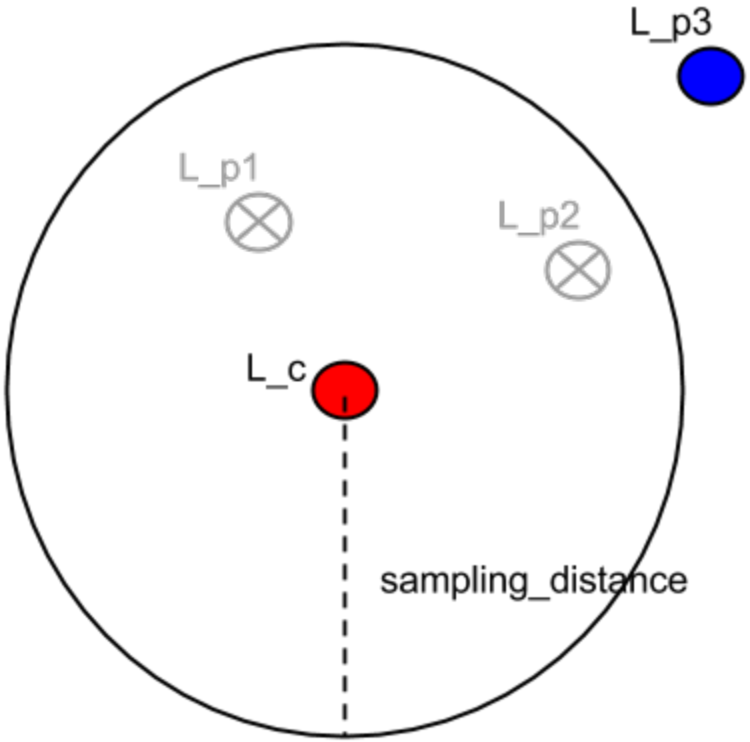
L_p - potential location

L_c - current location

Equitime tracking

Time: T_c + 1.5 min

L_p(3) gets broadcasted



L_p - potential location

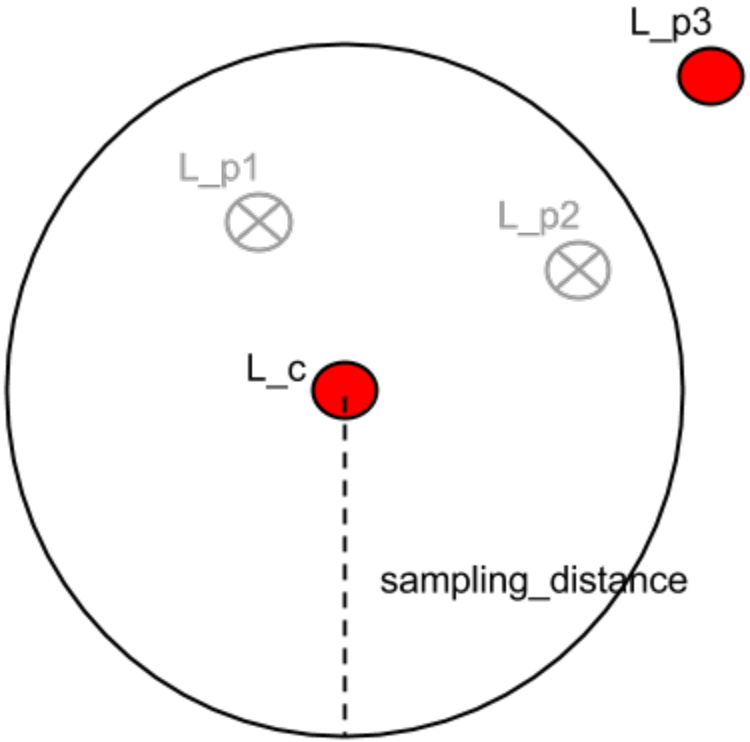
L_c - current location

Equitime tracking

Time: T_c + 1.5 min

L_p(3) gets broadcasted

L_p(3) **passes** the clustering filter



L_p - potential location

L_c - current location

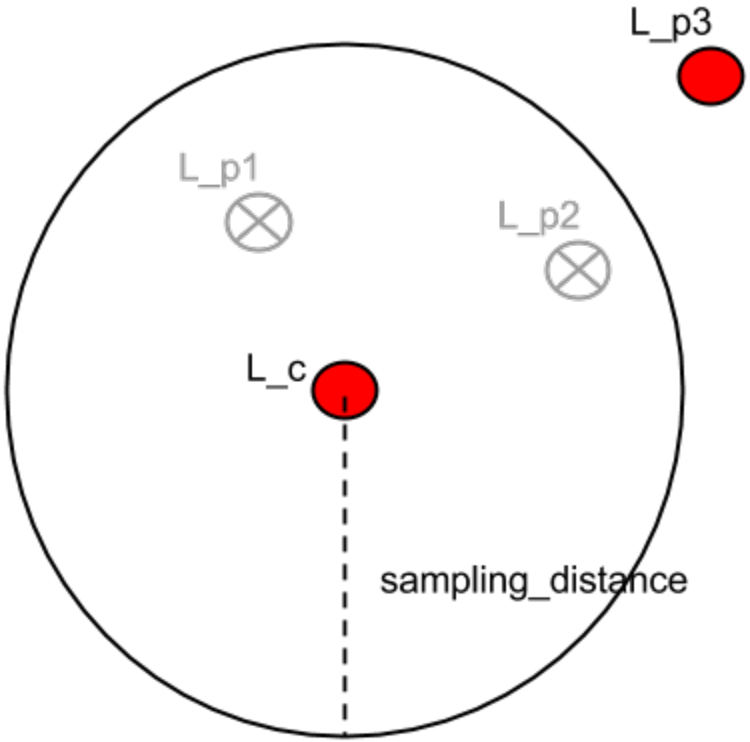
Equitime tracking

Time: T_c + 1.5 min

L_p(3) gets broadcasted

L_p(3) **passes** the clustering filter

L_p(3) gets **sent** to the programming interface



L_p - potential location

L_c - current location

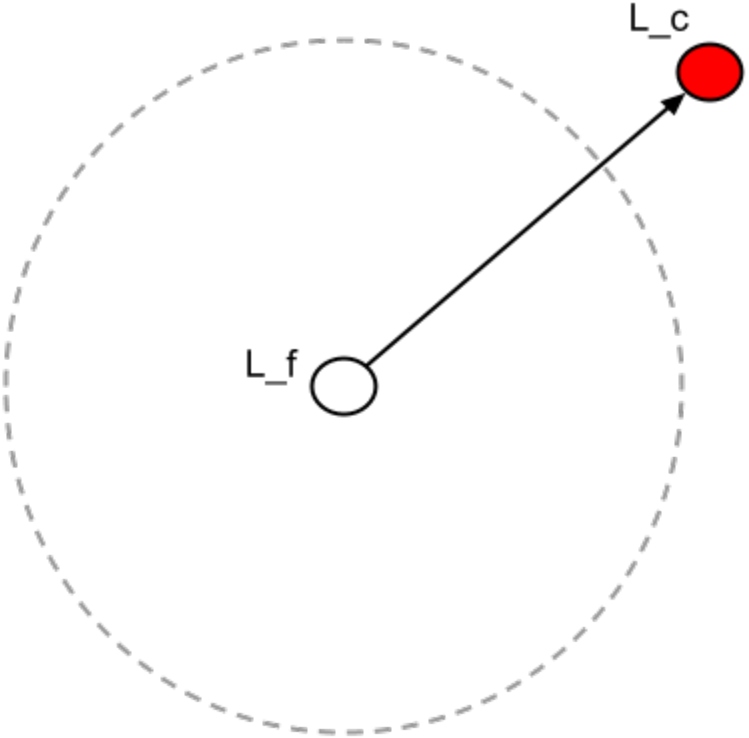
