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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- Introduction
- Installation
- Modules

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

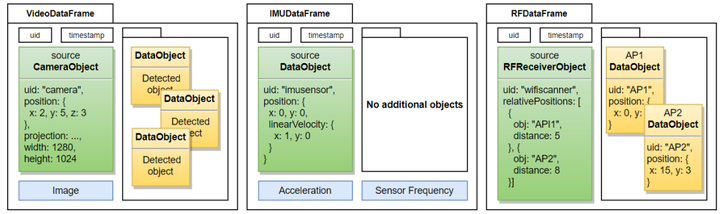
Advanced Concepts
- Remote Service
- Threading

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

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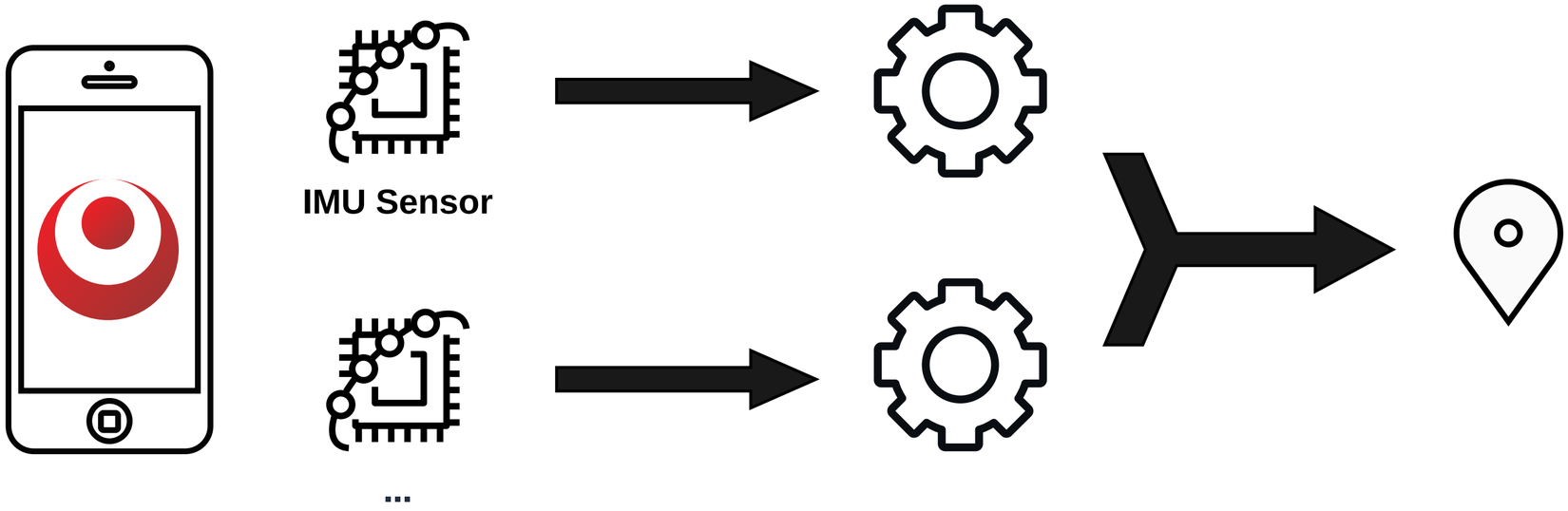
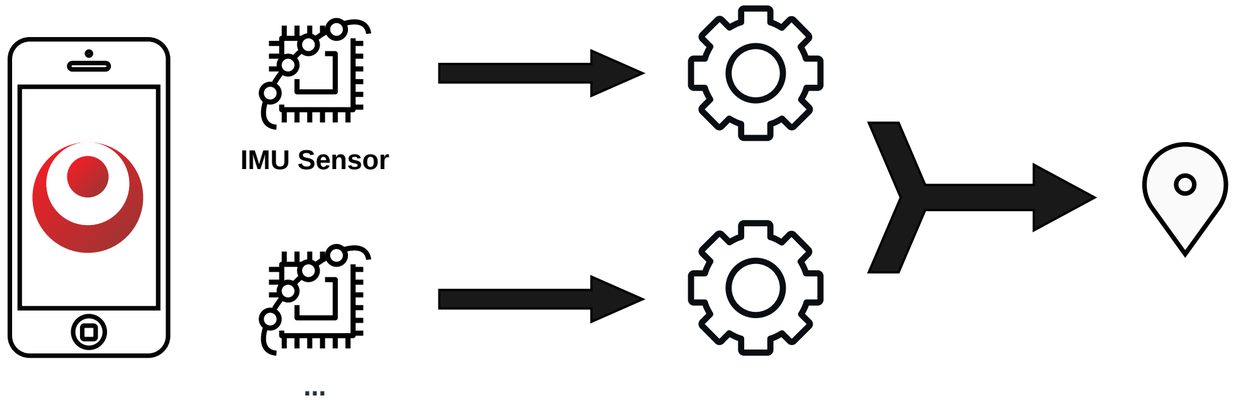
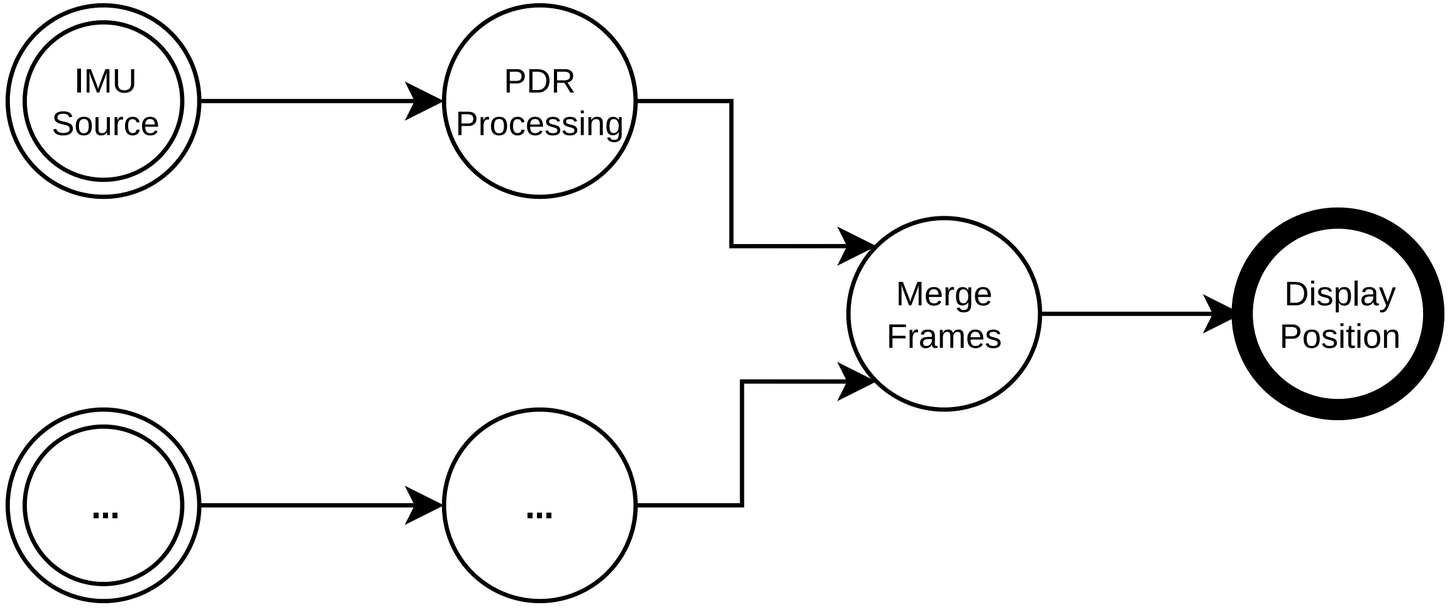


Process Network Design ...

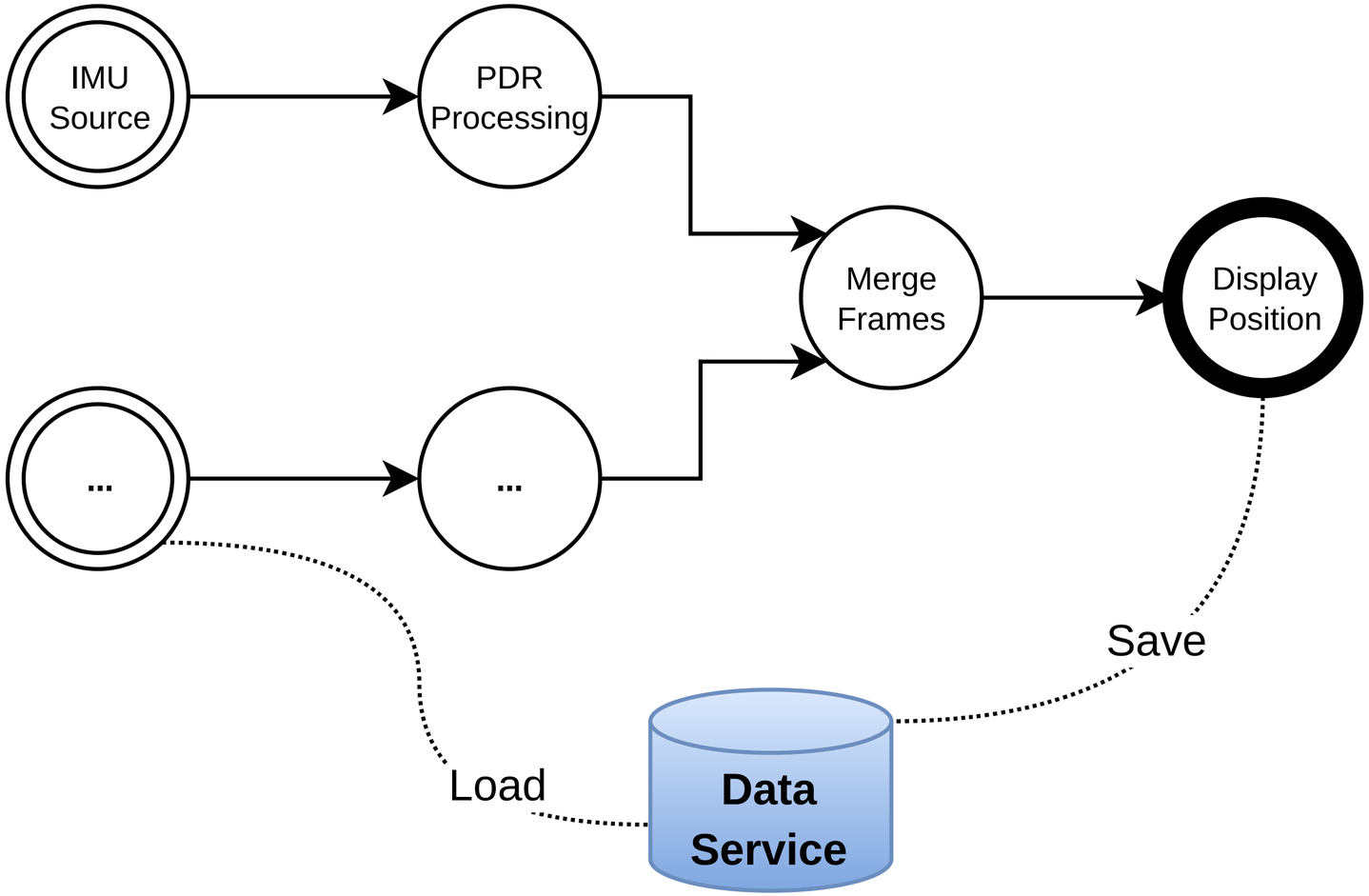
OpenHPS





Process Network Design ...

