Indoor Positioning Using the OpenHPS Framework

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OpenHPS

What is OpenHPS?

OpenHPS

An Open Source Hybrid Positioning System

OpenHPS DOCS BLOG GITHUB

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Installation
Modules

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Data Frame
Creating data frames
Creating a custom data frame
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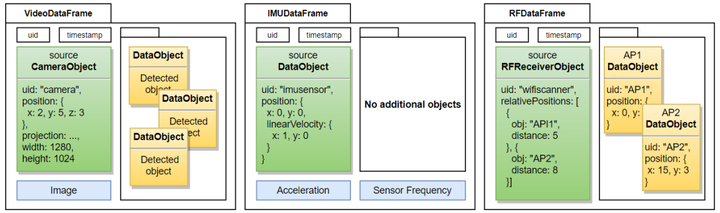
Data Frame

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?

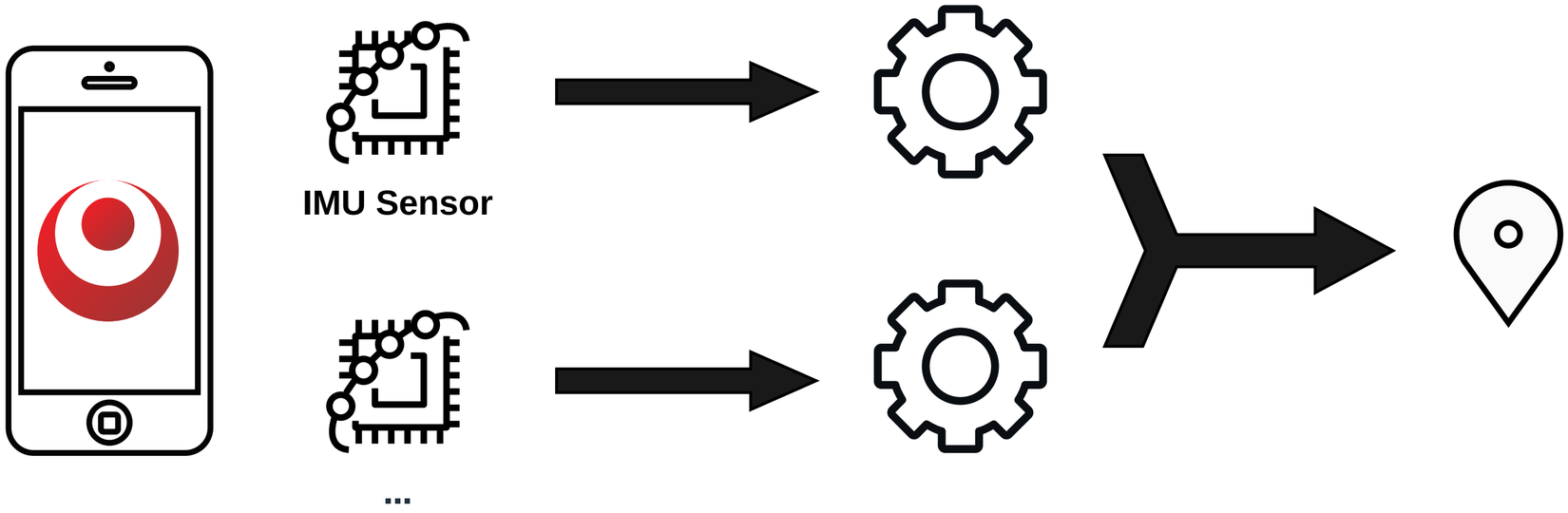
OpenHPS

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

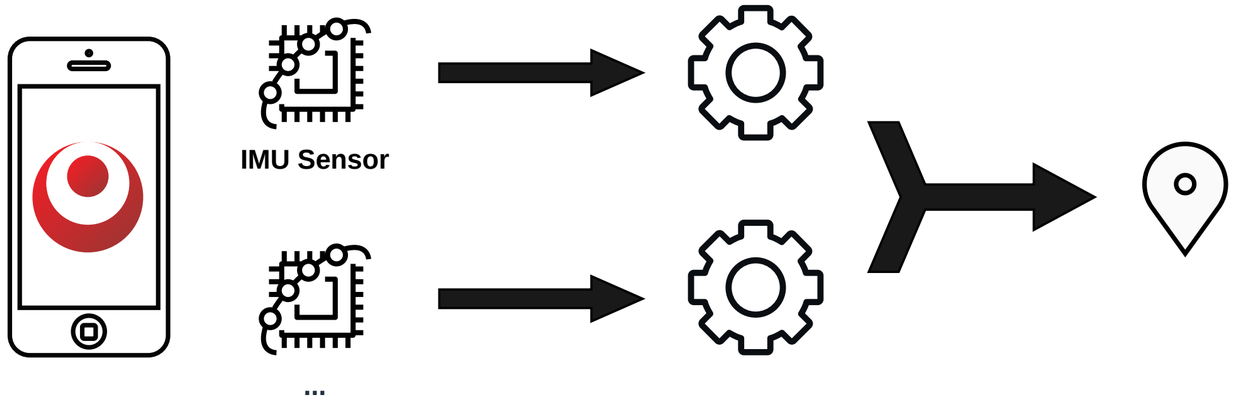
Process Network Design

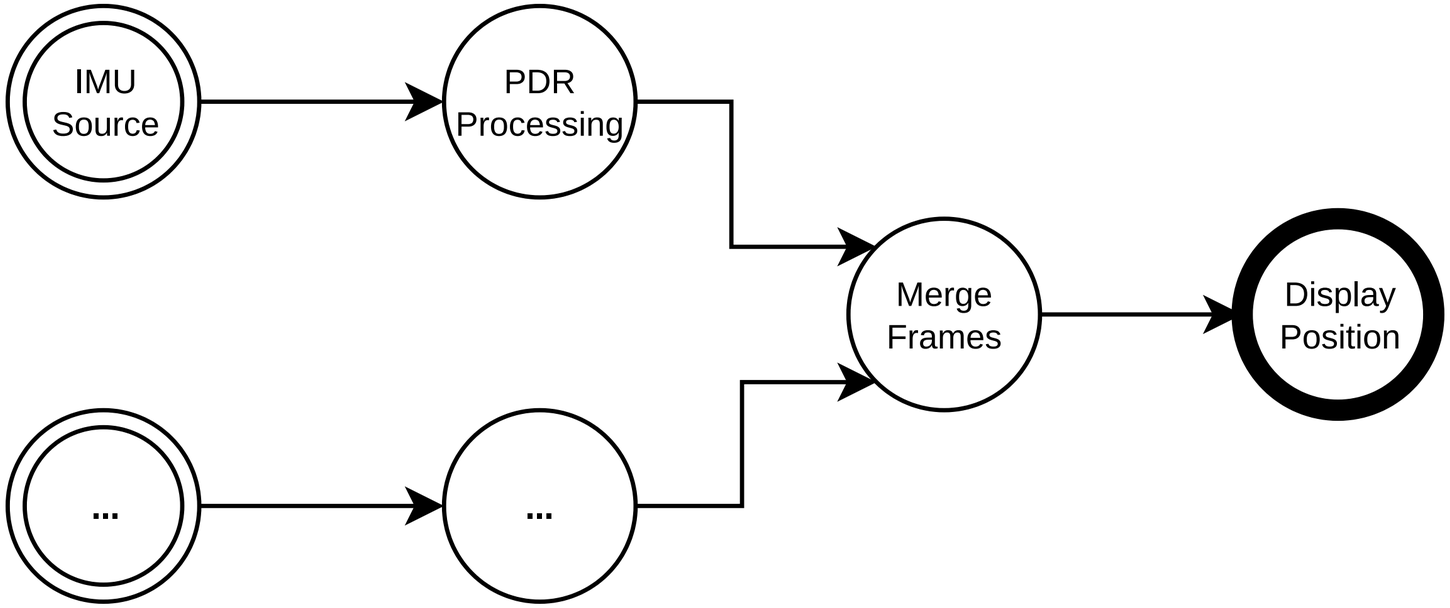
OpenHPS



Process Network Design ...

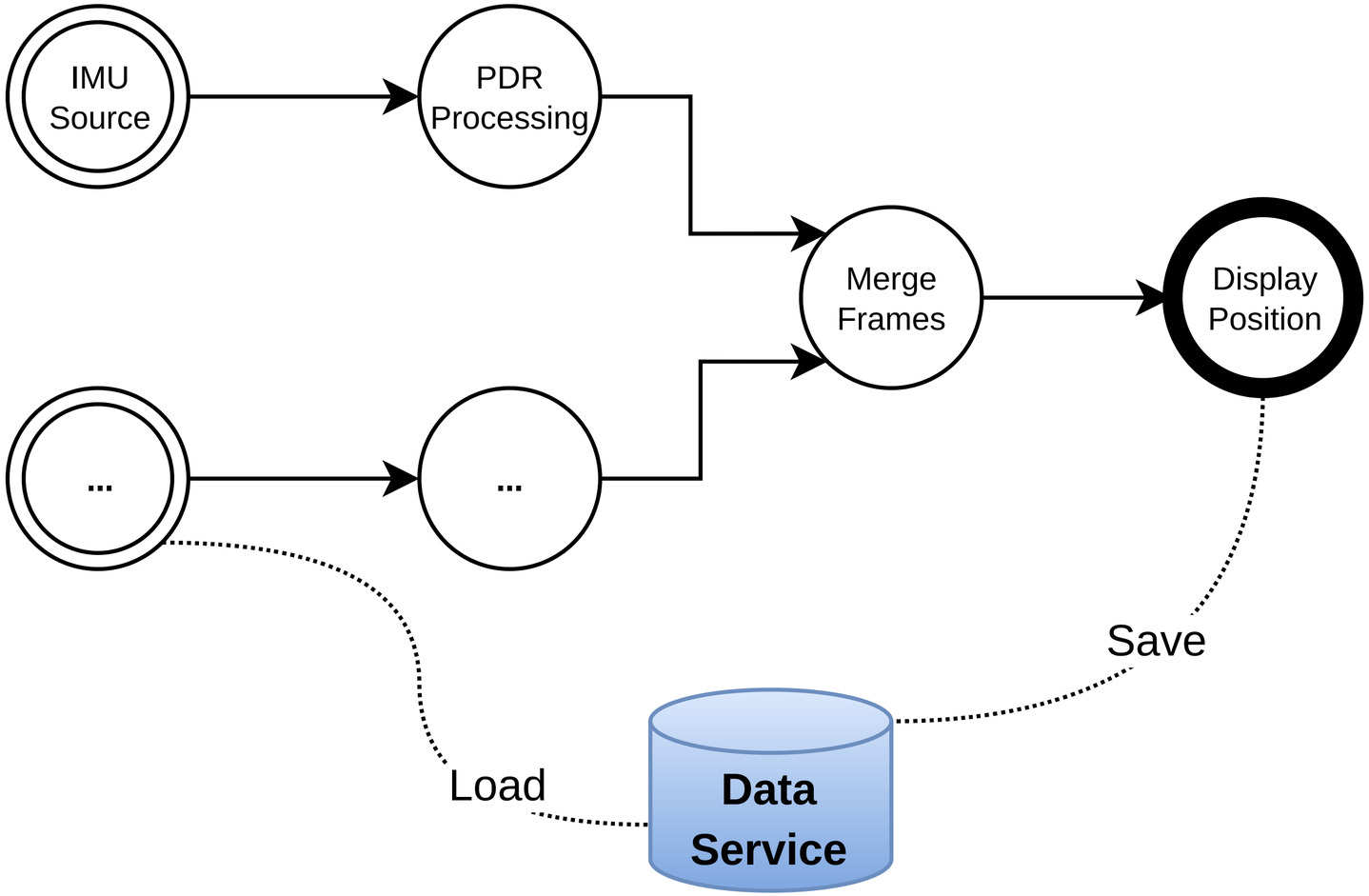
OpenHPS





Process Network Design ...