Equitime tracking

Time: T_c + 1.5 min

L_p(3) gets broadcasted

L_p(3) **passes** the clustering filter

L_p(3) **becomes** the reference for future fixes

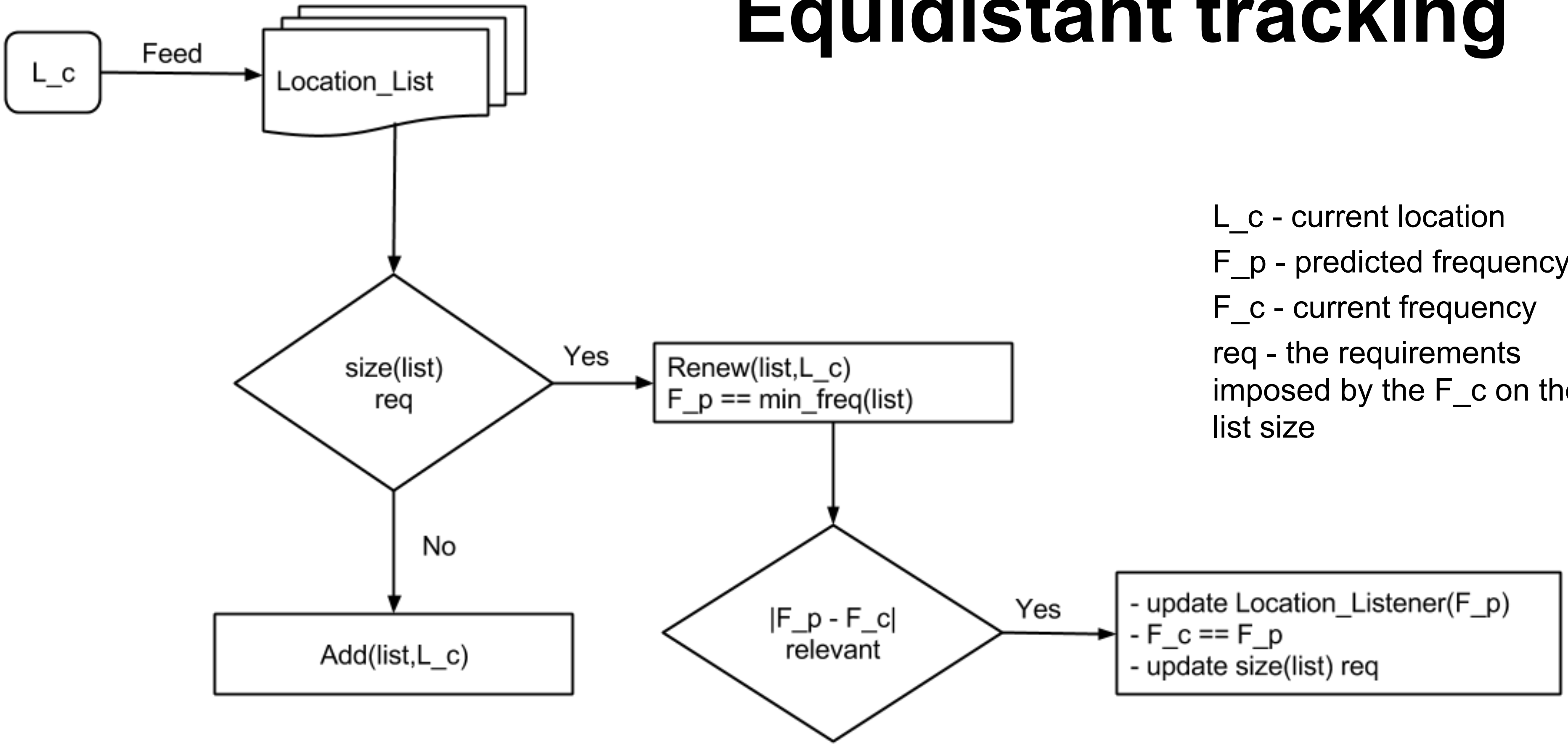


L_p - potential location

L_c - current location

L_f - former instance of L_c

Equidistant tracking



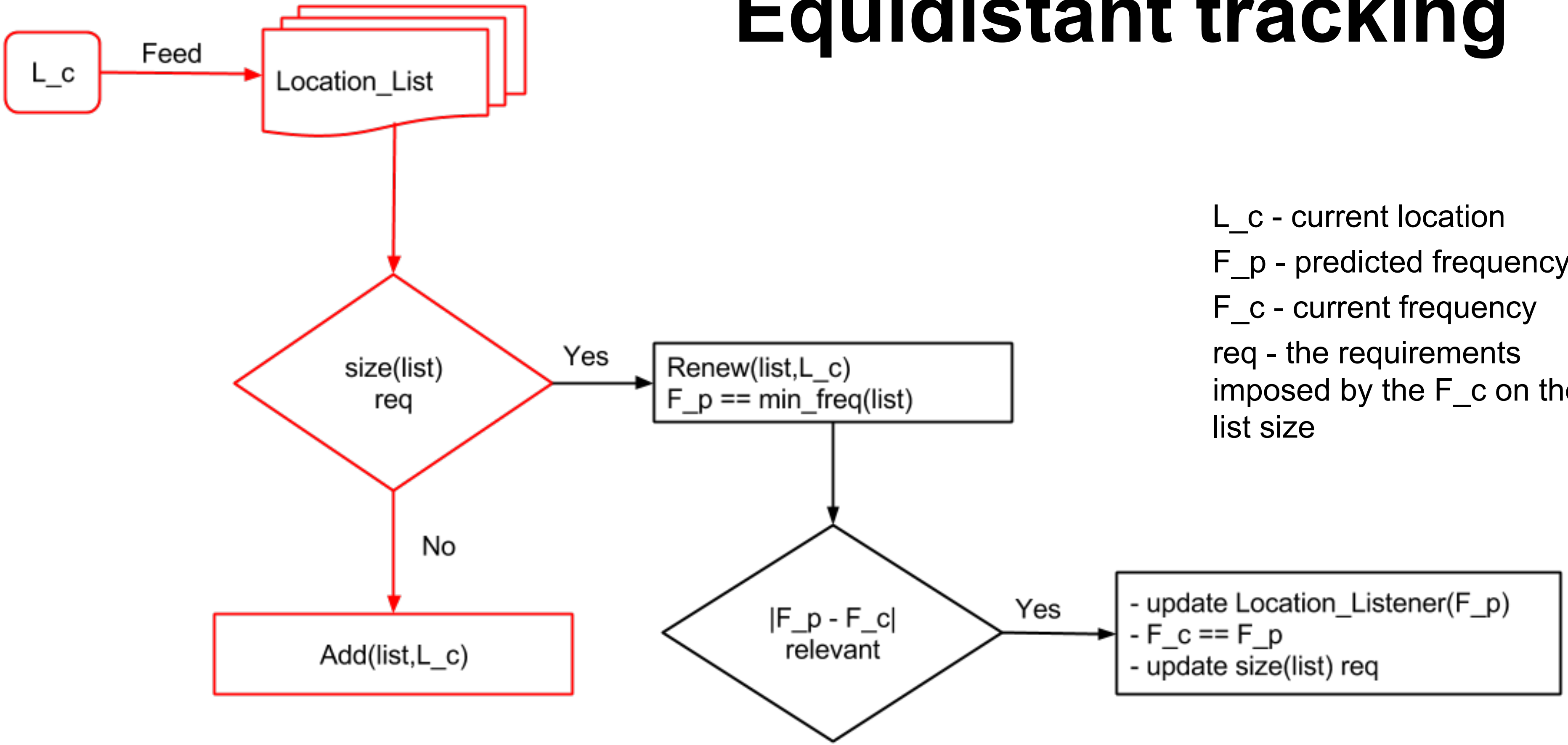
L_c - current location

F_p - predicted frequency

F_c - current frequency

req - the requirements imposed by the F_c on the list size

Equidistant tracking



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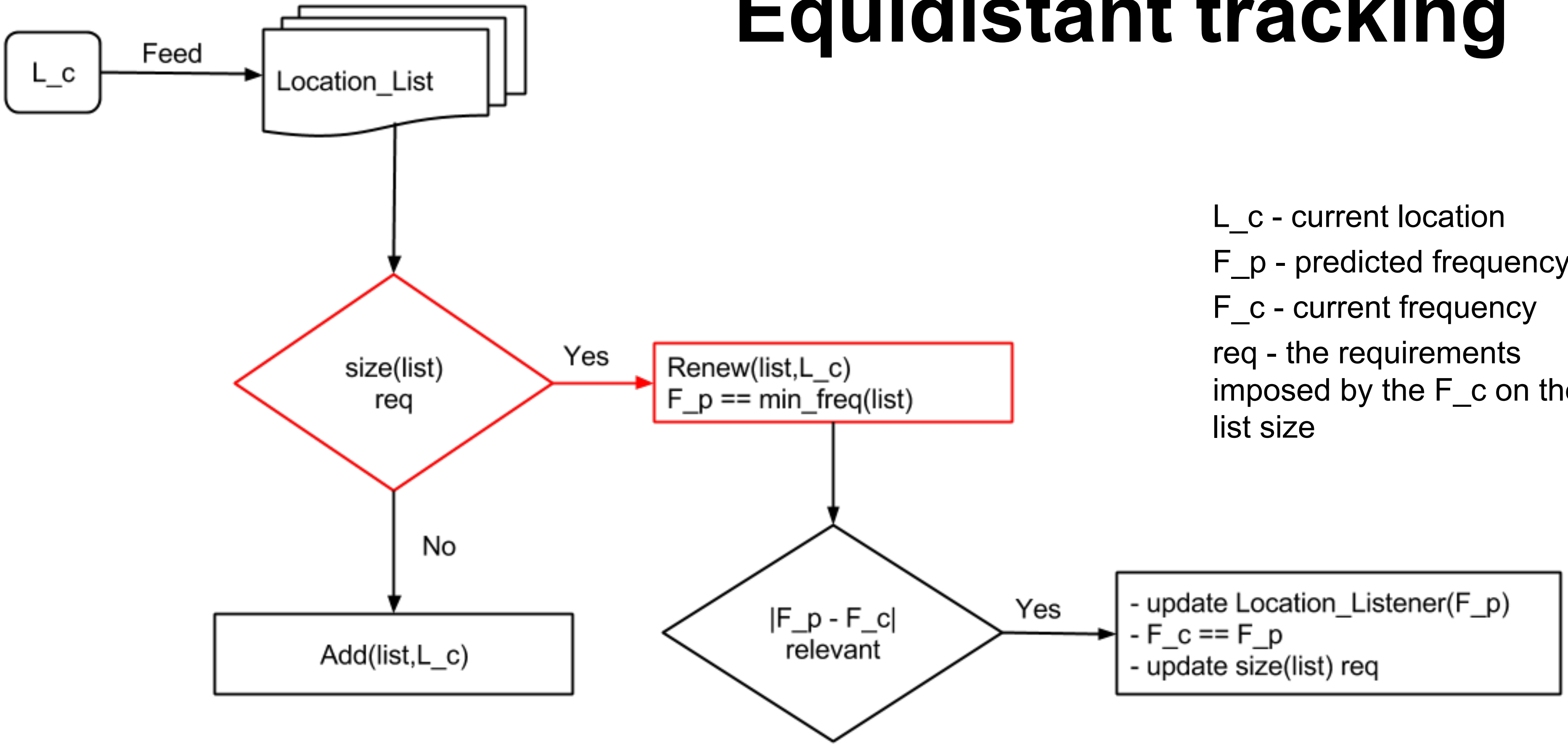

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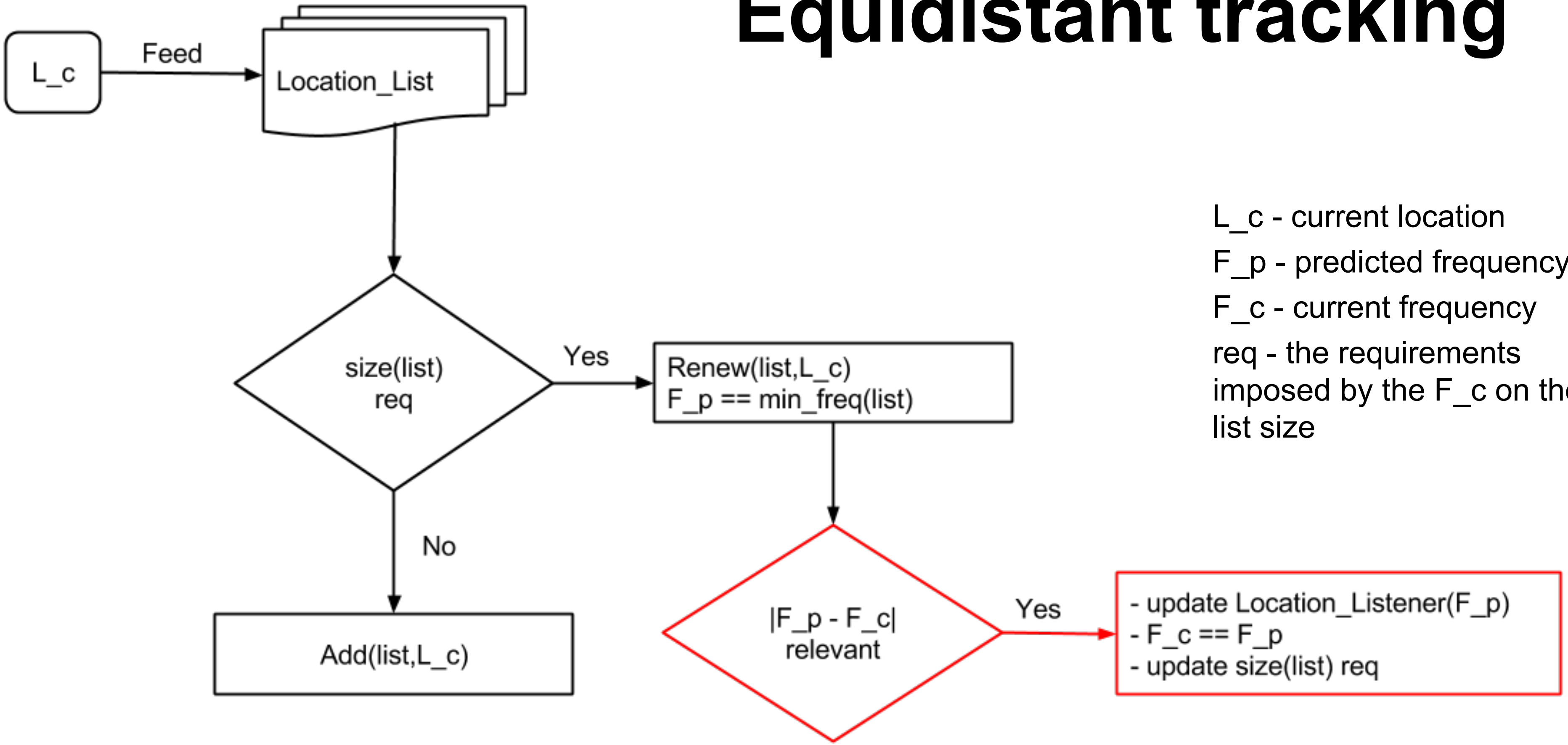

