Hochschule für Technik
Stuttgart

HOCHSCHULE LUZERN
Engineering & Architecture

iHomeLab

The iLoc indoor localisation system

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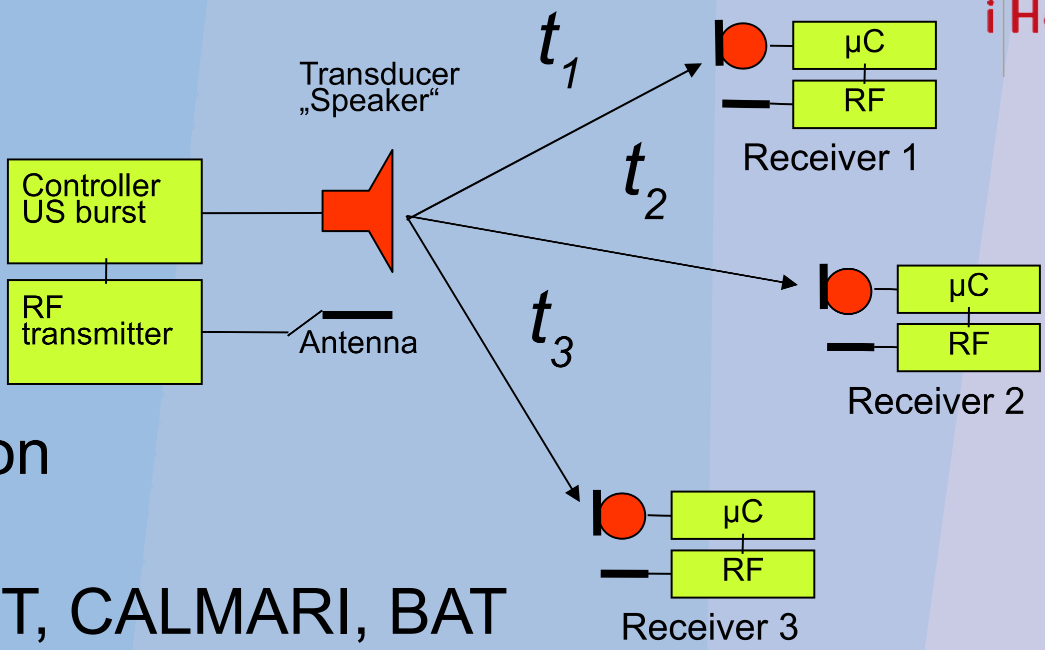
The iHomeLab is the Swiss platform for ...
- Smart Home and AAL Research & Education
- newest Building Automation Products & Trends
- Events and Presentations
- National and International Partner Projects

The Embedded Systems Lab at HFT Stuttgart
- is the German Research Partner for indoor localisation
- embedded and geo-software engineering
- National and International Partner Projects