OpenHPS



Modularity

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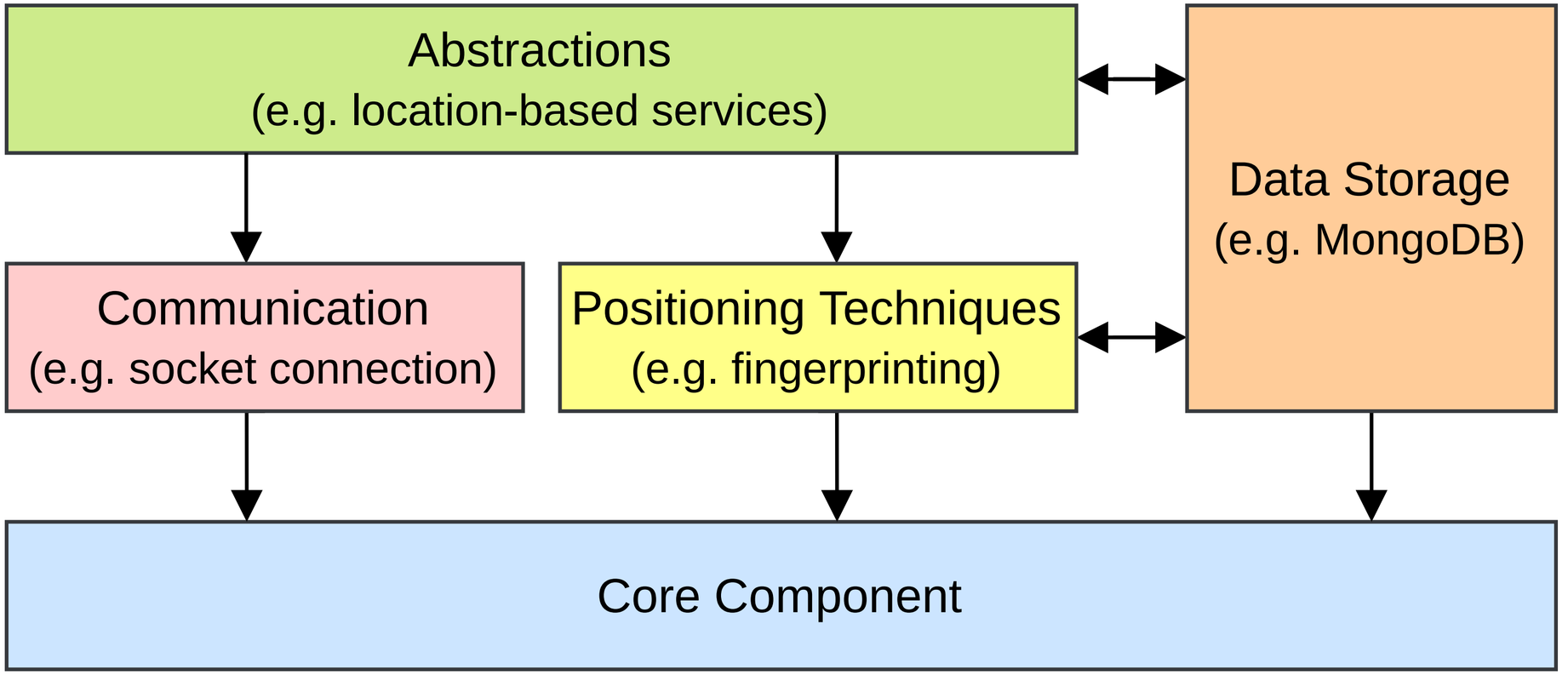

Modularity ...

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Communication

Socket, MQTT, REST API, ...

Data Storage

MongoDB, LocalStorage, RDF, ...

Positioning Algorithms

IMU, fingerprinting, OpenVSLAM, ...

Abstractions

Geospatial, location-based services, geojson, ...

Other

React-Native, NativeScript, Sphero, ...

Data Processing

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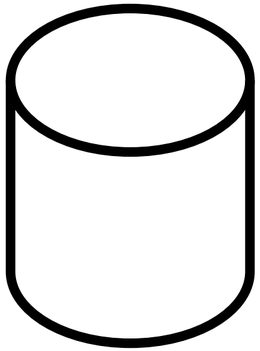
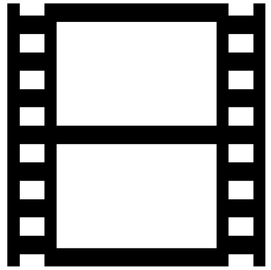
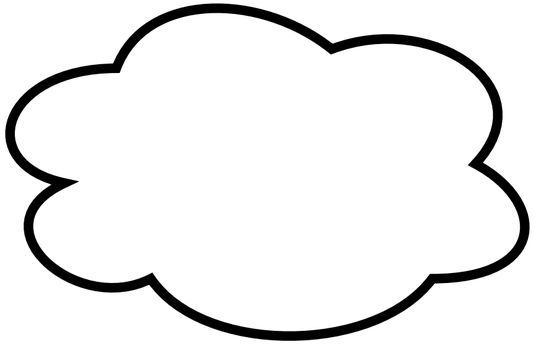


Knowledge



Raw Data



Processed Data

DataObject

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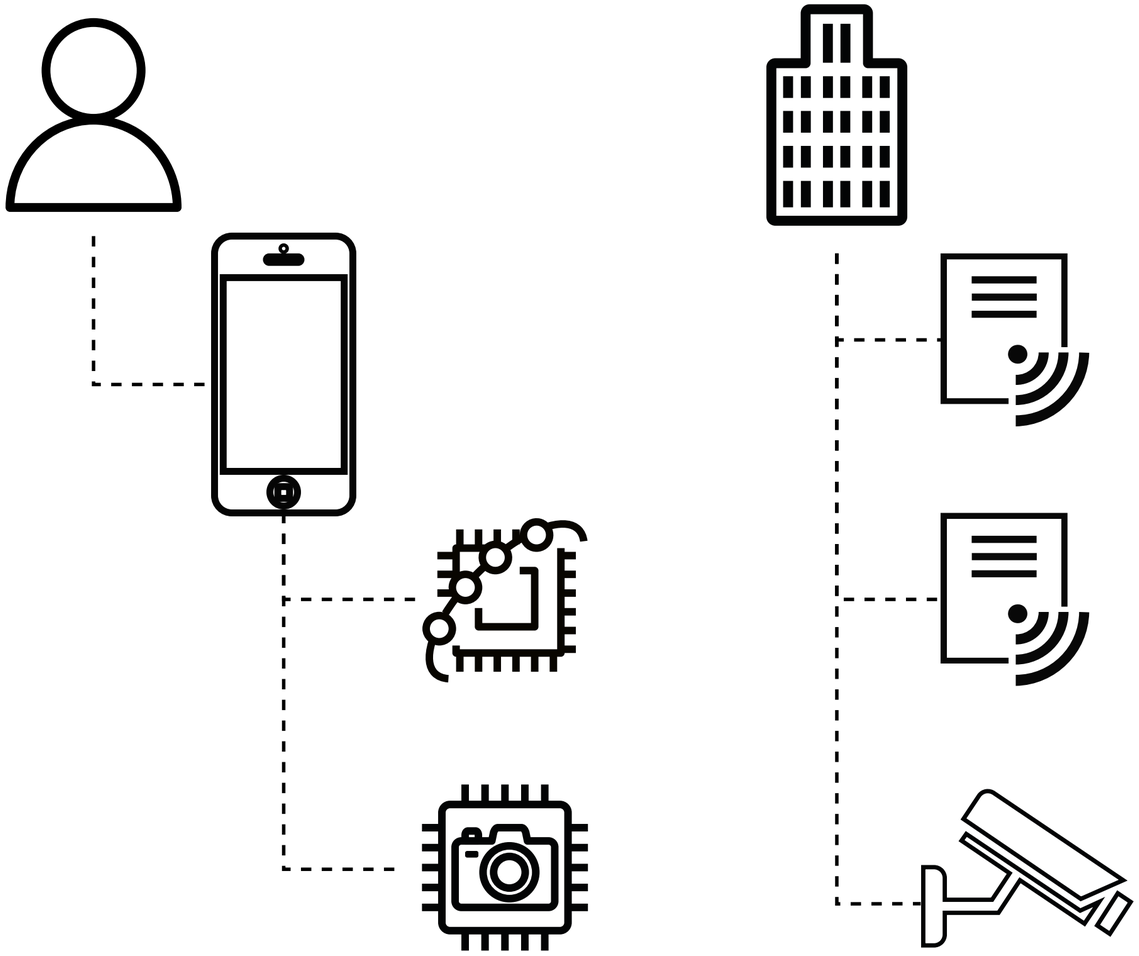

