Indoor Positioning Using the OpenHPS Framework

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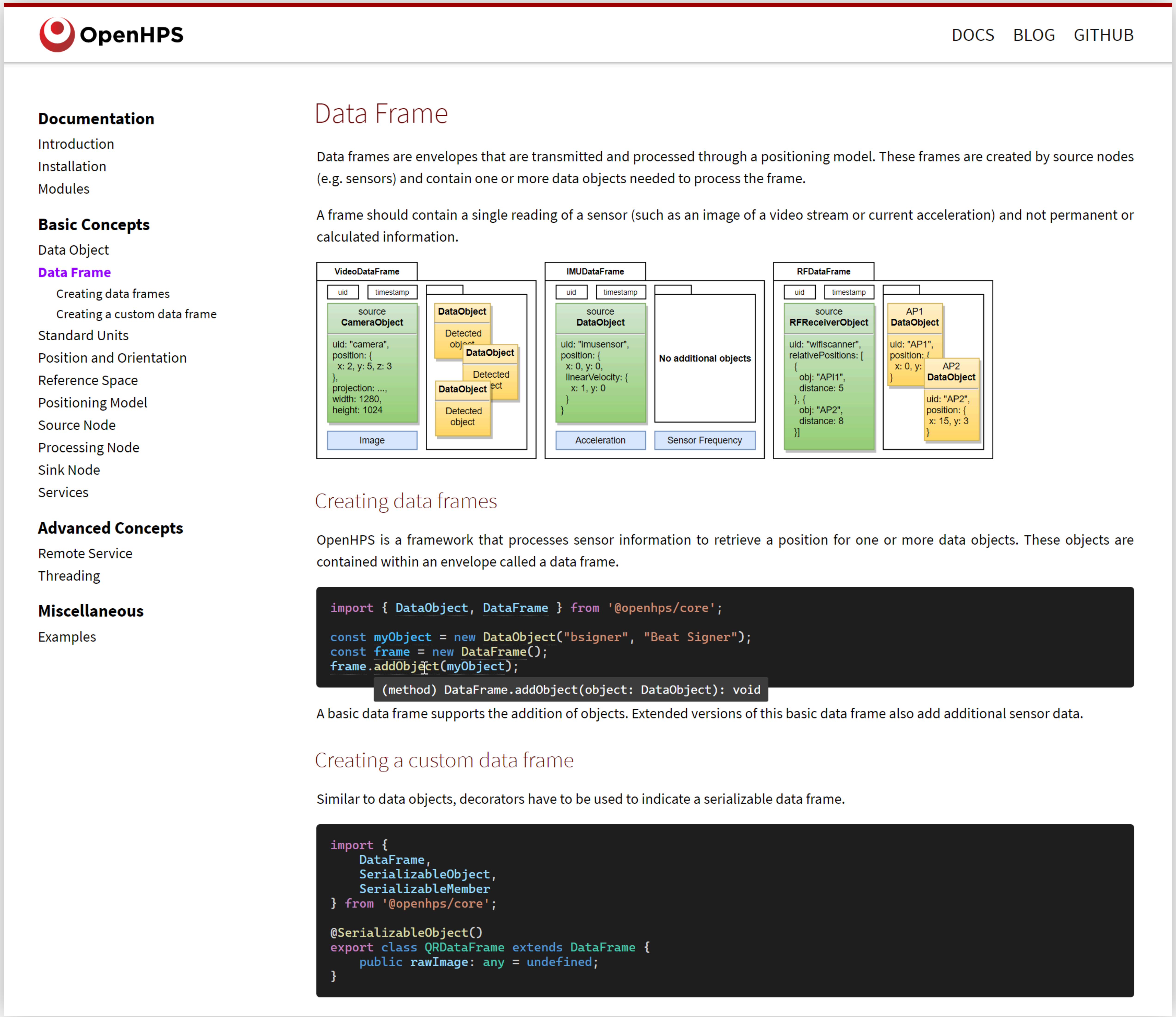
What is OpenHPS?

OpenHPS

An Open Source Hybrid Positioning System



OpenHPS

DOCS BLOG GITHUB

Documentation

Introduction
Installation
Modules

Basic Concepts

Data Object
Data Frame
Creating data frames
Creating a custom data frame
Standard Units
Position and Orientation
Reference Space
Positioning Model
Source Node
Processing Node
Sink Node
Services

Advanced Concepts

Remote Service
Threading

Miscellaneous

Examples

Data Frame

Data frames are envelopes that are transmitted and processed through a positioning model. These frames are created by source nodes (e.g. sensors) and contain one or more data objects needed to process the frame.

A frame should contain a single reading of a sensor (such as an image of a video stream or current acceleration) and not permanent or calculated information.

Creating data frames

OpenHPS is a framework that processes sensor information to retrieve a position for one or more data objects. These objects are contained within an envelope called a data frame.

```
import { DataObject, DataFrame } from '@openhps/core';

const myObject = new DataObject("bsigner", "Beat Signer");
const frame = new DataFrame();
frame.addObject(myObject);
```

(method) DataFrame.addObject(object: DataObject): void

A basic data frame supports the addition of objects. Extended versions of this basic data frame also add additional sensor data.

Creating a custom data frame

Similar to data objects, decorators have to be used to indicate a serializable data frame.

```
import {
    DataFrame,
    SerializableObject,
    SerializableMember
} from '@openhps/core';

@SerializableObject()
export class QRDataFrame extends DataFrame {
    public rawImage: any = undefined;
}
```

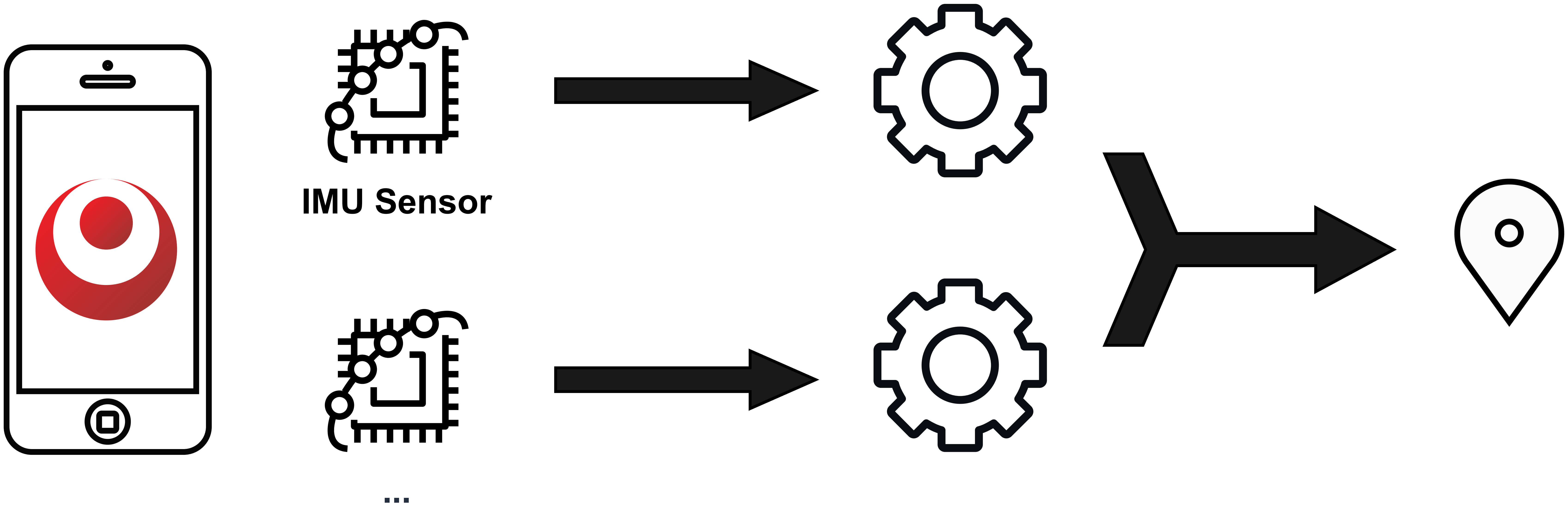
What is OpenHPS?

OpenHPS

An Open Source Hybrid Positioning System

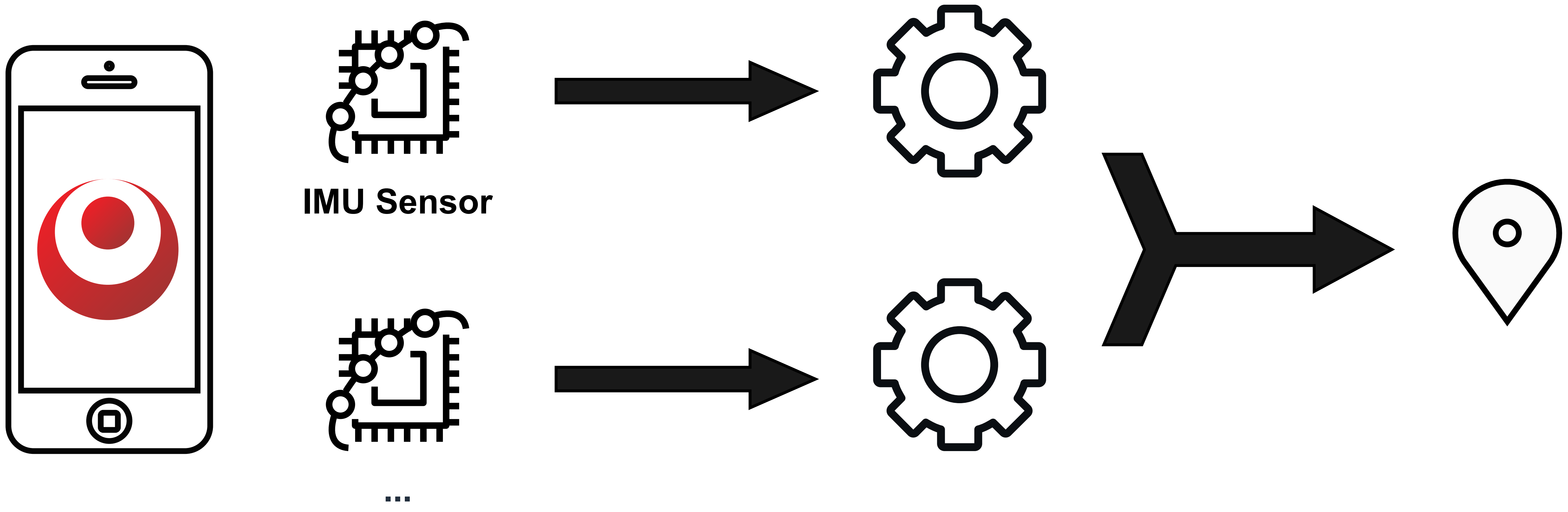
- Any technology
- Any algorithm
- Various use cases
- Flexible processing and output
  - Accuracy over battery consumption, reliability, ...
- Aimed towards
  - Developers
  - Researchers