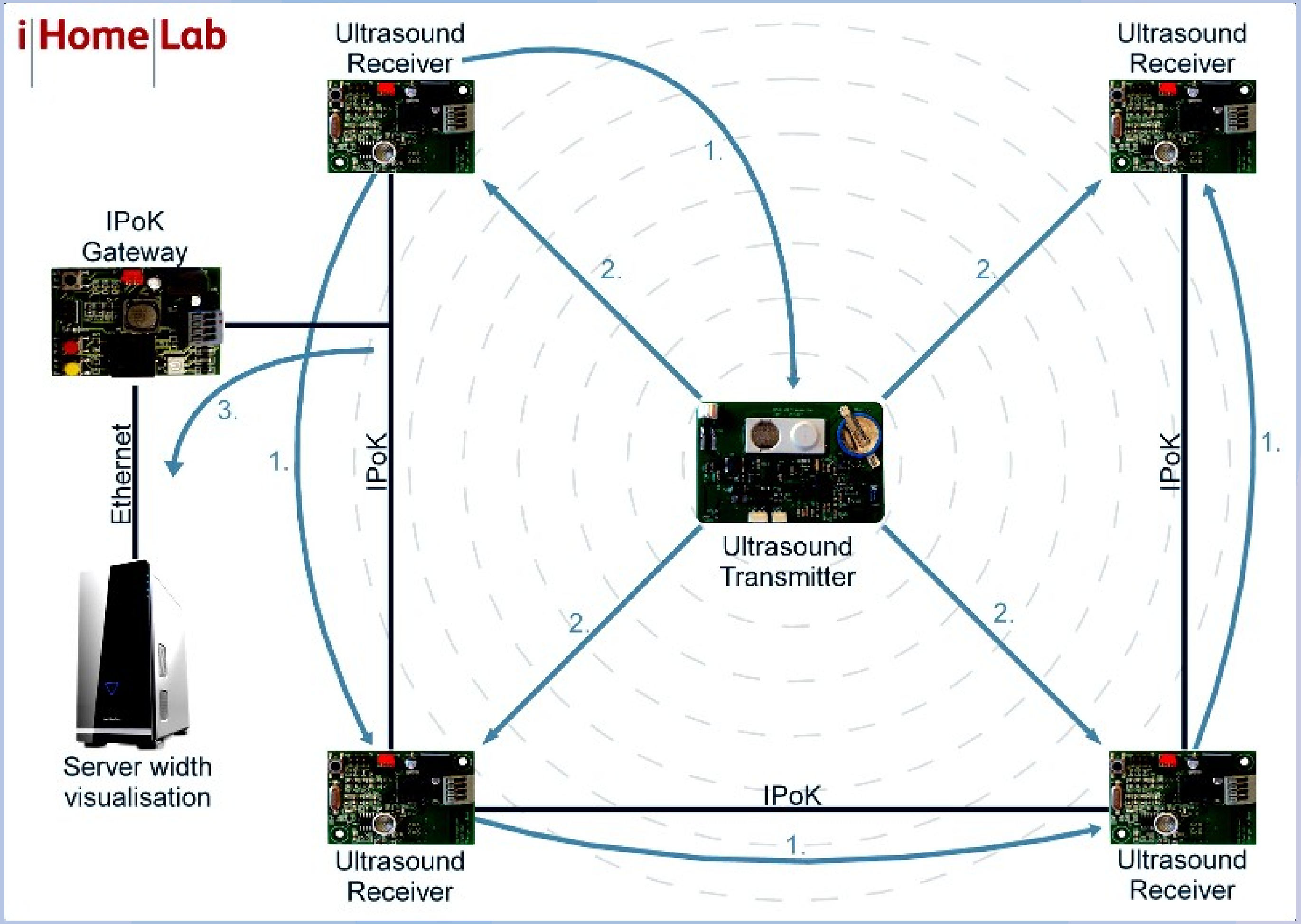
iLoc ultrasound localisation



- Ultrasound localisation
  - well established
  - Projects: CRICKET, CALMARI, BAT
  - Accuracy below 10 cm
- iLOC advantages
  - improved 2-point detection scheme (amplitude-TOA correction)
  - 2 wire backbone bus system
  - state-of-the-art hardware
  - easy deployment (.. EvAAL – approved !)

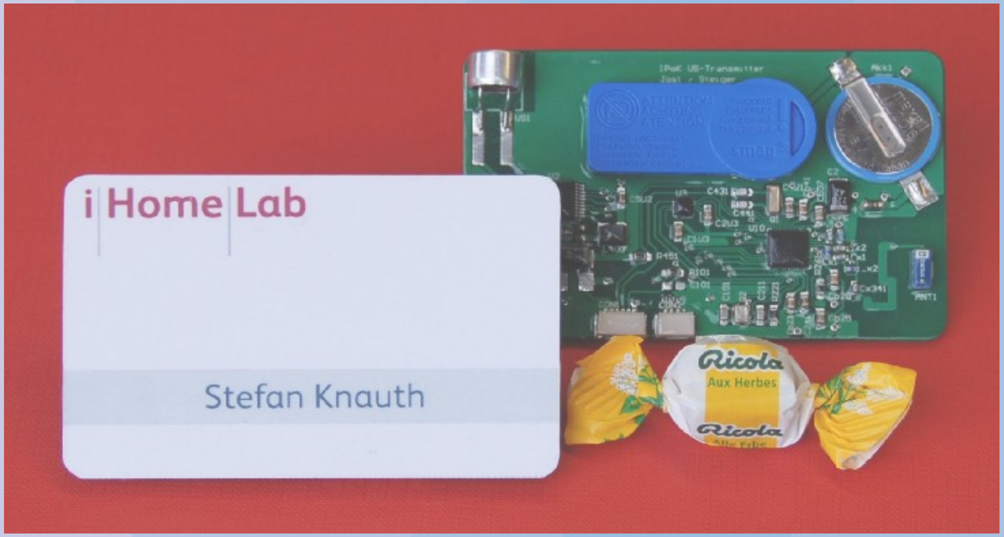
Principle of Operation

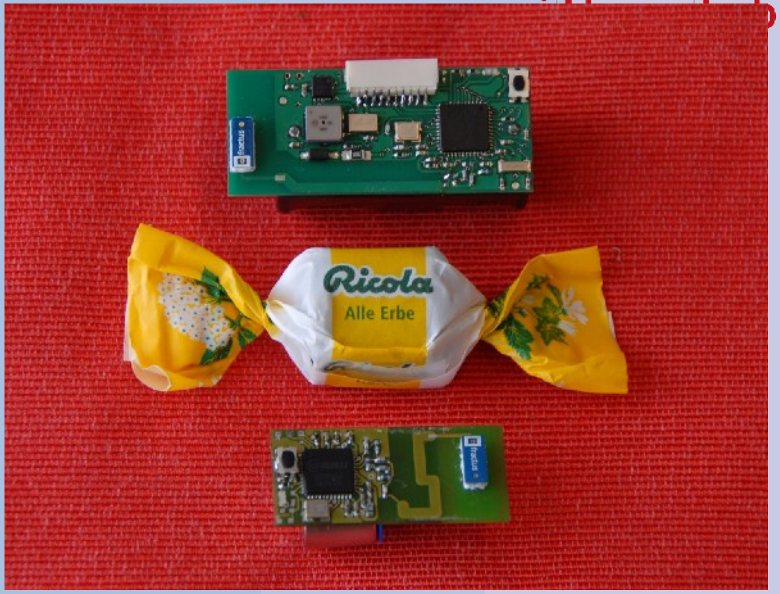
i Home Lab



- Reference nodes (4 shown) are connected via IPoK backbone
- One (or alternating) Reference node sends out syncronisation pulses via RF and IPoK
- Mobile node (Badge) (center) transmitts a synchronized ultrasound pulse
- the US pulse reception time is recorded by the reference nodes and transmitted to a server