Absolute and Relative Positions

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Absolute

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

Relative

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

DataFrame

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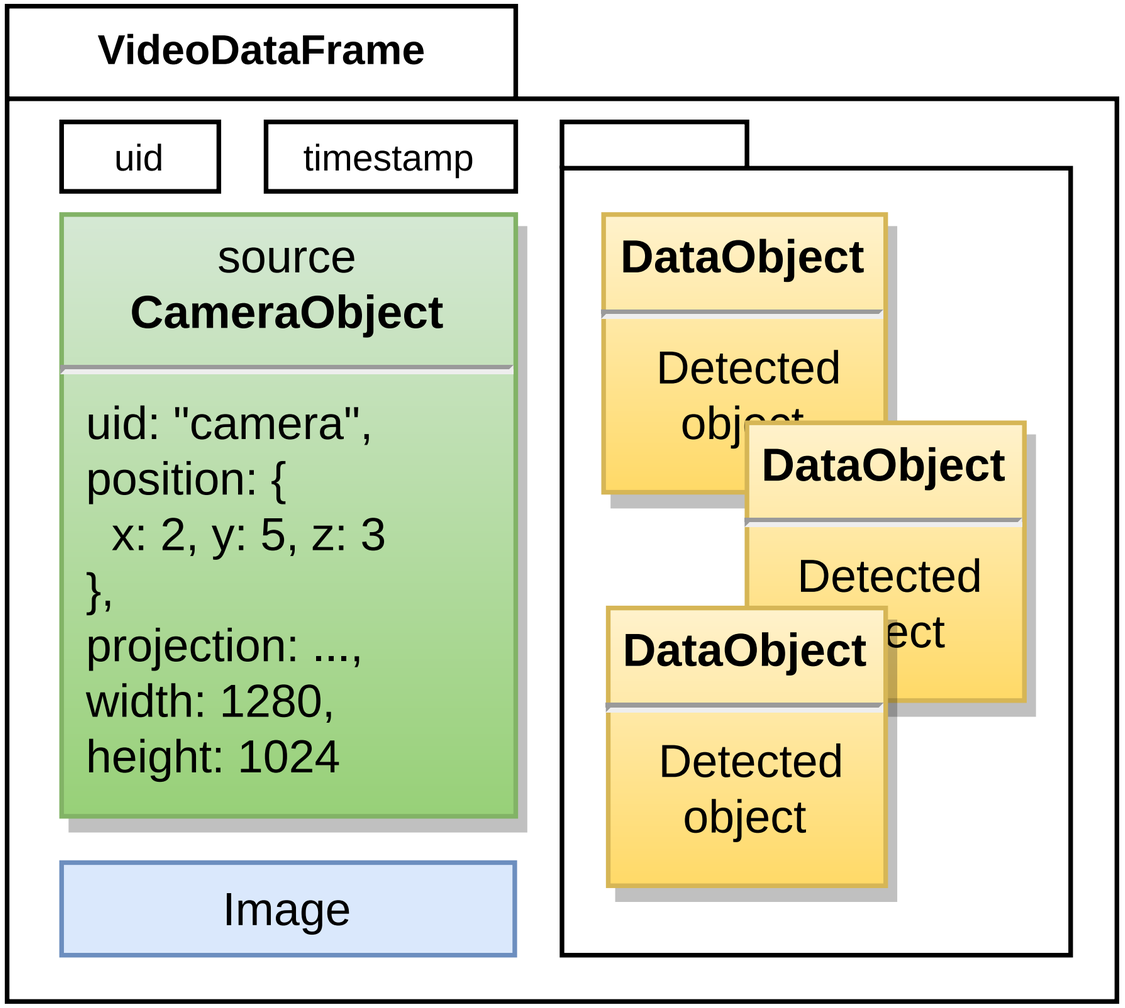
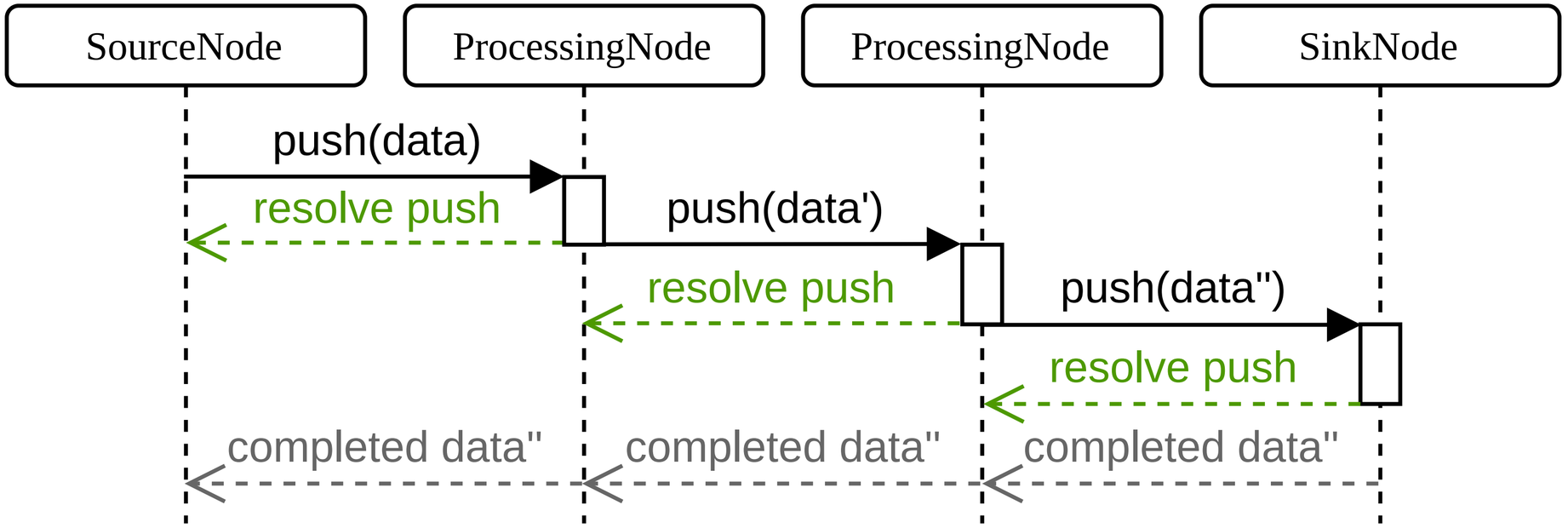


DataFrame ...

OpenHPS

Pushing Data



DataFrame ...

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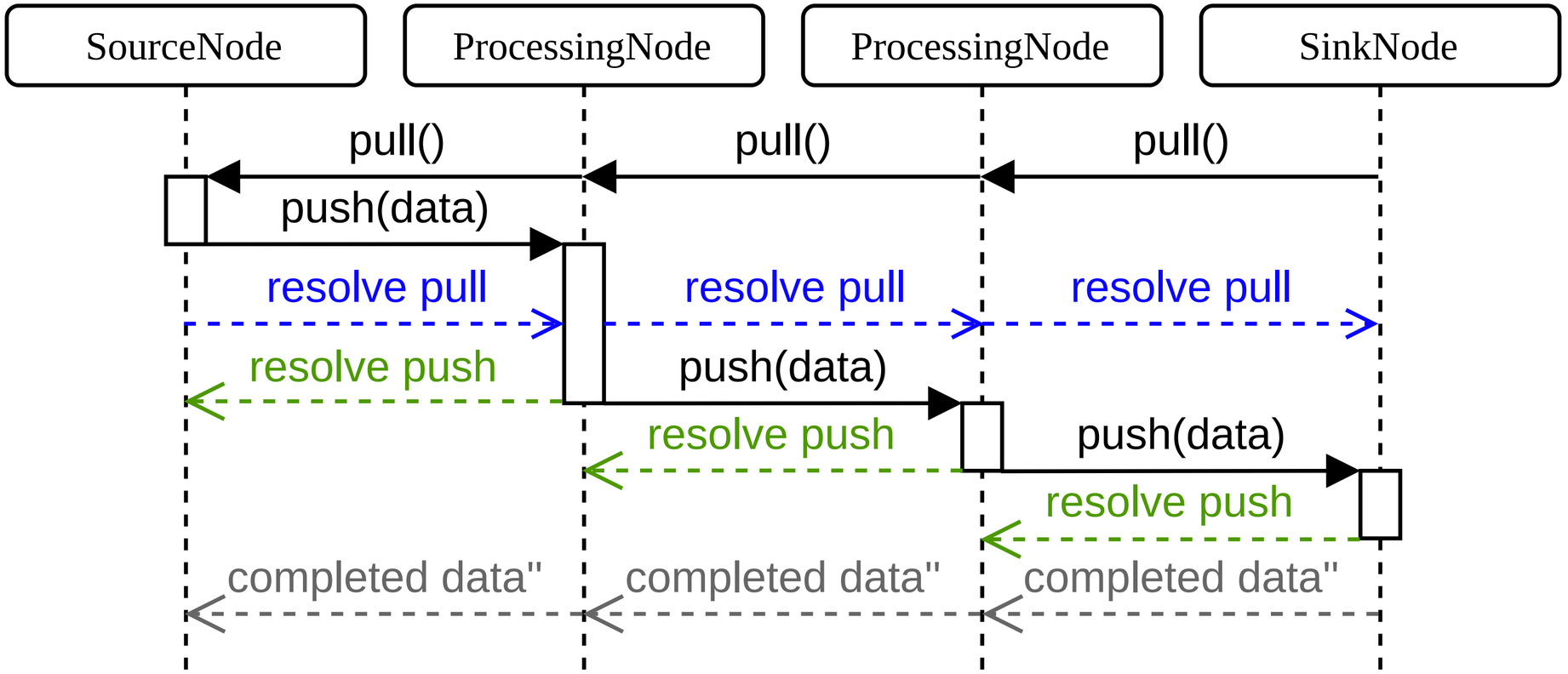
Pulling Data



DataFrame ...