OpenHPS



Modularity

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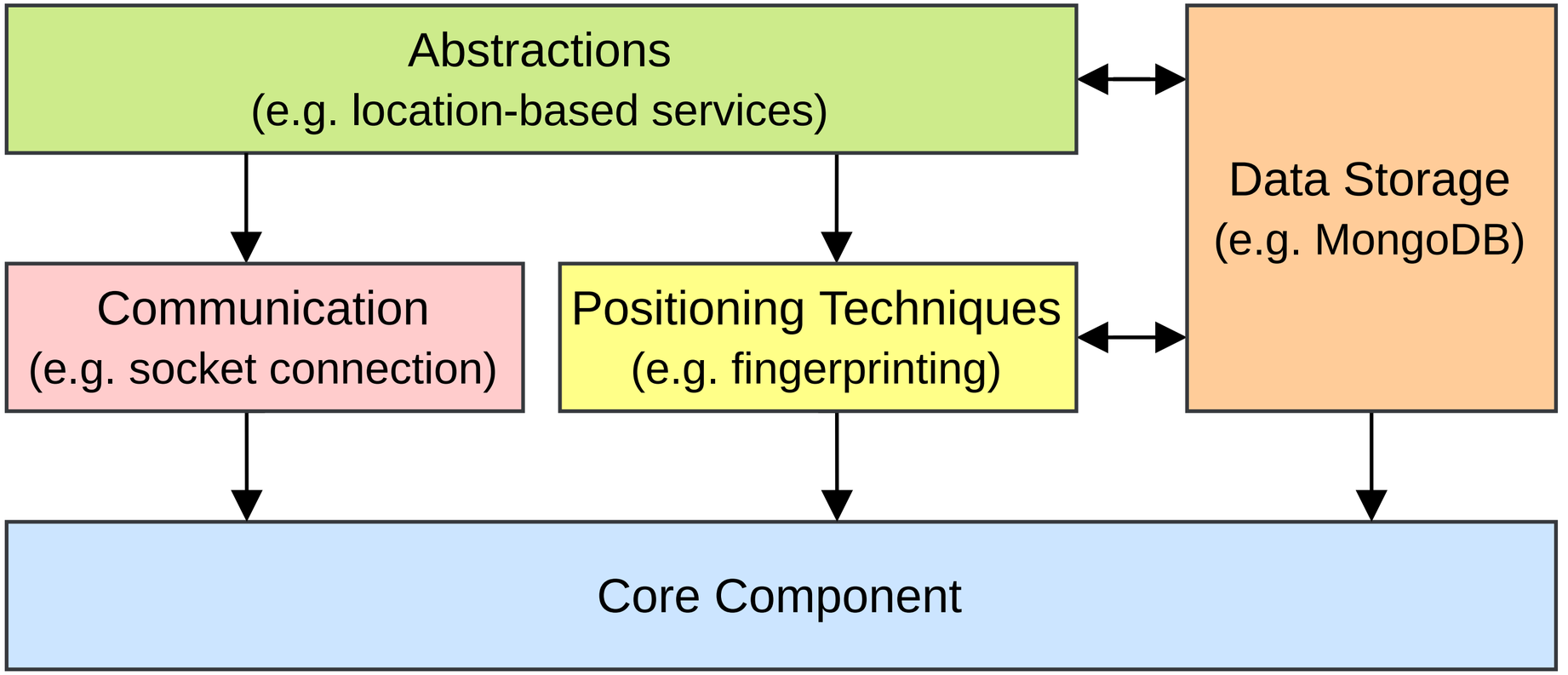

Modularity ...

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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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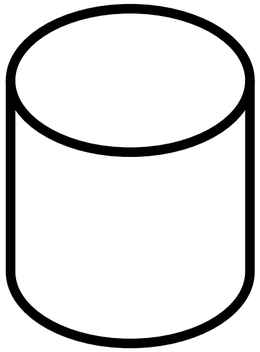
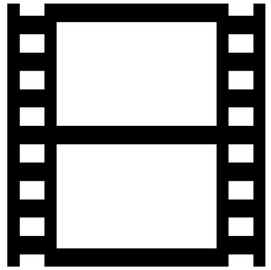
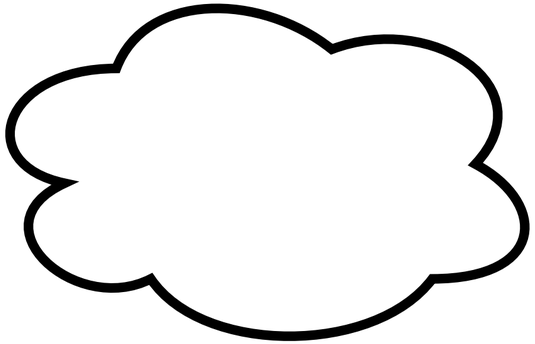


Knowledge



Raw Data



Processed Data

DataObject

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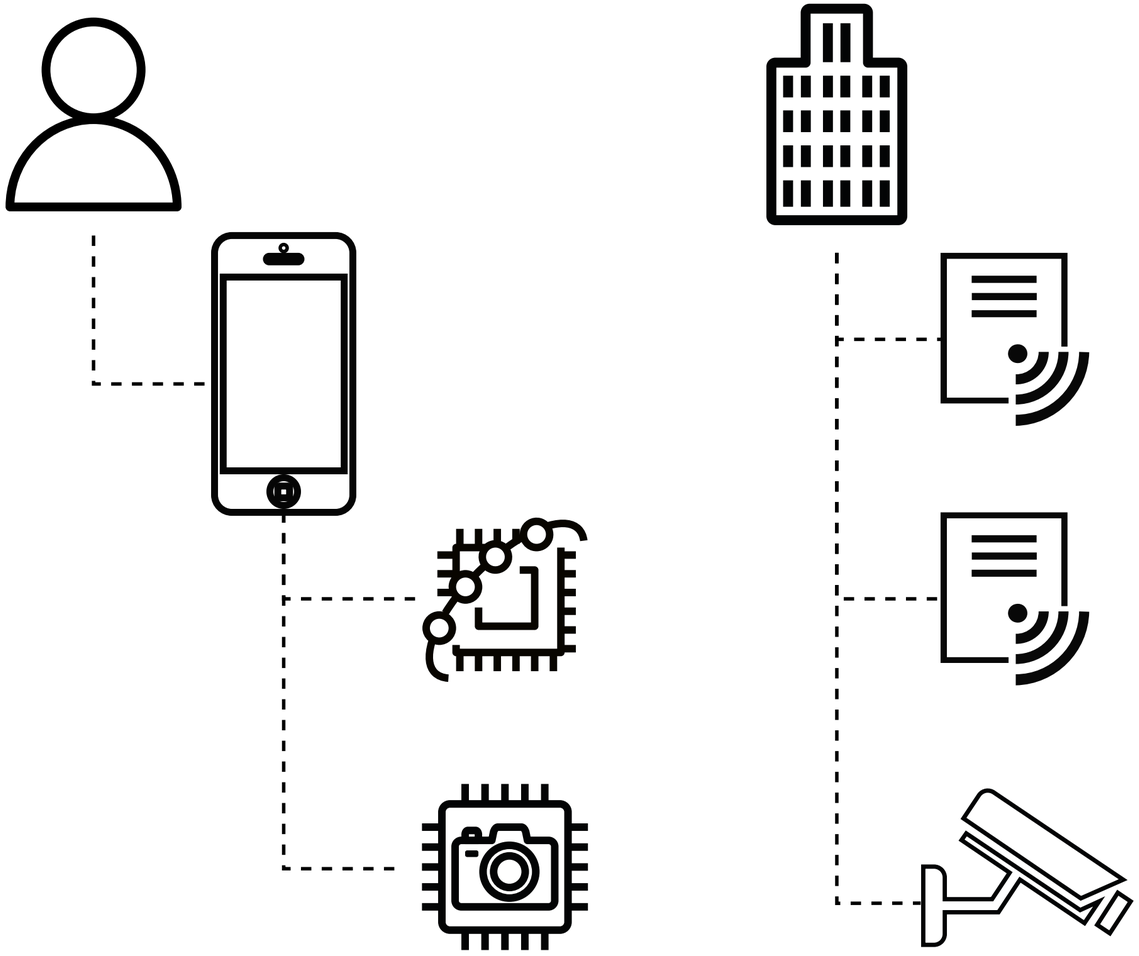