Mobile node hardware I



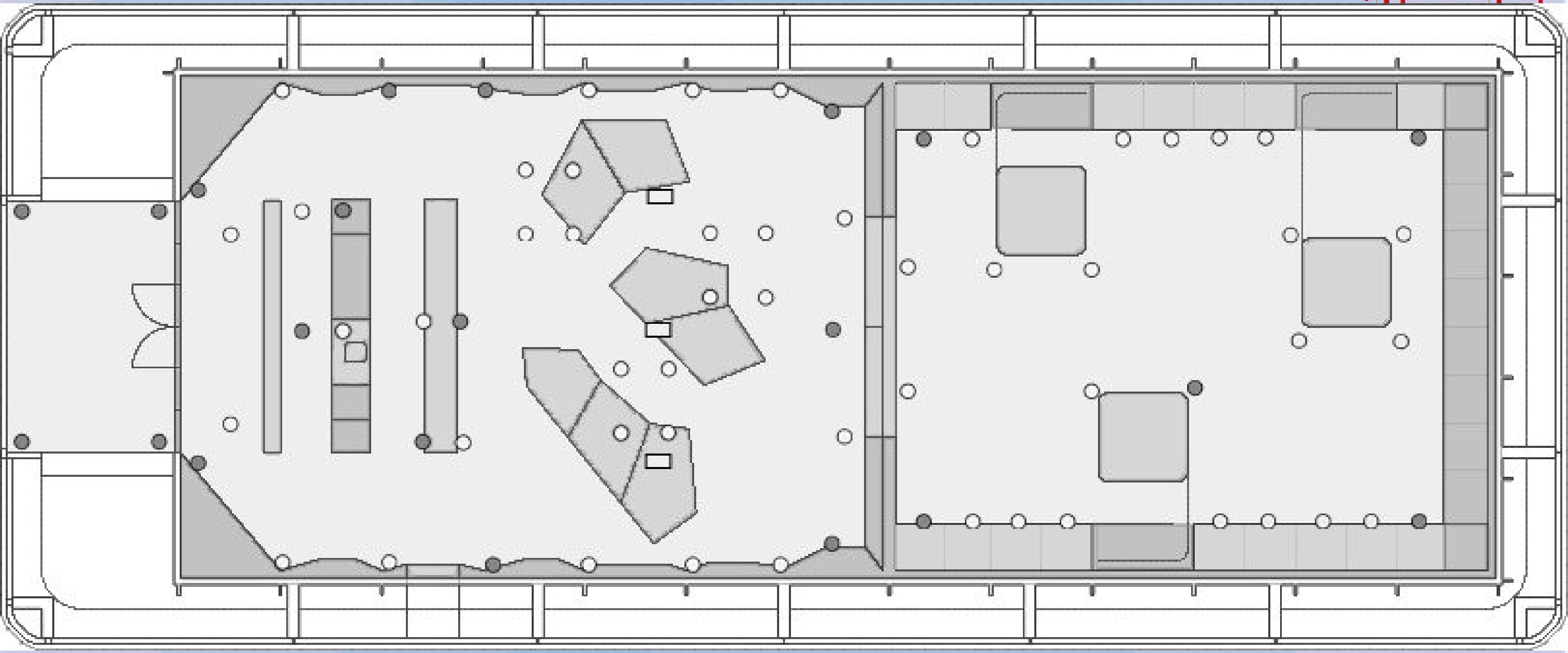


- Localisation Tags
  - Interactive (may send / receive data)
  - Remotely updateable poweless e-book display
  - Acceleration sensor, temperature sensor
  - long battery life

