

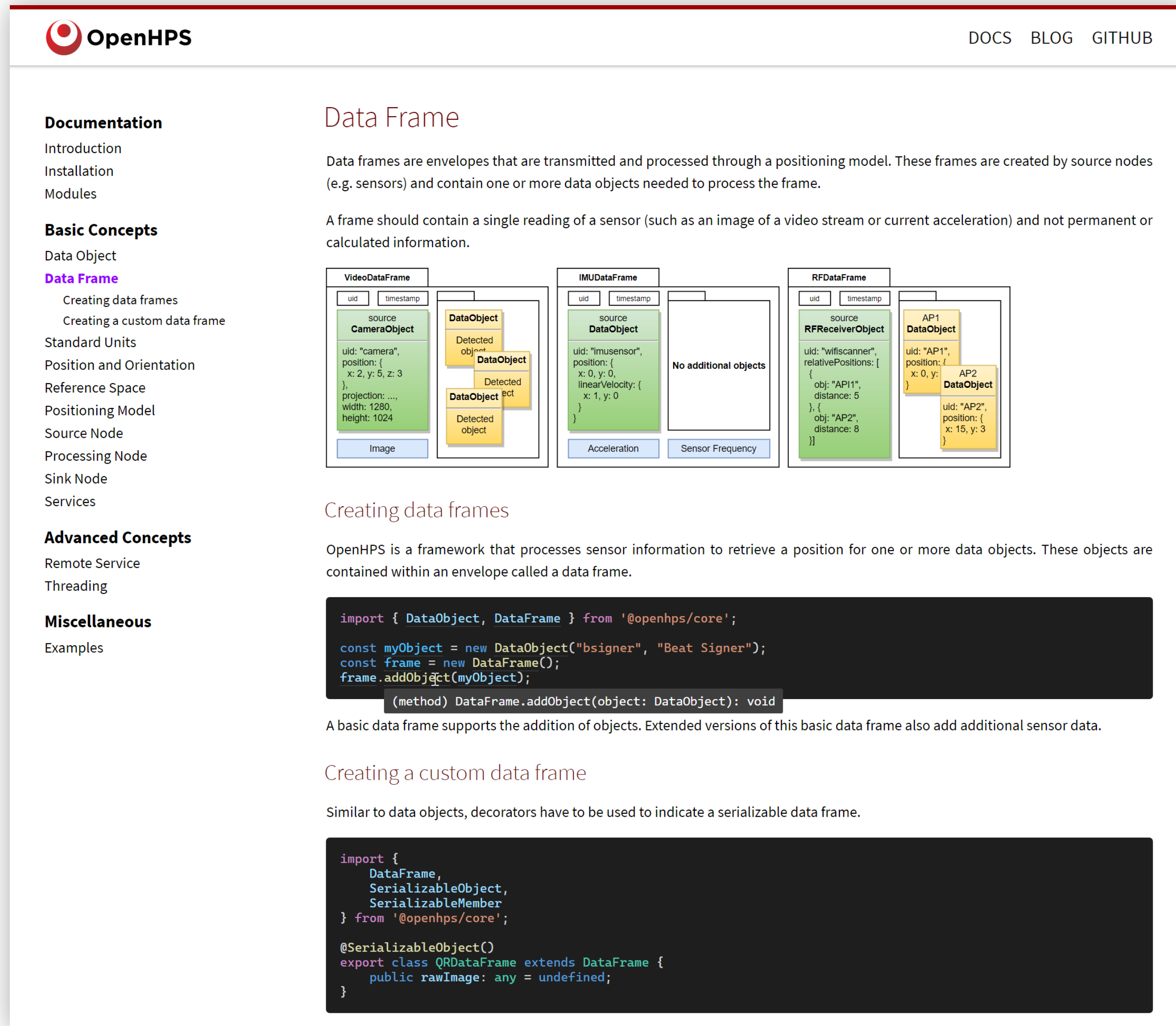
# Indoor Positioning Using the OpenHPS Framework

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Maxim Van de Wynckel, Beat Signer

*Web & Information Systems Engineering Lab  
Vrije Universiteit Brussel*

# An Open Source Hybrid Positioning System



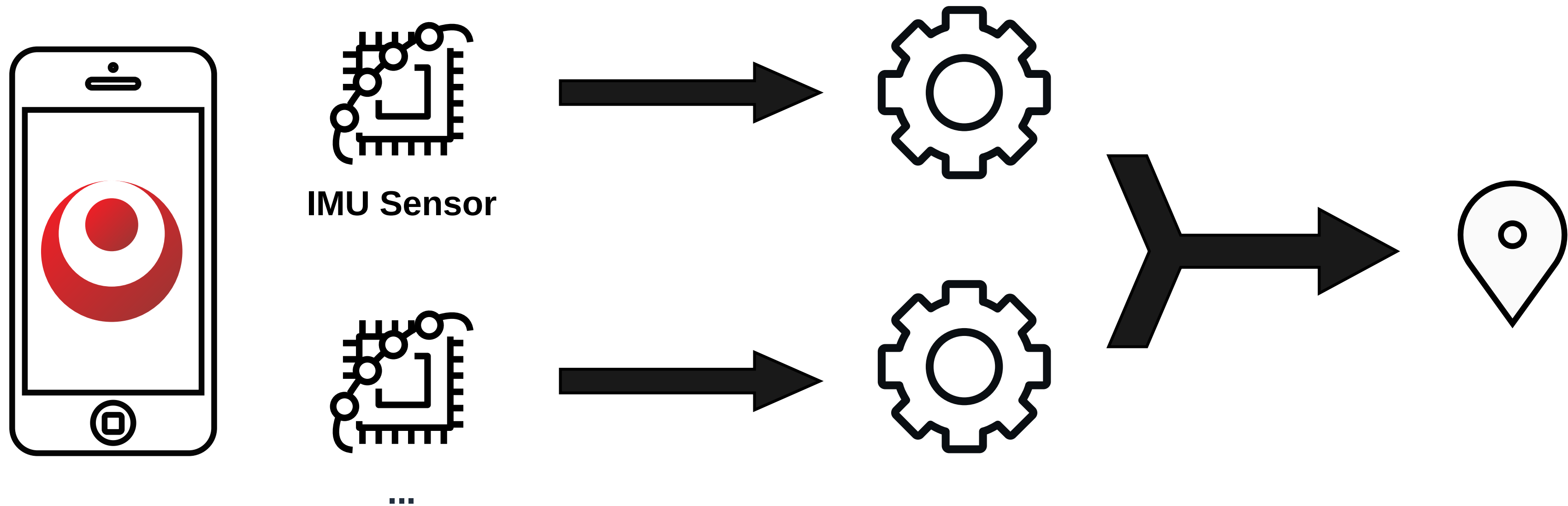
# What is OpenHPS?