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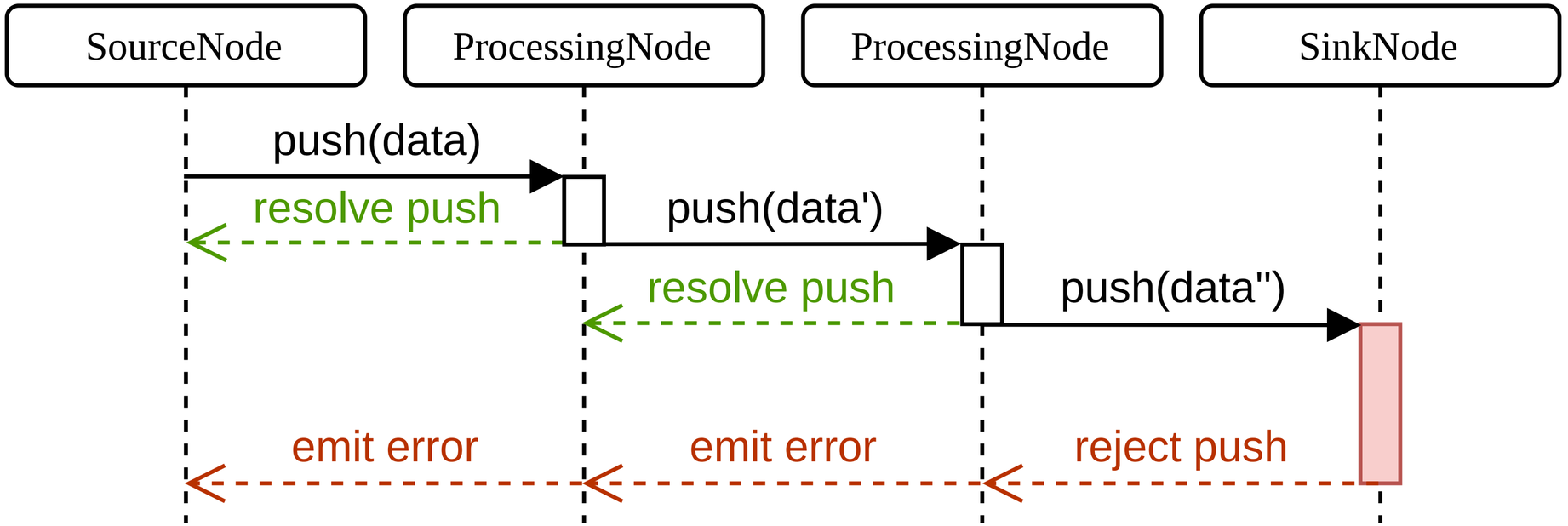
Pushing Error



SymbolicSpace

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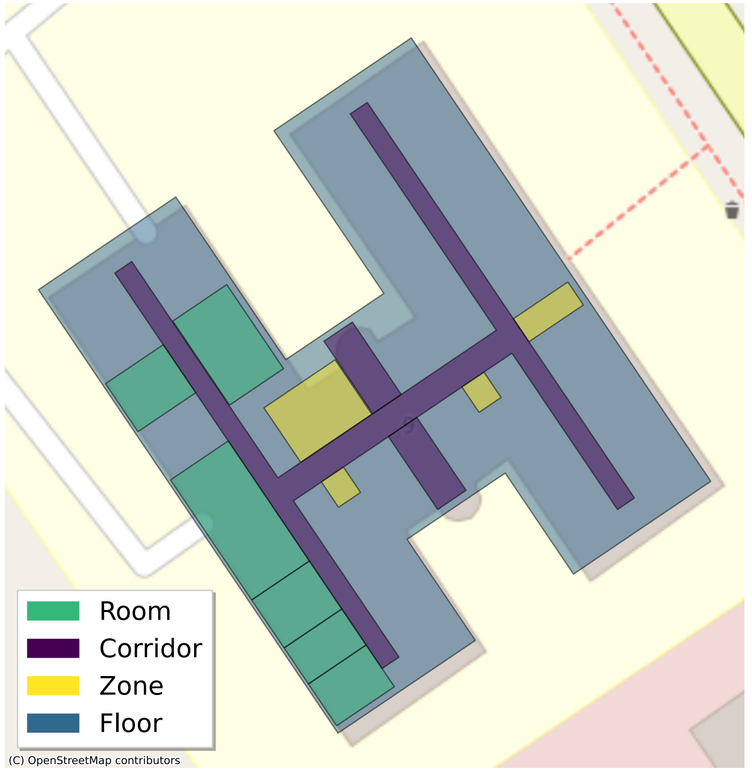
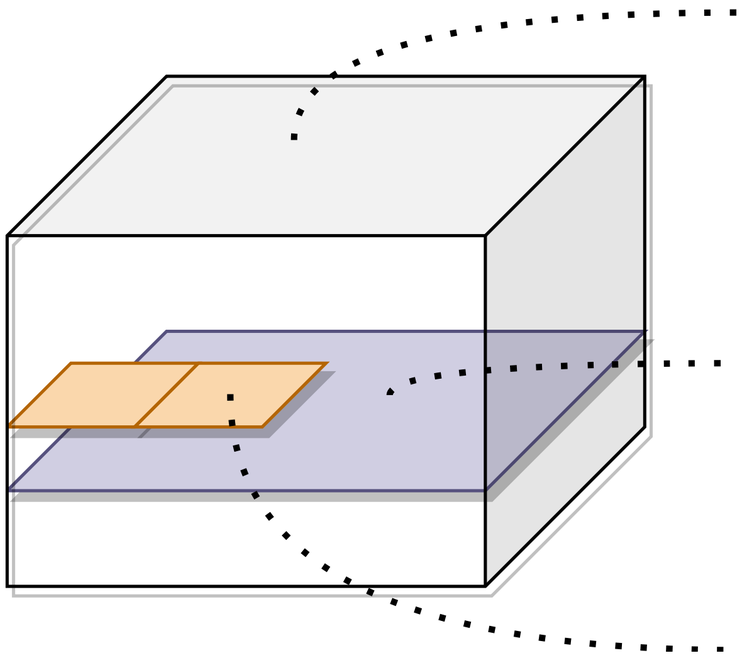
An object that semantically defines a space

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



SymbolicSpace ...

OpenHPS



```
const building = new Building("PL9")
    .setBounds({
        topLeft: new GeographicalPosition(
                50.8203,
                4.3922),
        width: 46.275,
        height: 37.27,
        rotation: -34.04
    });

const floor = new Floor("PL9.3")
    .setBuilding(building)
    .setFloorNumber(3);

const office = new Room("PL9.3.58")
    .setFloor(floor)
    .setBounds([
        new Absolute2DPosition(4.75, 31.25),
        new Absolute2DPosition(8.35, 37.02),
    ]);
```

Location-based Service

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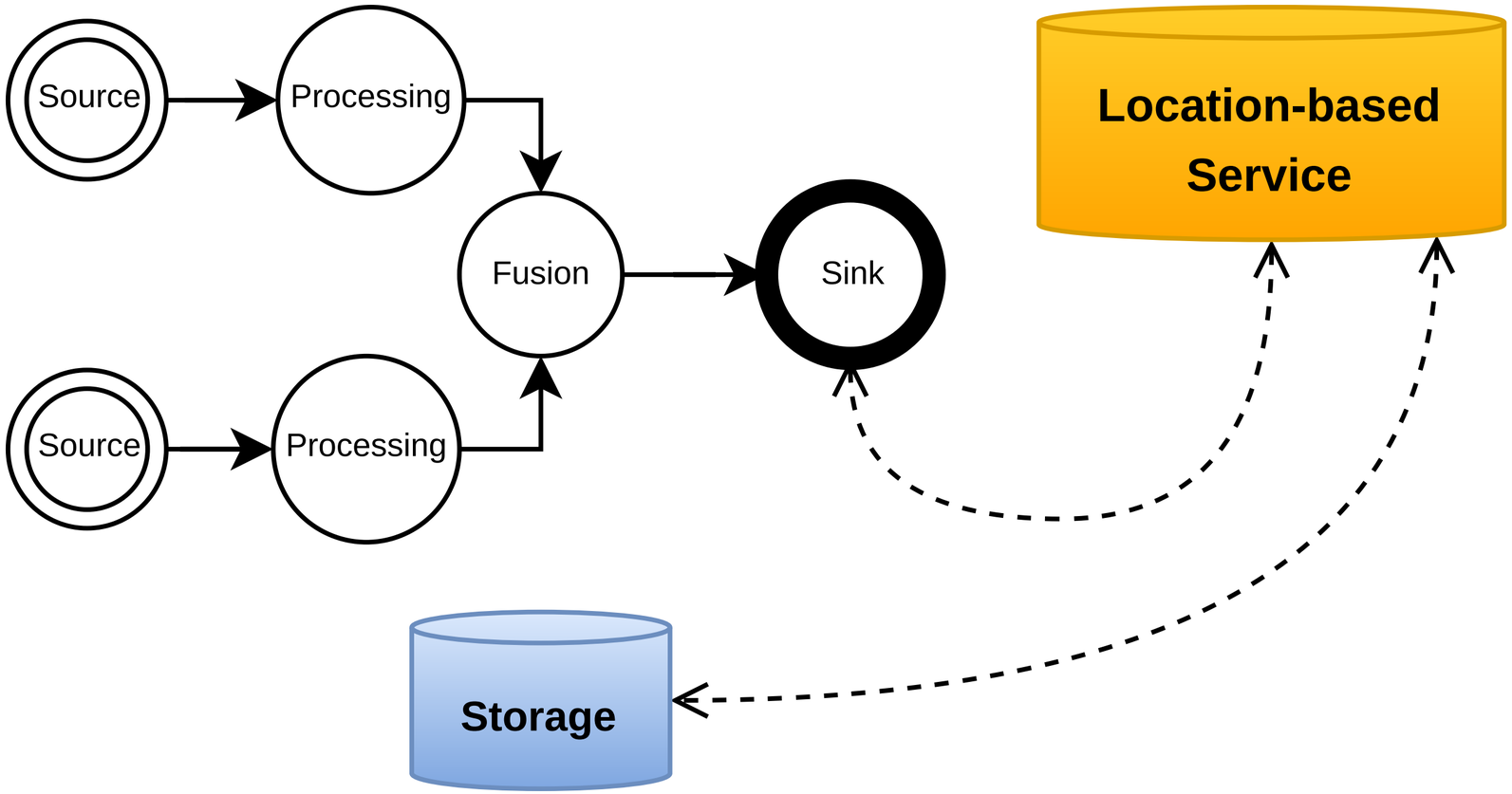
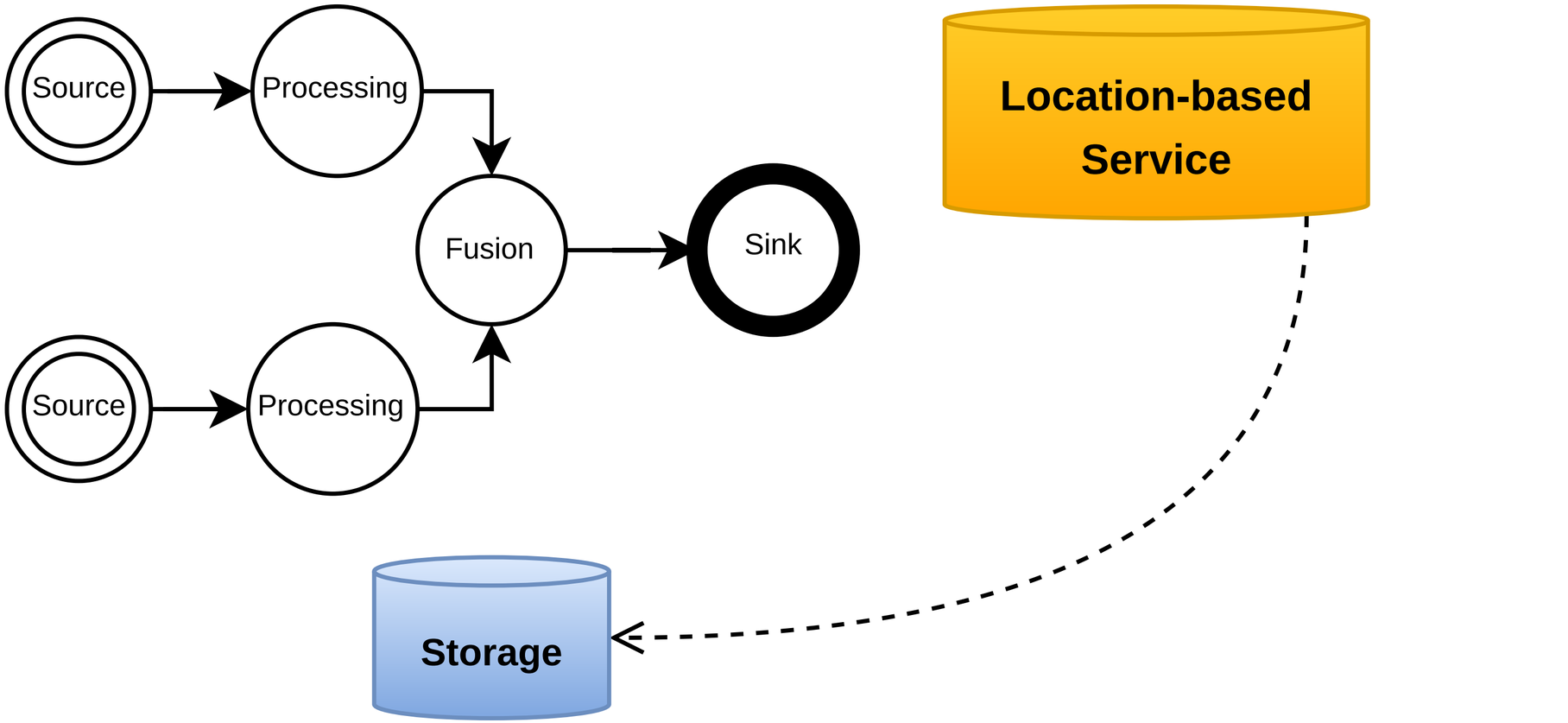
```
getCurrentPosition("me", ...)
```