deployment in the iHomeLab

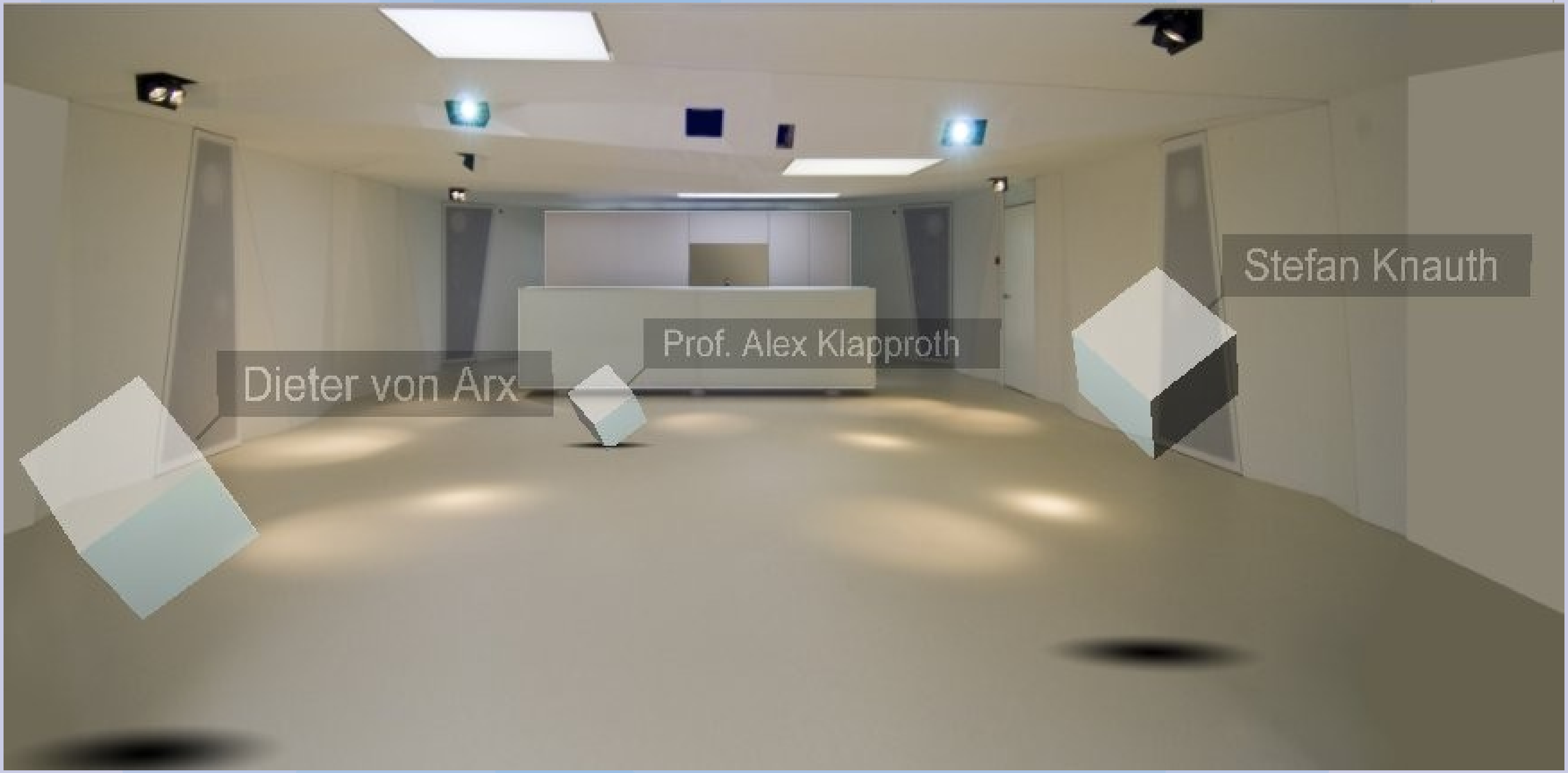
- Receivers are nearly invisible
- Obtained accuracy < 5 cm (mean deriv.)
- 20 transmitters are detected with an update rate of 1 Hz

deployment in the iHomeLab II



- volume 32 x 10 x 2 meters
- maximum signal range 16 m -> goal: not exceed 5 meters
- 50+ nodes in 6 bus lines
- reference node positions determined by “reverse engineering”