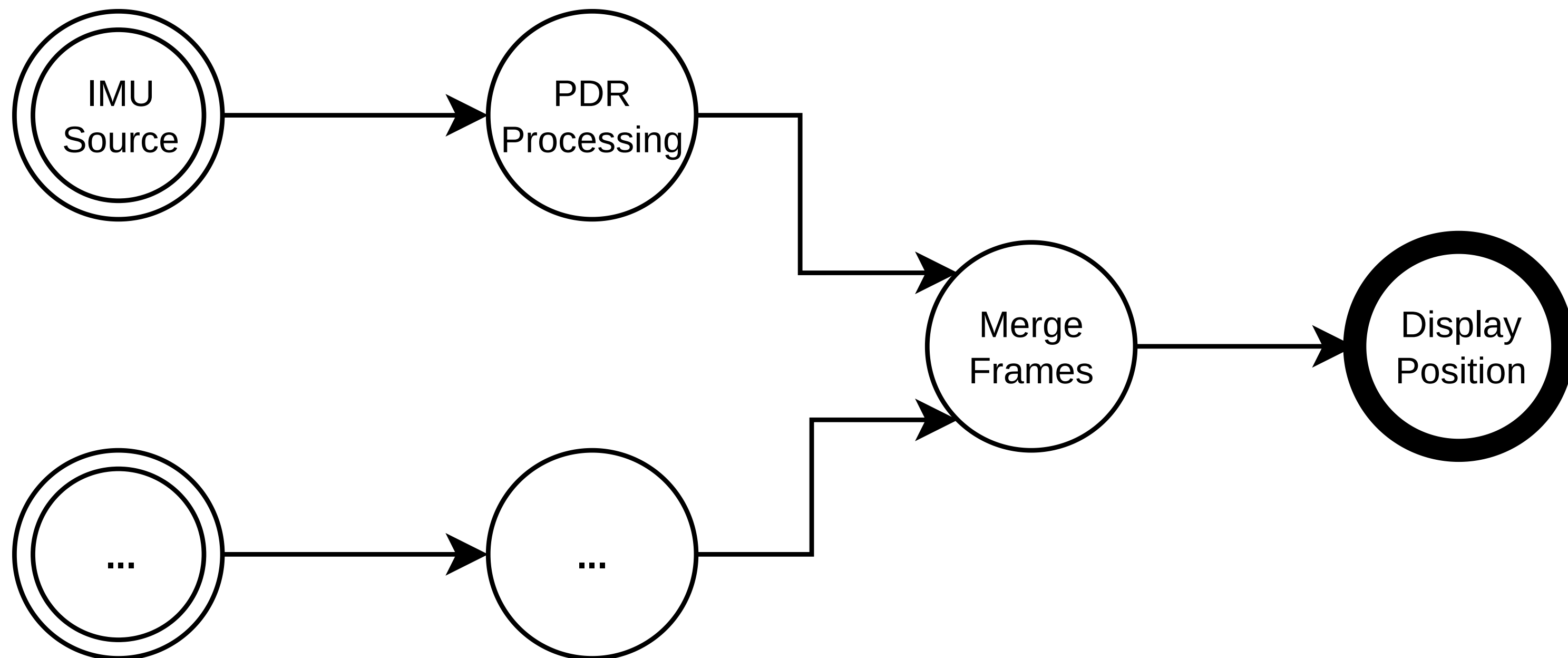
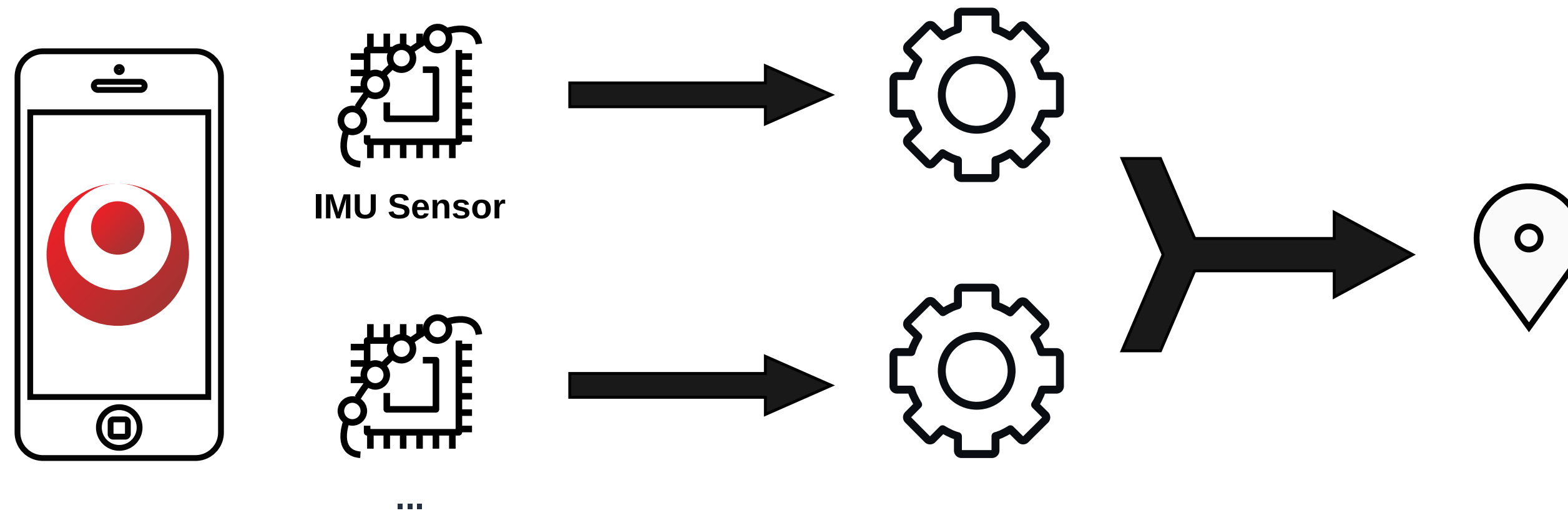
## An Open Source Hybrid Positioning System

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

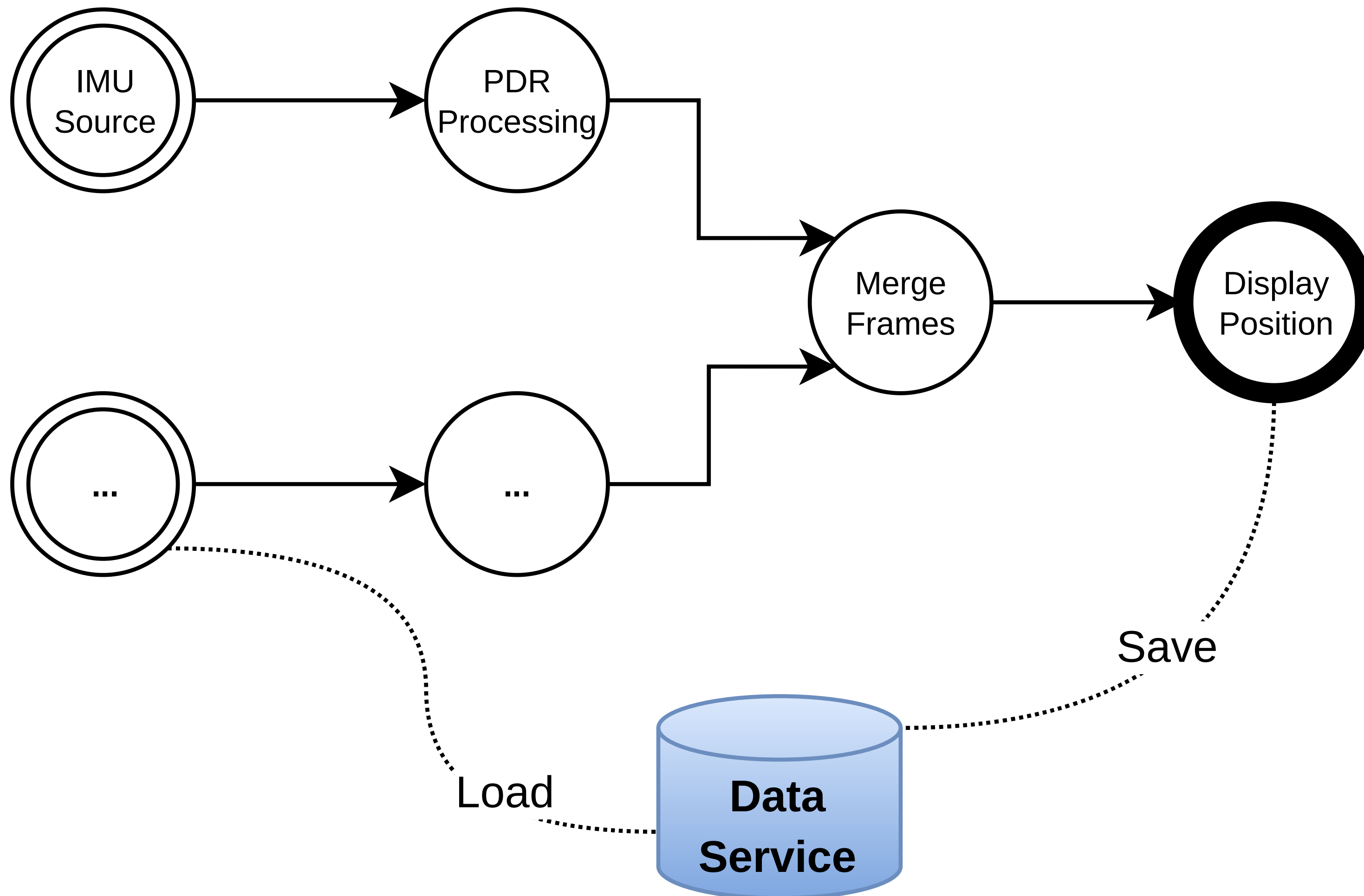
# Process Network Design



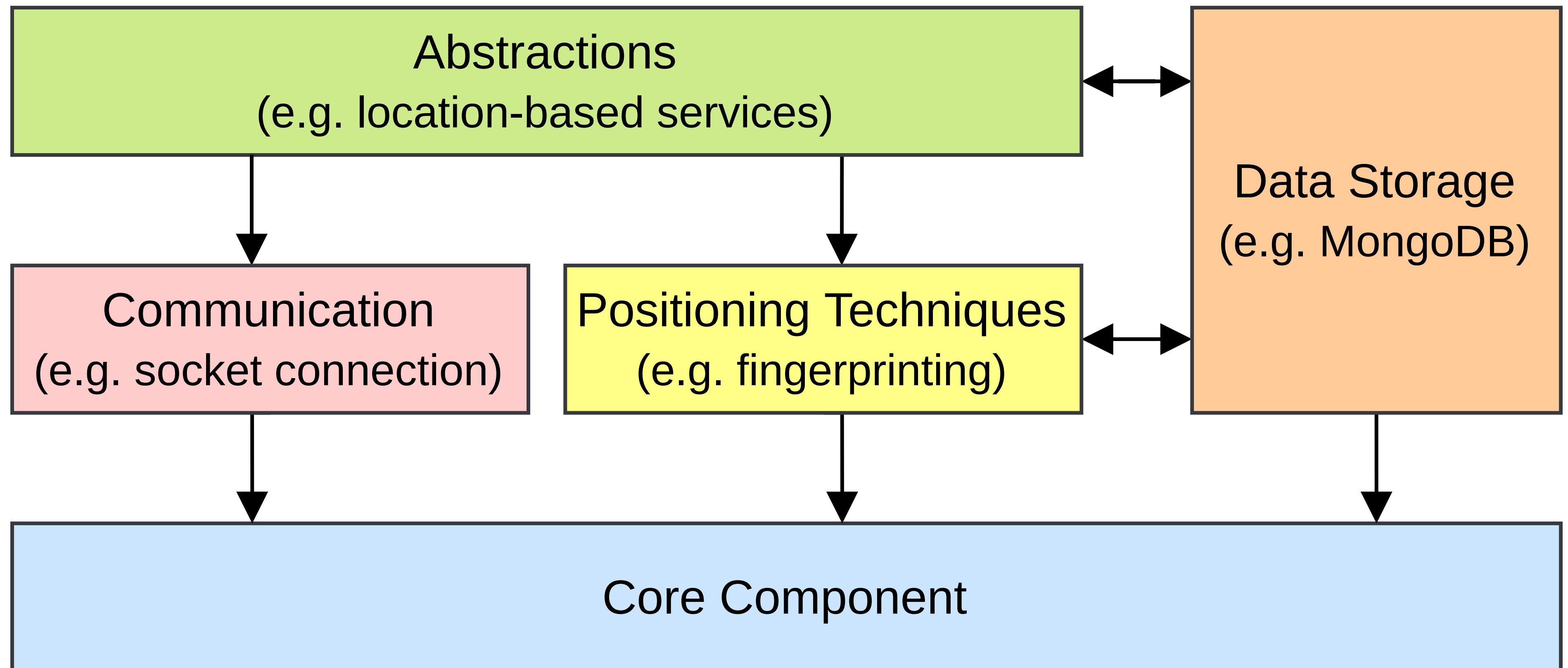
# Process Network Design ...