Absolute and Relative Positions

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Absolute

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

Relative

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

DataFrame

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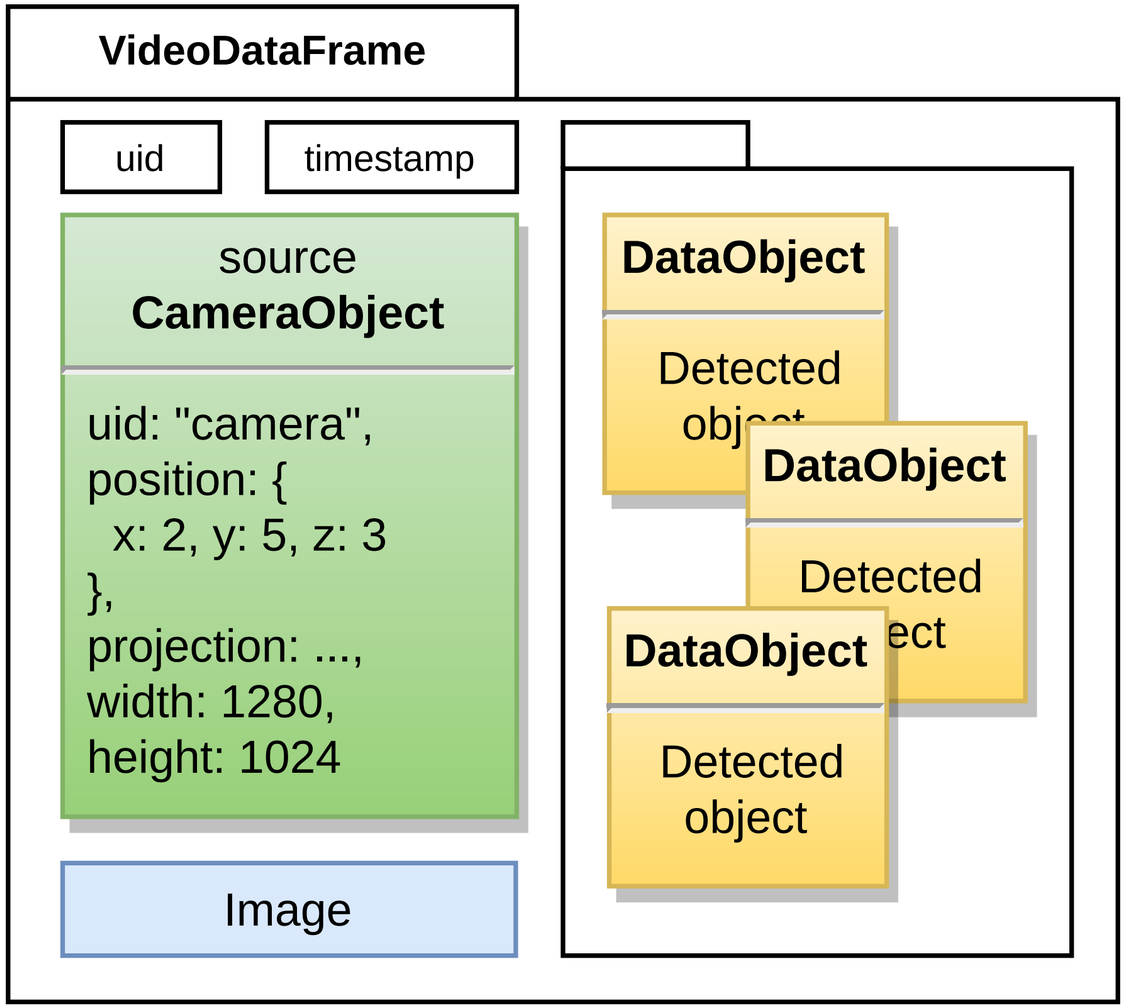

DataFrame ...

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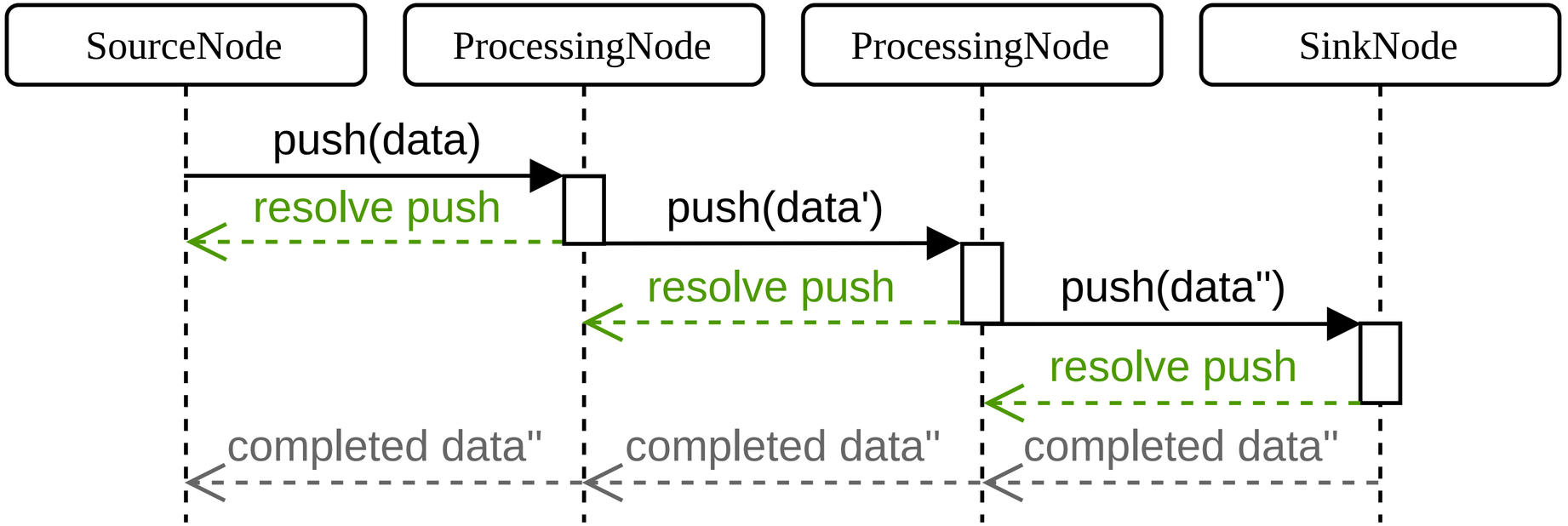
Pushing Data



DataFrame ...

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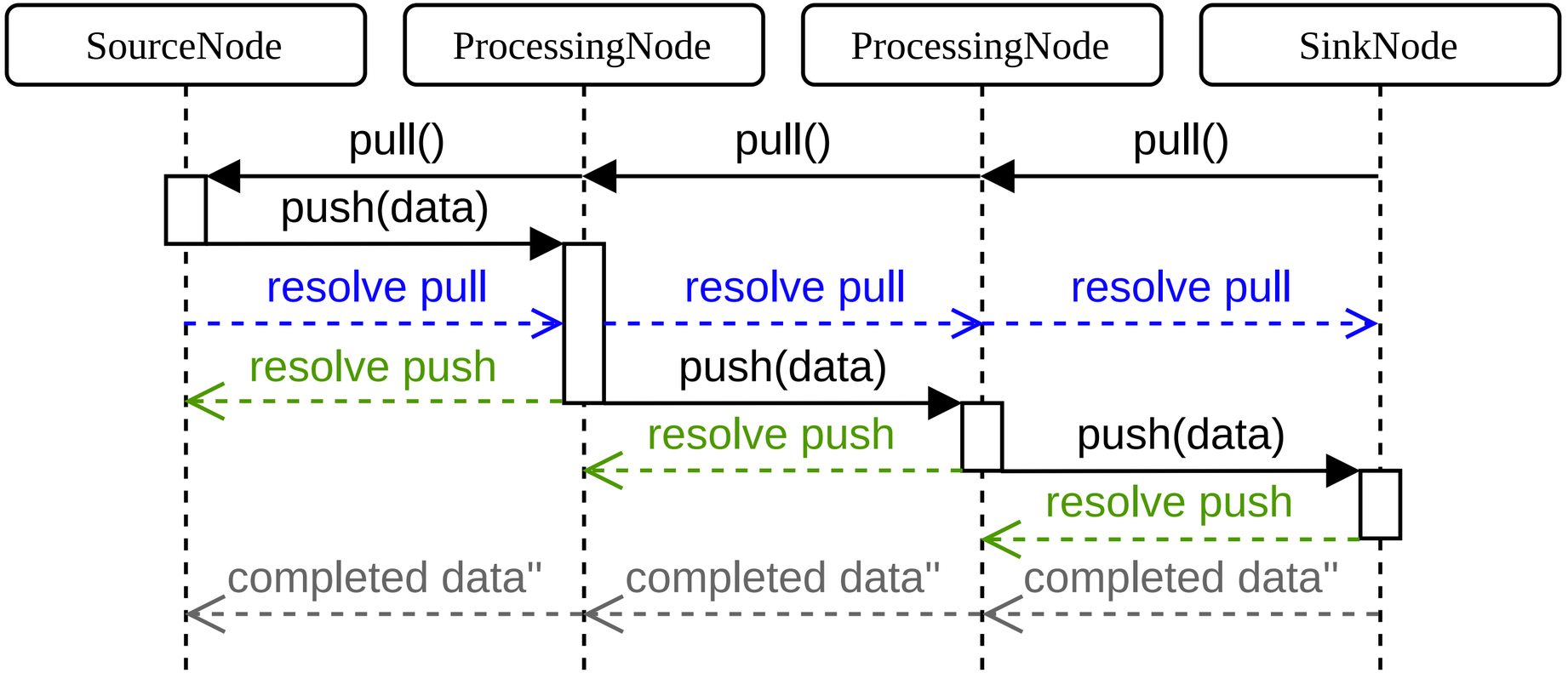
Pulling Data



DataFrame ...