Process Network Design



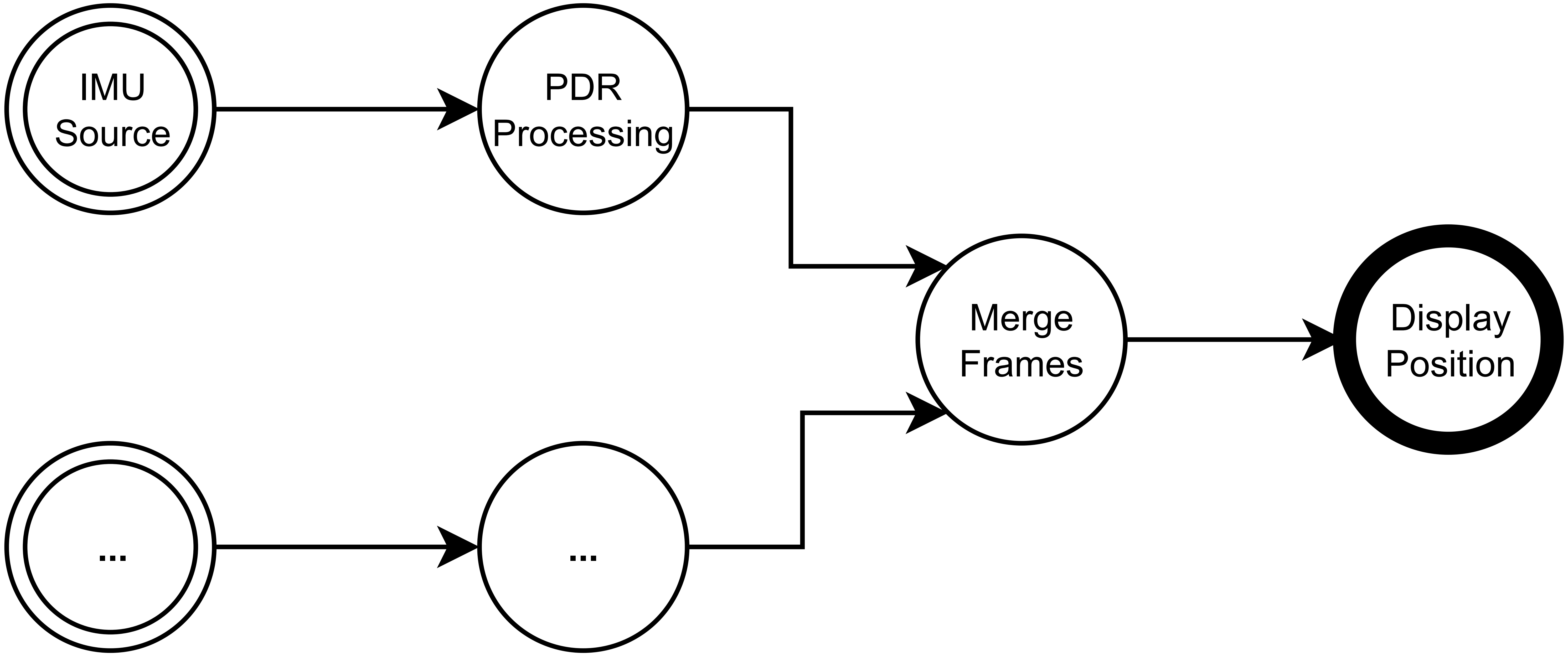
Process Network Design ...

OpenHPS



IMU Sensor

...



IMU Source

PDR Processing

Merge Frames

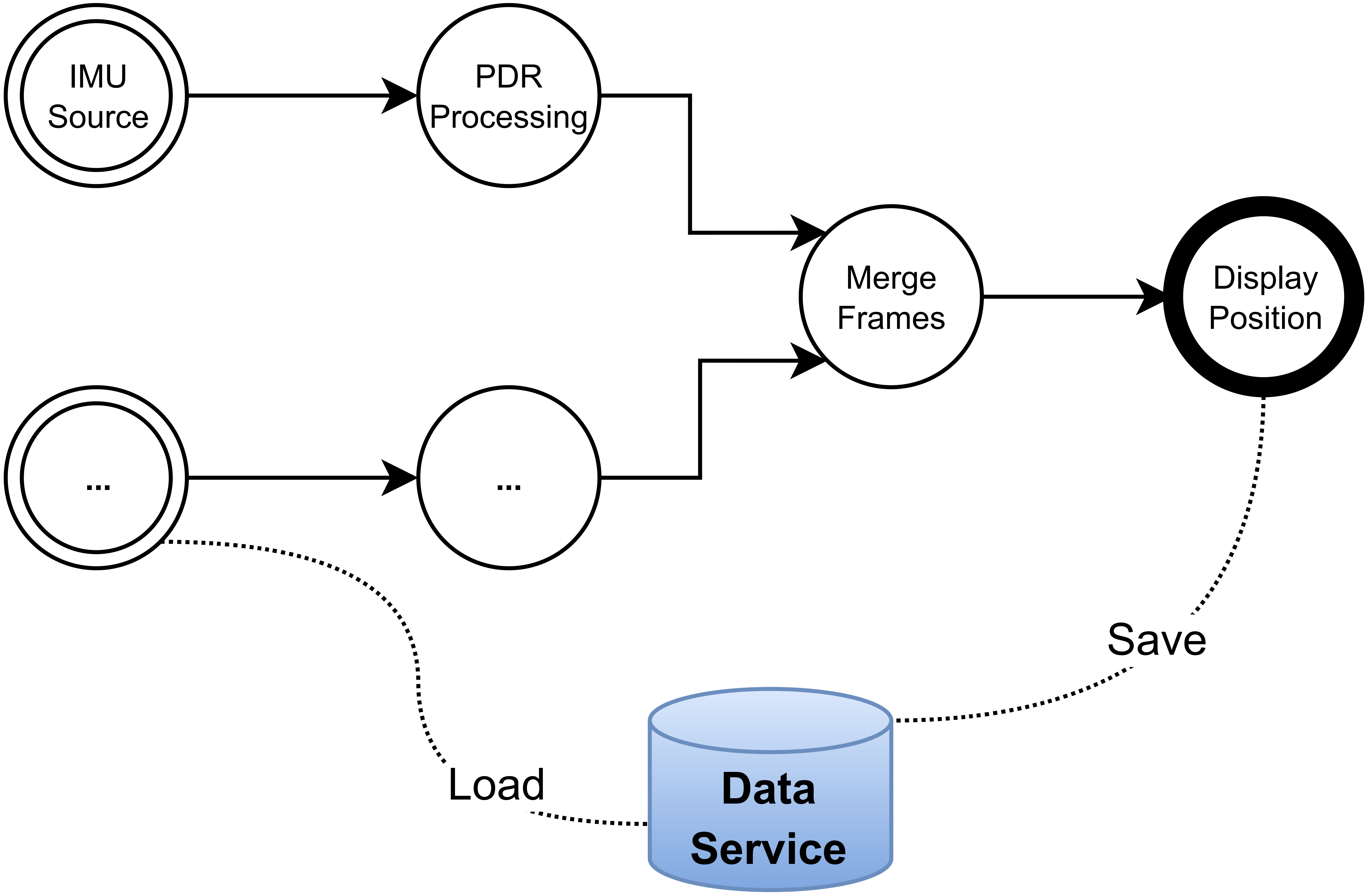
Display Position

...

...