Location-based Service ...

OpenHPS

```
setCurrentPosition("me", ...)
```



Location-based Service ...

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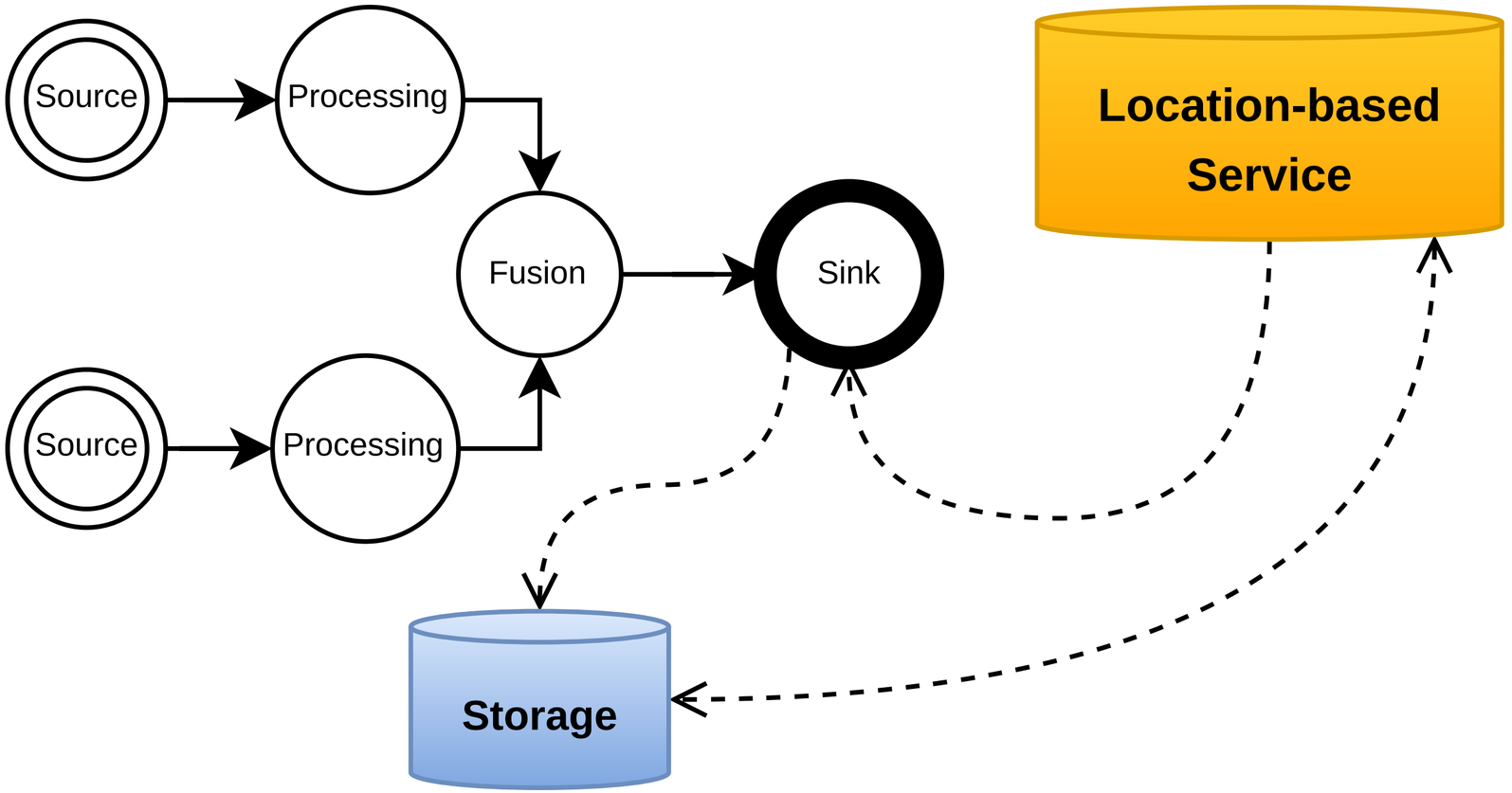
```
watchPosition("me", ...)
```