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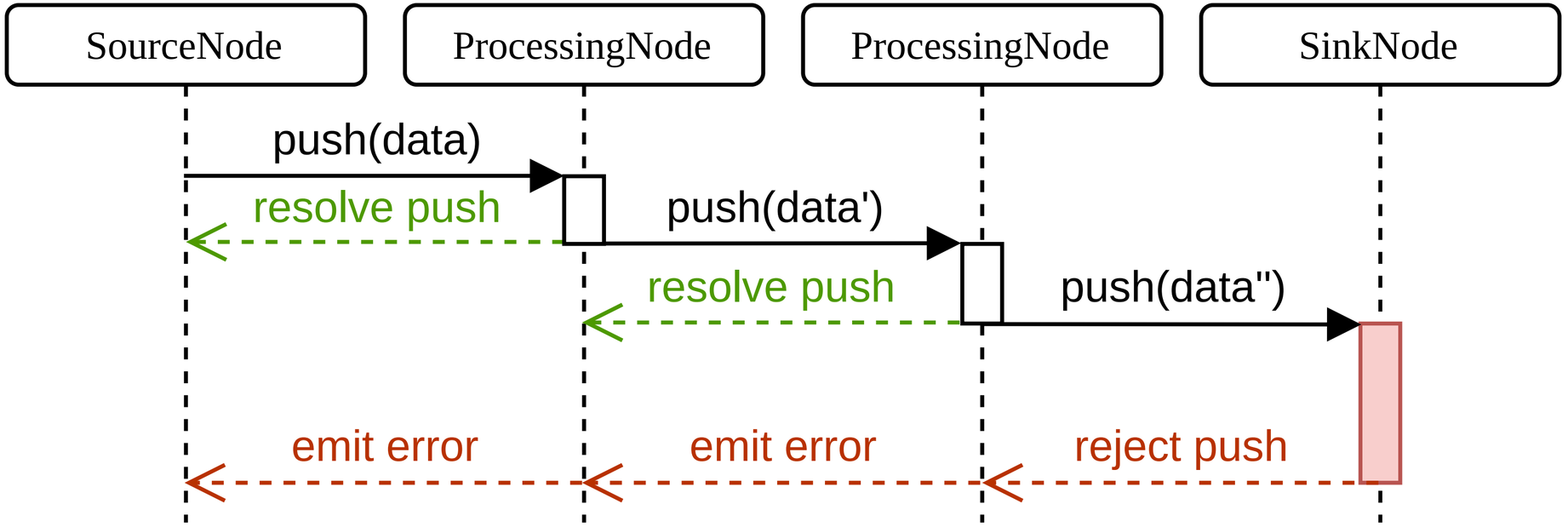
Pushing Error



SymbolicSpace

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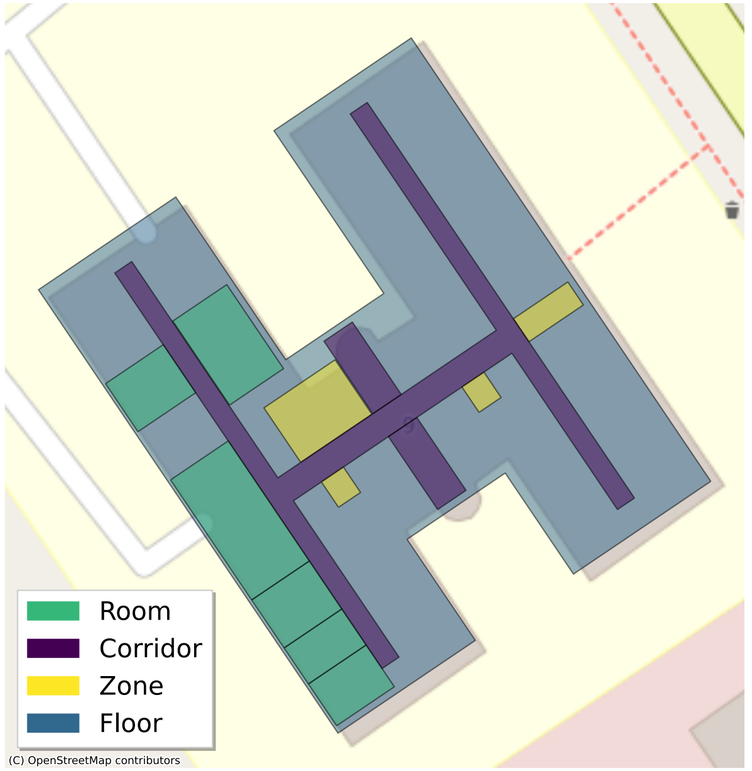
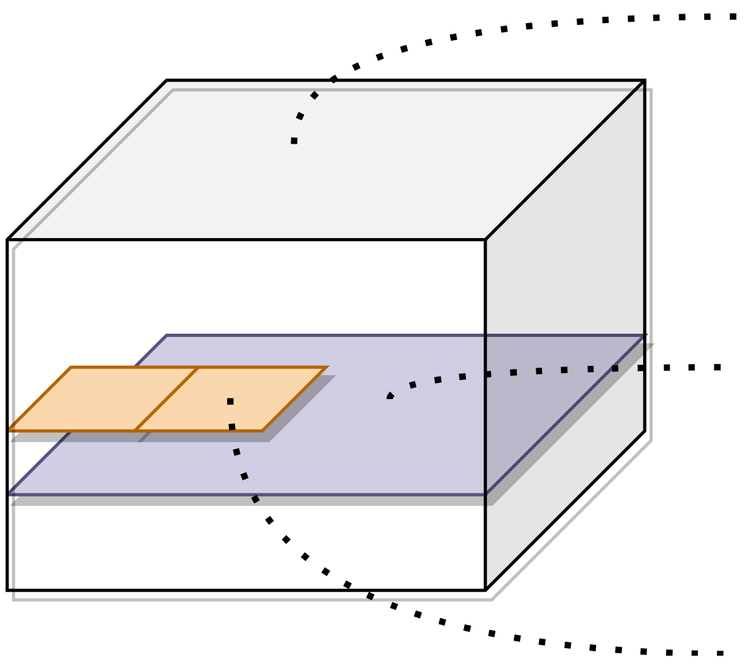
An object that semantically defines a space

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



SymbolicSpace ...