Visualisation

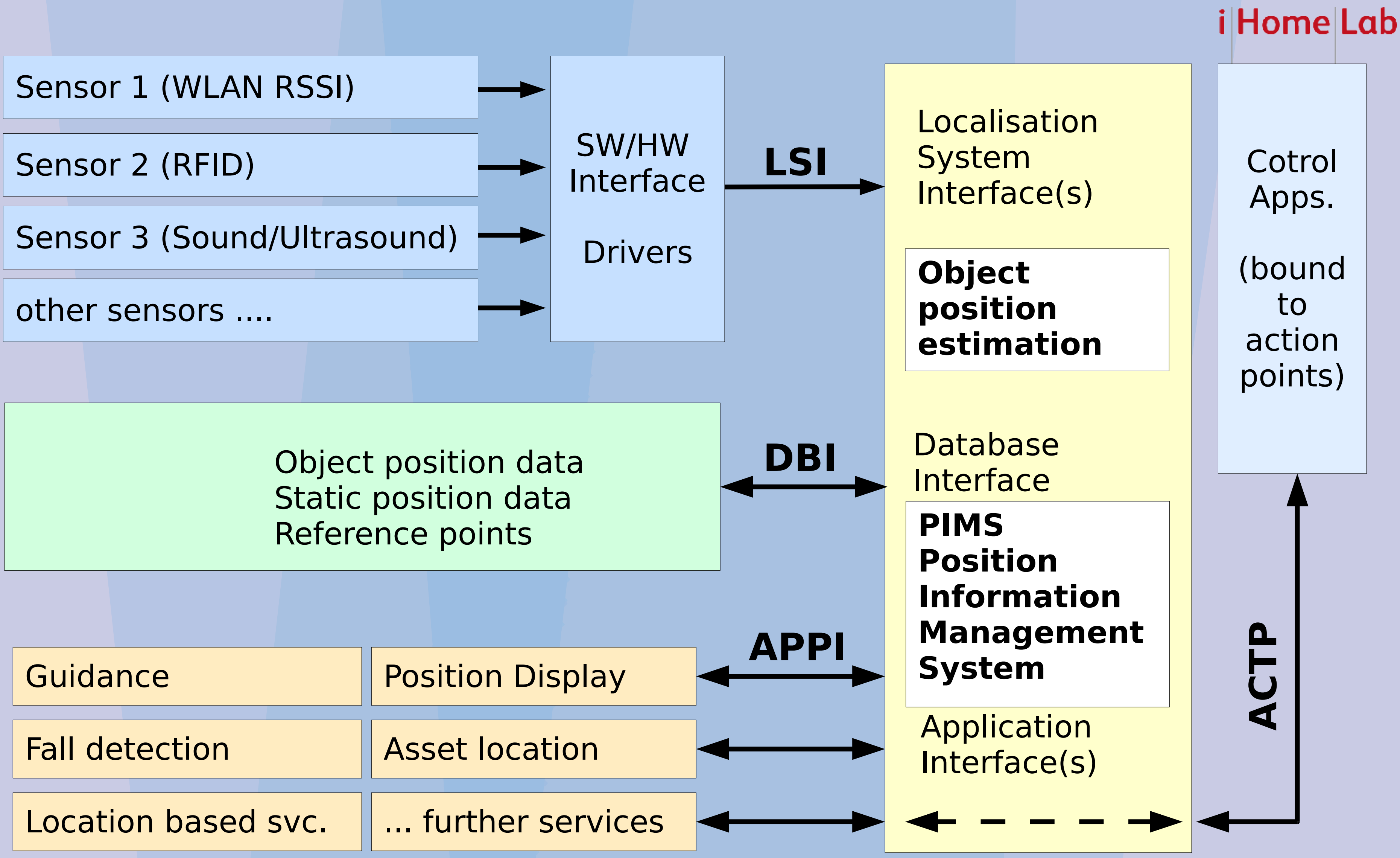


- Visualisation of bearers position in the iHomeLab

Visual Building Automation

- Position-based information & automation system control

Position Information Management



Applications

- Fall detection
- Behavioural monitoring
- Tracking
- Guidance
- Asset finding

Summary

- The iLoc indoor localisation system
  - is currently deployed by iHomeLab / Lucerne University of Applied sciences and Stuttgart University of Applied Sciences
  - allows accurate position determination of so-called tags, which can be for example attached to people
  - 20 position estimates per second, to be distributed between number of applied tags. Accuracy below 10 cm
  - needs moderate infrastructure
    - may be deployed temporarily
    - is currently not intended to be mass-deployed in households
  - is open as research infrastructure for experiments in the frame of behavioural monitoring
  - examples: behavioural monitoring, fall detection

Evaal / Outlook

- Setup and Test run at Valencia
  - Positions of receivers were already defined in advance and adjusted by the roof grid
  - 28 pre-wired receivers were taped on the lab roof
  - Successful operation … but learned a lot in the 3 hours
  - Score ? (We will know it later ...)
- Opportunities