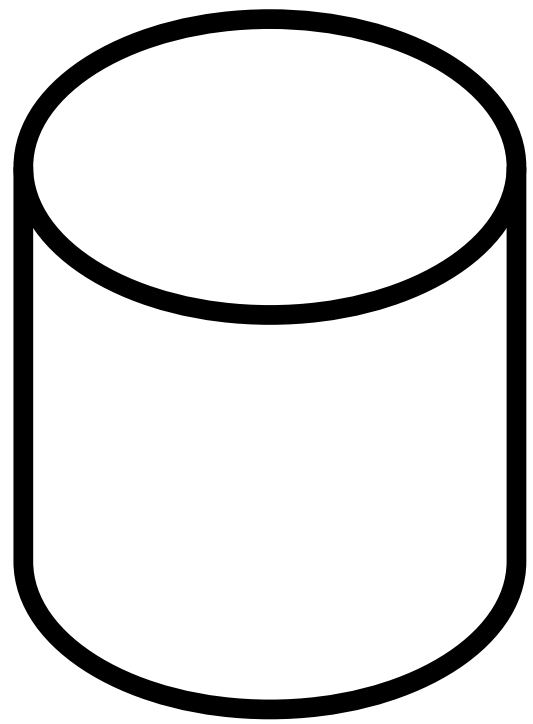
# Process Network Design ...