OpenHPS

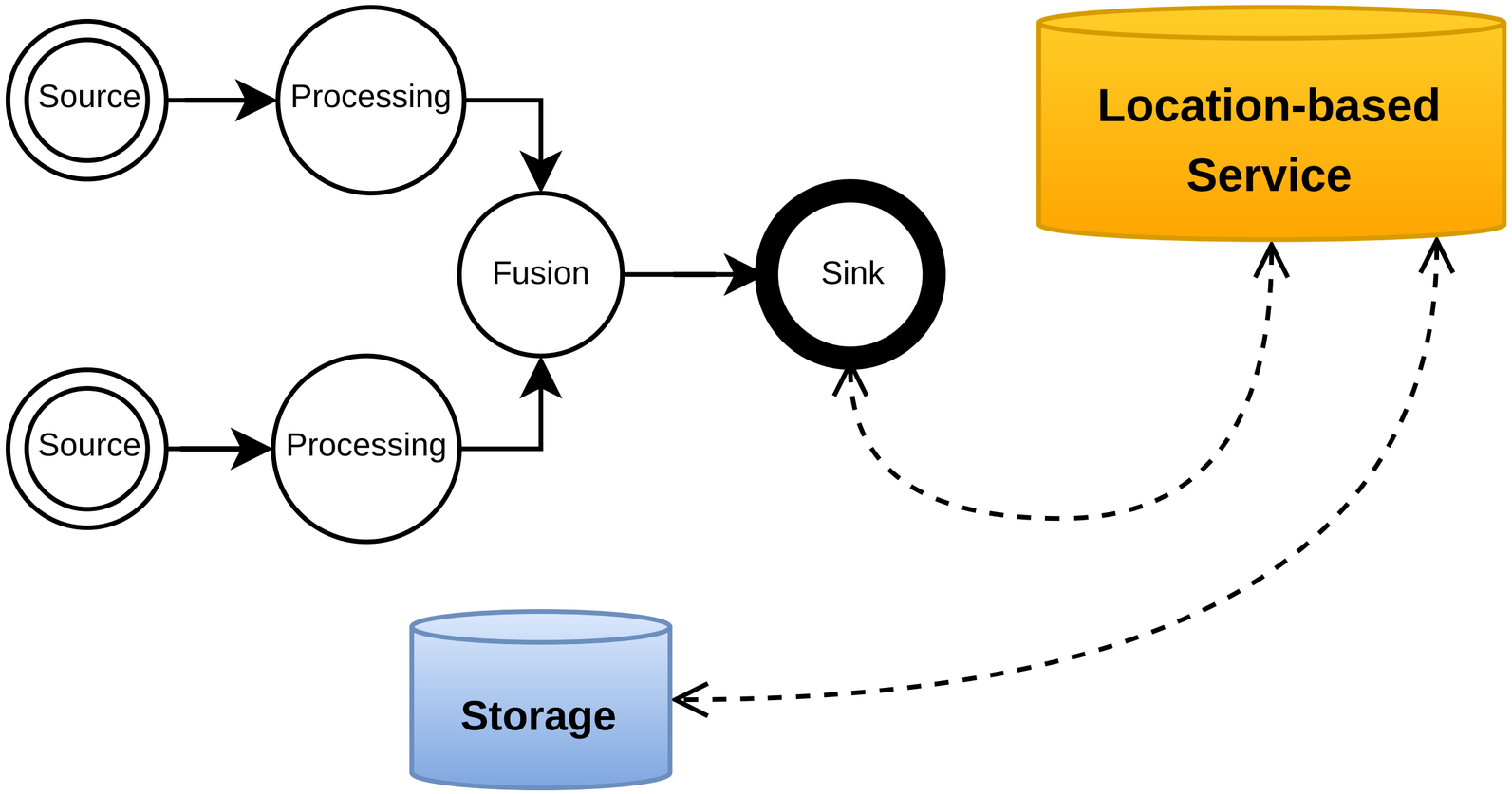


```
const building = new Building("PL9")
    .setBounds({
        topLeft: new GeographicalPosition(
                50.8203,
                4.3922),
        width: 46.275,
        height: 37.27,
        rotation: -34.04
    });

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

OpenHPS

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



Location-based Service ...

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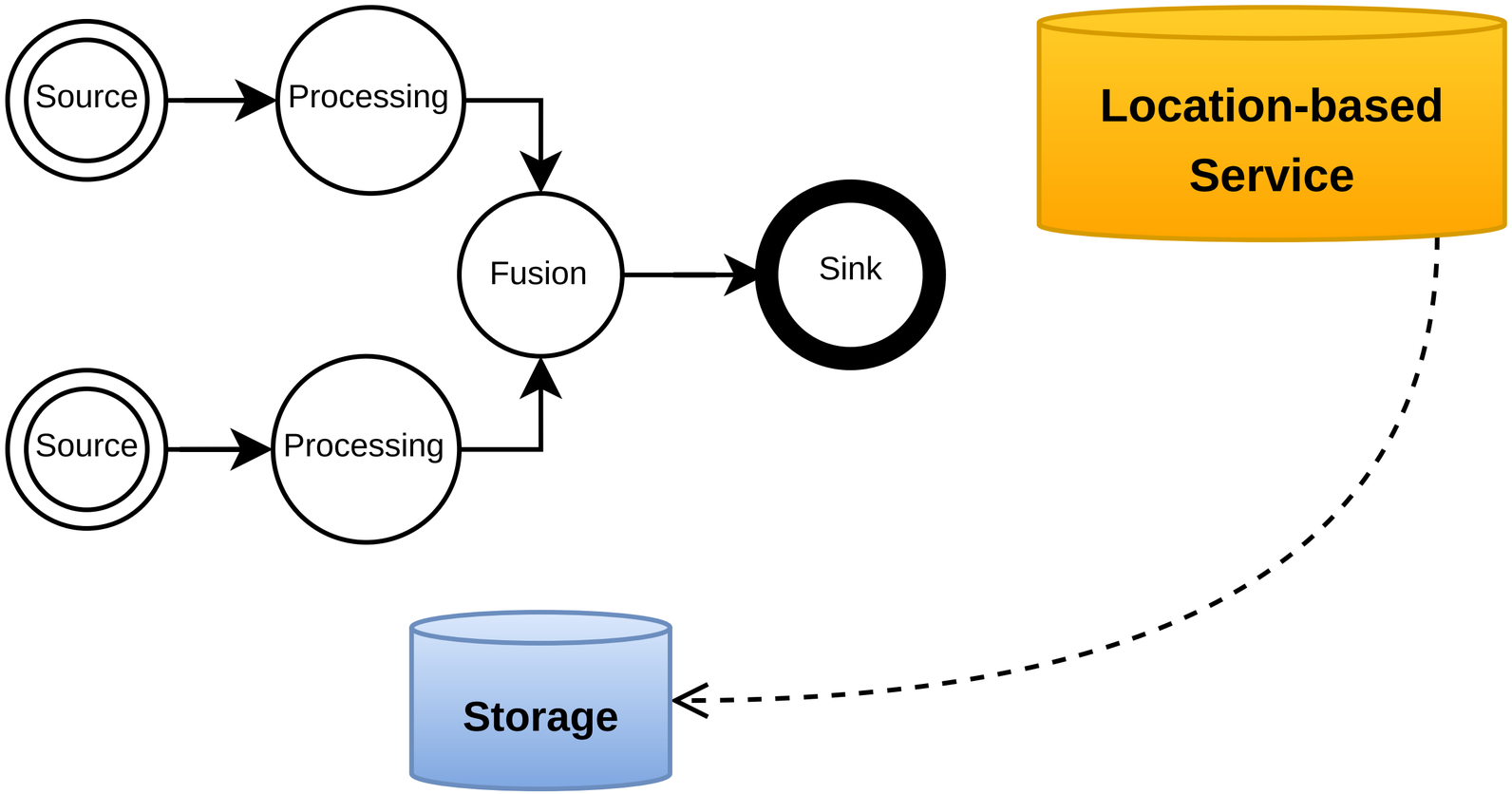
```
setCurrentPosition("me", ...)