  - Competition brought together leading indoor localisation specialists and approaches from academia and industry
  - Expertise and technological leadership of the competitors is approved by EU AALOA/EvAAL not only by review but also by evaluation process of already existing prototypes and technologies
  - Great succes for EvAAL
  - → joint project ?

Credits

- Thanks to the iLoc team members

  Lukas Kaufmann, Mattias Schulz-Merkel, and Christian Jost

  - for great efforts in providing the hardware, reconfiguring and extending the system software and providing the interfaces
  - and of course for the negotiation at Valencia
- Thanks to the EvAAL Team
  - For their immense and probably not completely forseeable effort in making this competition happen
  - For great support and hospitality at Valencia
  - For prompt clarifications of any issues
  - For professionality and strict commitment to fairness and transparency

HOMER
A Modular Platform for Event Recognition in Smart Homes

Thomas Fuxreiter

(AIT Austrian Institute of Technology / Biomedical Systems)

What is HOMER?

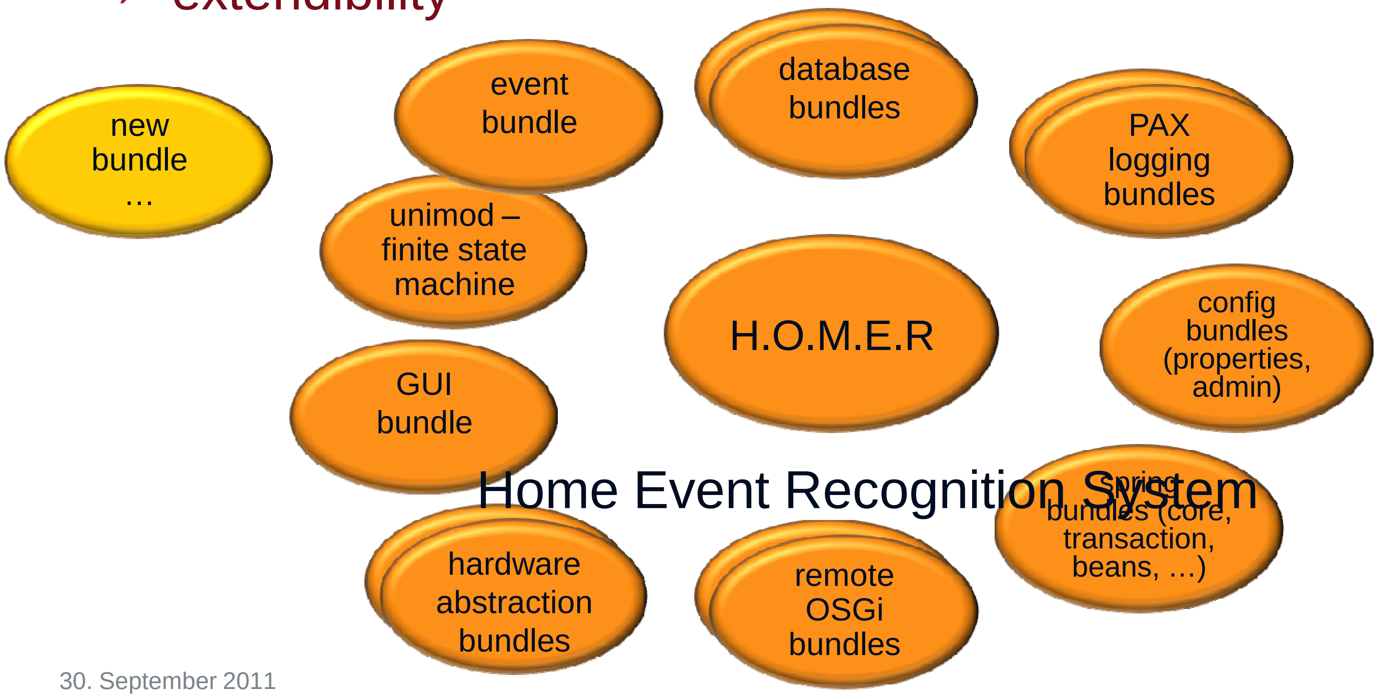
- Software platform for Smart Homes
- Integration of various home automation systems (Eaton, Legrand, KNX)
- Core functionality: Event and situation recognition