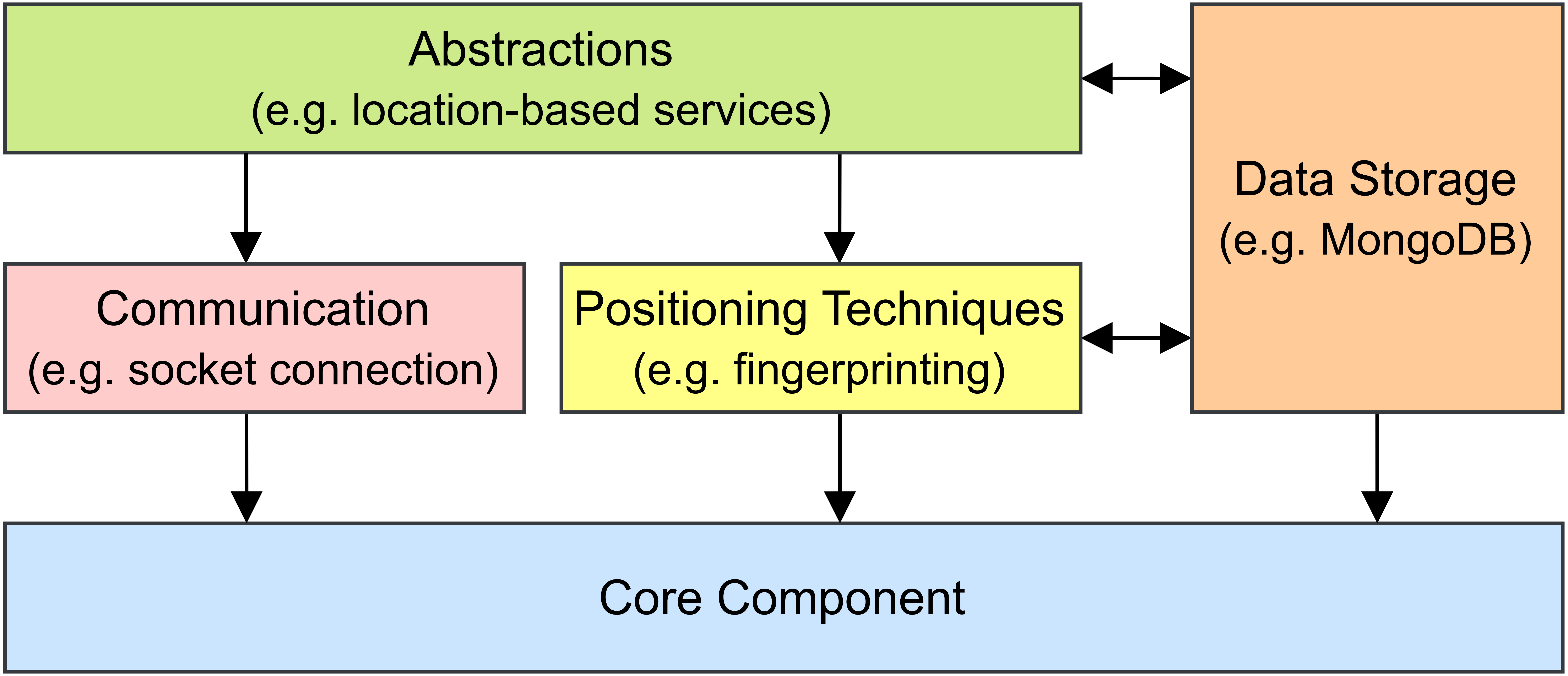
Process Network Design ...

OpenHPS



Modularity

OpenHPS


Abstractions
(e.g. location-based services)

Communication
(e.g. socket connection)

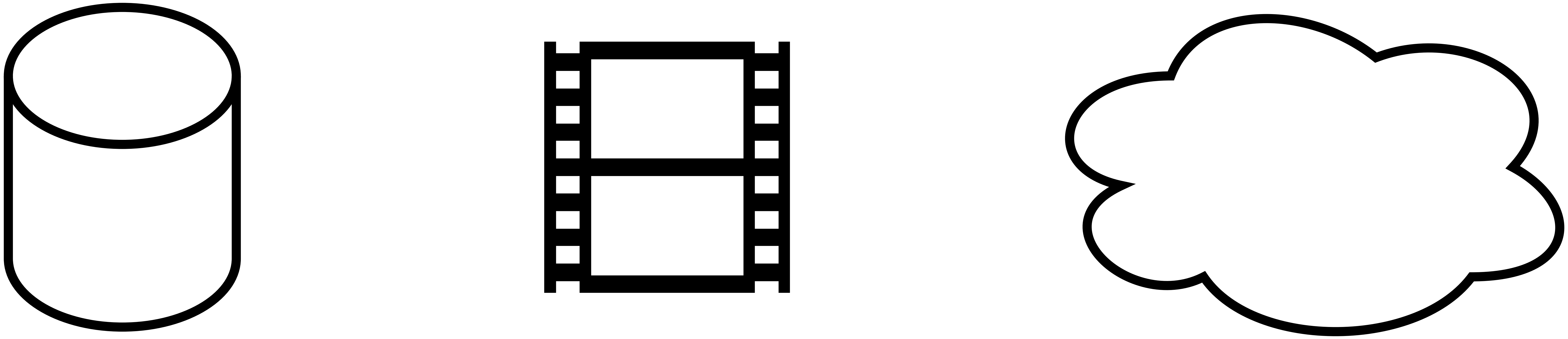
Positioning Techniques
(e.g. fingerprinting)

Data Storage
(e.g. MongoDB)

Core Component

Data Processing

OpenHPS

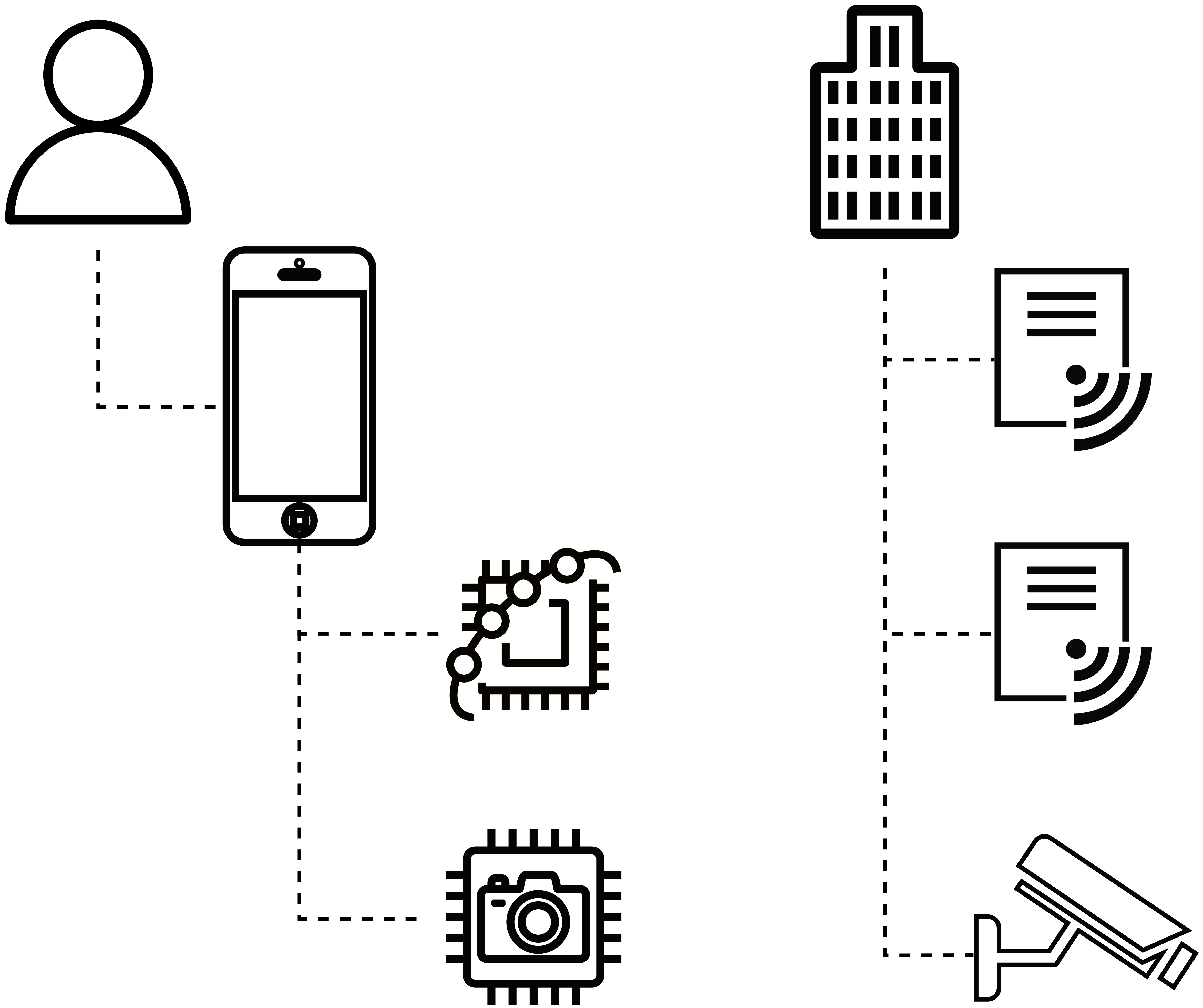


Knowledge

Raw Data

Processed Data

DataObject



Absolute and Relative Positions

Absolute

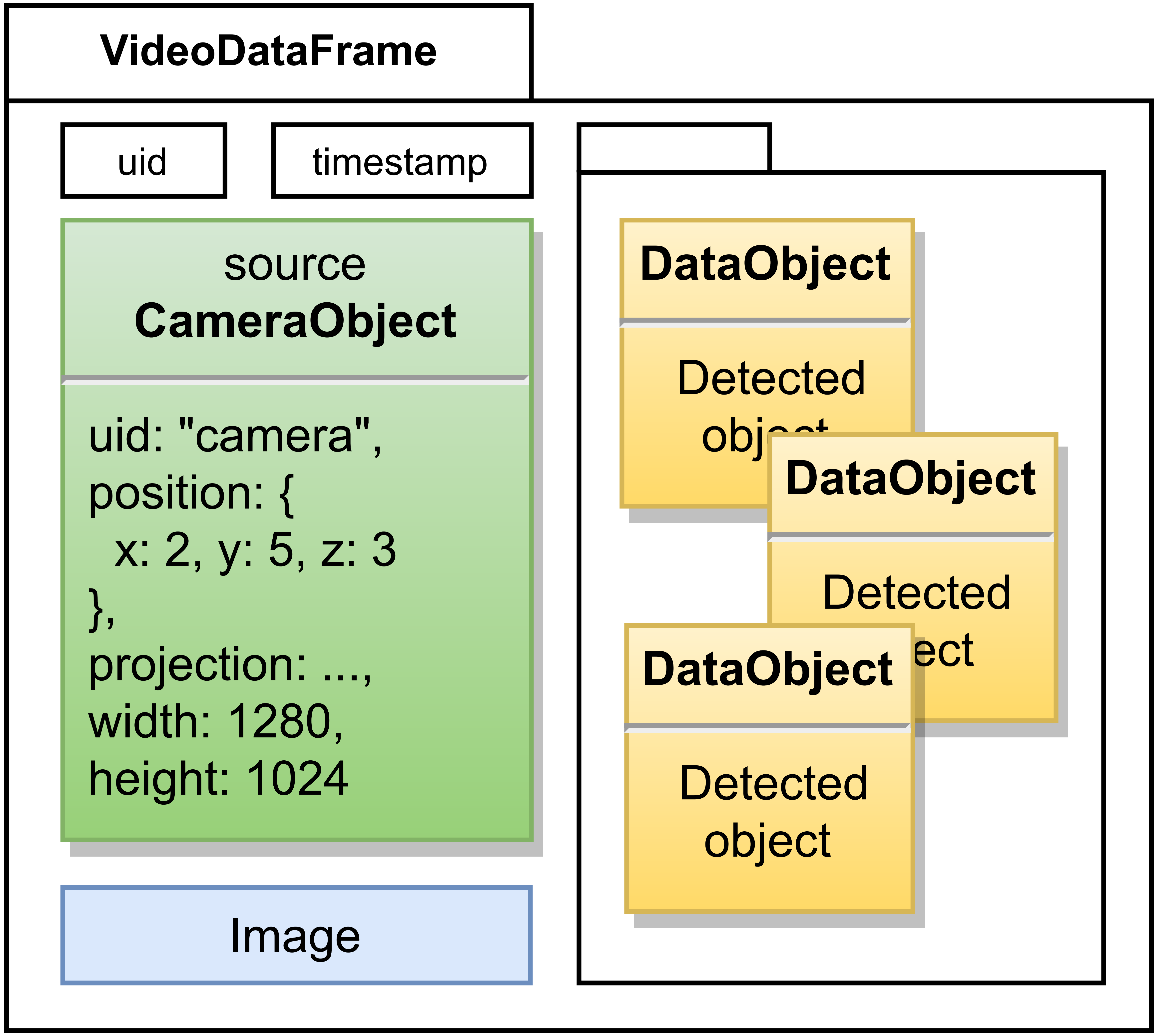
- 2D, 3D, Geographical, ...