```



Location-based Service ...

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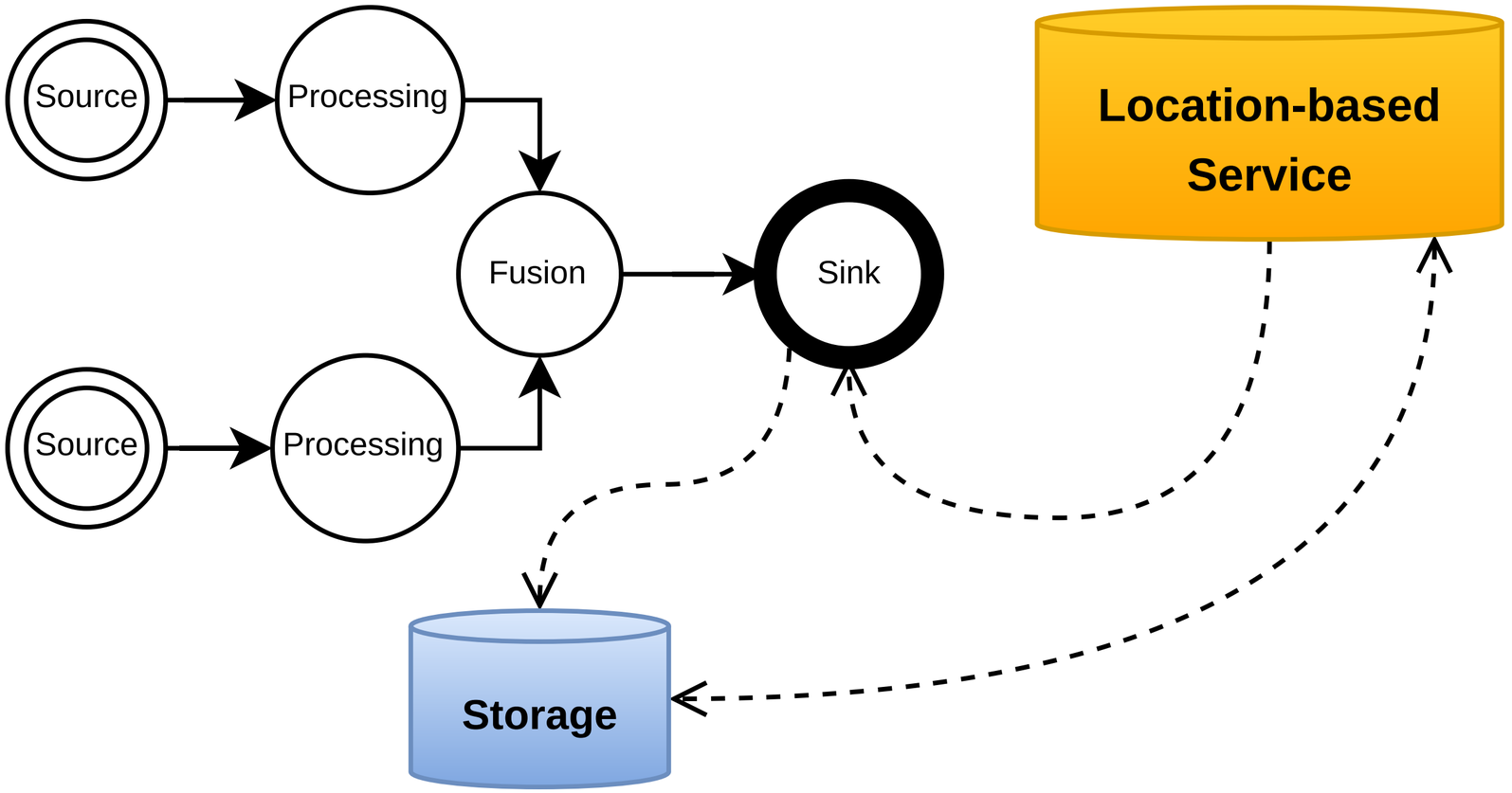
```
watchPosition("me", ...)
```



Demonstration

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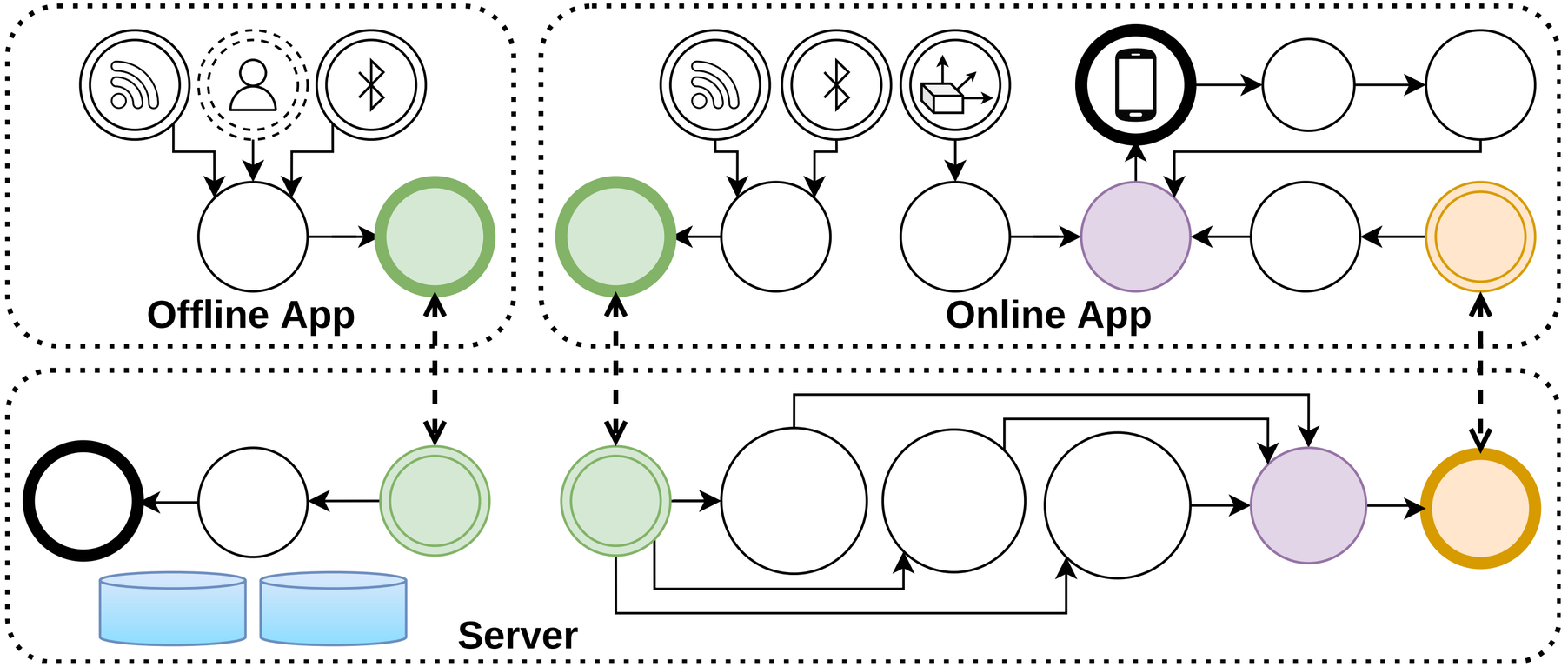
- Indoor positioning **use case**
- Use **existing techniques**
- Validation of **flexibility** and modularity



Positioning Model

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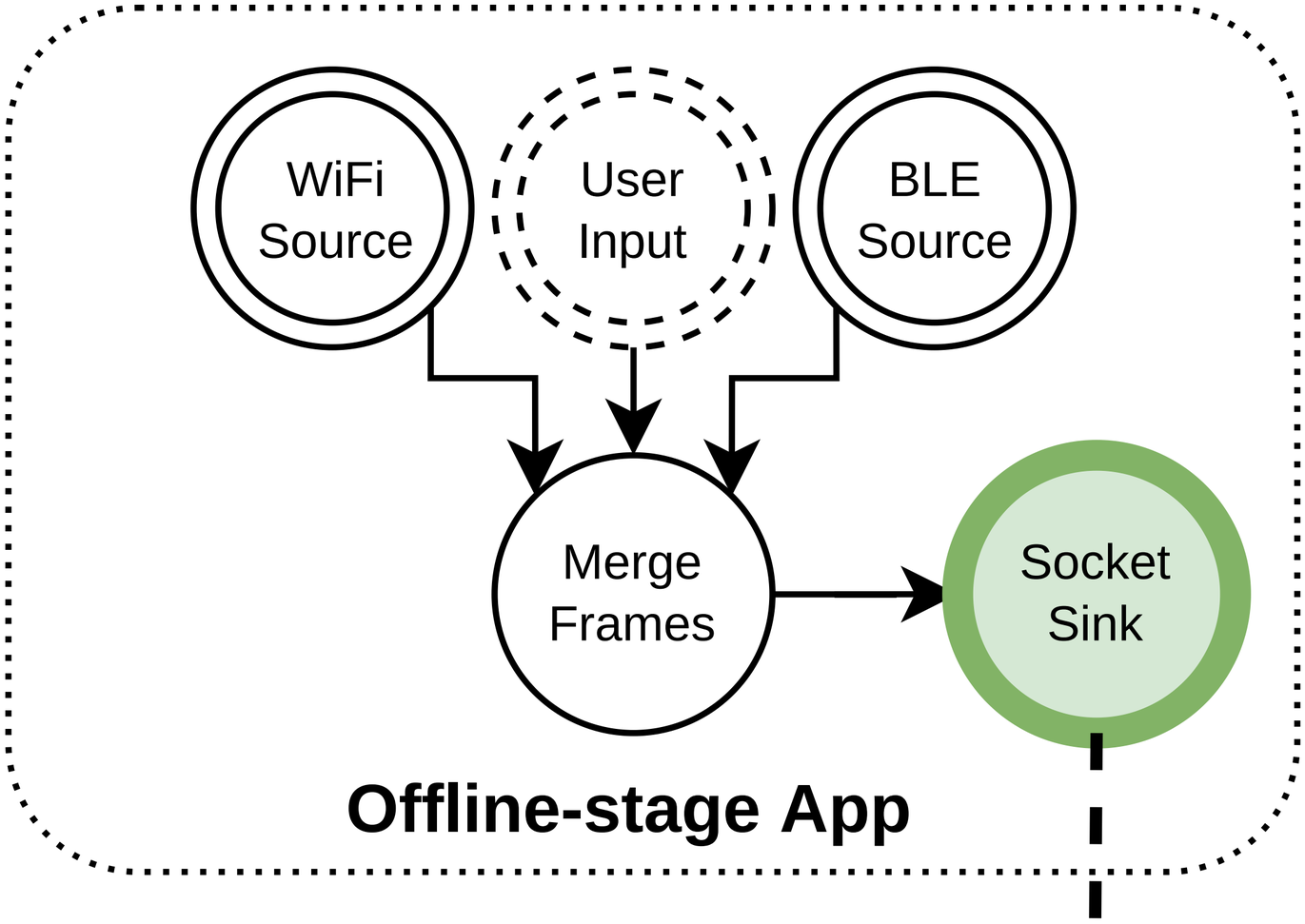
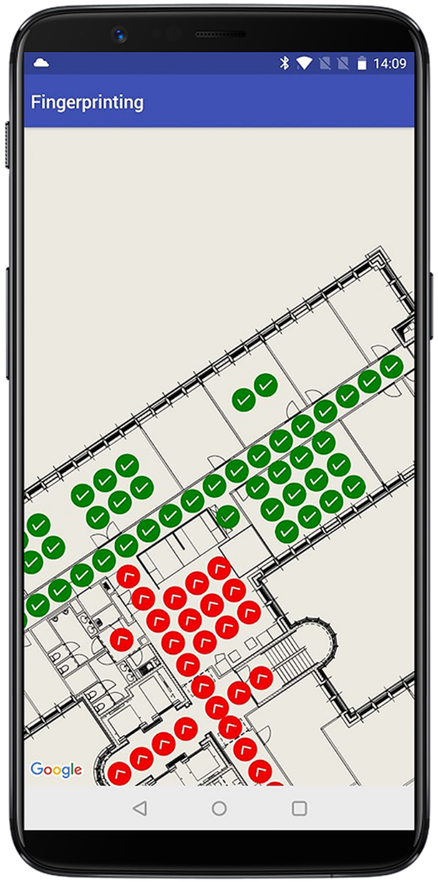