- In the AAL domain HOMER can help increasing:
  - Safety
  - Autonomy
  - Self-confidence
- Smart Home features:
  - Comfort (e.g. automatic switching of appliances)
  - Energy-efficiency

Modularity and flexibility

- Apache Felix OSGi framework implements the OSGi R4 service platform specification
- Spring DM make it easy to run Spring applications in an OSGi platform – or run OSGi bundles as a standalone application

⟶ extendibility

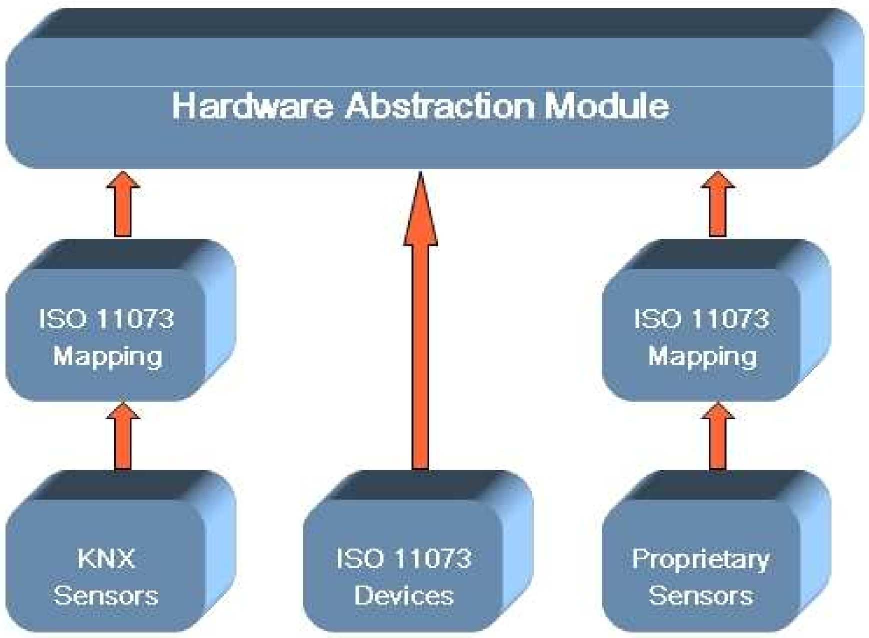


currently 44 bundles in total

Standardized hardware integration

- Standardized format for sensor and device communication

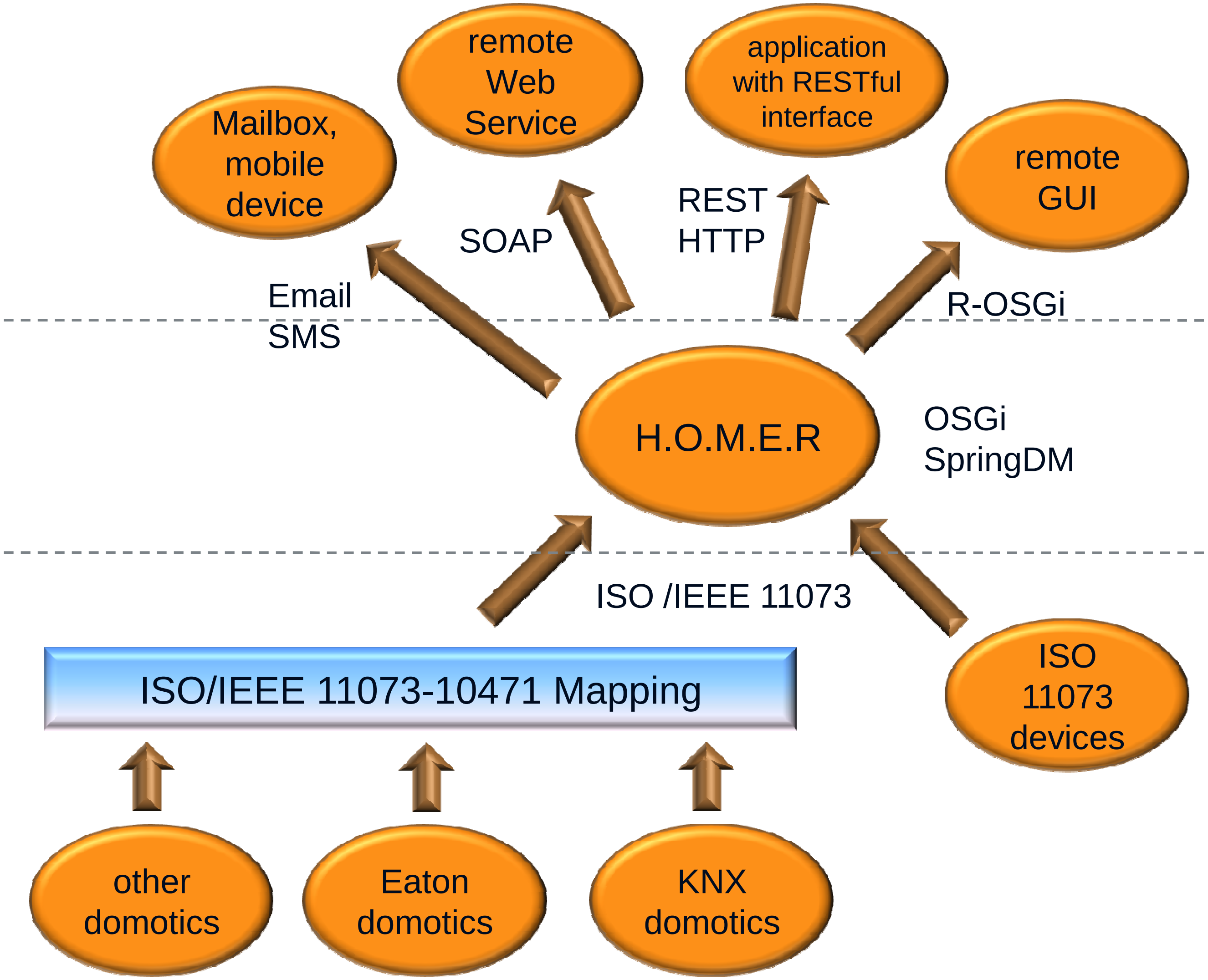
→ ISO/IEEE 11073 – 10471 Independent Living Activity Hub Specification



All connected systems are mapped to 11073 standard,
e.g. KNX, LON, and other proprietary protocols (Eaton, Legrand,…)