Relative

- Distance, angle, velocity, ...
- Relative to another *object*

DataFrame

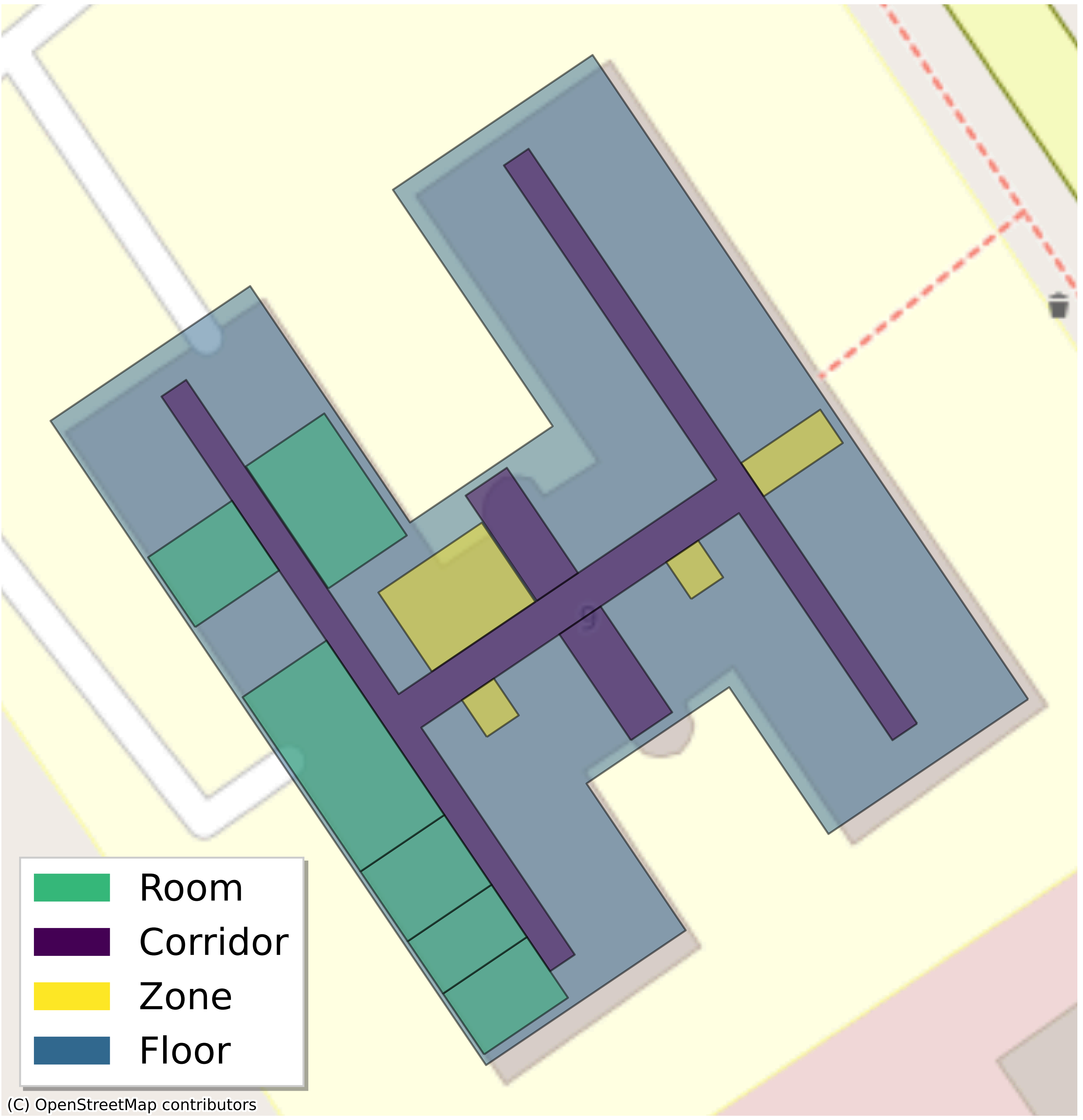
OpenHPS



SymbolicSpace

An object that semantically defines a space

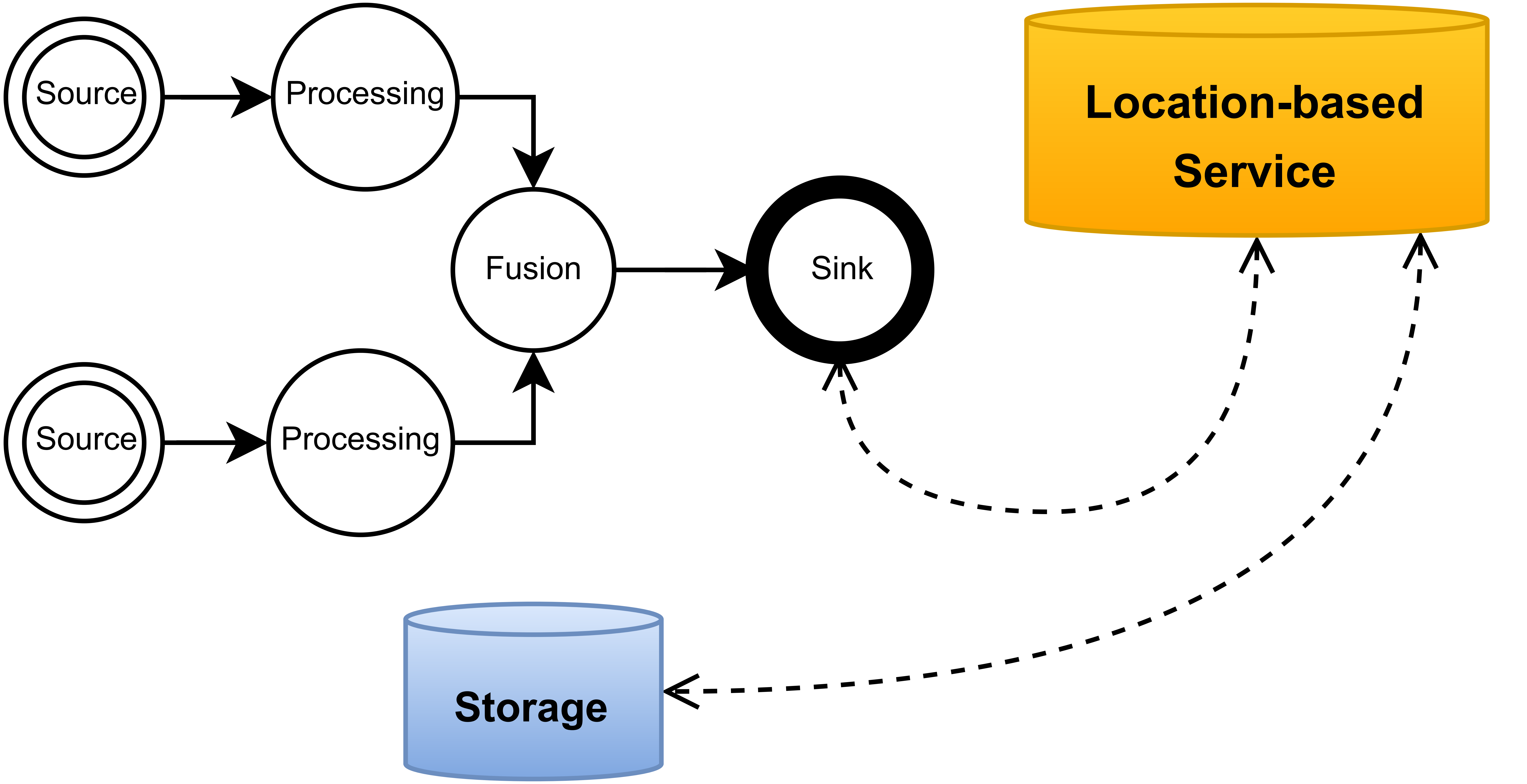
- Spatial hierarchy
- Graph connectivity with other spaces
- Geocoding
- GeoJSON compatibility
- Can be used as a location
- Can be extended ...