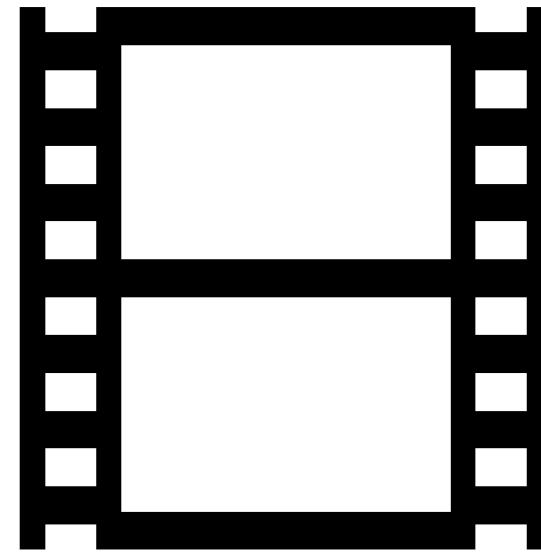
# Modularity



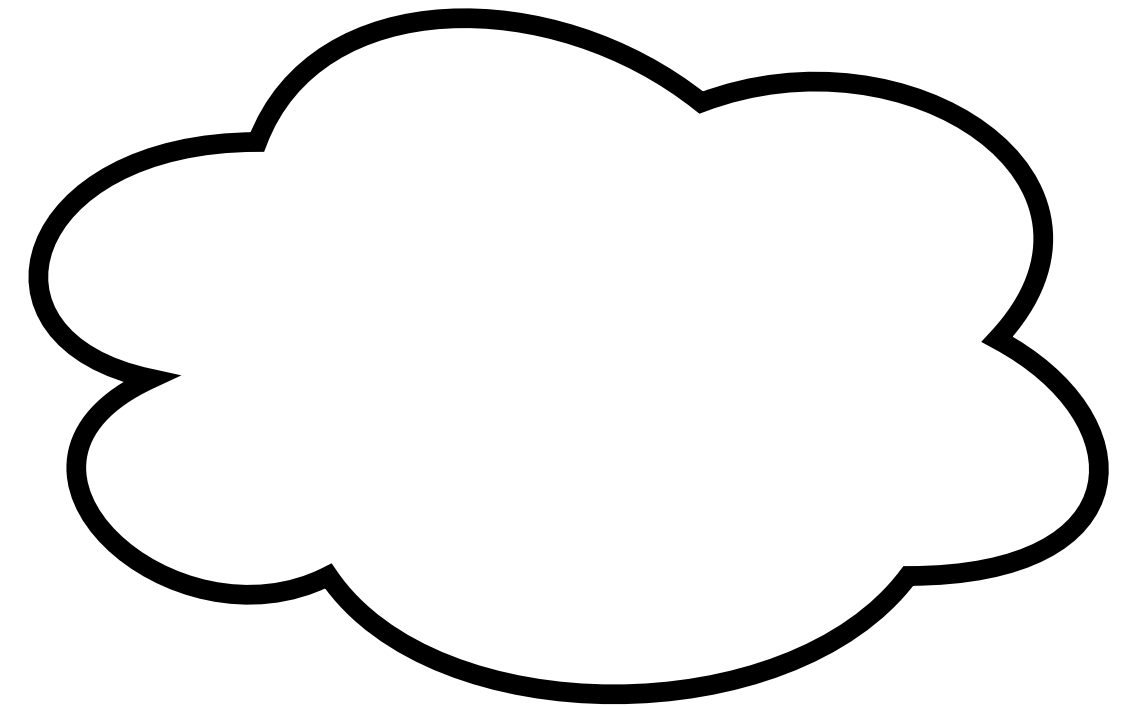
# Data Processing



**Knowledge**



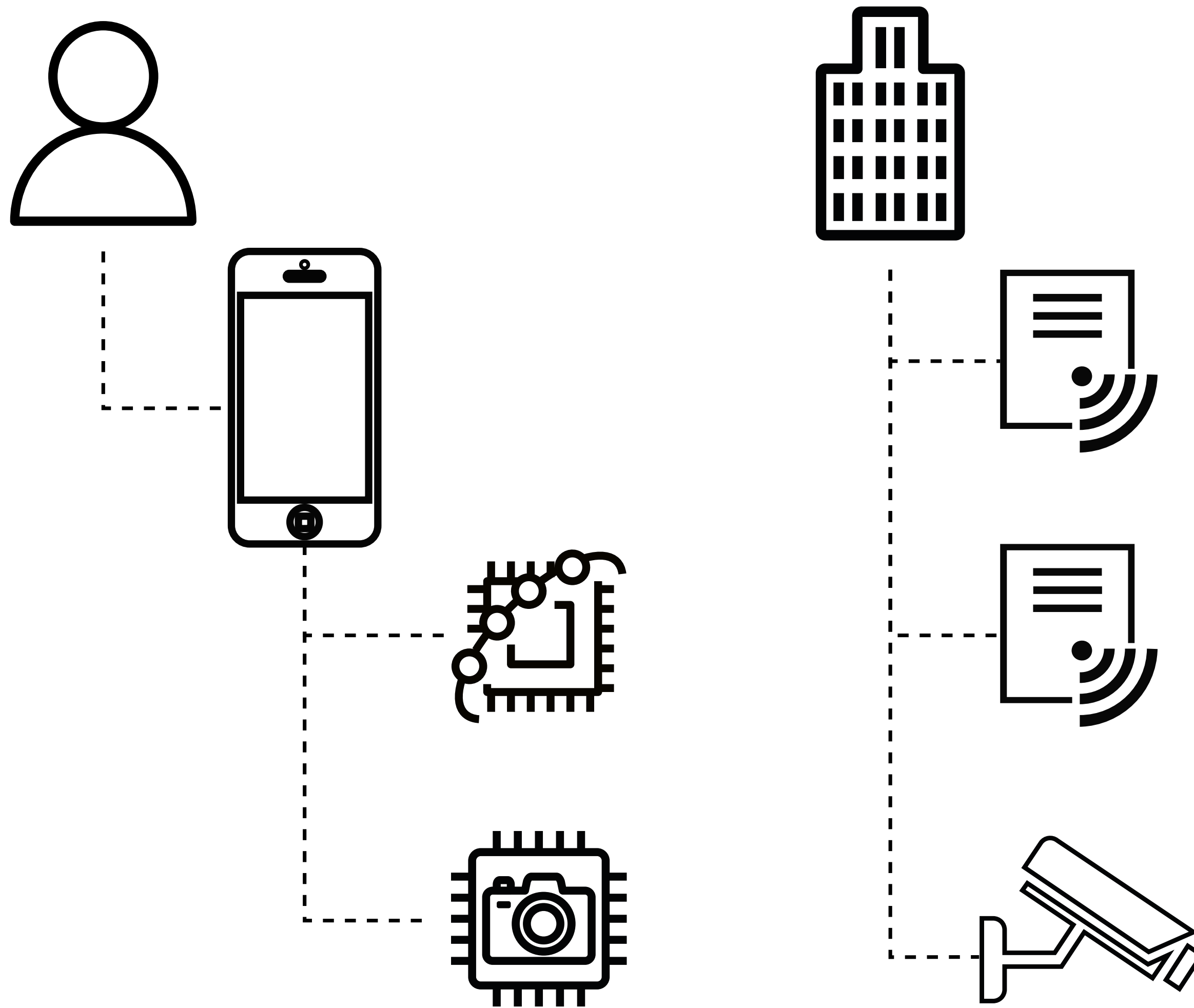
**Raw Data**



**Processed Data**



# DataObject



# Absolute and Relative Positions

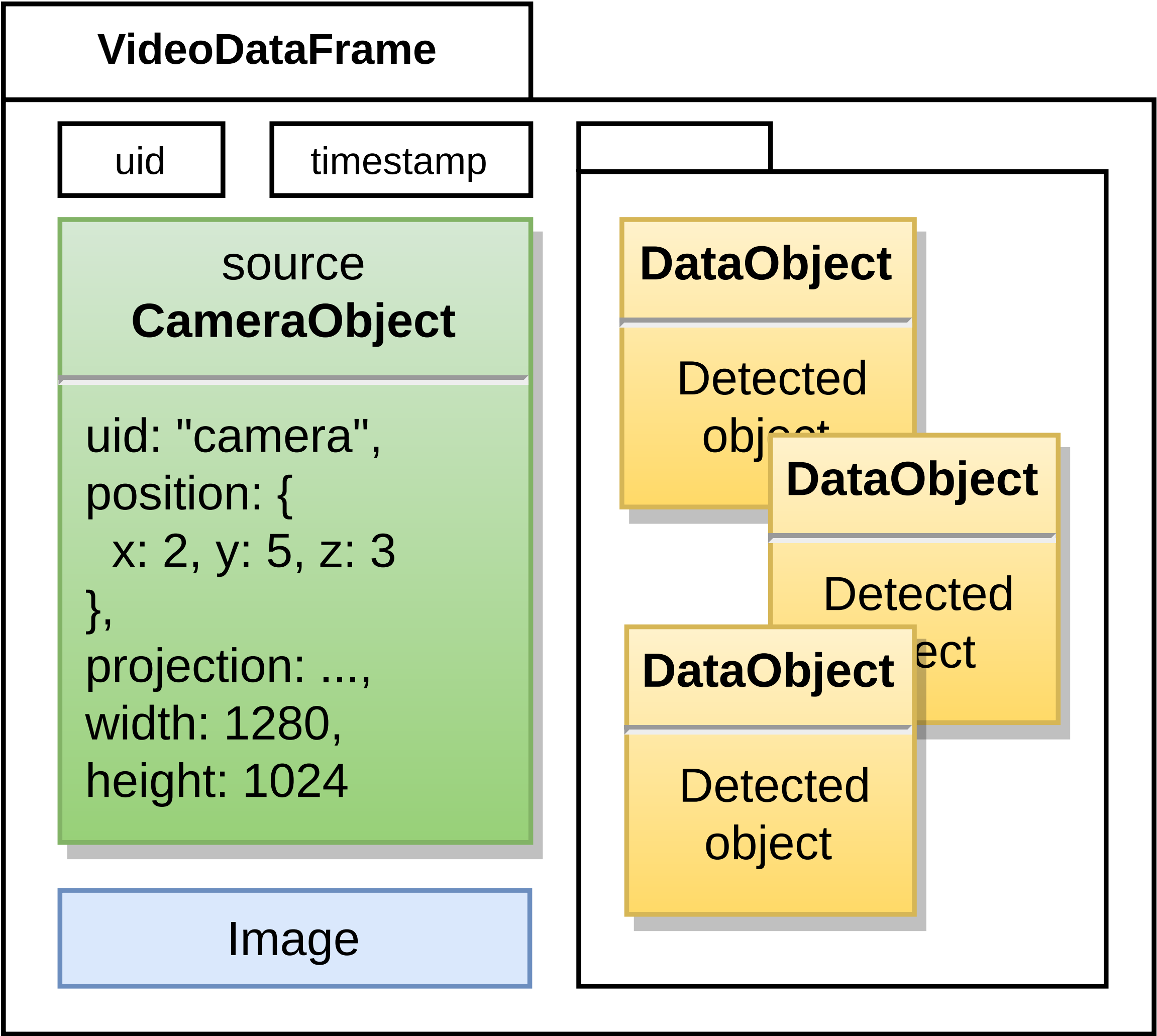
## Absolute

- ▶ 2D, 3D, Geographical, ...

## Relative

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

# DataFrame



# SymbolicSpace

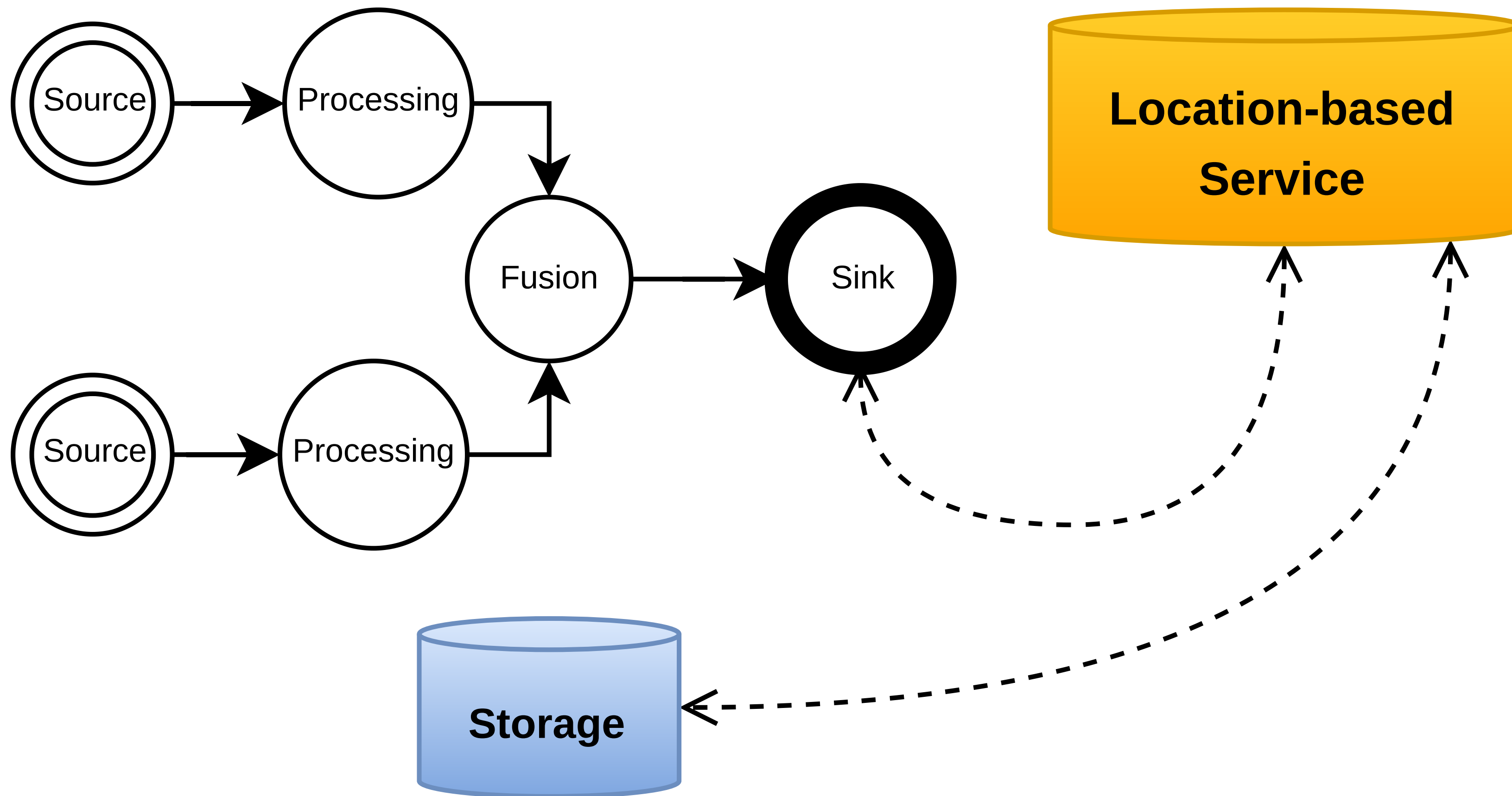
*An object that semantically defines a space*