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F_p - predicted frequency

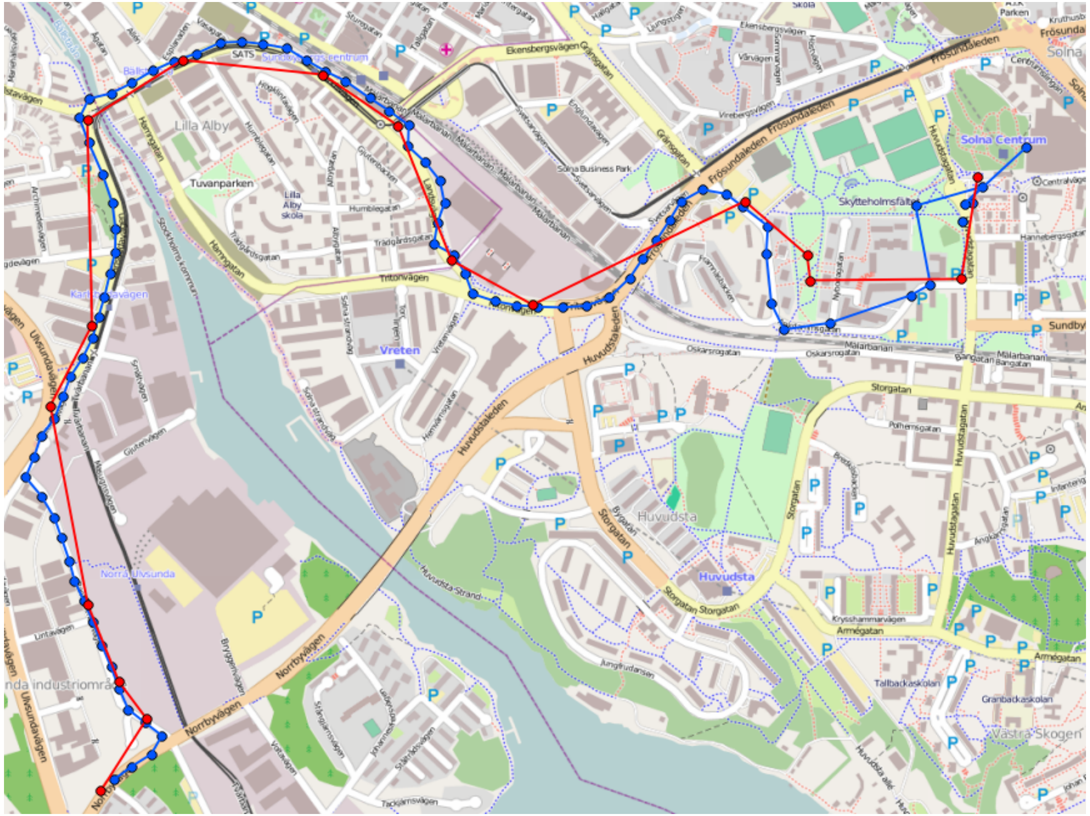
F_c - current frequency

req - the requirements imposed by the F_c on the list size

Equitime vs. Equidistant Tracking

Equidistant(Blue)
Equitime(Red)

Sampling time = 50 s
Sampling distance = 50 m



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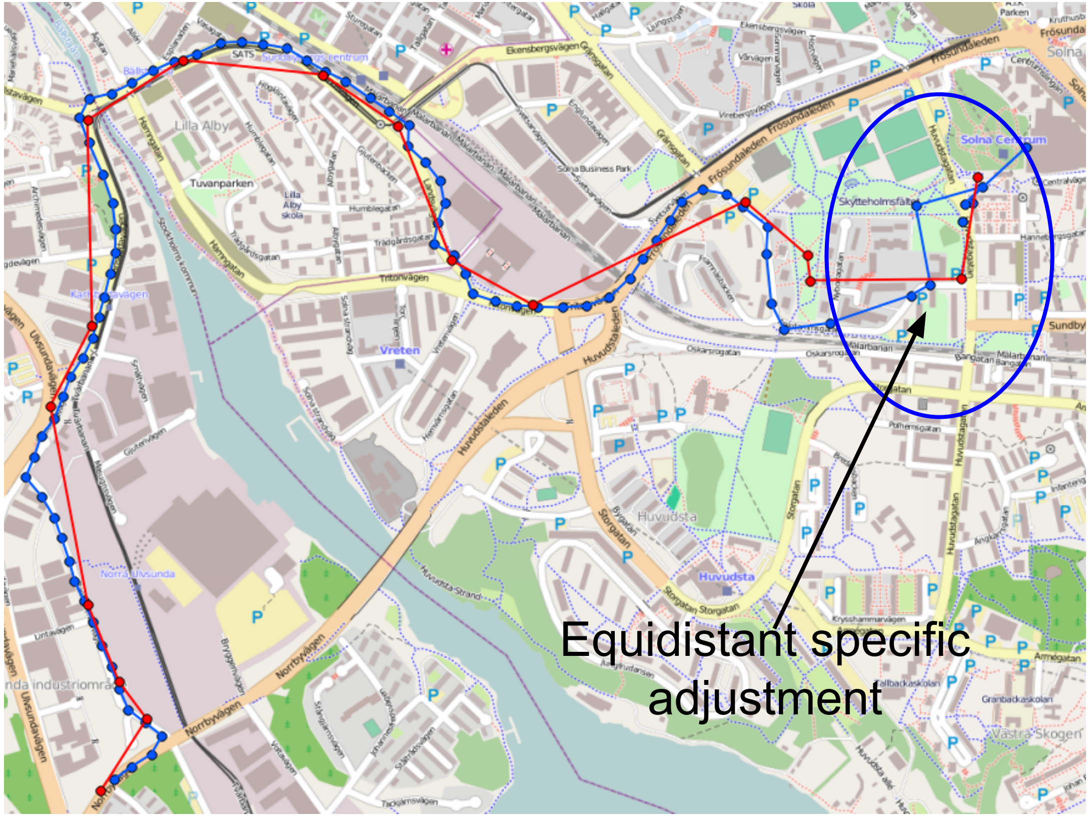
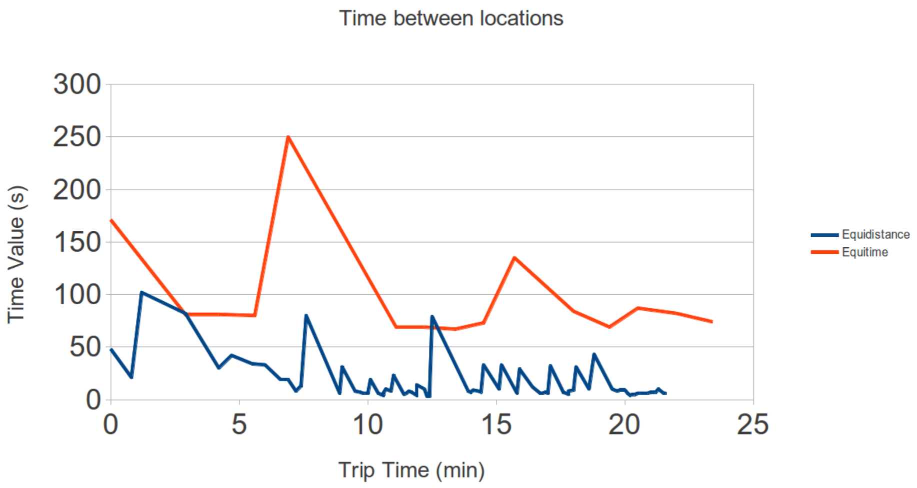
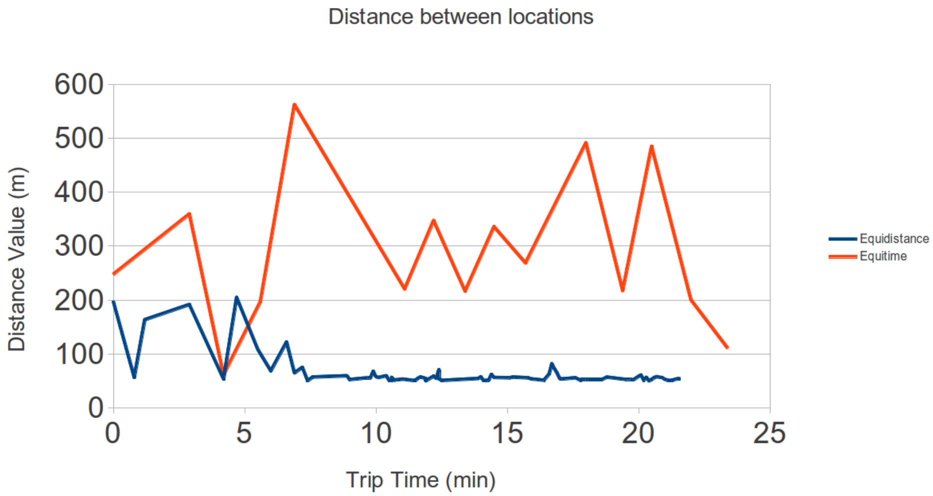
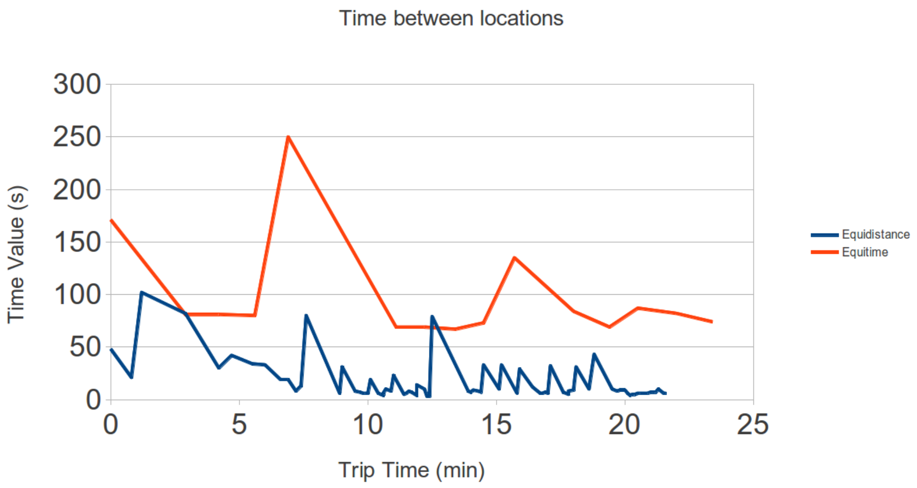