Location-based Service

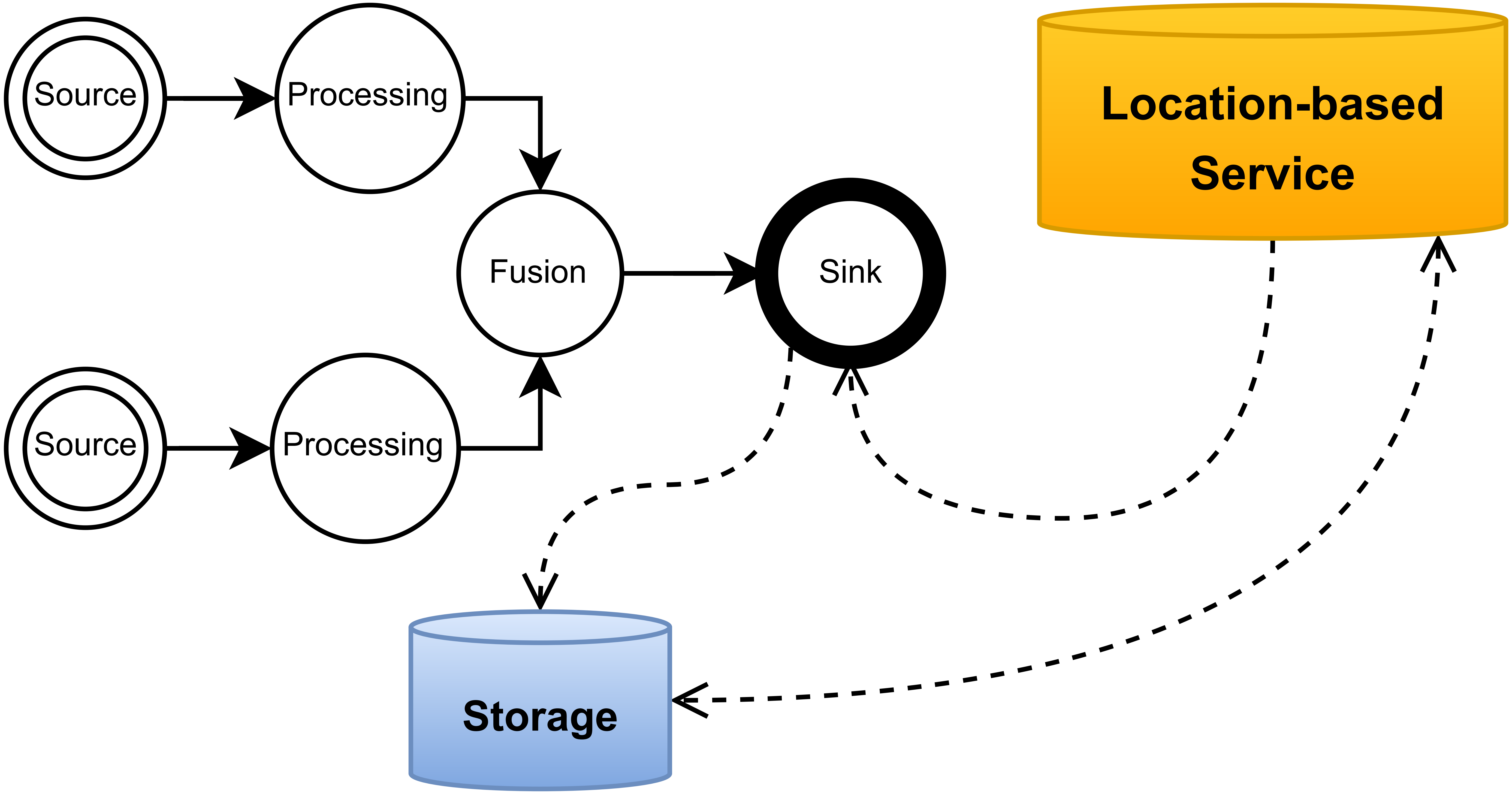
OpenHPS

`getCurrentPosition("me", ...)`



Location-based Service ...

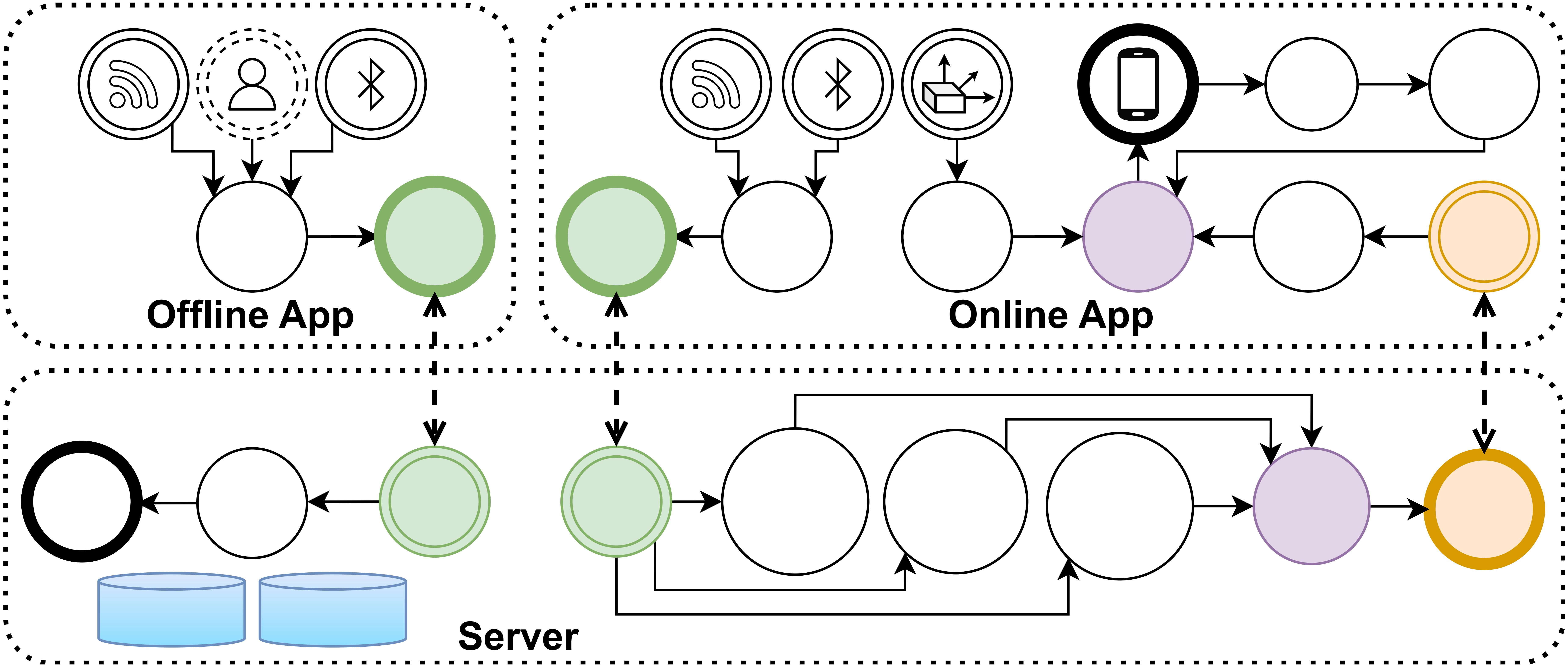
`watchPosition("me", ...)`



Demonstration

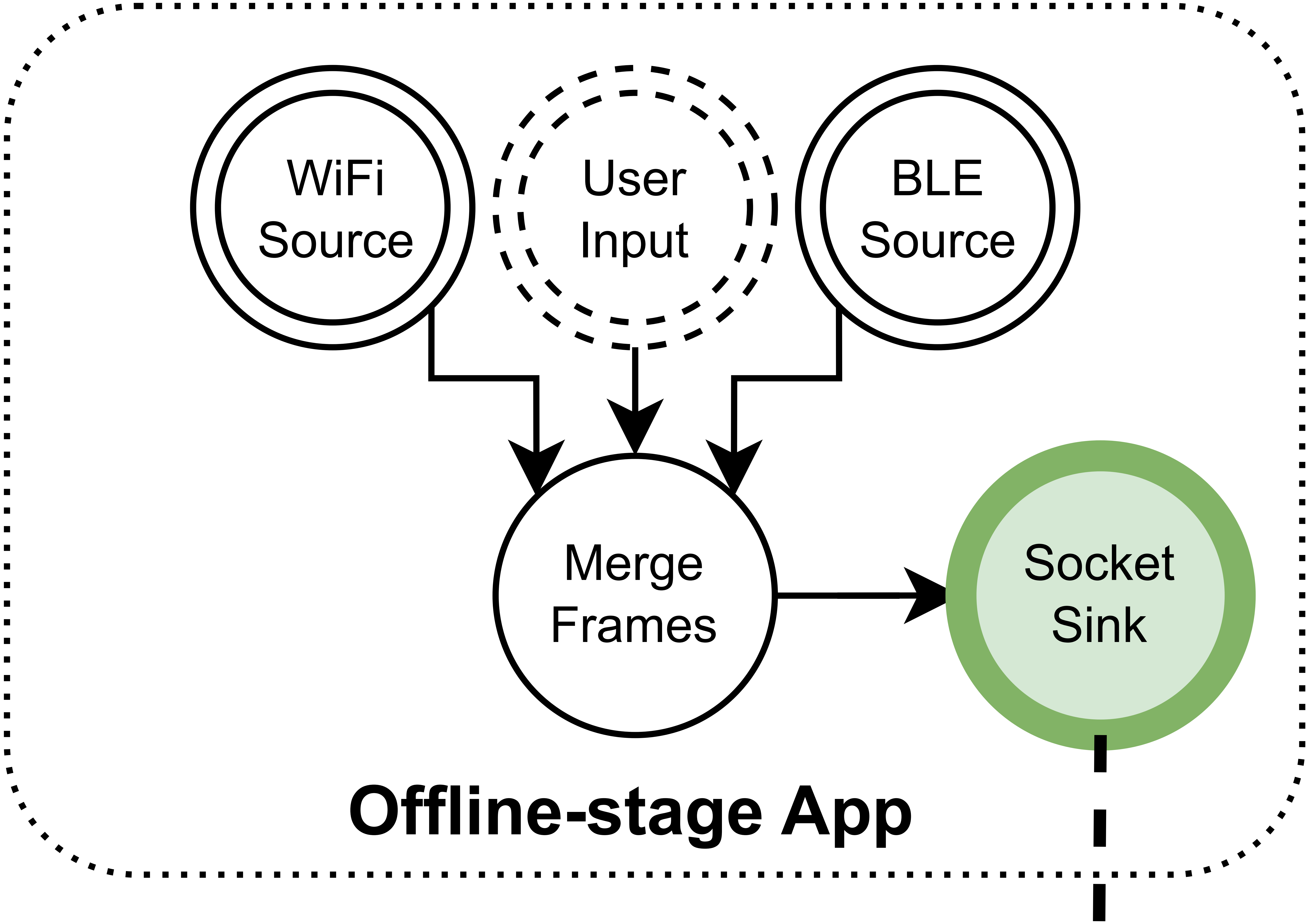
OpenHPS

- Indoor positioning **use case**
- Use **existing techniques**
- Validation of **flexibility** and modularity