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



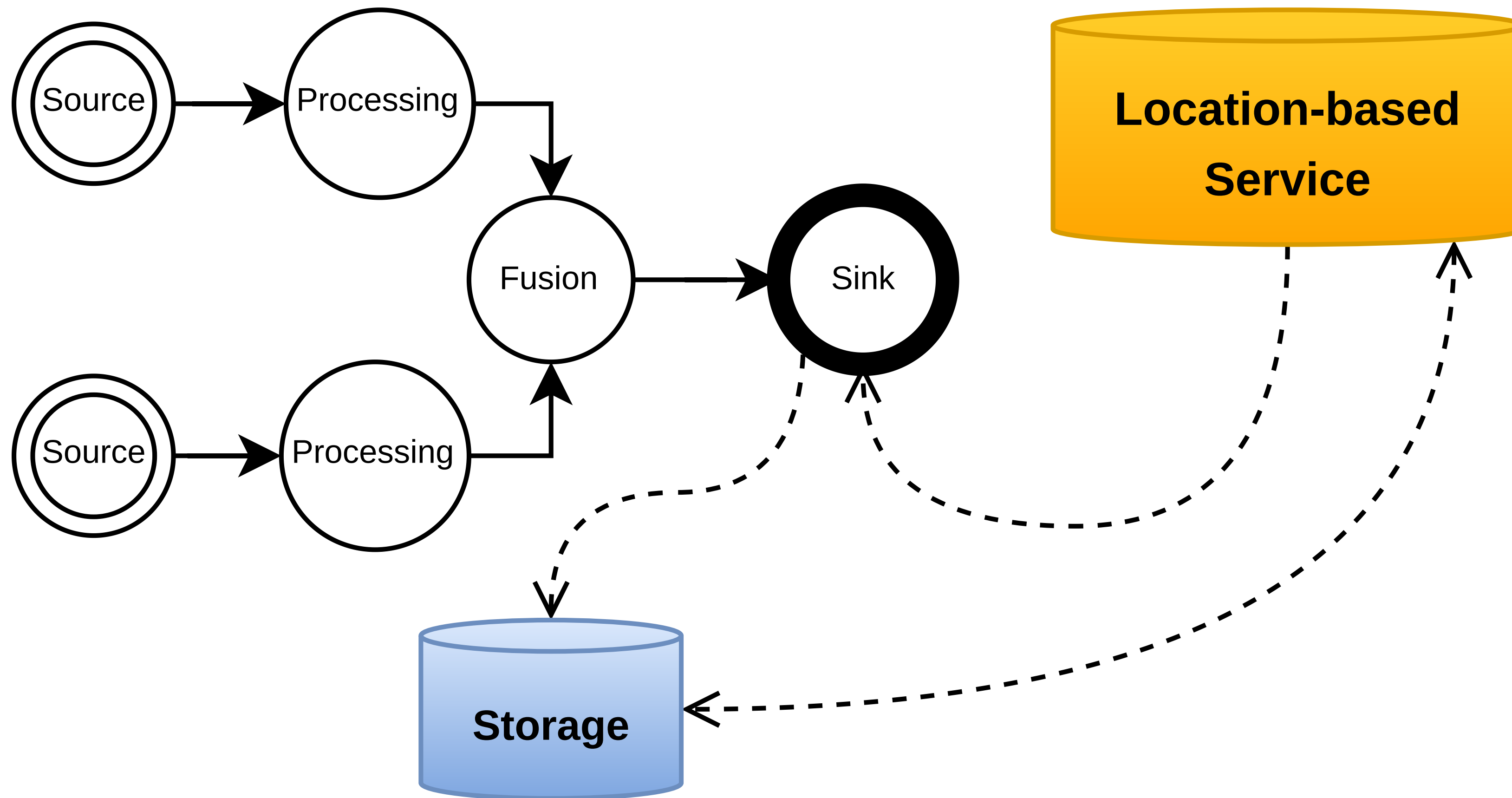
# Location-based Service

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



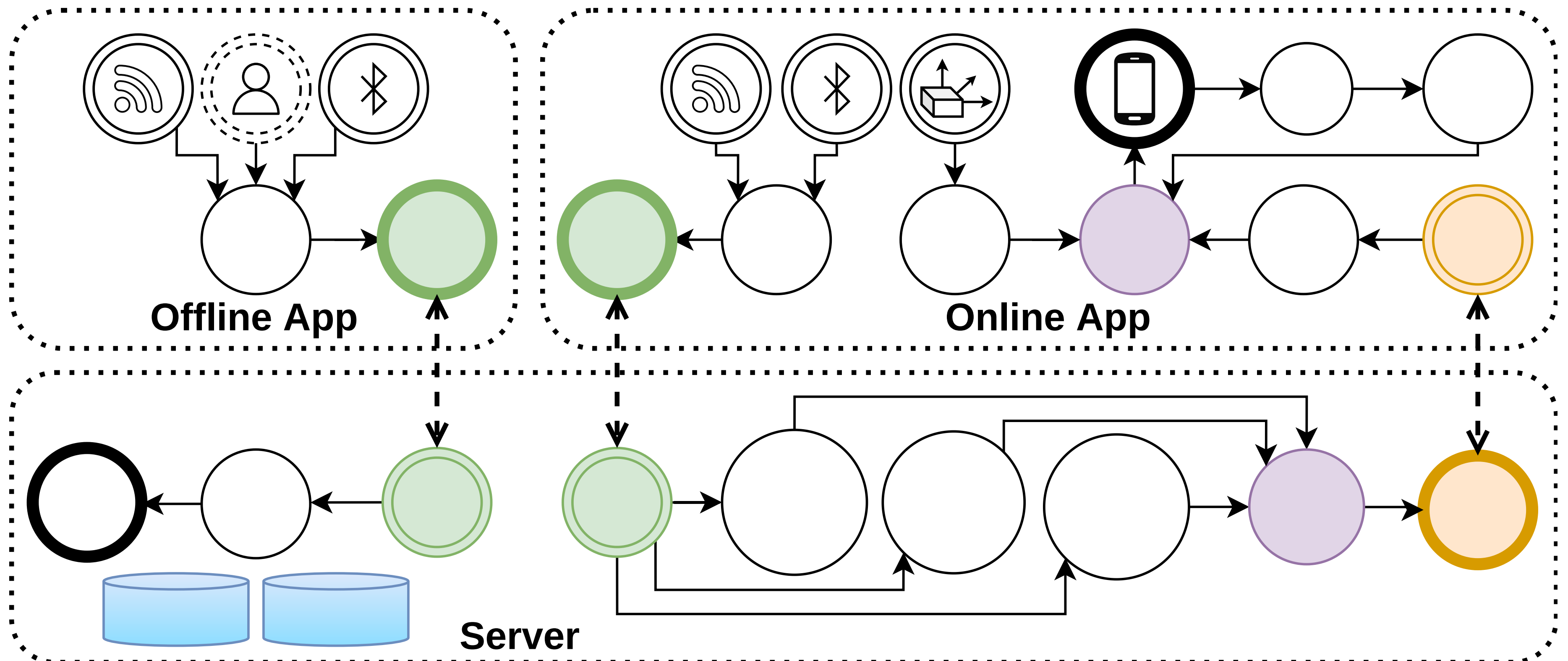
# Location-based Service ...