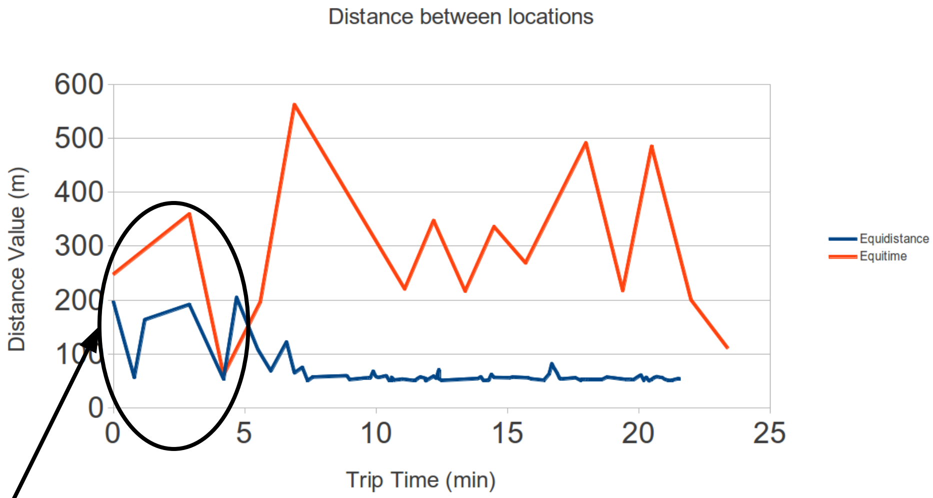
Equitime vs. Equidistant Tracking





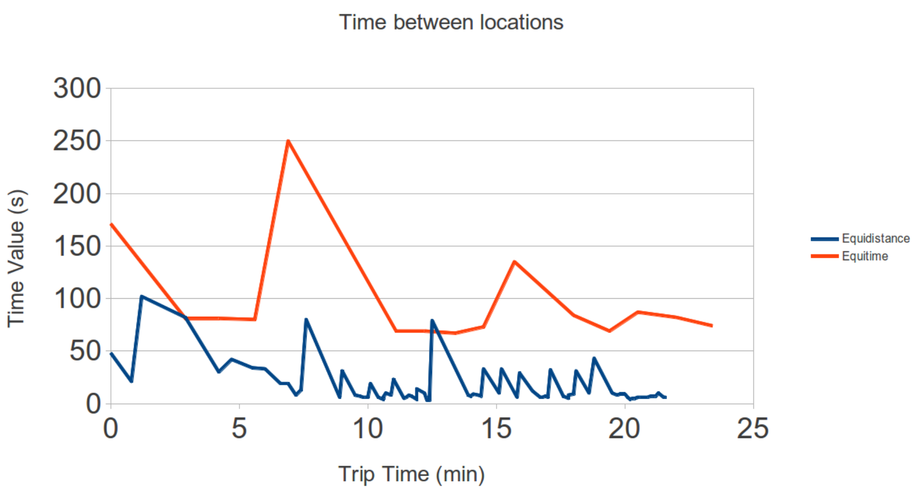
Equitime vs. Equidistant Tracking

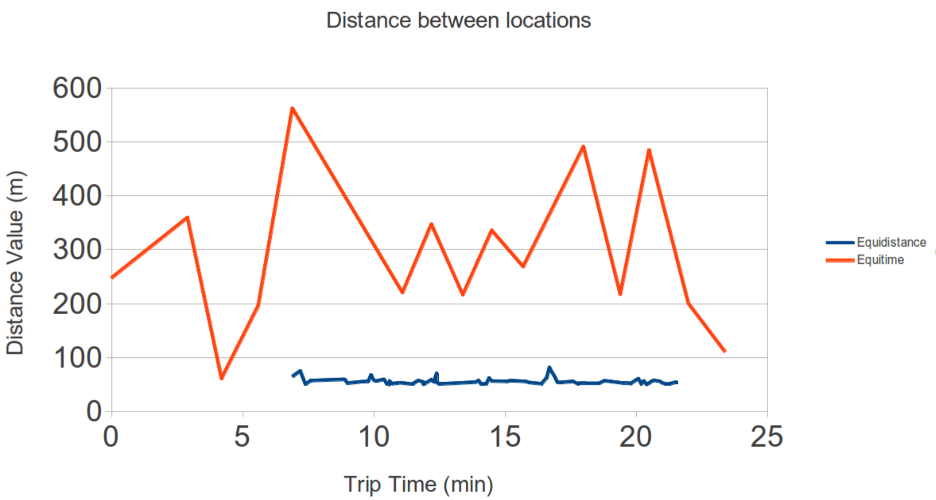




Equidistant specific
adjustment

Equitime vs. Equidistant Tracking





Equitime vs. Equidistant Tracking

Stats	Equitime		Equidistant		Equidistant – after initialization	
	Distance (m)	Time (s)	Distance (m)	Time (s)	Distance (m)	Time (s)
Avg	287.9	98.1	64.2	15.8	56.1	12.1
Std. Dev.	141.9	50.7	30.8	19.2	6.0	14.1
Min	61.3	67.0	50.1	3.0	50.1	3.0
Max	562.4	250.0	204.9	102.0	82.0	80.0
# of Records	15		82		73	

Sampling time = 50 s

Sampling distance = 50 m

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1. Low number of records
2. Time for the "actual" fix

Sampling time = 50 s

Sampling distance = 50 m

Equitime vs. Equidistant Tracking

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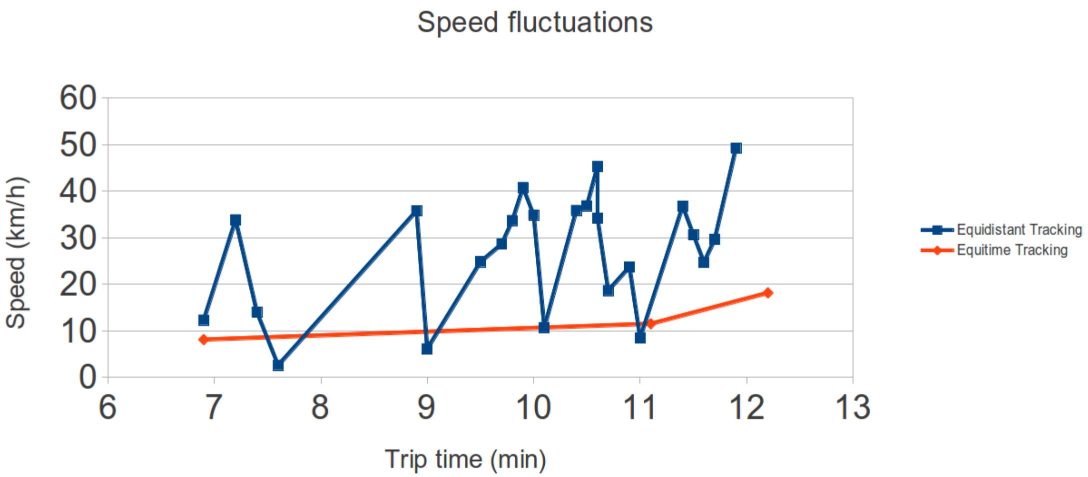
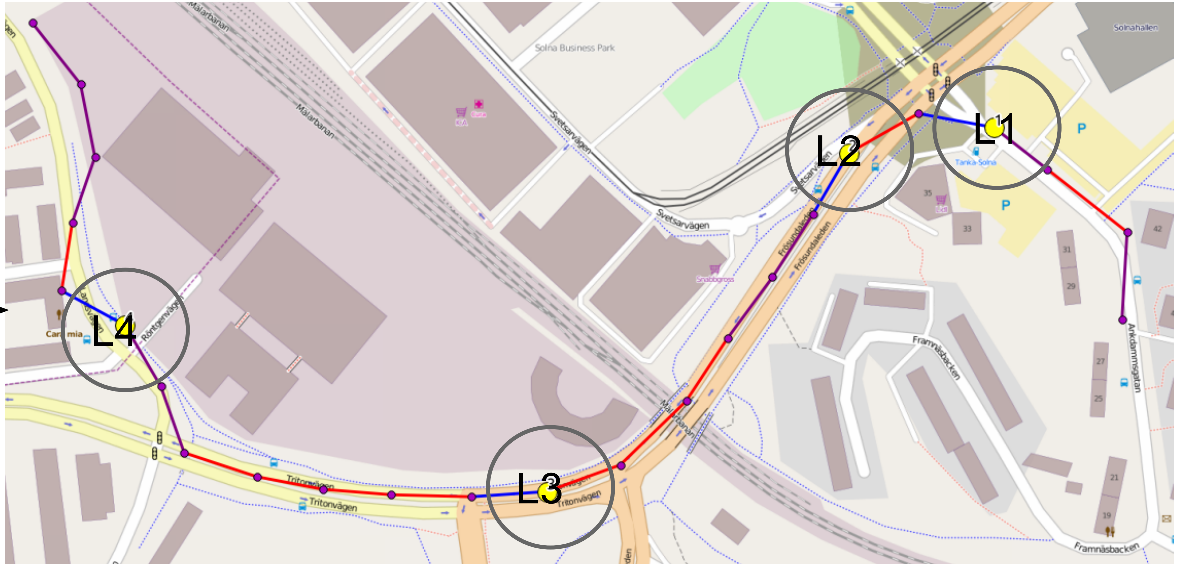
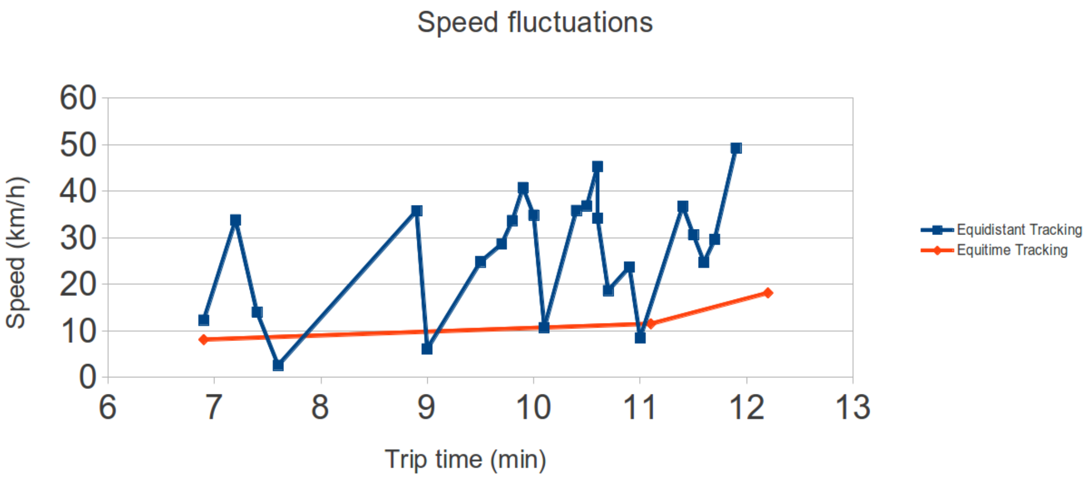
Case study



OSM-derived semantics

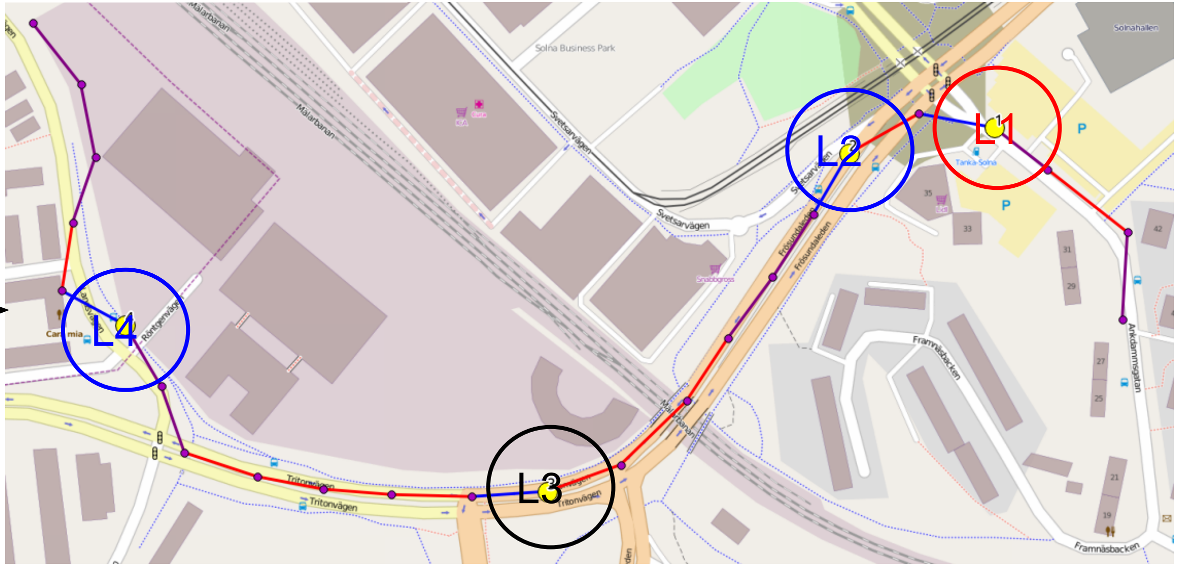


Case study



Analysis (based on proximity) result:
L1 - traffic light
L2,L4 - bus stop
L3 - no features of interest in its vicinity