Positioning Model

OpenHPS



WiFi Source

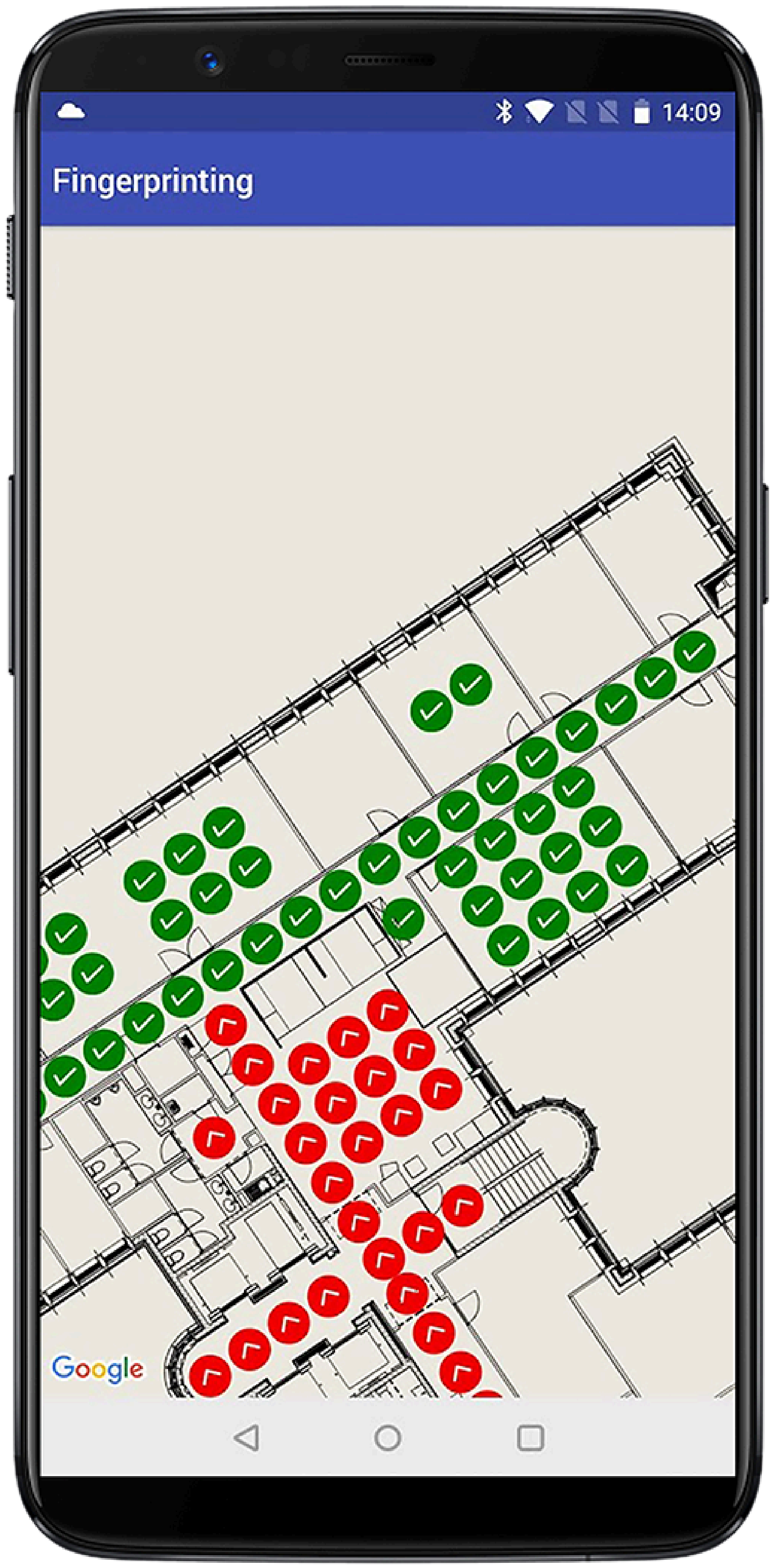
User Input

BLE Source

Merge Frames

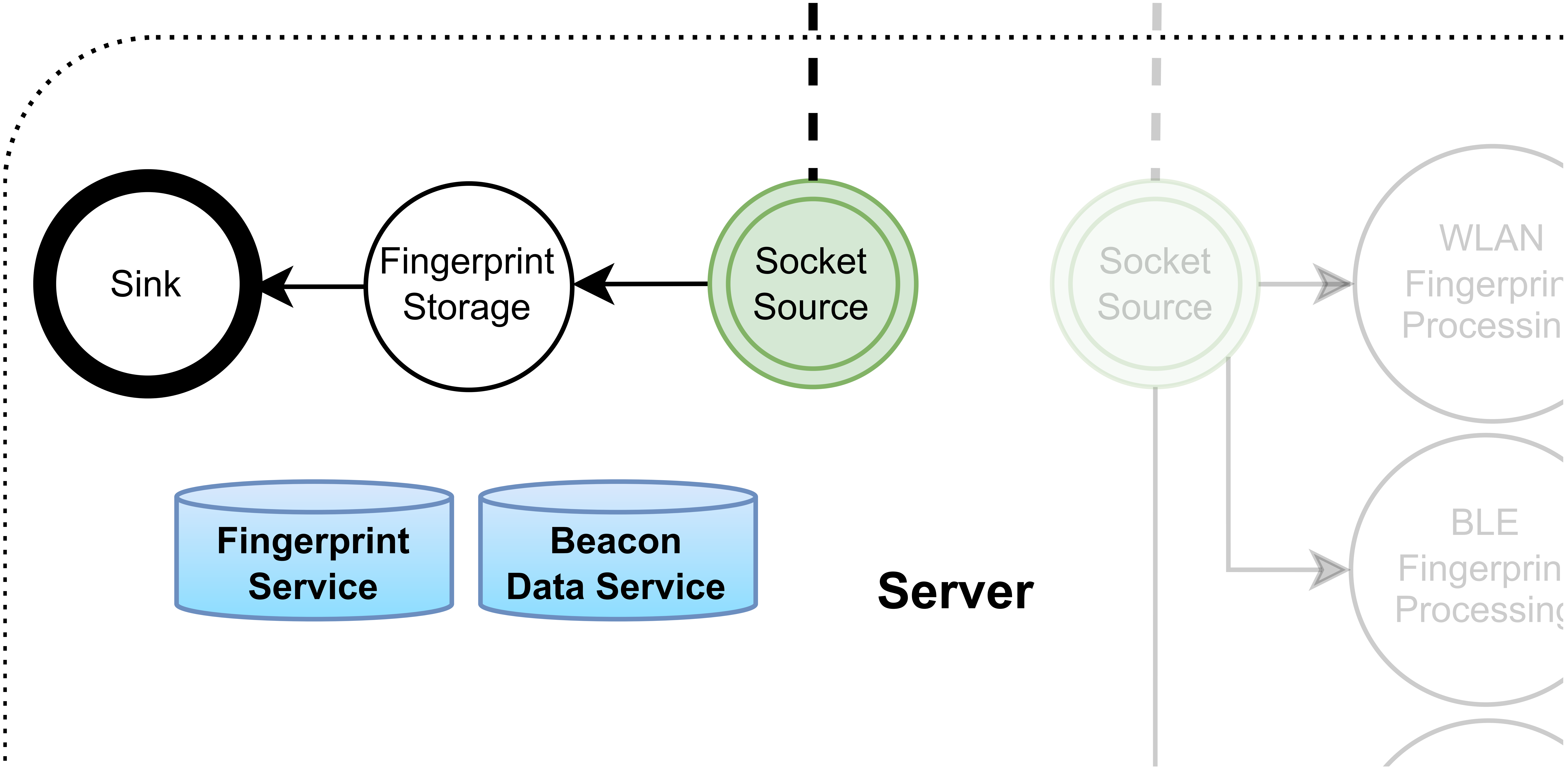
Socket Sink

Offline-stage App