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



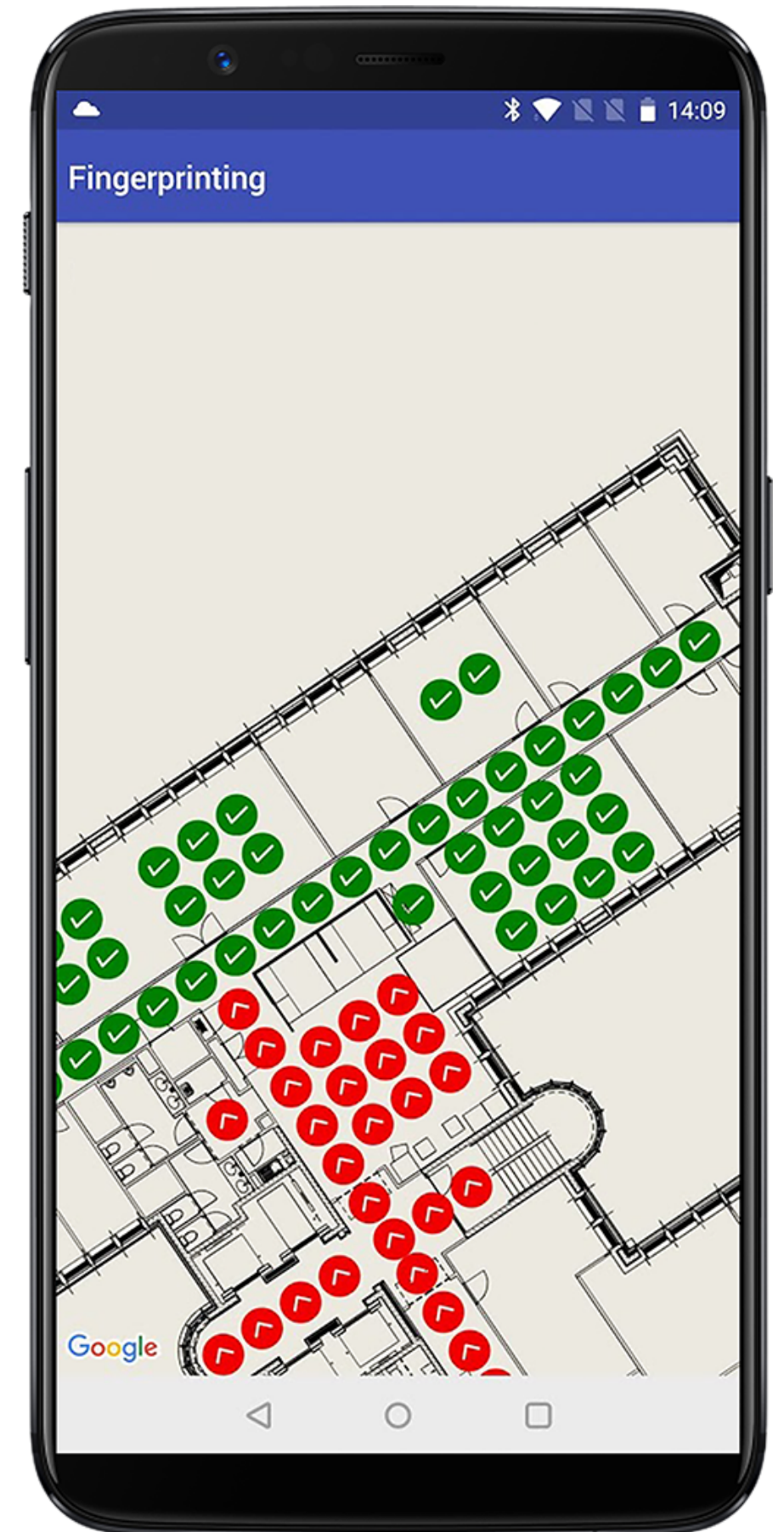
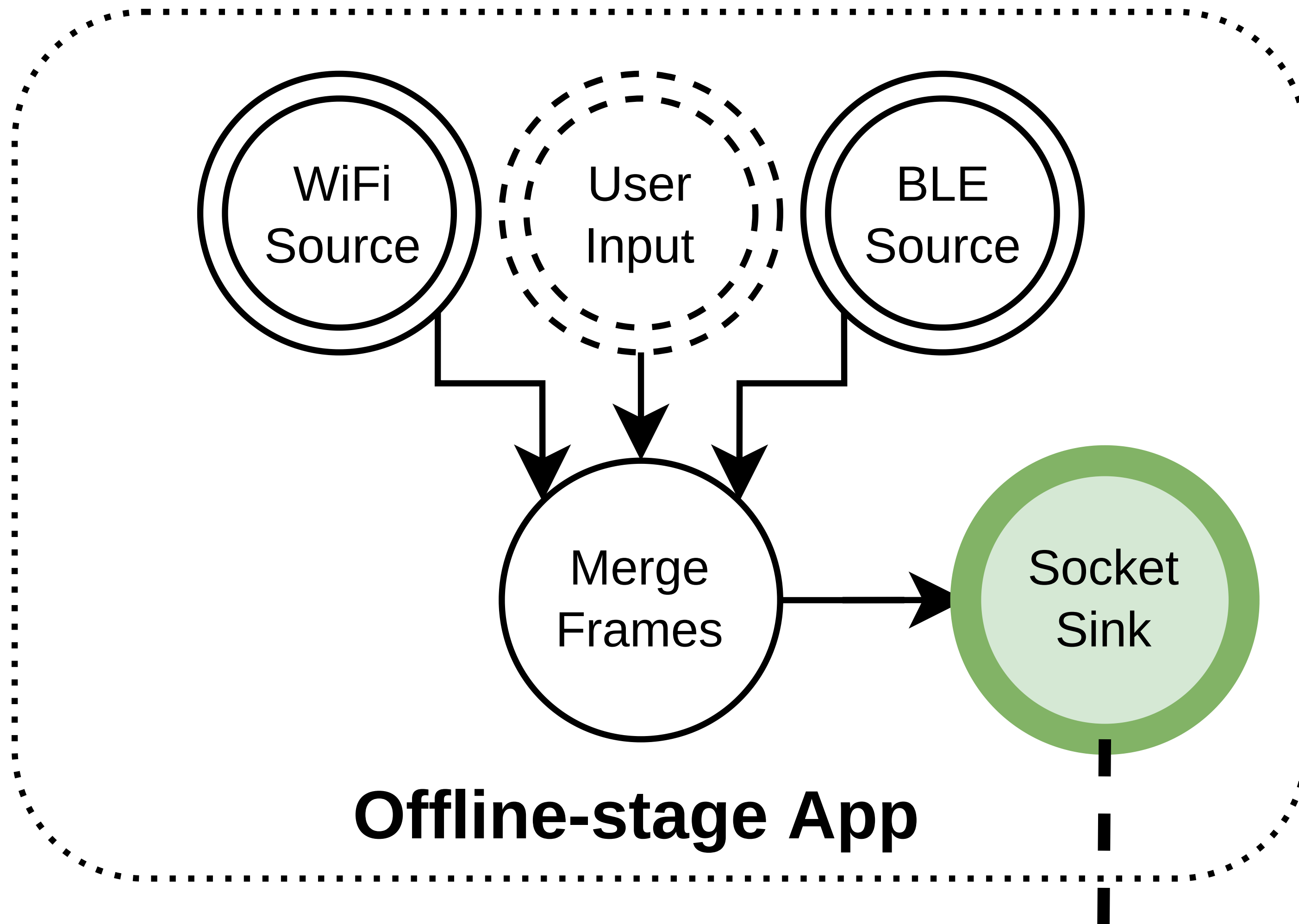
# Demonstration