OSM-derived semantics



Equitime vs. Equidistant Tracking

<u>Equitime</u> tracking

- Good for general purpose apps

- Spatial granularity is of little or no importance

- Linear battery drainage

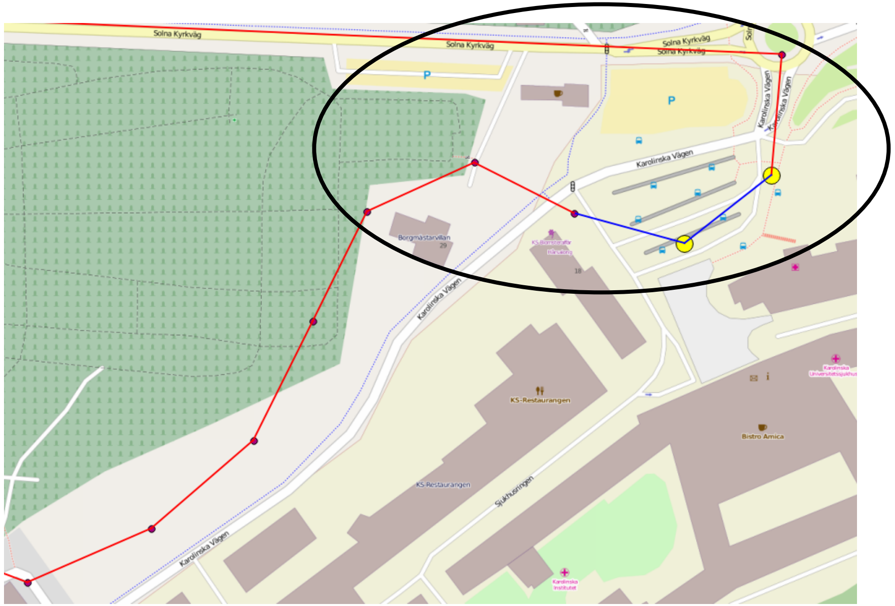
<u>Equidistant</u> tracking

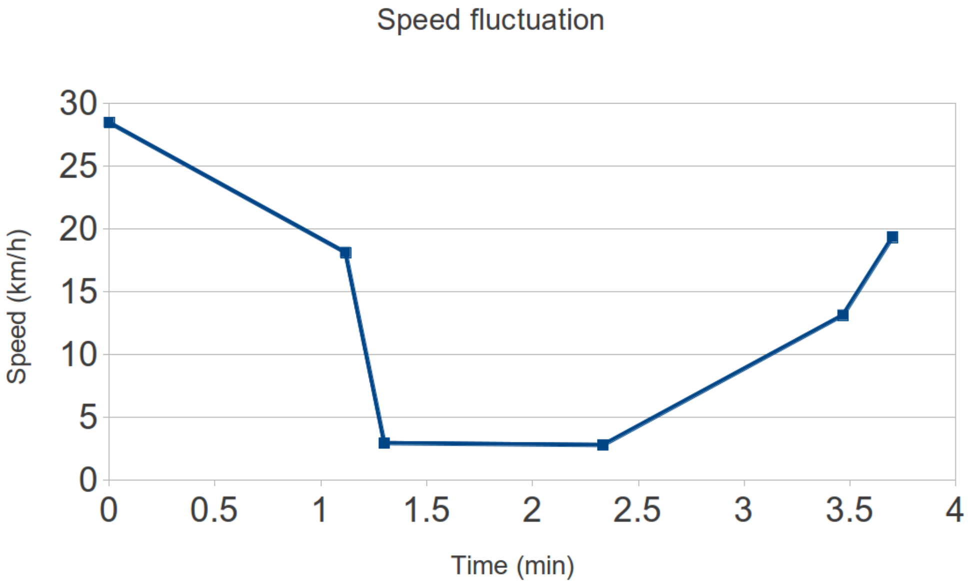
- Good for inferring context

- Spatial granularity takes precedence over the temporal one

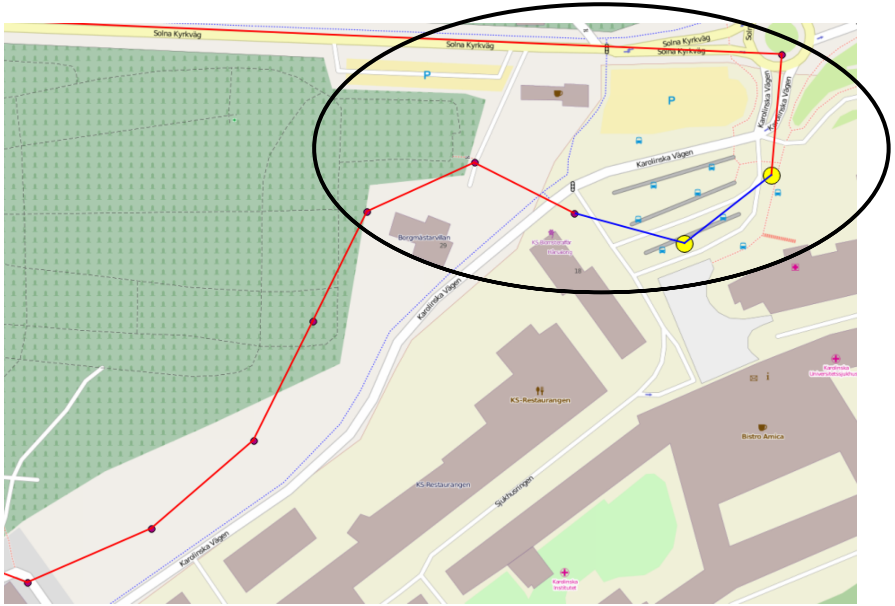
- Battery drainage depends on the speed of the phone bearer

Data (in)sufficiency



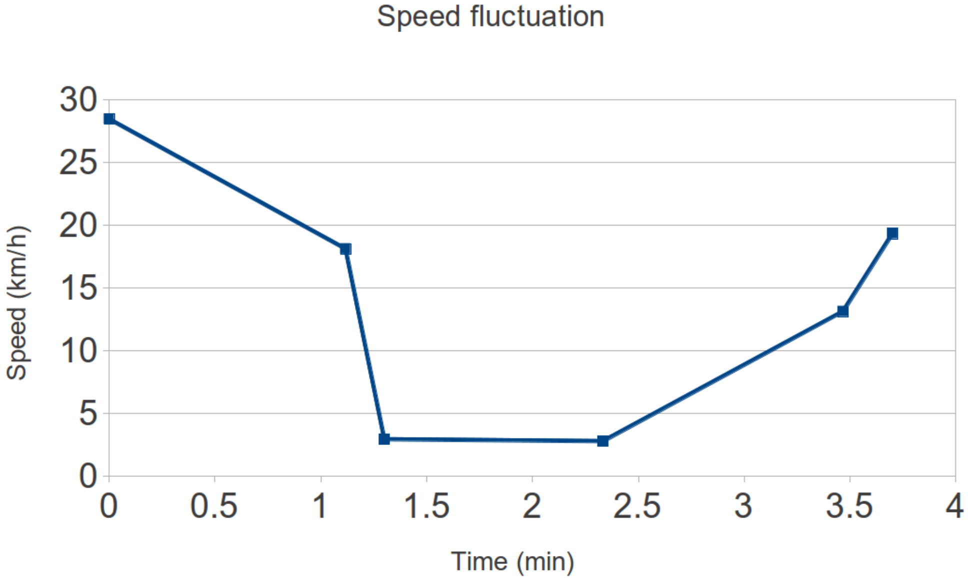


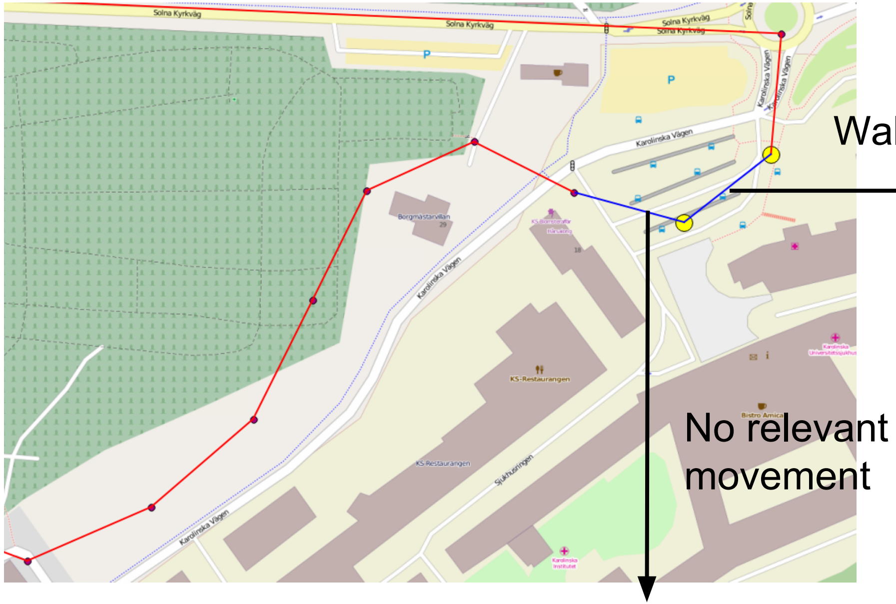
Data (in)sufficiency

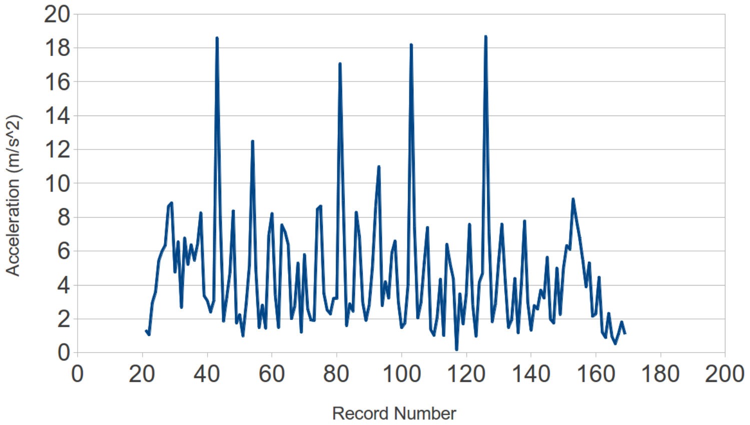


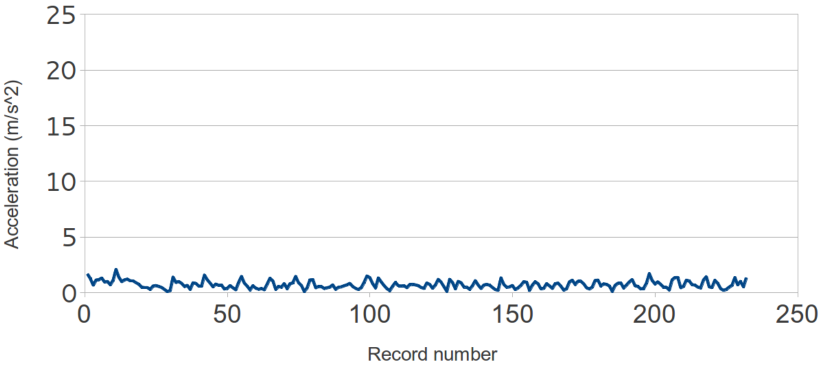
Location data ⇔ spatial displacement

Location data ≠ movement









Physical context makes the data robust

Embedded accelerometer

Basic statistics measurements (average, std. dev., min, max) for all axis and for total acceleration