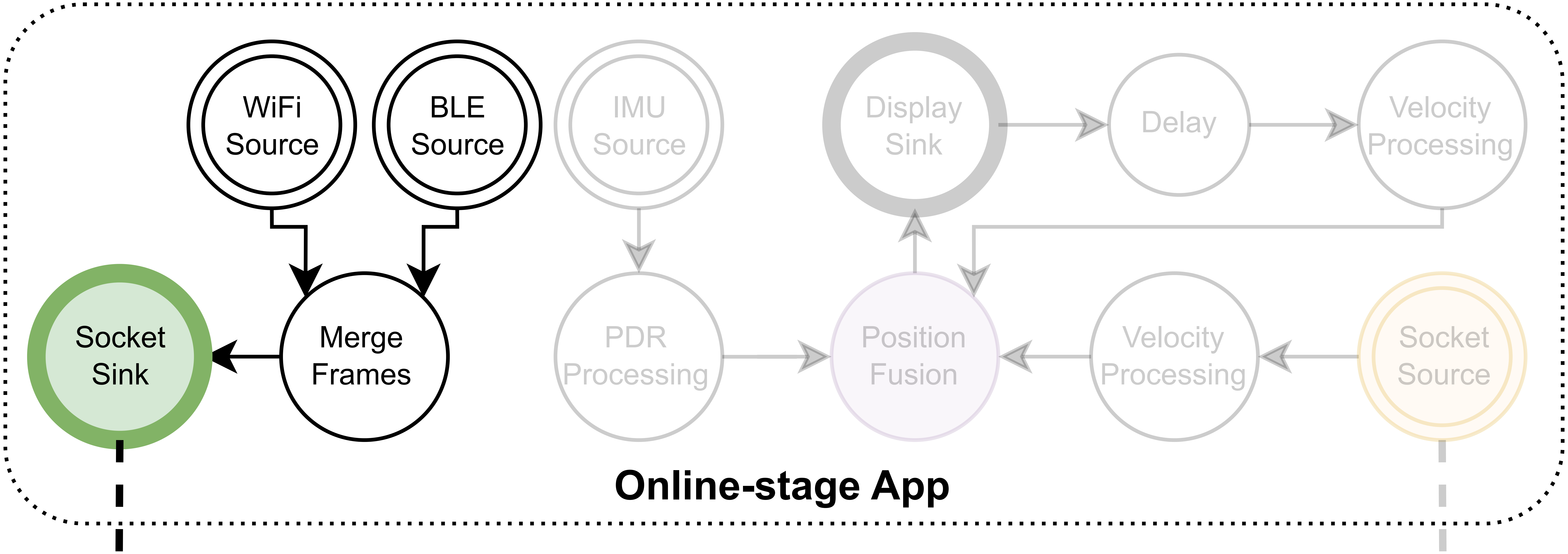


Positioning Model ...

OpenHPS

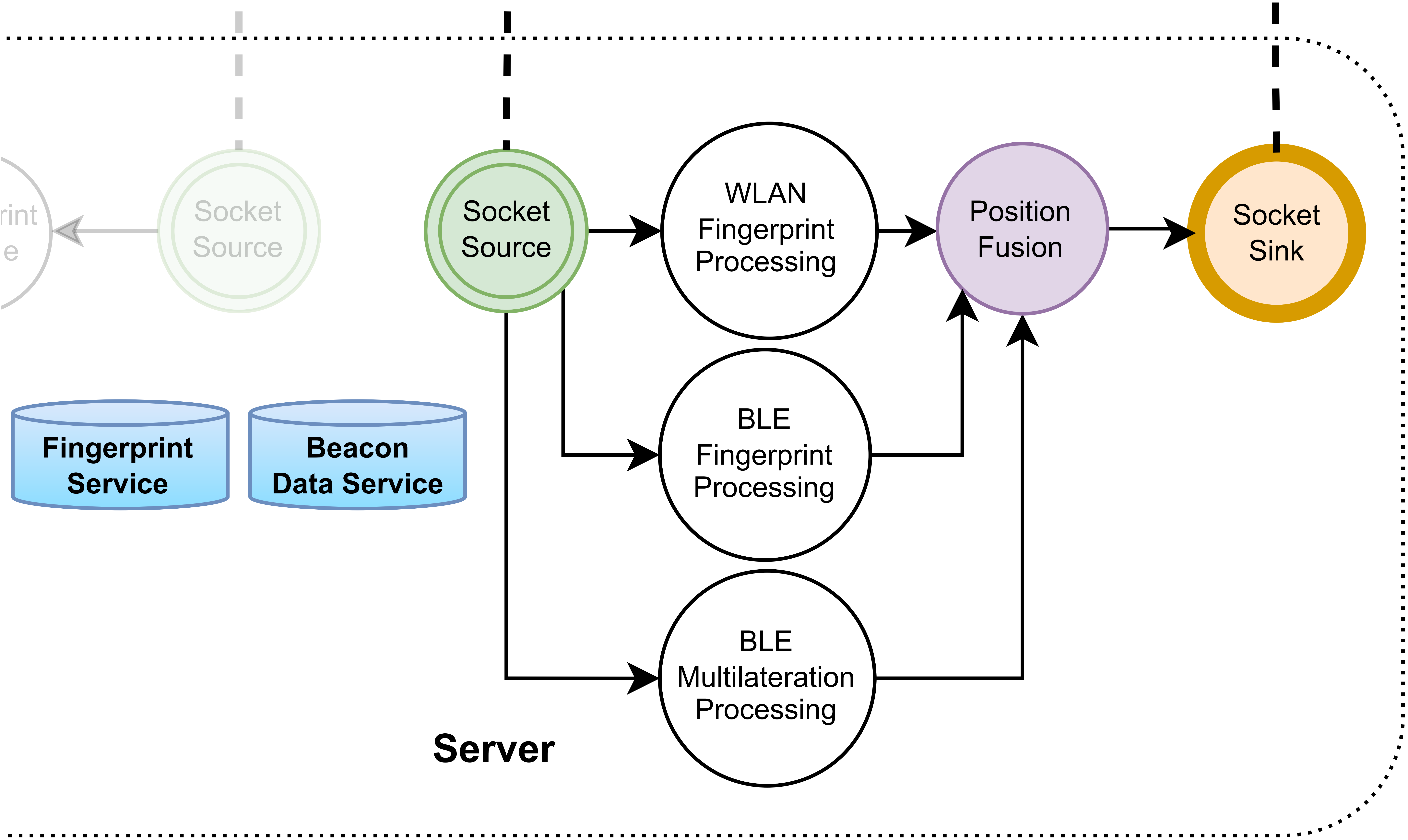


Positioning Model ...



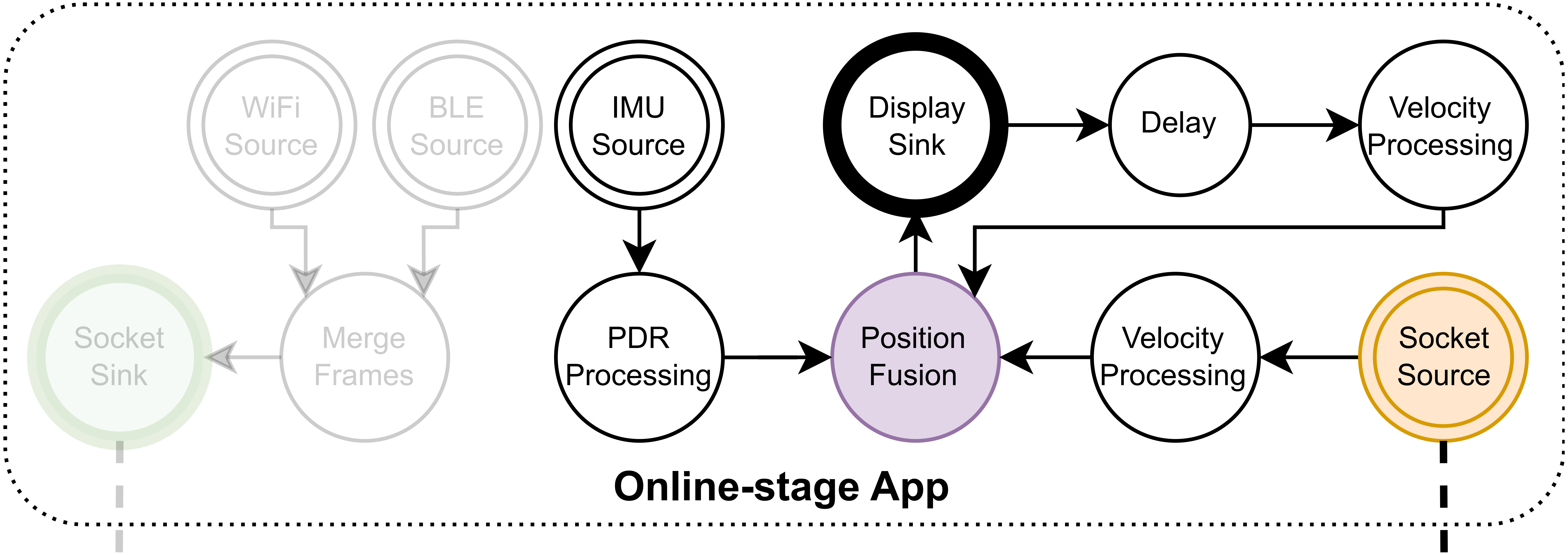
Positioning Model ...