Demonstration

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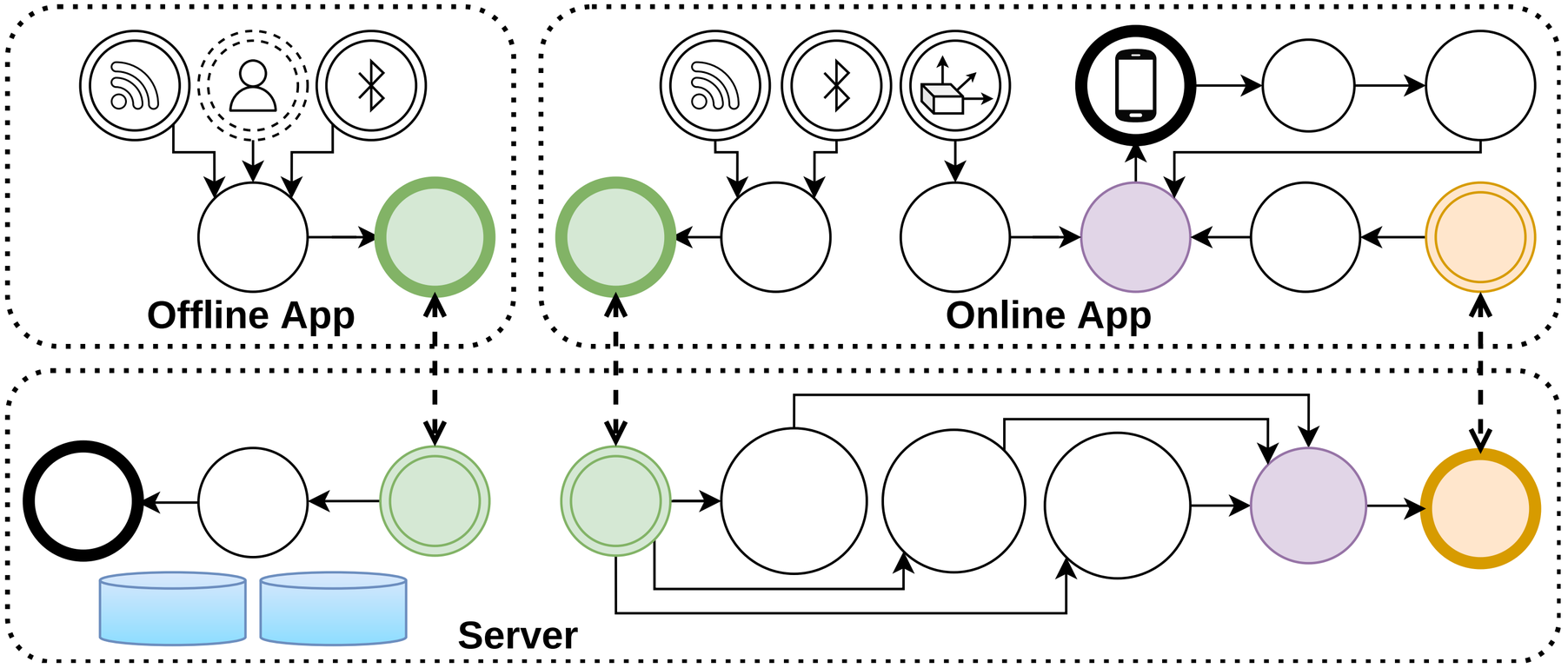
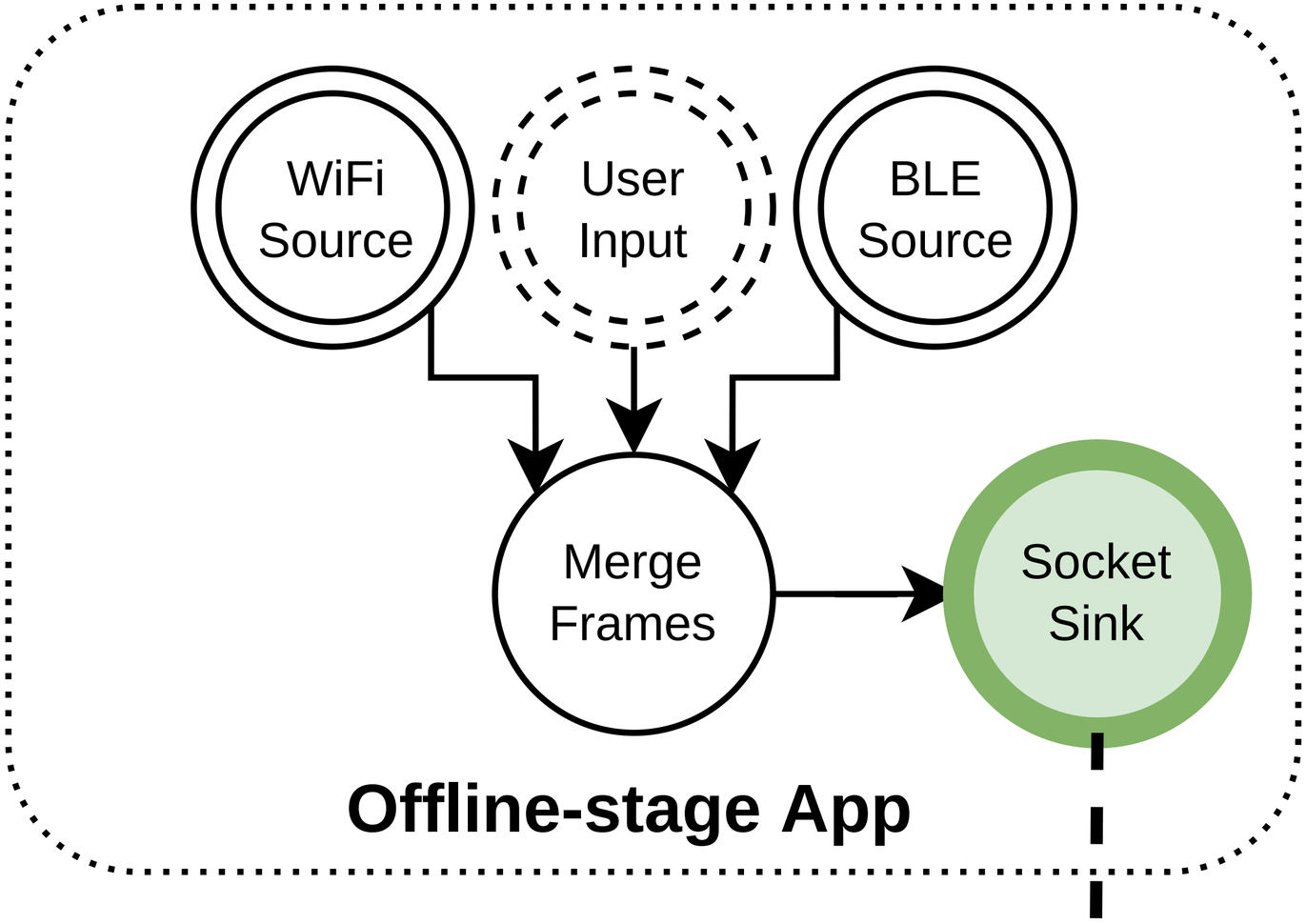
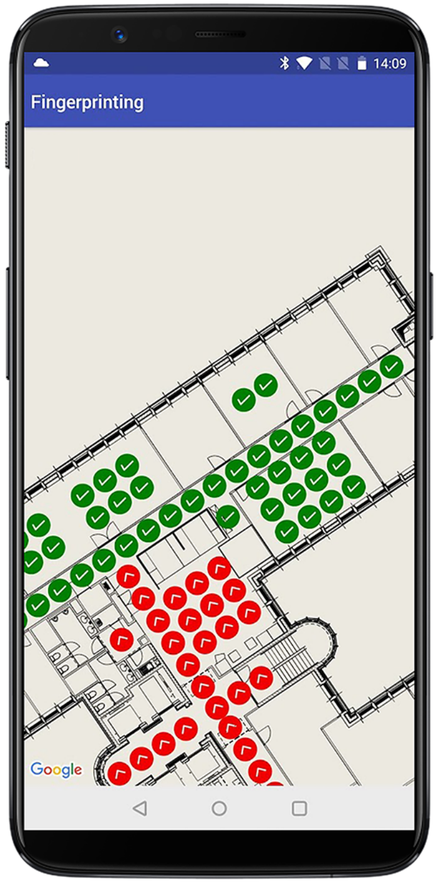
- Indoor positioning **use case**
- Use **existing techniques**
- Validation of **flexibility** and modularity



Positioning Model

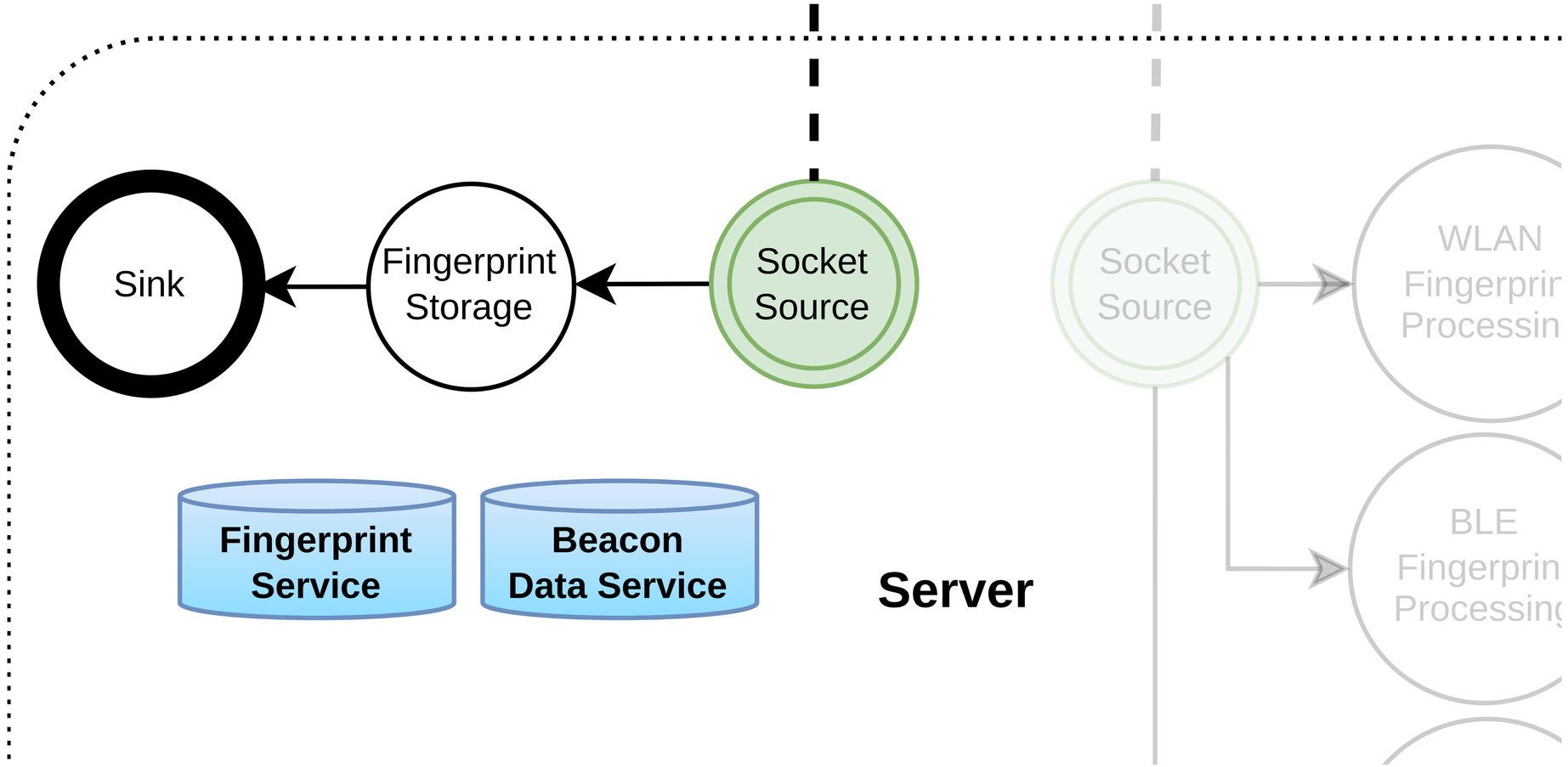
OpenHPS





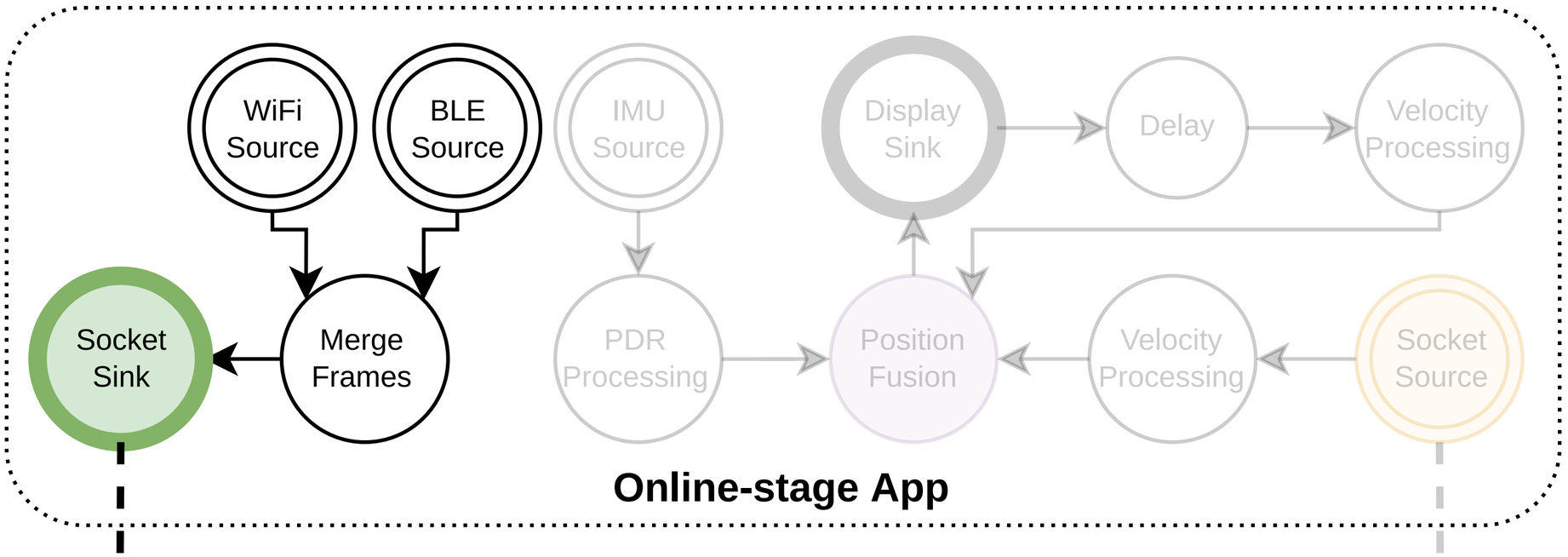
Positioning Model ...