Movement detection

Number of peaks

Pedometer

Embedded accelerometer

Basic statistics measurements (average, std. dev., min, max) for all axis and for total acceleration

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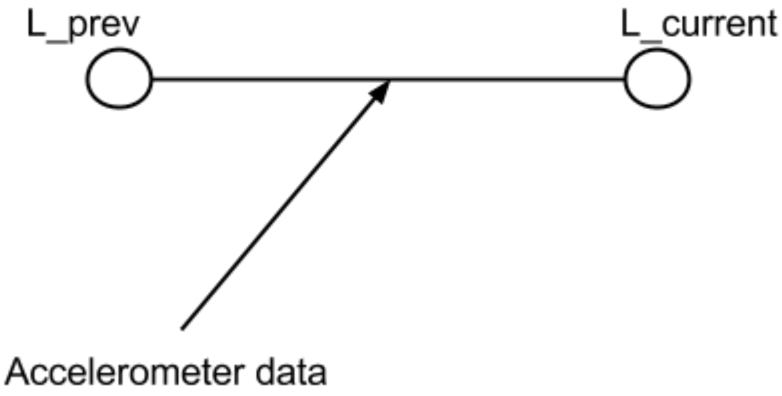
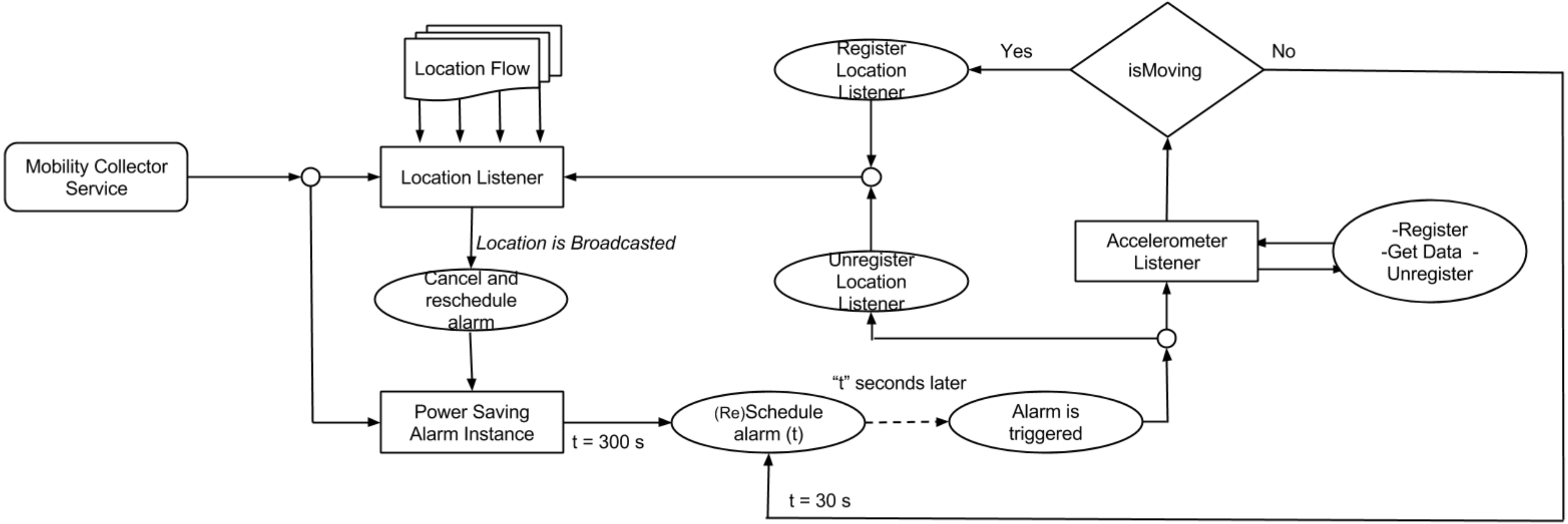


Usability

Battery drainage restricts the number of candidates in most research experiments

Users should still be able to use their phones while collecting data without having to worry about a battery overkill

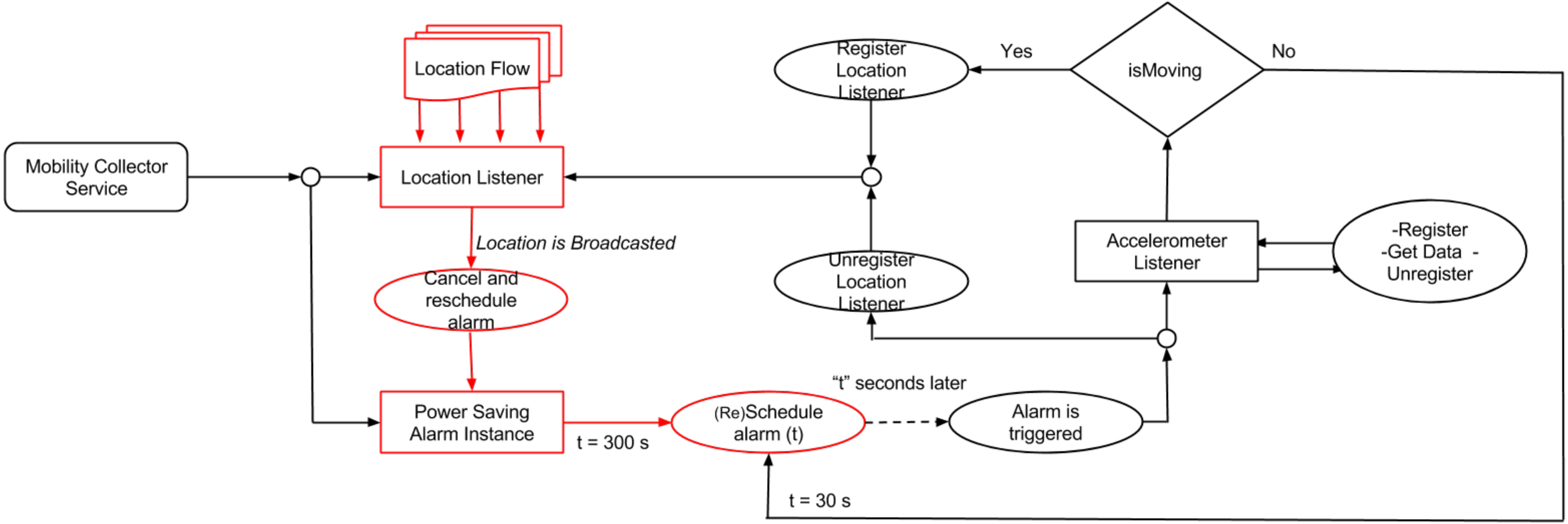
Power Saving



The alarm has two instances:

- location instance (spatial context)
- accelerometer instance (physical context)

Power Saving



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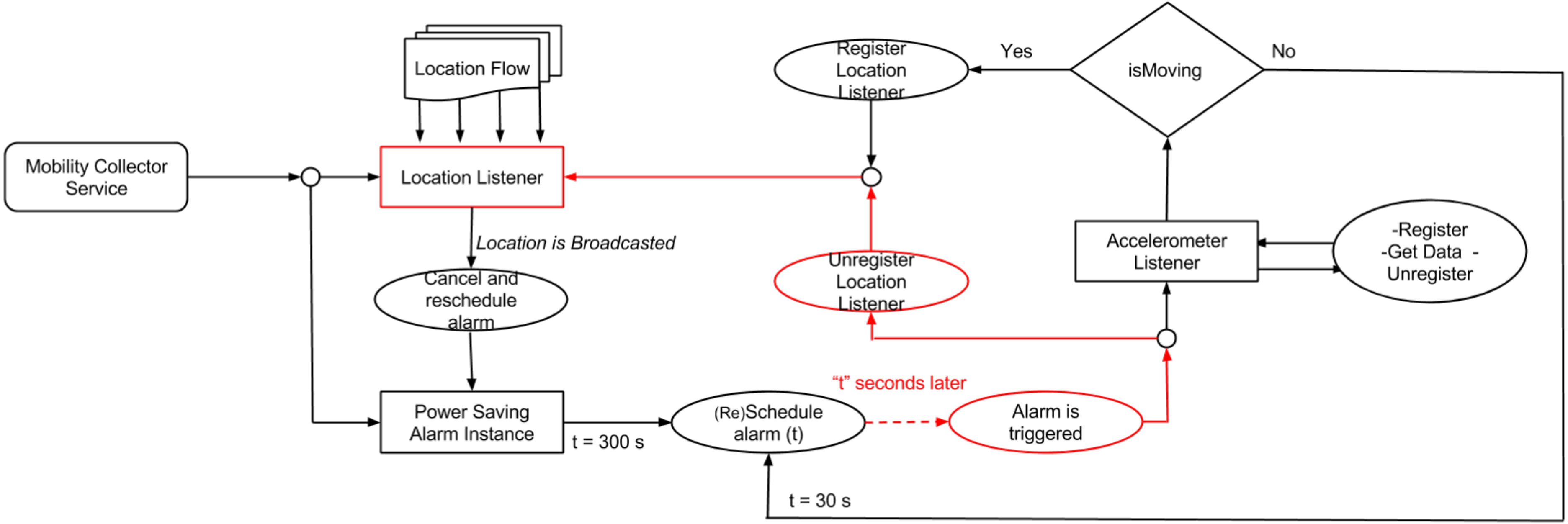

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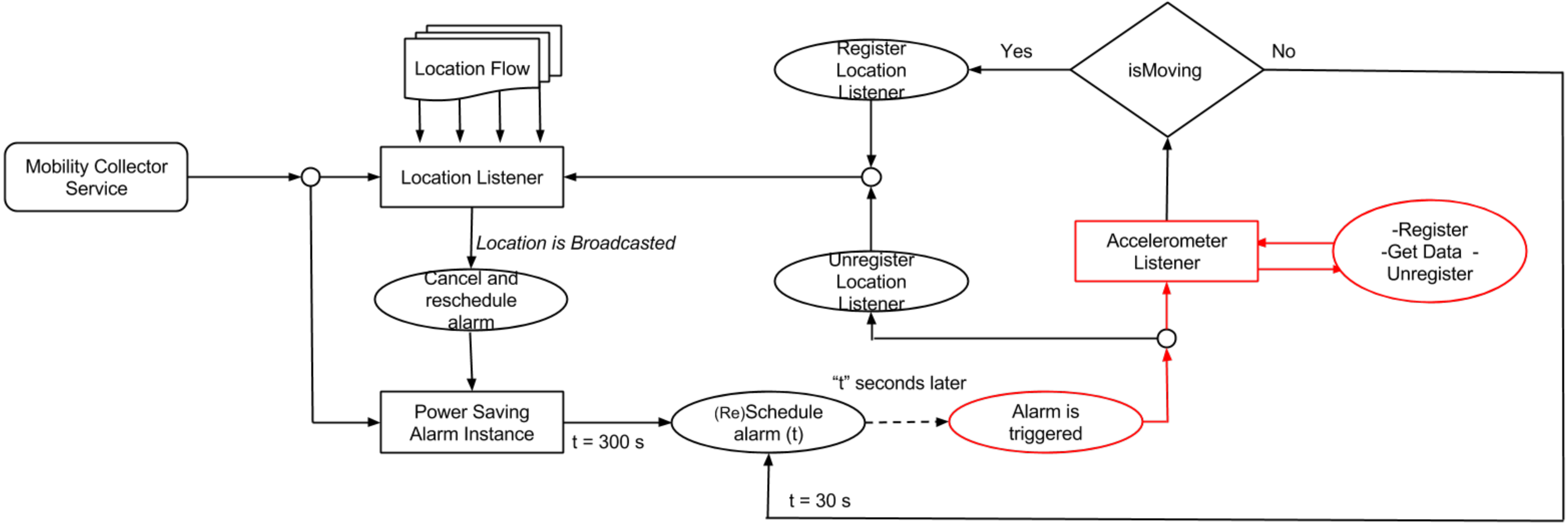