OpenHPS

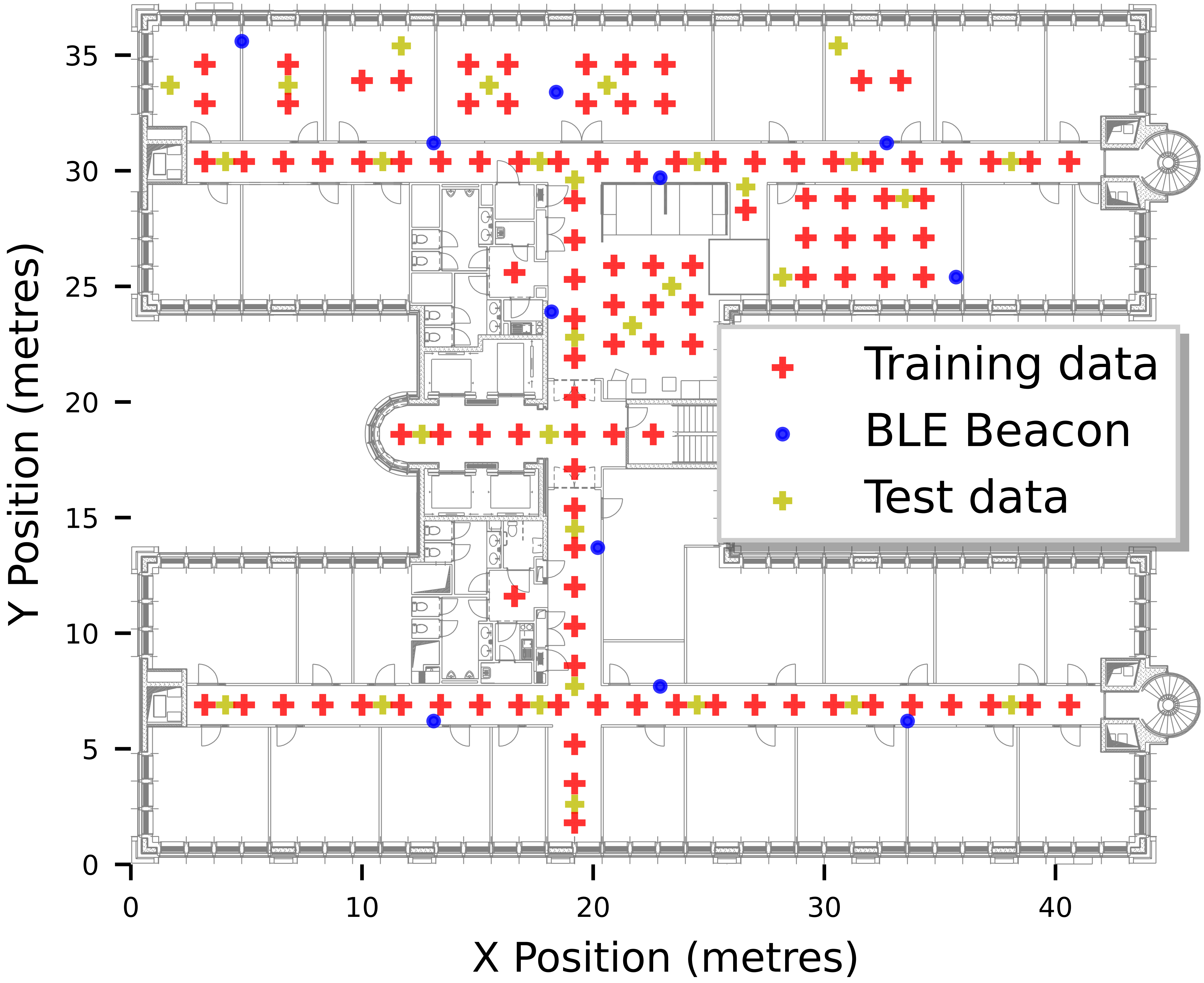


Positioning Model ...

OpenHPS



Dataset



Y Position (metres)
35
30
25
20
15
10
5
0
0
10
20
30
40
X Position (metres)
Training data
BLE Beacon
Test data

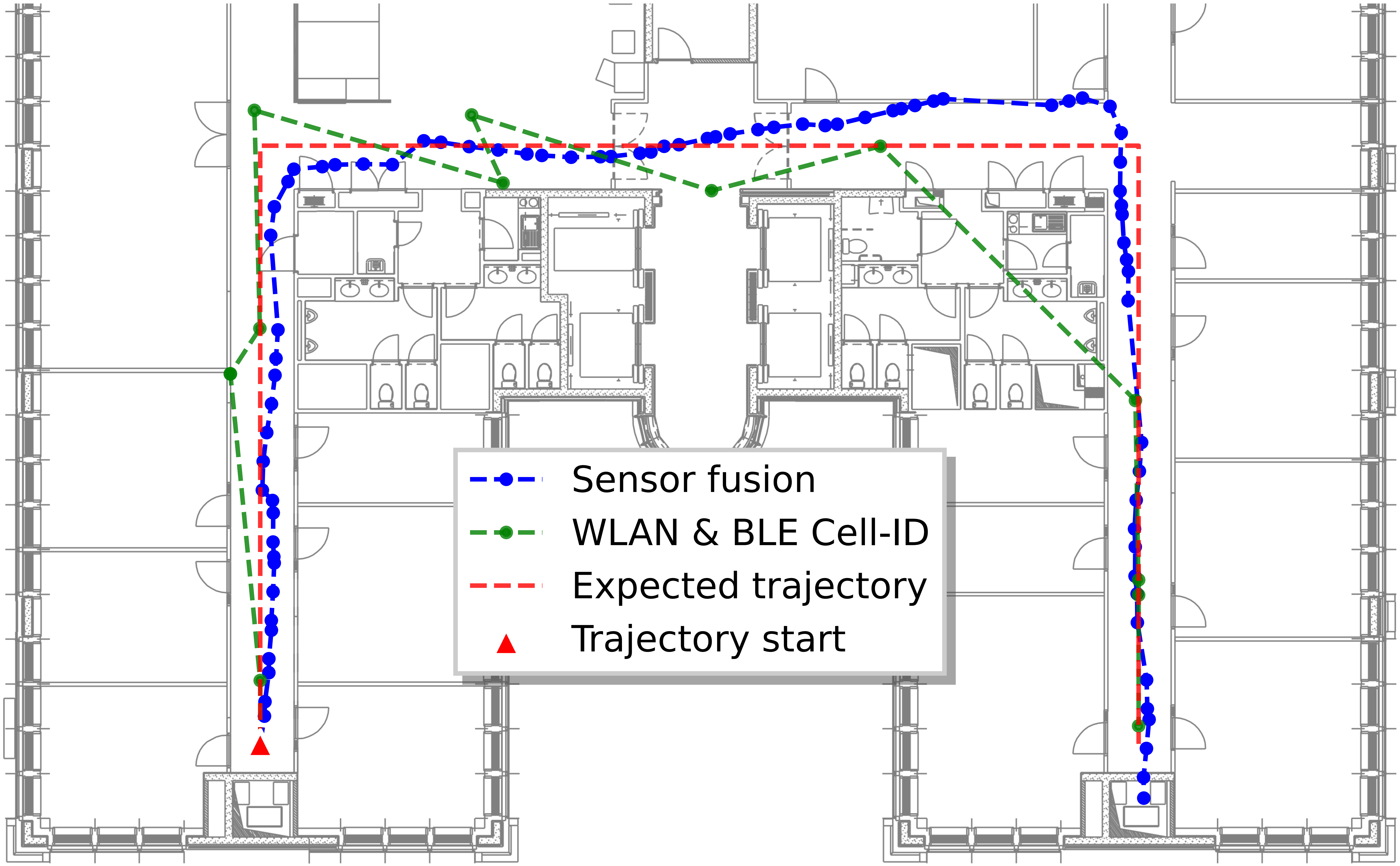
Validation Results

Static Positioning

	WLAN fingerprinting	**BLE** fingerprinting	**BLE** multilateration	**Fusion**
failed points	0	6	12	0
average error	1.23 m	3.23 m	4.92 m	1.37 m
minimum error	0.01 m	0.17 m	0.74 m	0.01 m
maximum error	4.77 m	15.39 m	19.26 m	9.75 m
hit rate	95.82 %	80.83 %	52.50 %	**96.67 %**

Validation Results ...

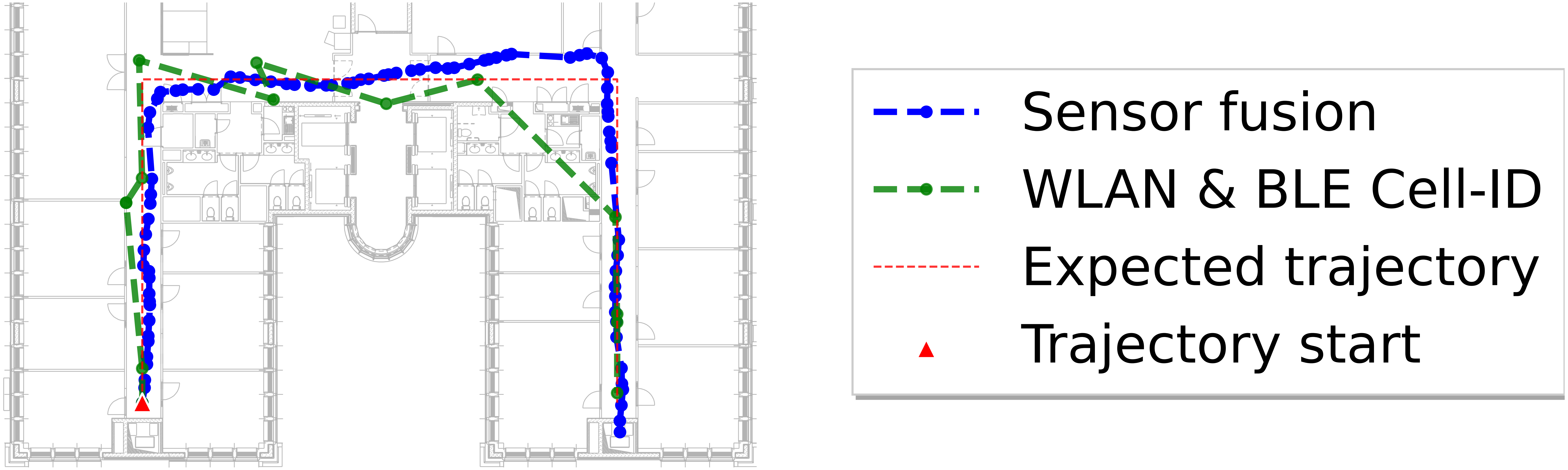
Trajectories



Validation Results ...

Trajectories

	WLAN + BLE	WLAN + BLE + IMU
average error	3.28 m	1.26 m
maximum error	9.60 m	3.10 m
average update frequency	3.04 s	0.52 s



Contributions and Conclusions

OpenHPS

- OpenHPS: **open source** framework for hybrid positioning
  - Aimed towards **developers** and **researchers**
- **Abstractions** such as location-based services and spaces
- Validation of an indoor positioning use case
- Configurable and interchangeable **nodes** and **services**
- **Public dataset** with multiple orientations

Visit https://openhps.org for additional resources, documentation, source code and more!