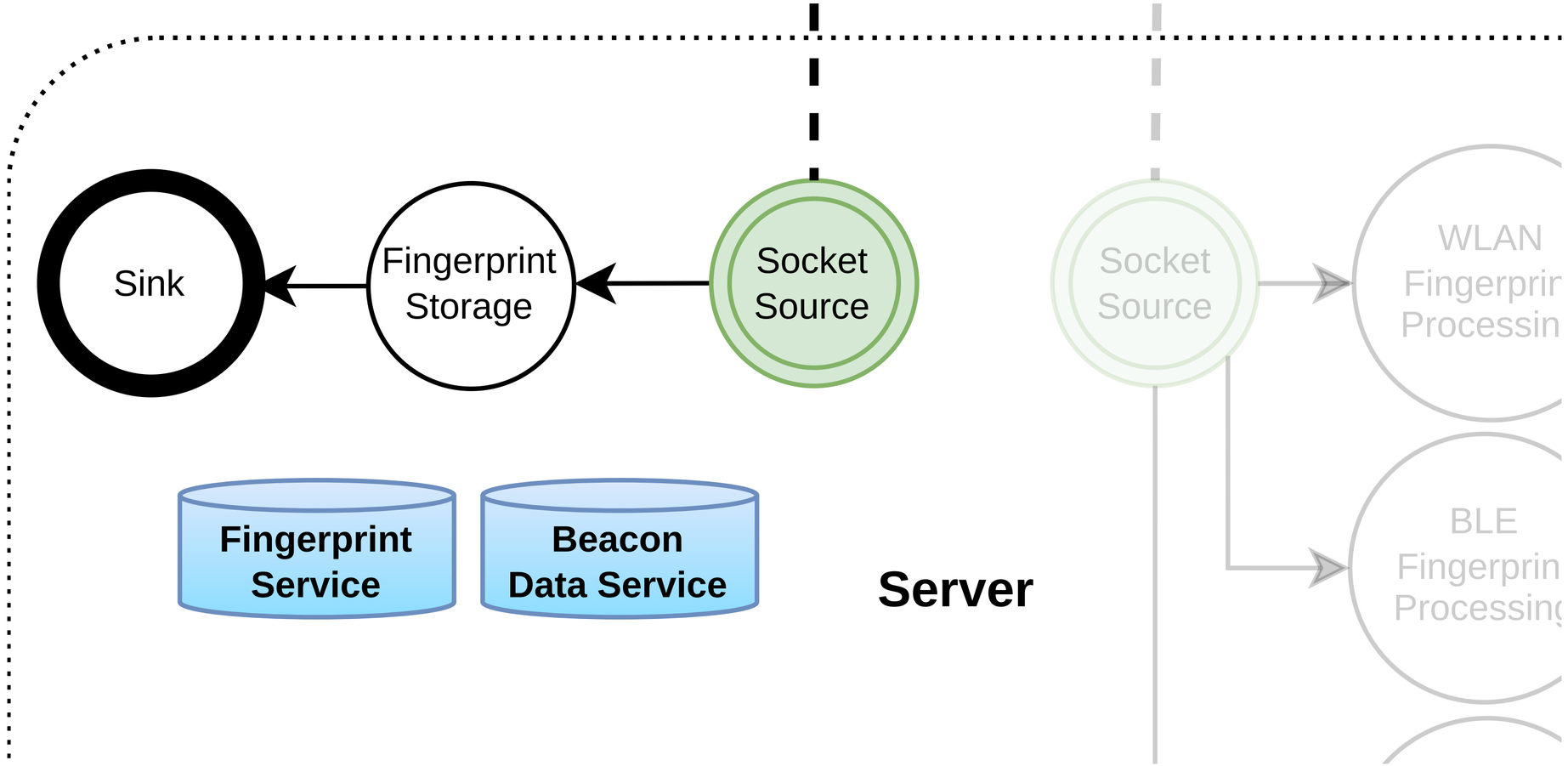




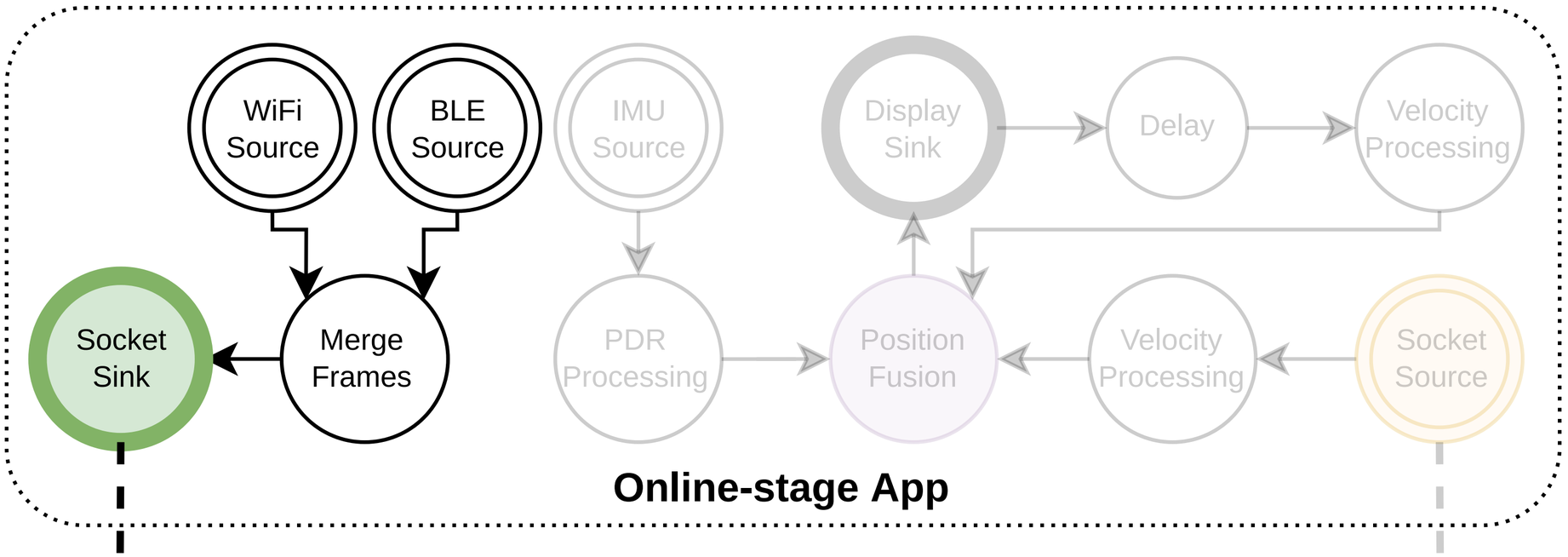
Positioning Model ...

OpenHPS



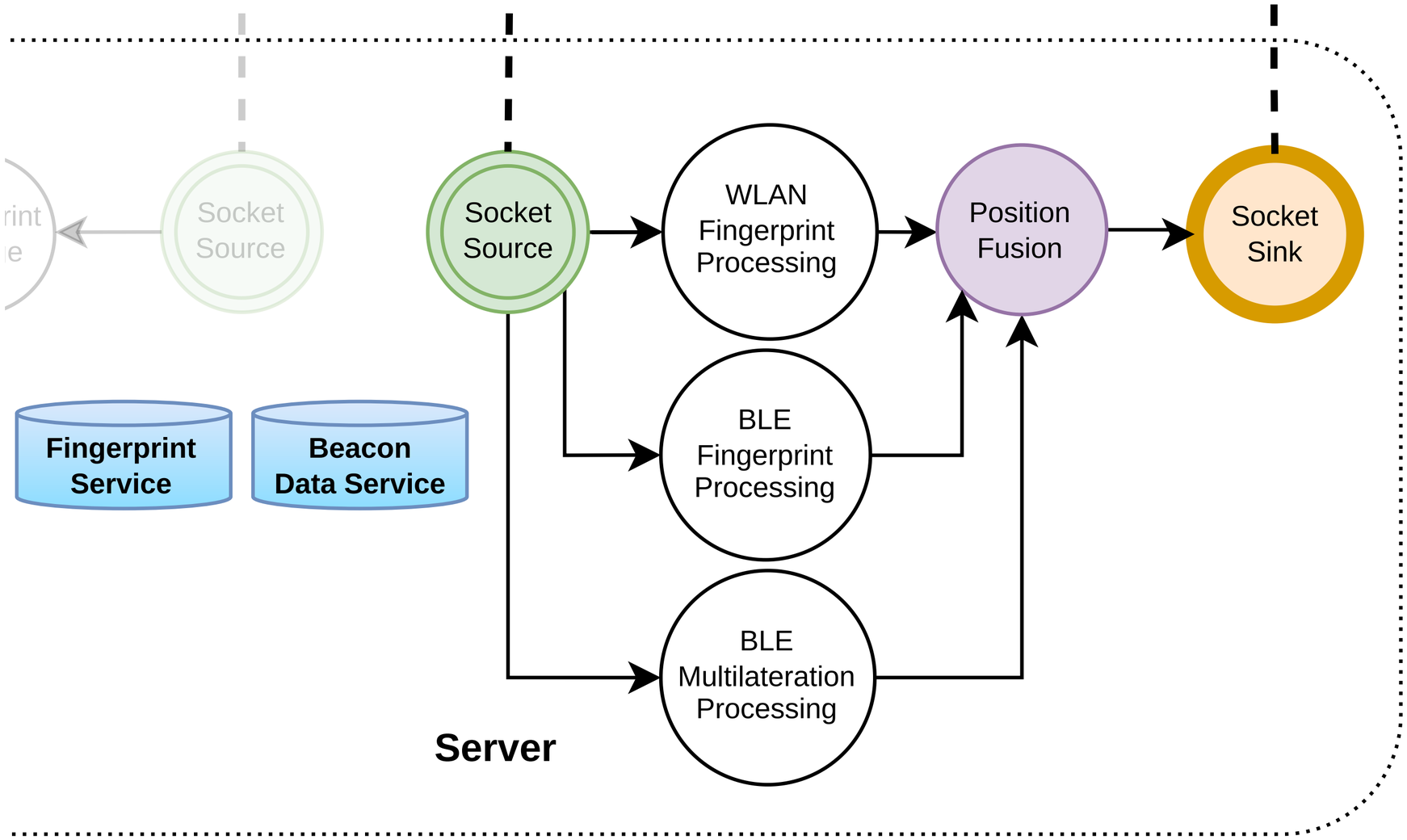
Positioning Model ...

OpenHPS



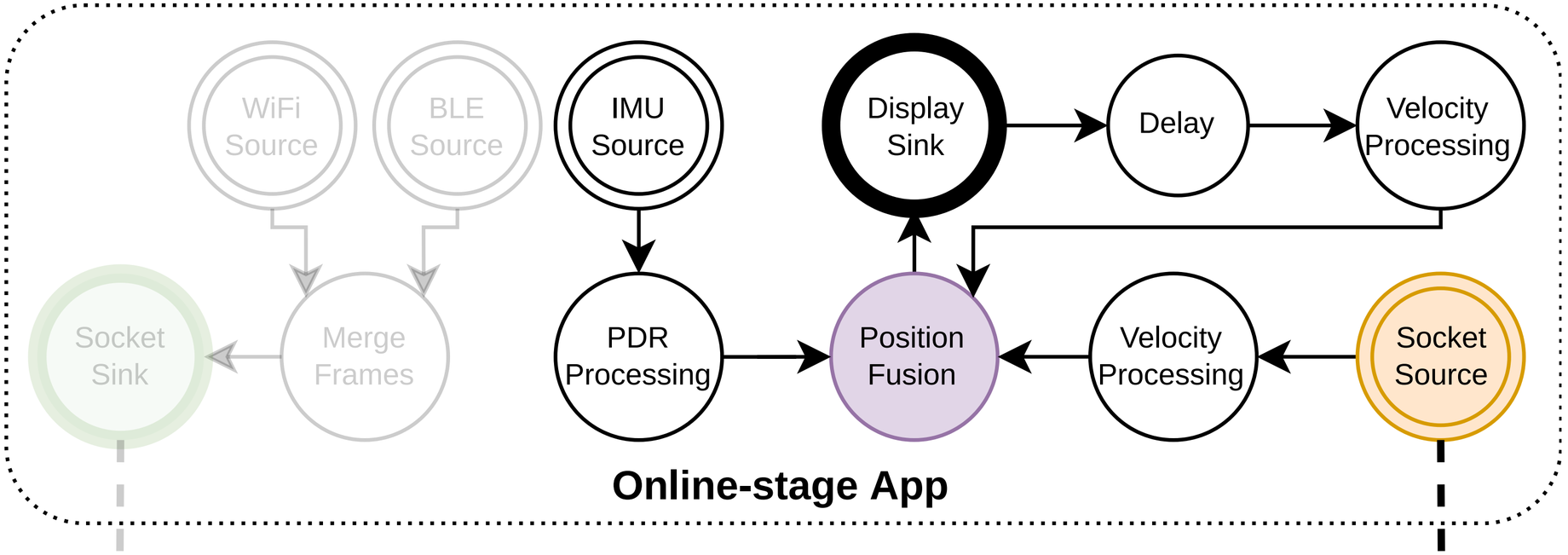
Positioning Model ...

OpenHPS



Positioning Model ...

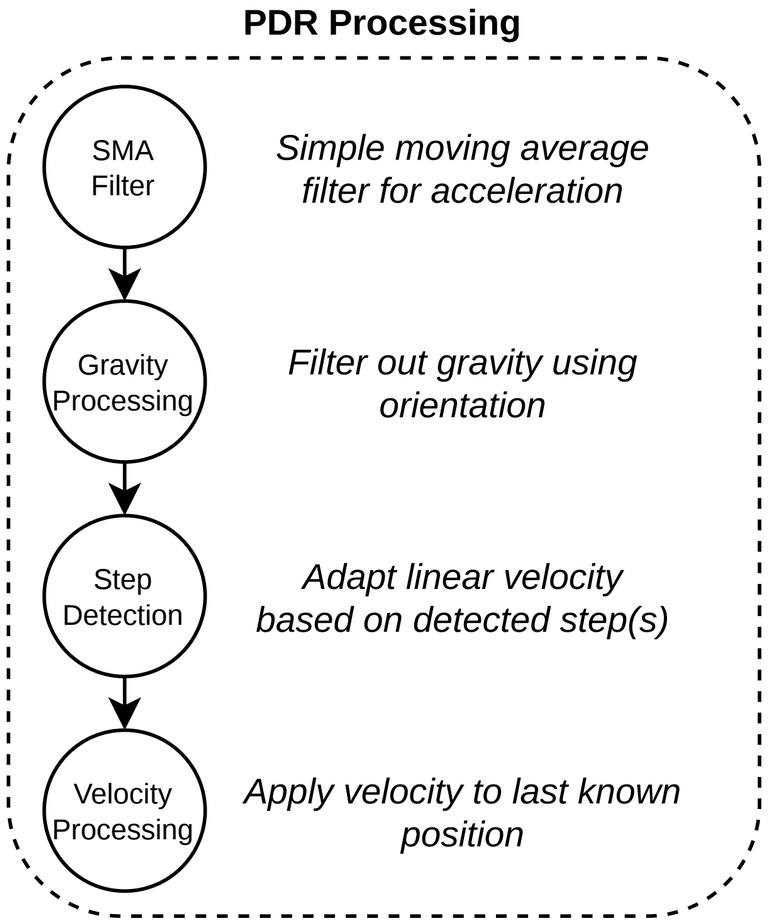
OpenHPS



Positioning Model

OpenHPS

Online App



Positioning Model

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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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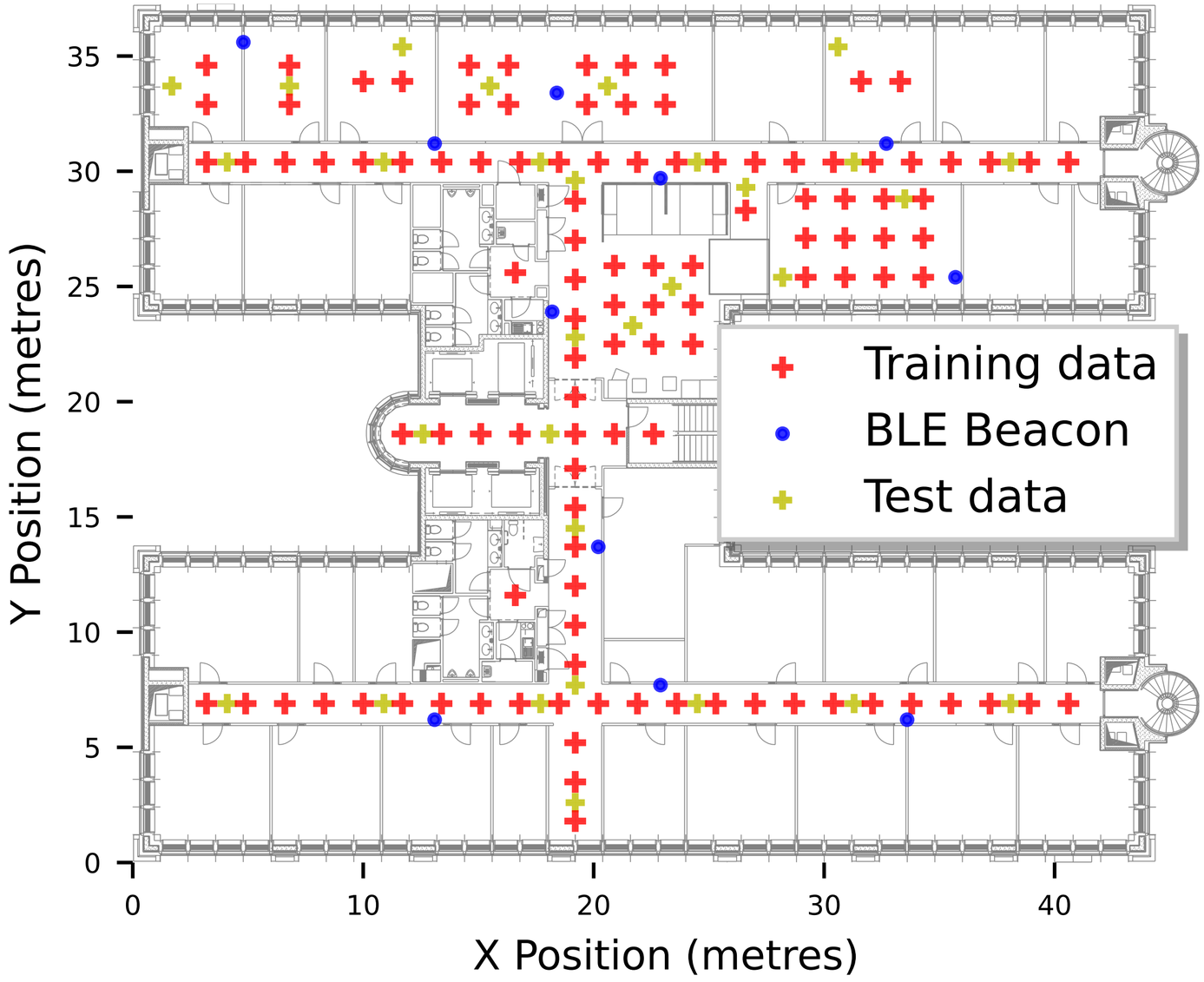