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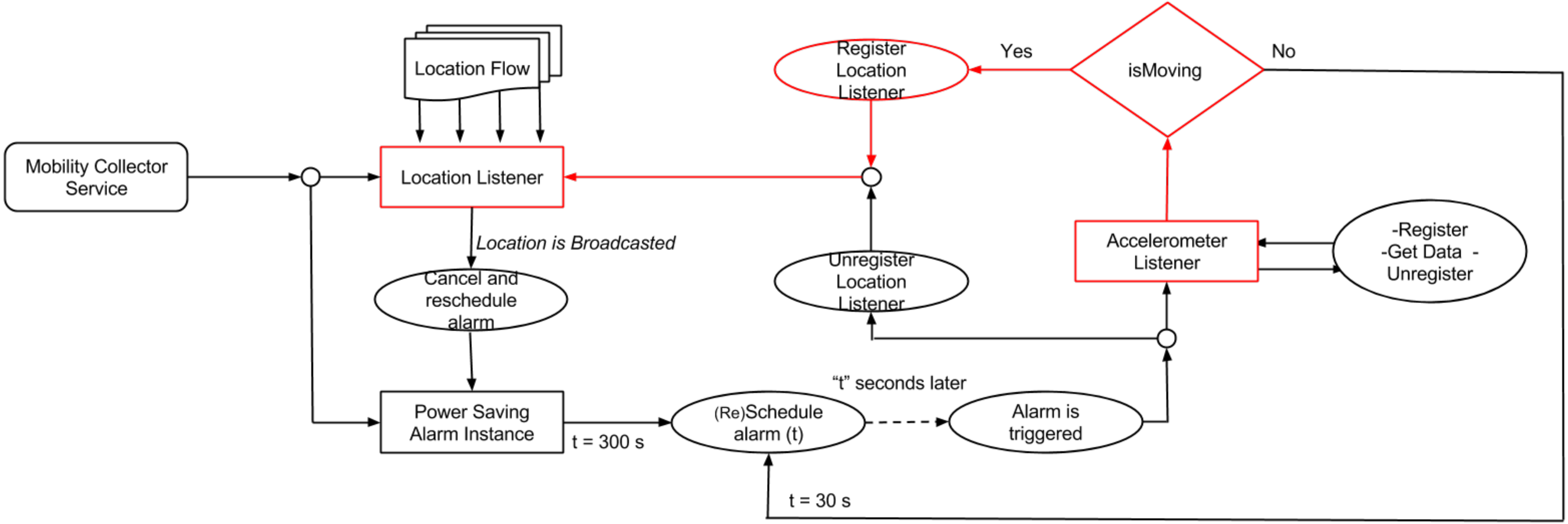

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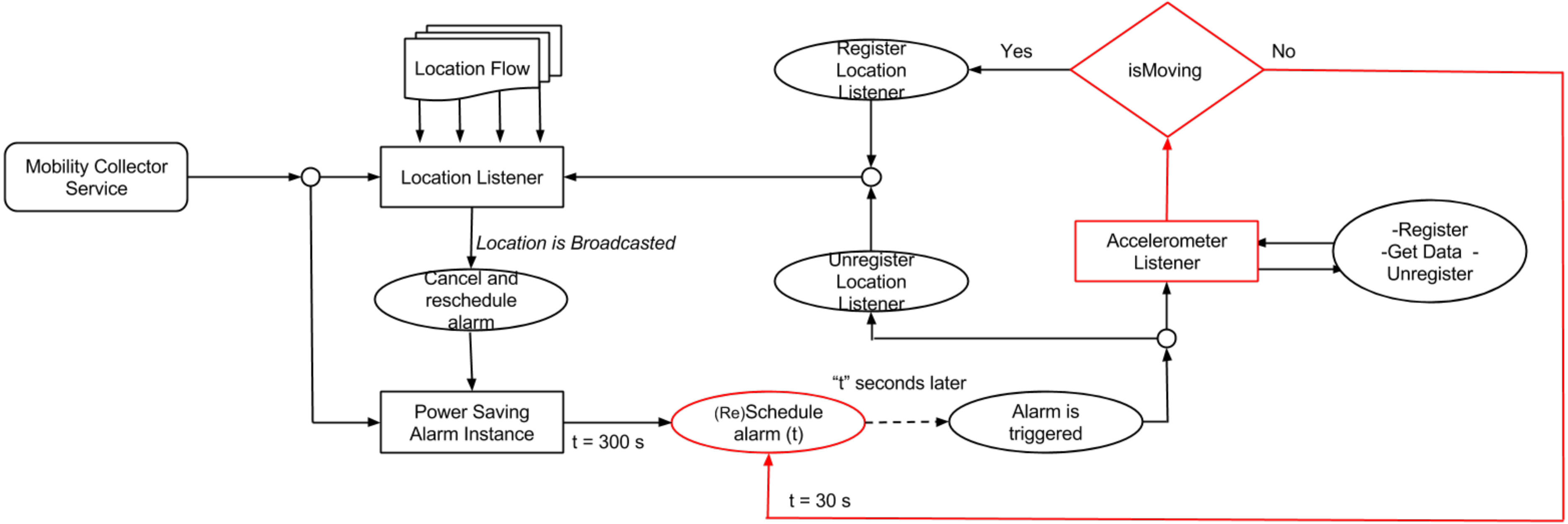

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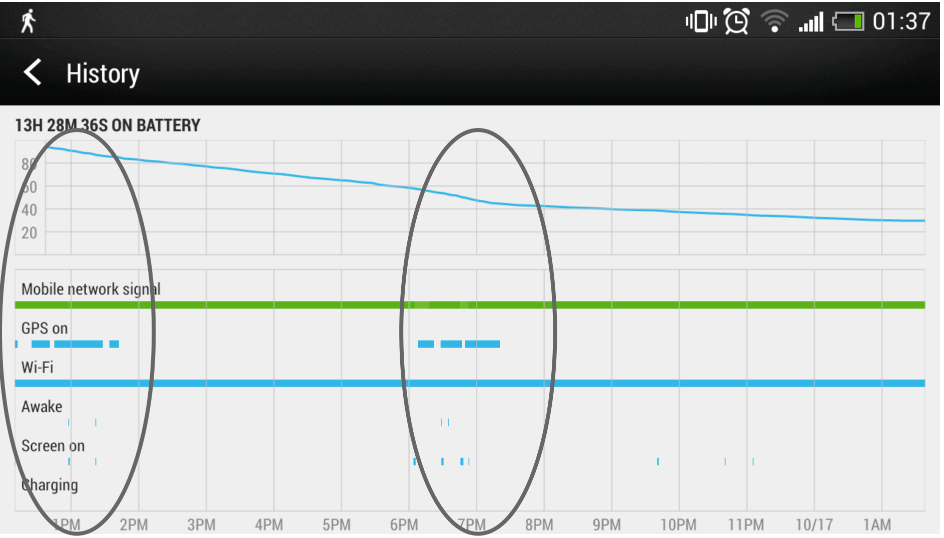
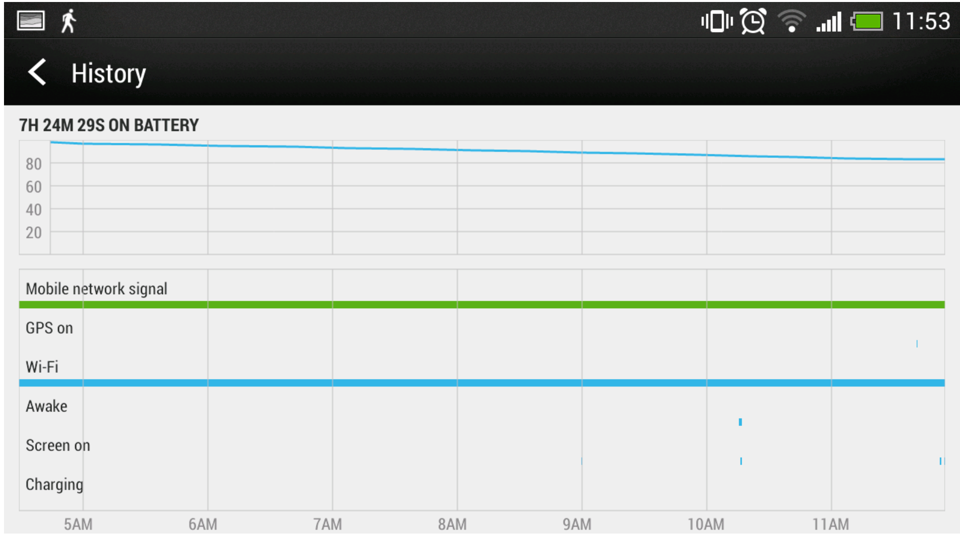
Battery Saving Results





Annotations

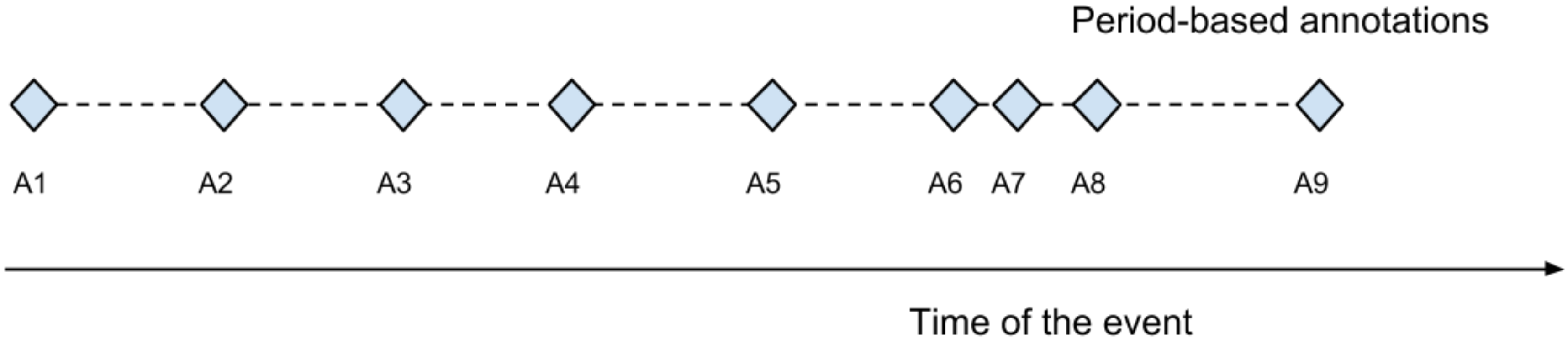
Annotations are particularly useful:

- For obtaining training samples for different types of classifications

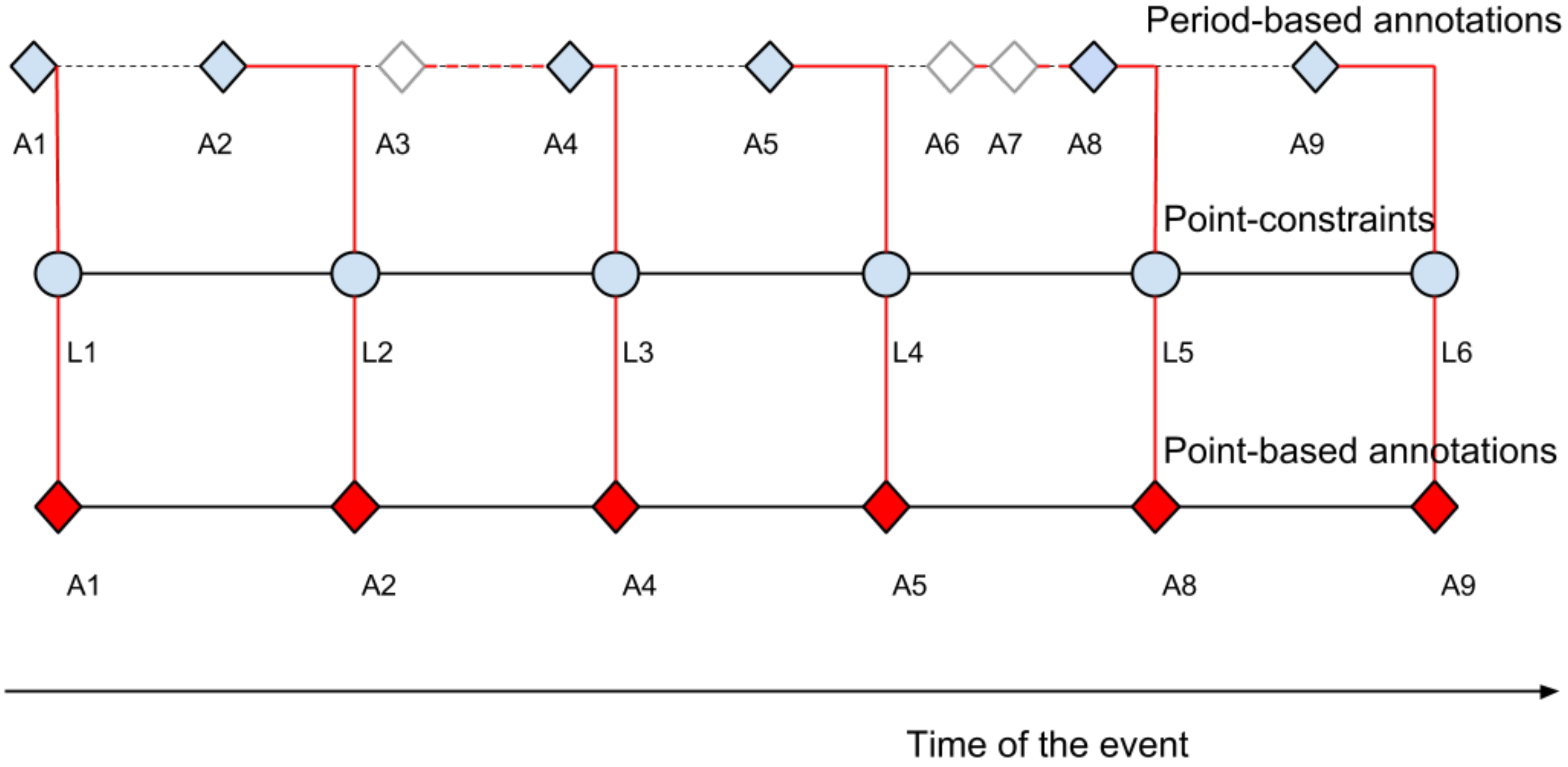
- As a measure of (re)assurance for the correctness of particular types of algorithms

- Adding a spatial component to qualitative data types

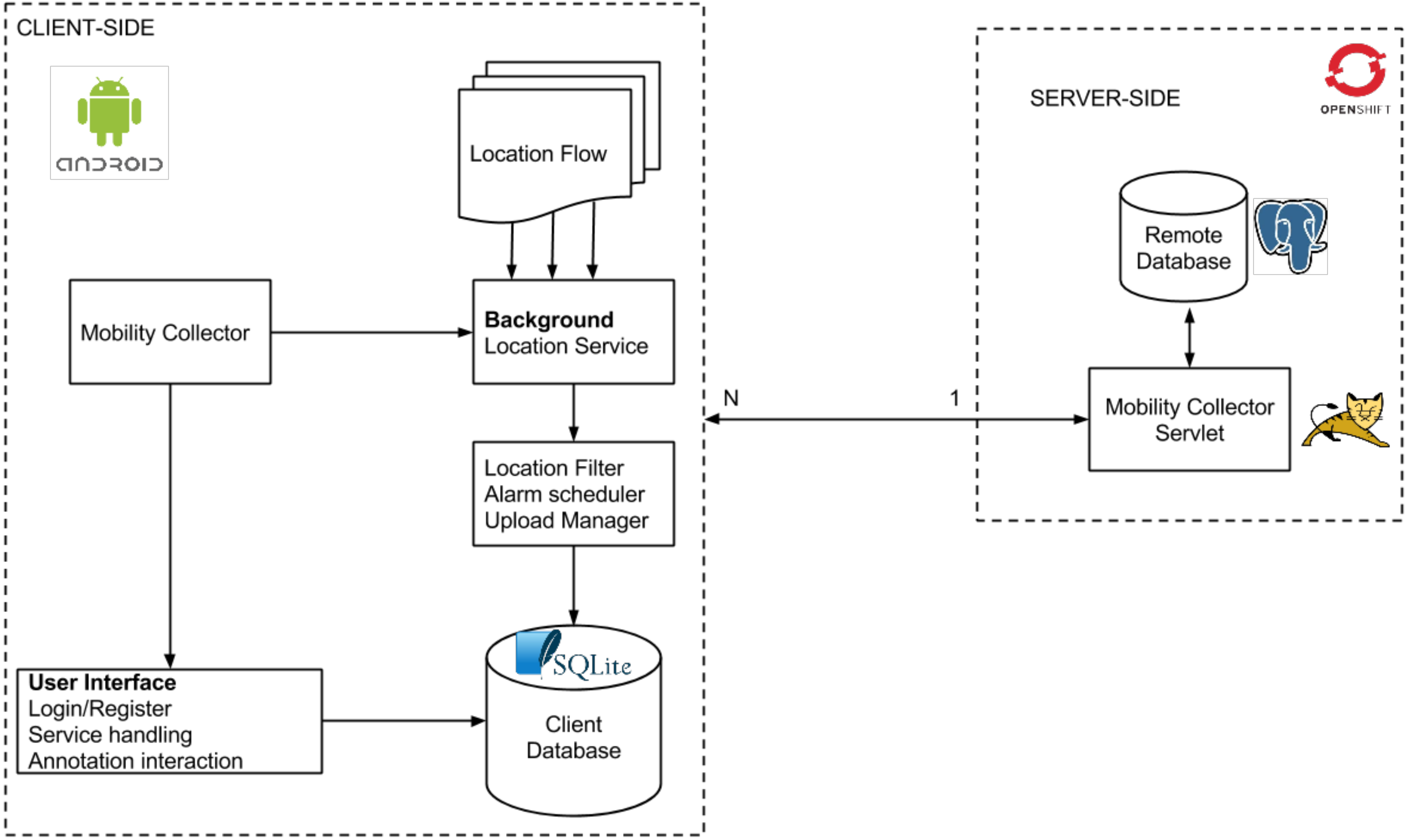
Point- and period-based annotations

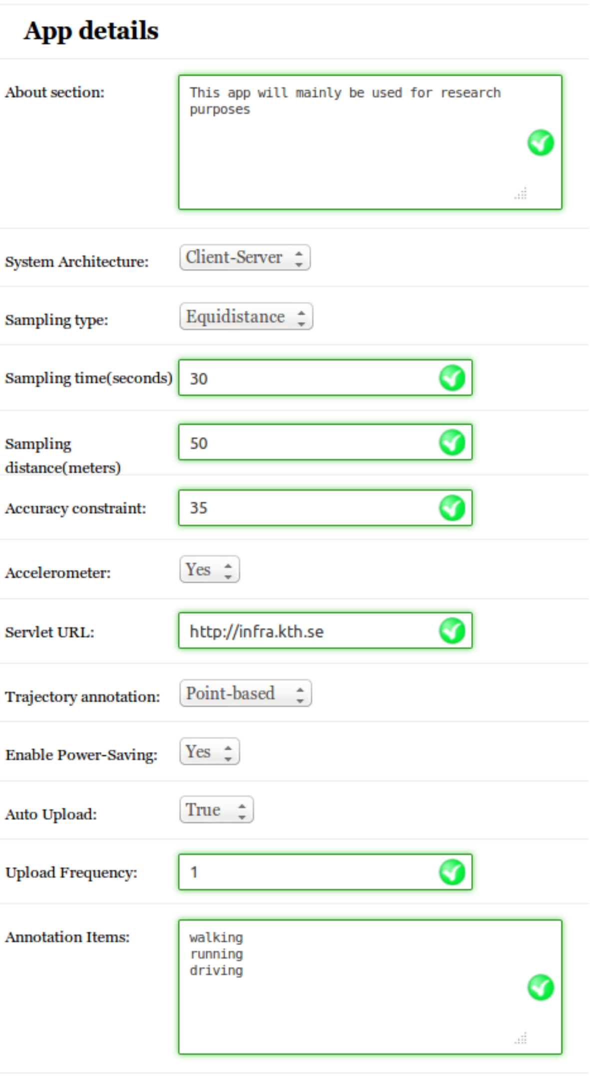


Point- and period-based annotations



Architecture





App details

About section:	This app will mainly be used for research purposes
System Architecture:	Client-Server
Sampling type:	Equidistance
Sampling time(seconds)	30
Sampling distance(meters)	50
Accuracy constraint:	35
Accelerometer:	Yes
Servlet URL:	http://infra.kth.se
Trajectory annotation:	Point-based
Enable Power-Saving:	Yes
Auto Upload:	True
Upload Frequency:	1
Annotation Items:	walking running driving

Using Mobility Collector

Service running in Alfa mode on a VM at: http://130.237.68.66:8080/Mobility_Collector_Form/HomePage.jsp

Tutorials and future references will be posted on GitHub

Android Application Source Code:

https://github.com/adrianprelipcean/Mobility_Collector_Android

Apache Tomcat Servlet Source Code:

https://github.com/adrianprelipcean/kth_mobility_collector

Summary

- Location tracking, its importance and current status

- Mobility Collector - a mobile tracking platform

- Equitime and equidistant tracking

- Data sufficiency and robustness

- Usability of Mobility Collector

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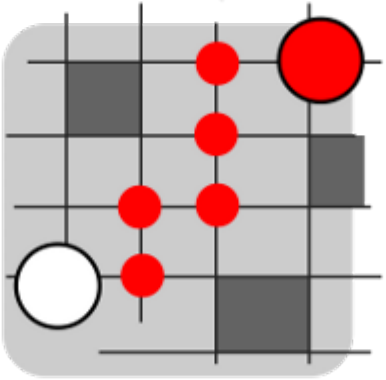
Thank you!



Q&A?

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