OpenHPS



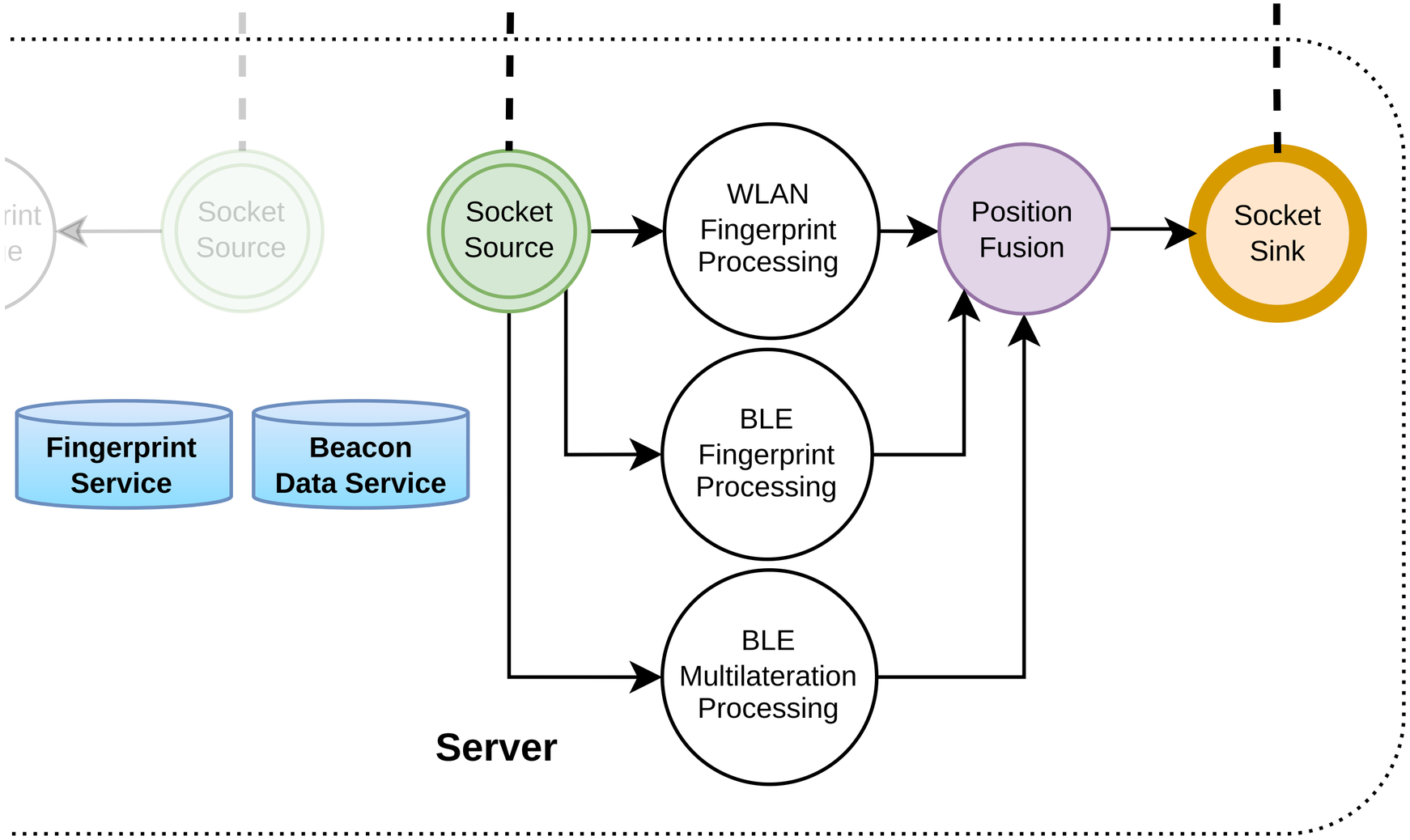
Positioning Model ...

OpenHPS



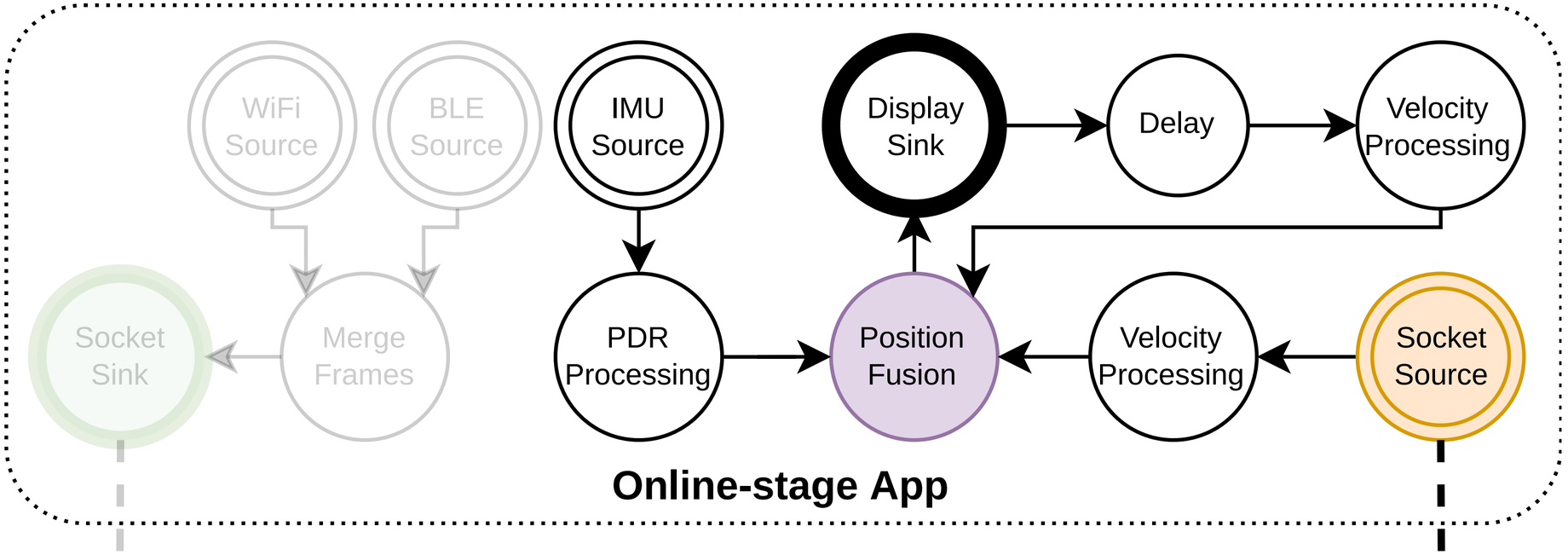
Positioning Model ...

OpenHPS



Positioning Model ...

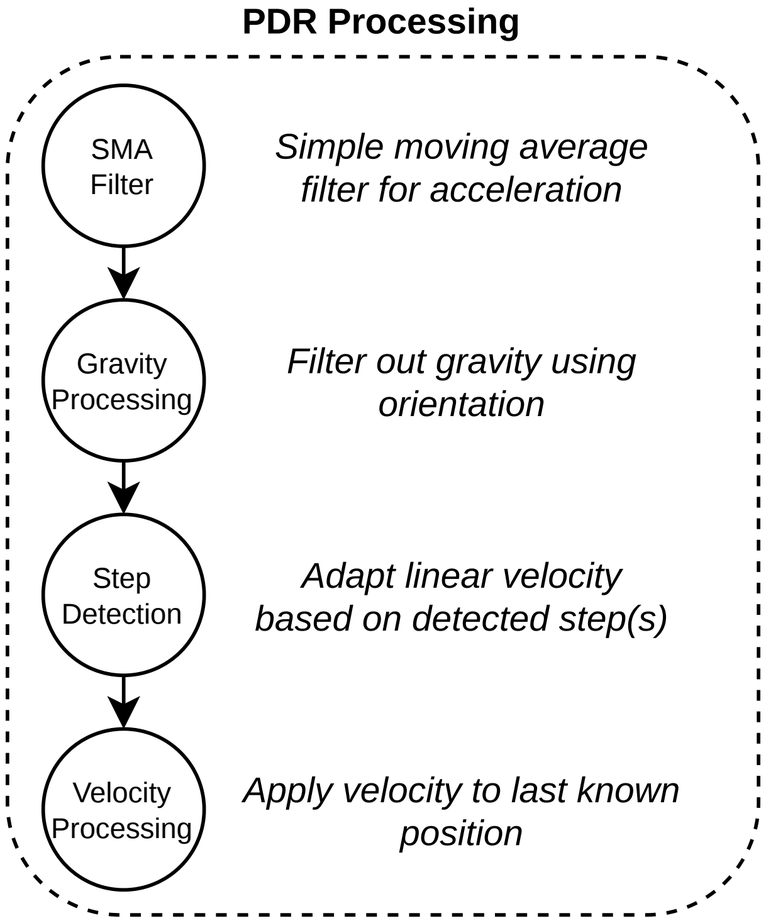
OpenHPS



Positioning Model

OpenHPS

Online App



Positioning Model

OpenHPS

Online App

```
ModelBuilder.create()
    .addShape(GraphBuilder.create()
        .from(new IMUSourceNode({
            source: new DataObject(phoneUID),
            interval: 20,
            sensors: [
                SensorType.ACCELEROMETER,
                SensorType.ORIENTATION
            ]
        }))
        .via(new SMAFilterNode(
            frame => [frame, "acceleration"],
            { taps: 10 }
        ))
        .via(new GravityProcessingNode({
            method: GravityProcessingMethod.ABSOLUTE_ORIENTATION
        }))
```