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



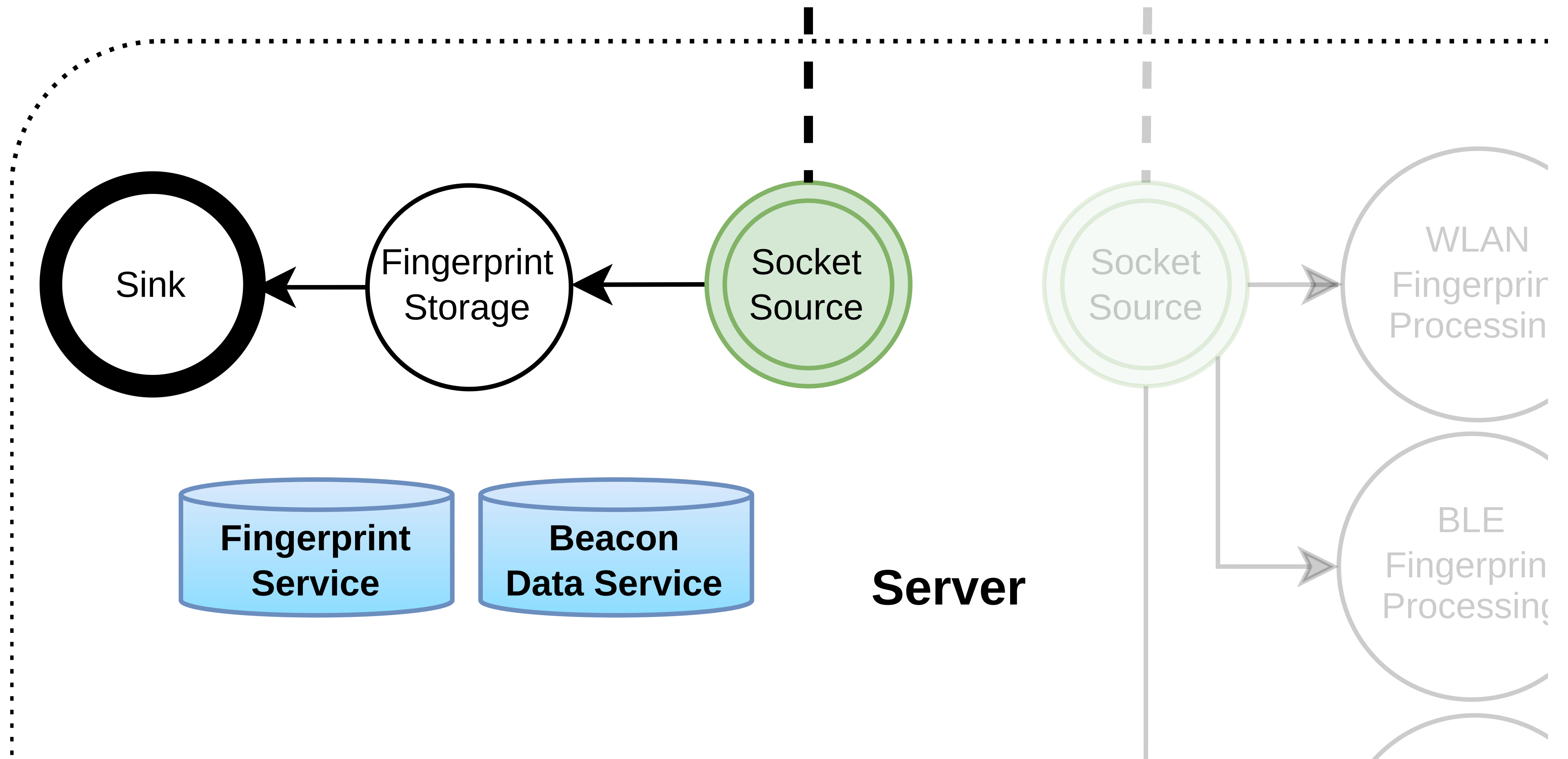


# Positioning Model

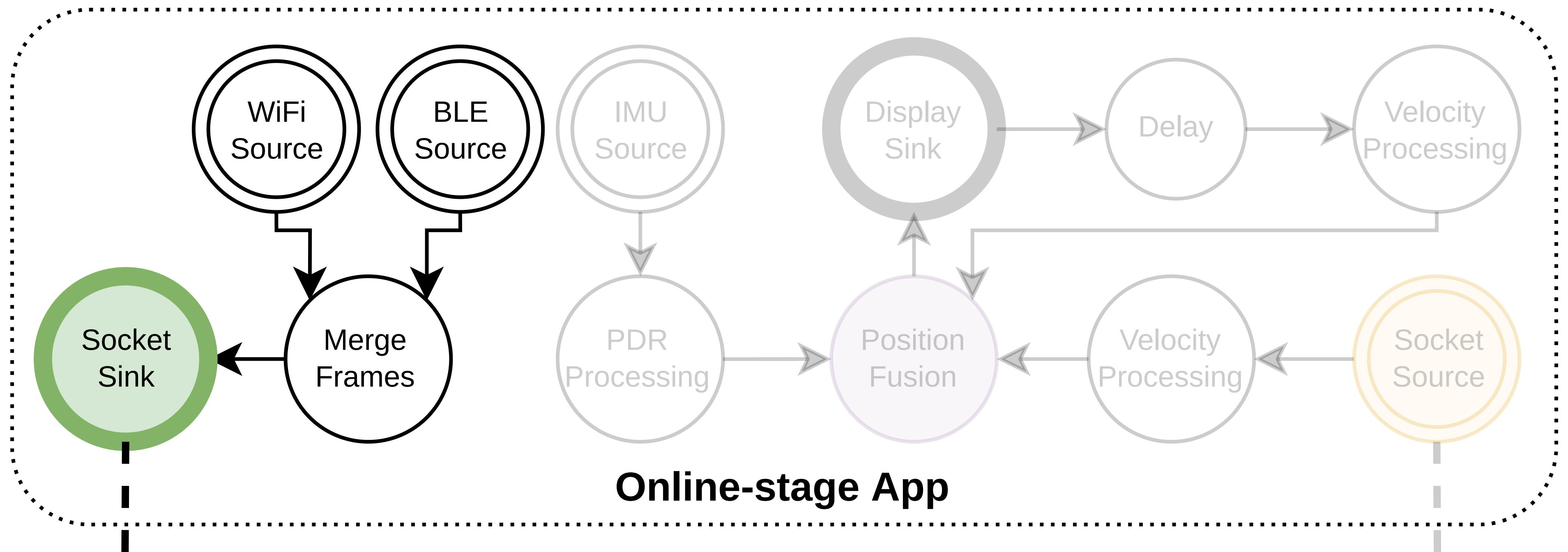




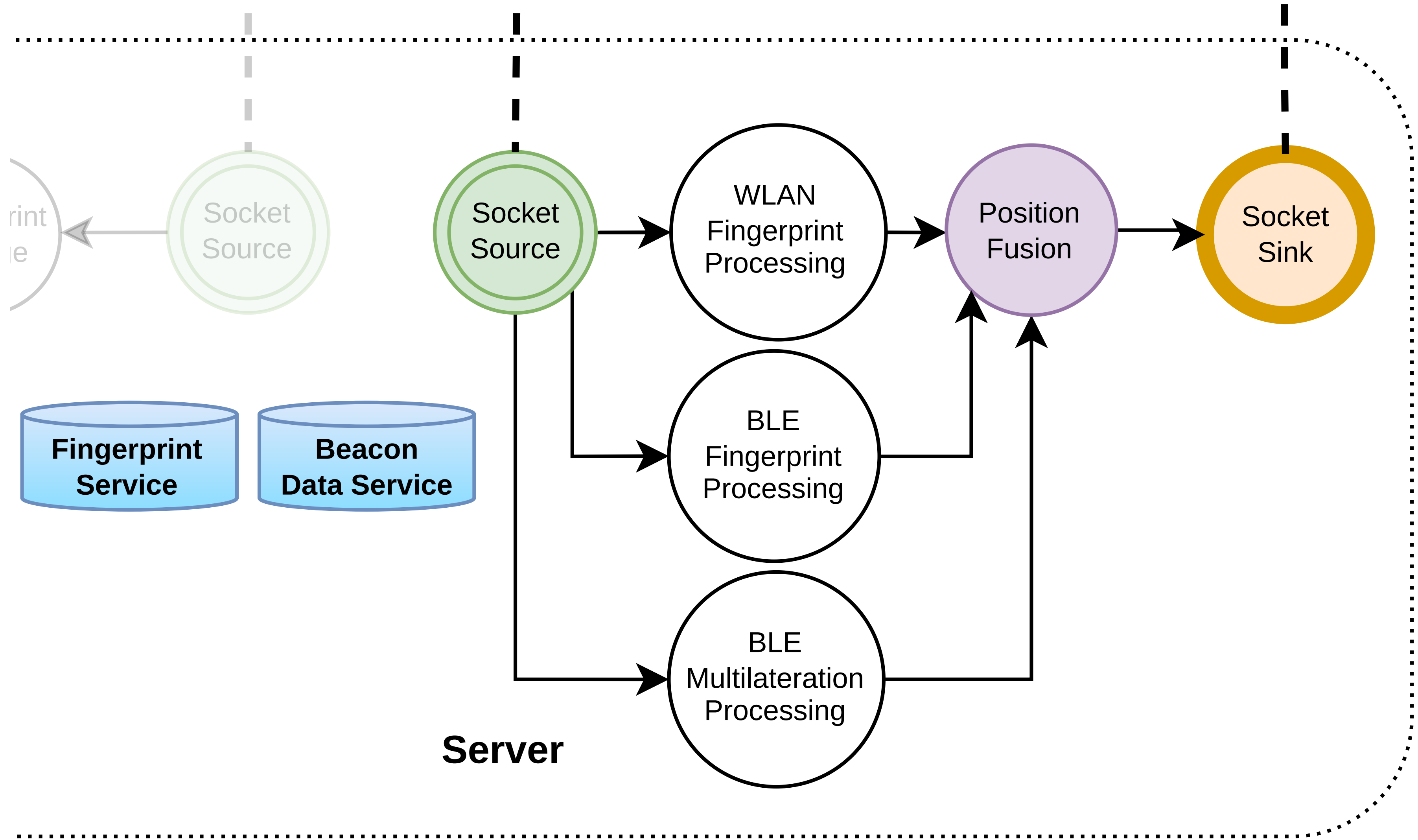
# Positioning Model ...