Dataset …

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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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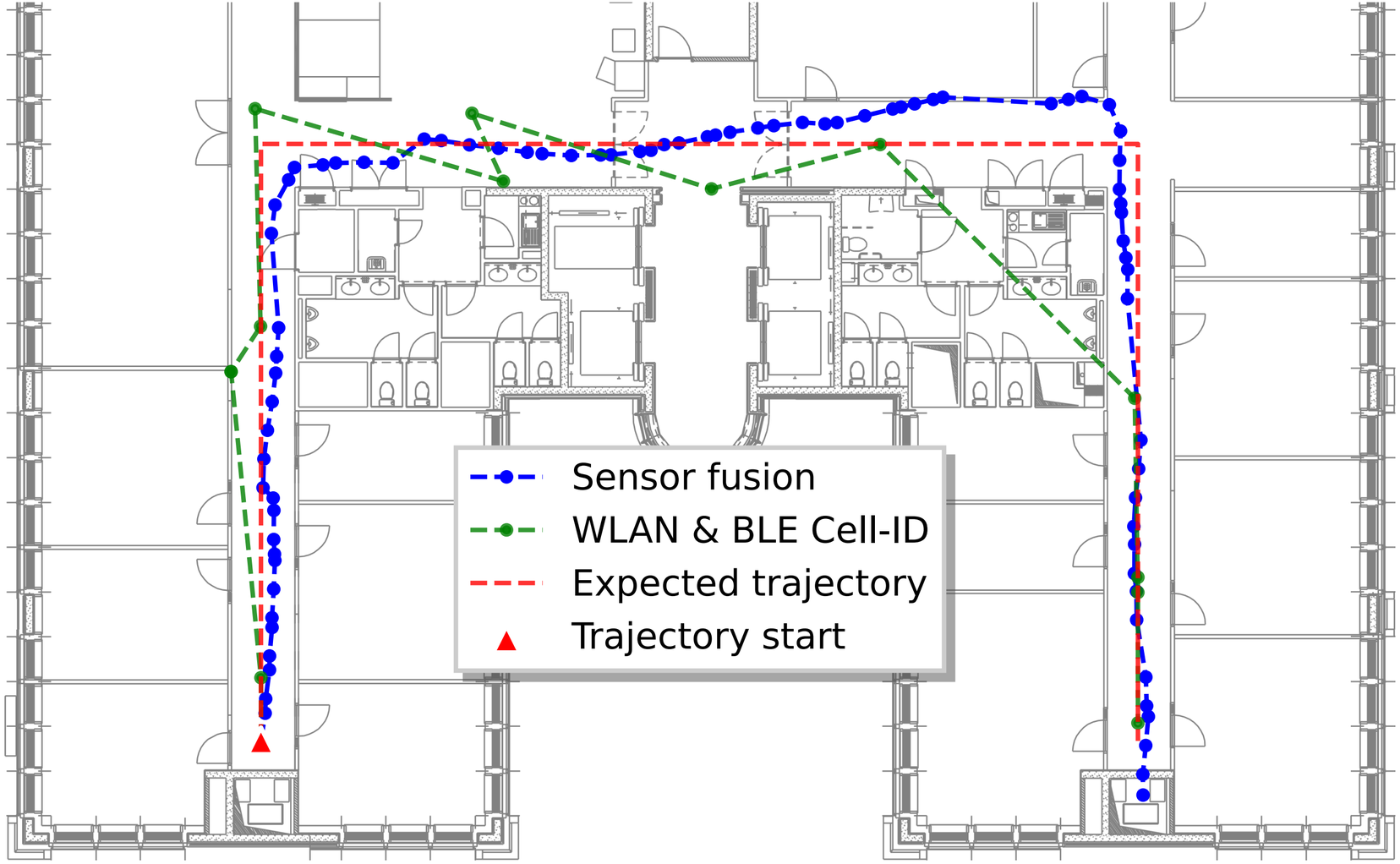
Static Positioning

	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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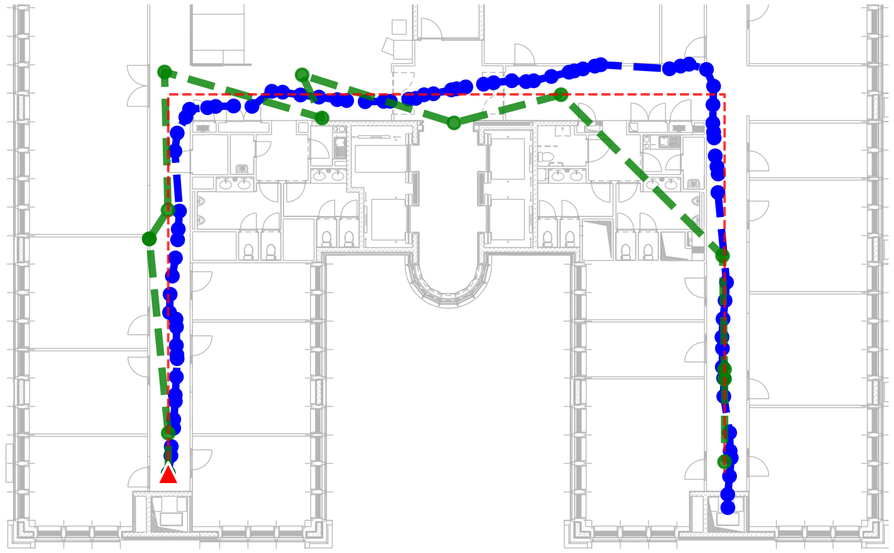
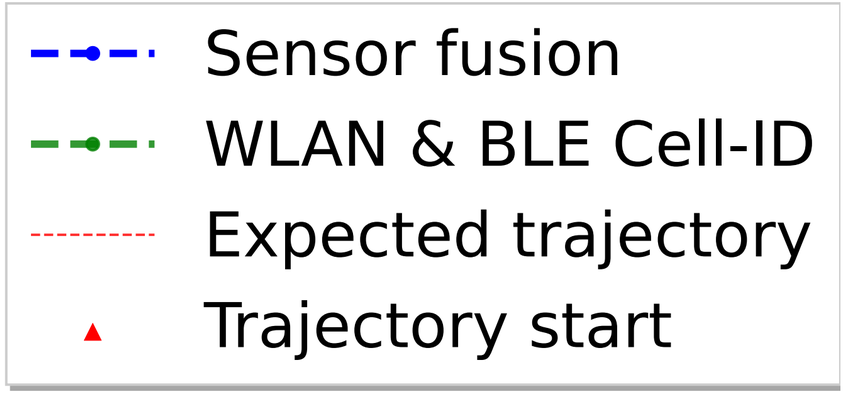
Trajectories

	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!