Dataset

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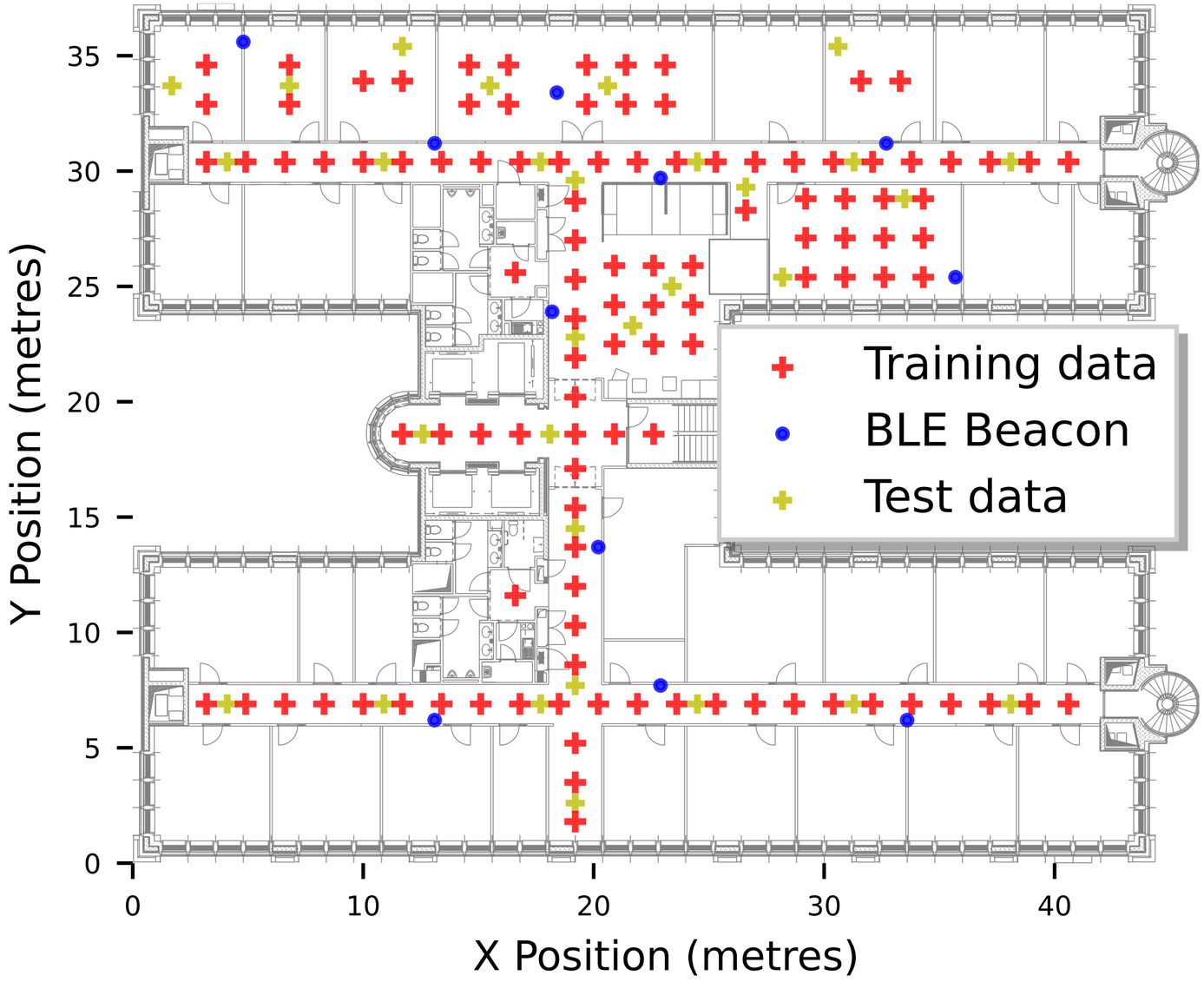

Dataset …

OpenHPS

Total BLE Beacons: 11

Total detected WLAN access points: 220

Total stable WLAN access points: 199

	Training	Test
Datapoints	110	30
Total fingerprints	440	120
Duration (per orientation)	20s	20s
Avg. WLAN Scans (per fingerprint)	6	6
Avg. BLE Advertisements (per fingerprint)	16	15

Validation Results

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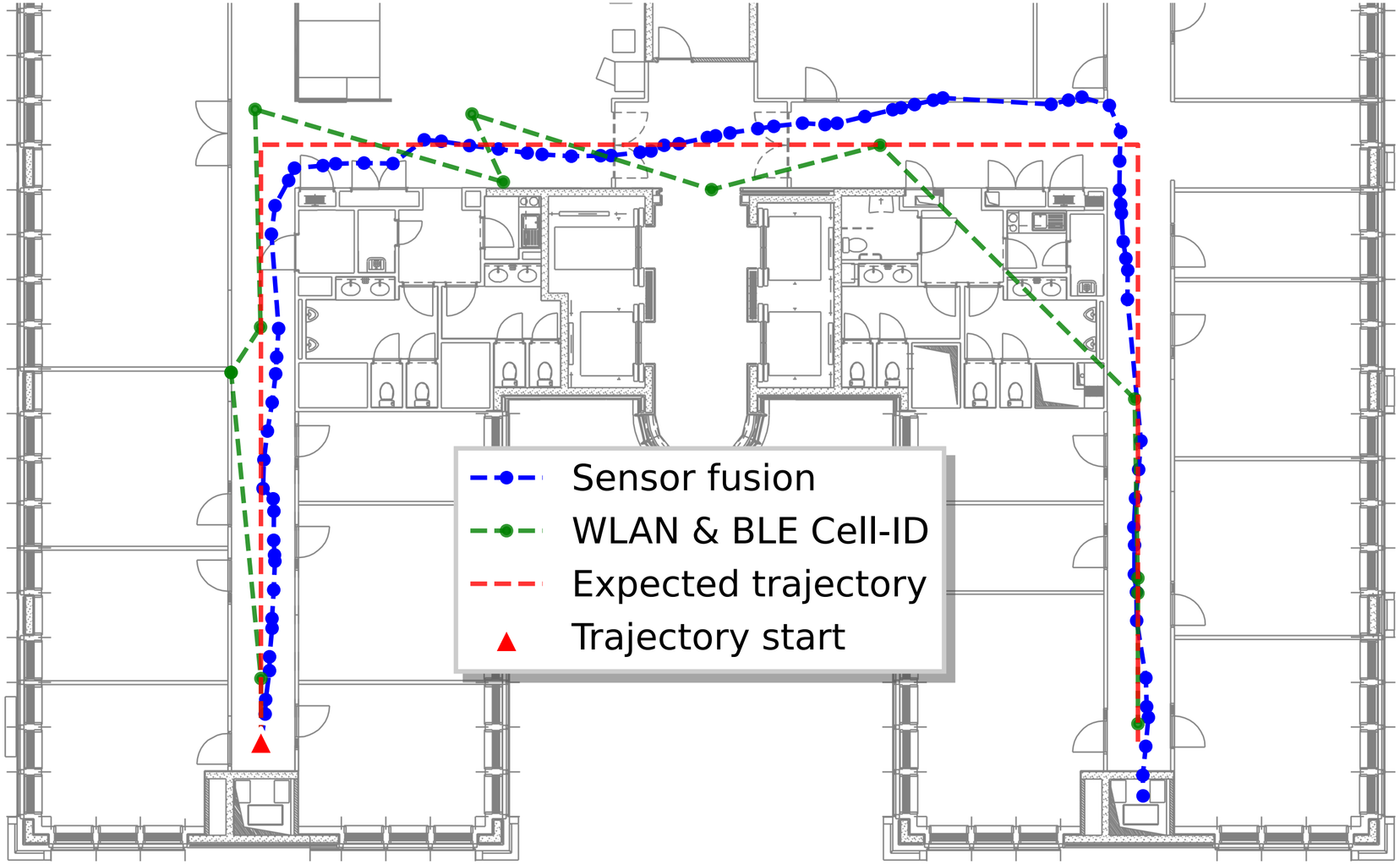
Static Positioning

	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 ...

OpenHPS

Trajectories



Validation Results ...

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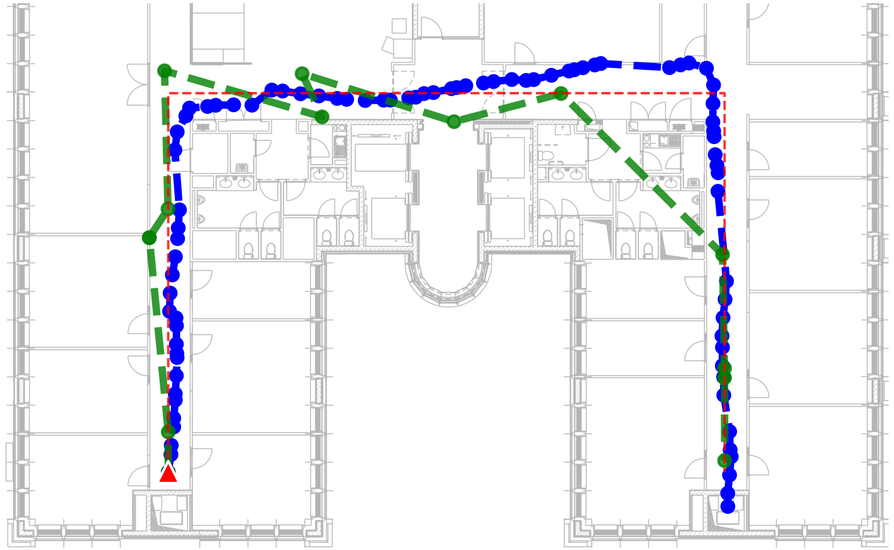
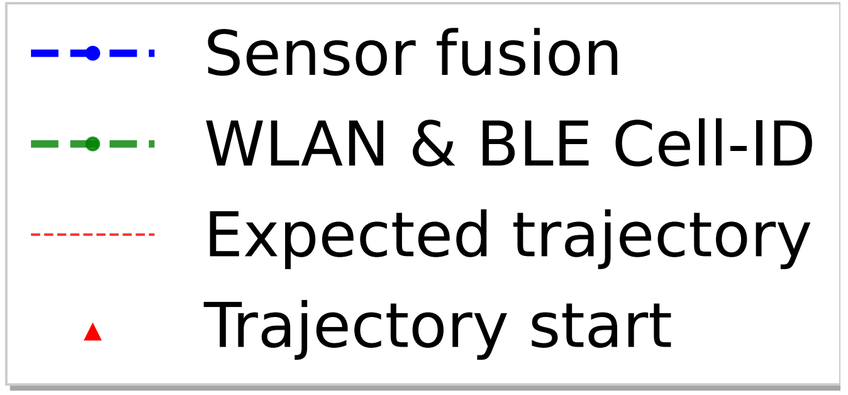
Trajectories

	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!