# Positioning Model ...

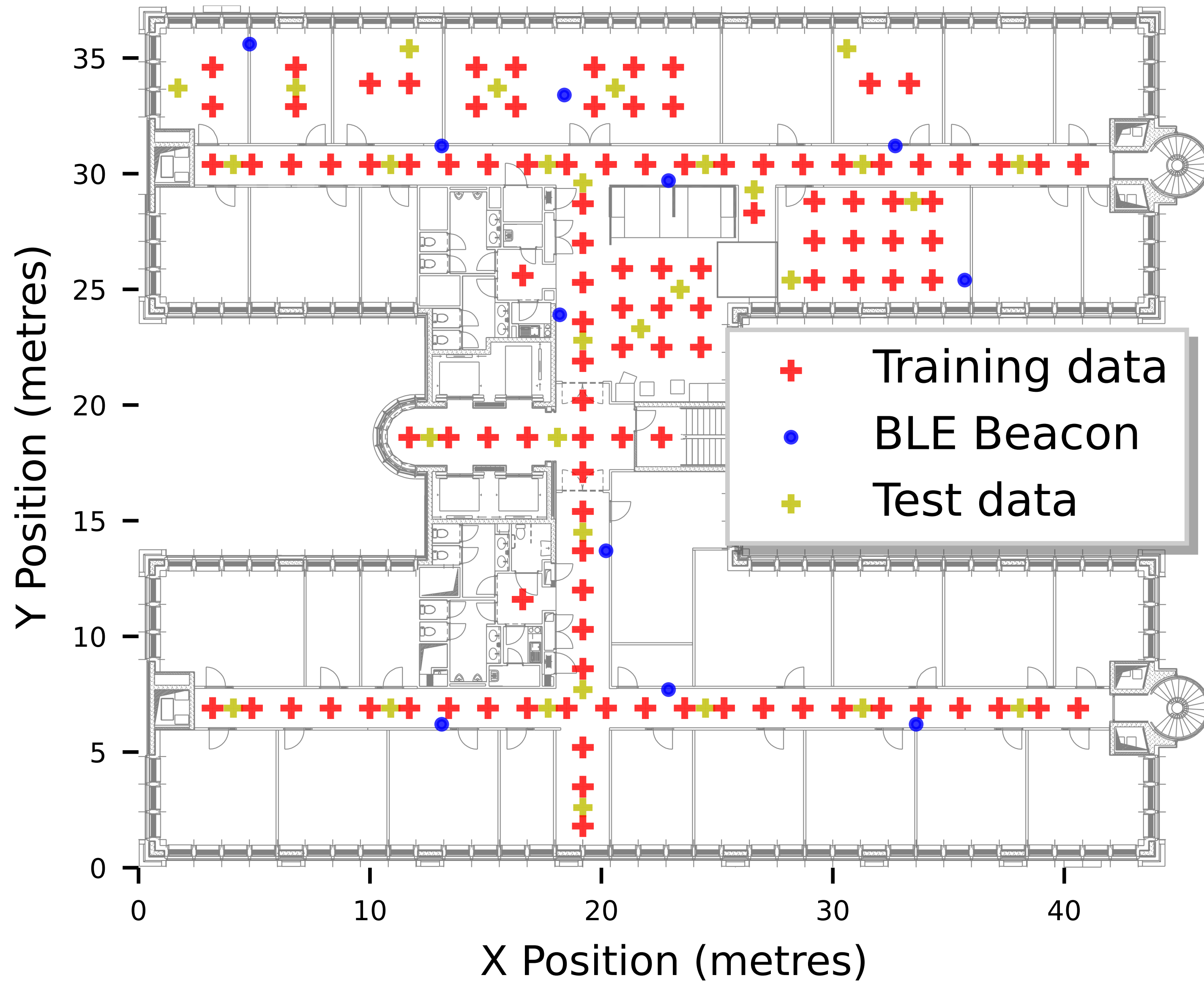


# Positioning Model ...





# Dataset



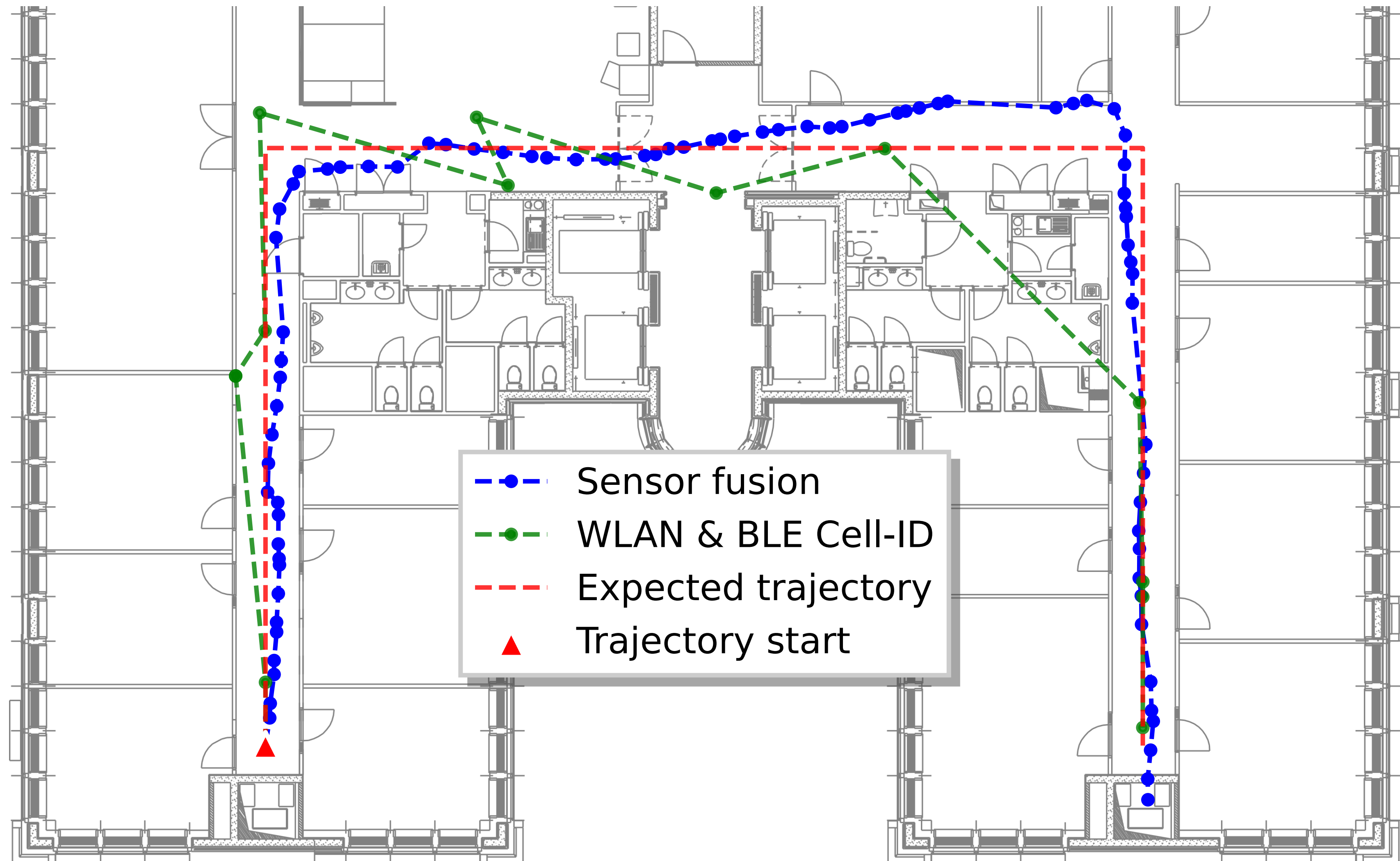
# Validation Results

## Static Positioning

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

# Validation Results ...

## Trajectories

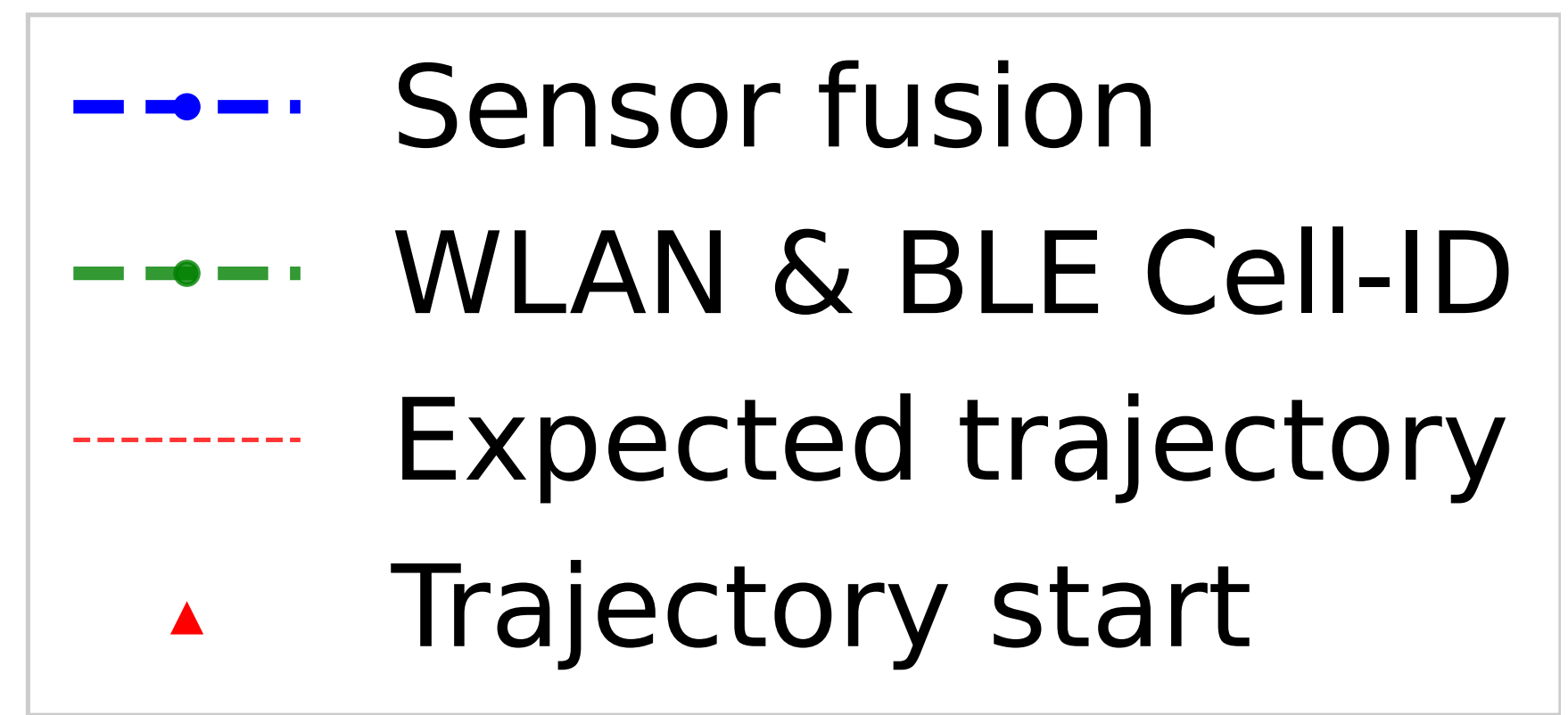




# Validation Results ...

## Trajectories

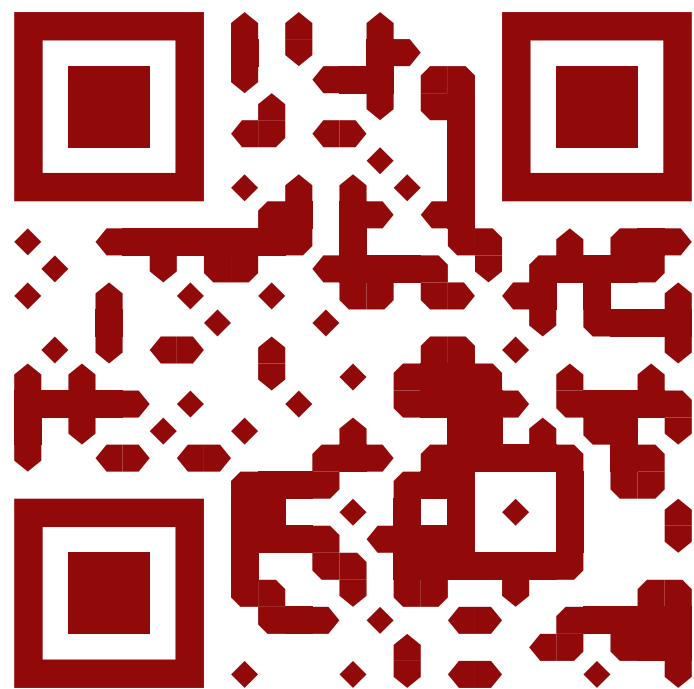
	WLAN + BLE	WLAN + BLE + IMU
<i>average error</i>	3.28 m	1.26 m
<i>maximum error</i>	9.60 m	3.10 m
<i>average update frequency</i>	3.04 s	0.52 s





# Contributions and Conclusions

- ▶ 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!