Mappings and hardware layers are itself exchangeable OSGI bundles

Interoperability with other systems

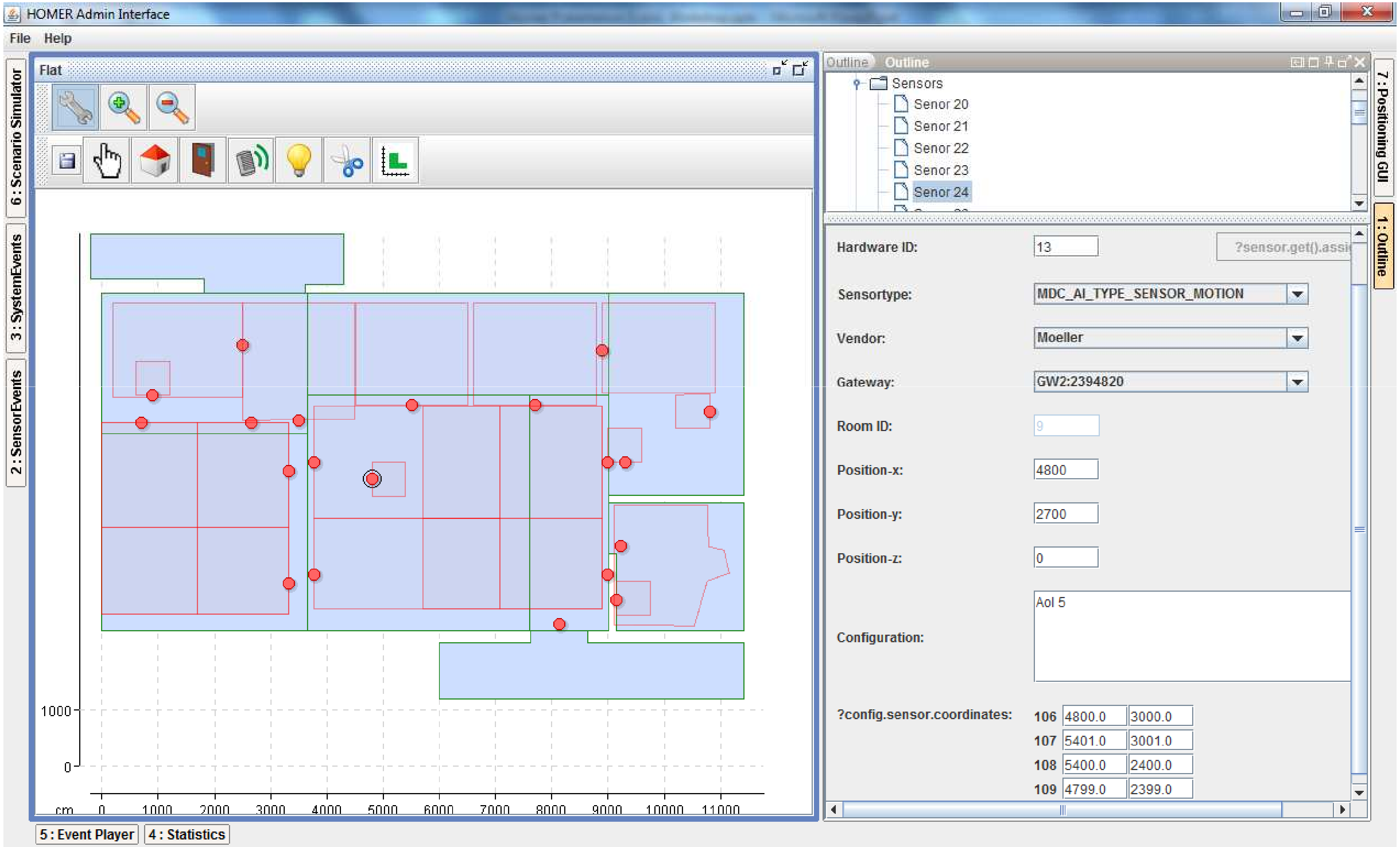


Interoperability with other/external systems

Modularity, extandability

Standardized hardware integration

Graphical user interface for configuration …



Processing of events with Finite State Machines

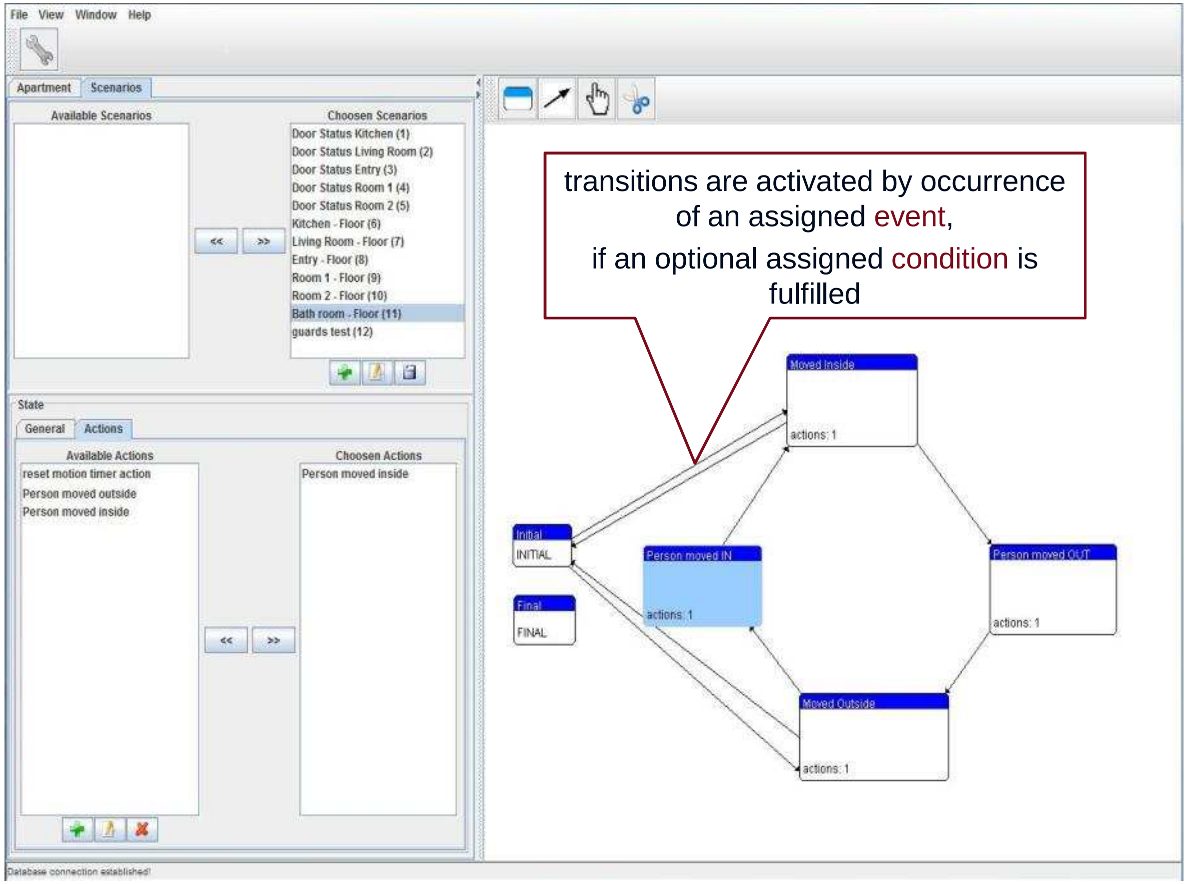
- Employs UniMod open source project (http://unimod.sourceforge.net)

Predefined rulesets for FSMs:

- door, window status
- room change
- device status through energy consumption

Actions:

- starting a timer
- raising an alarm
- setting a variable
- activate an actuator



First scenarios

- Person tracking
- Activity index
- Activity during nighttime
- Energy consumption monitoring
- Status of devices (on/off)
- Get up in the morning
- Came home before night

Mainly monitoring scenarios for safety in people's homes

Possible scenarios for primary user

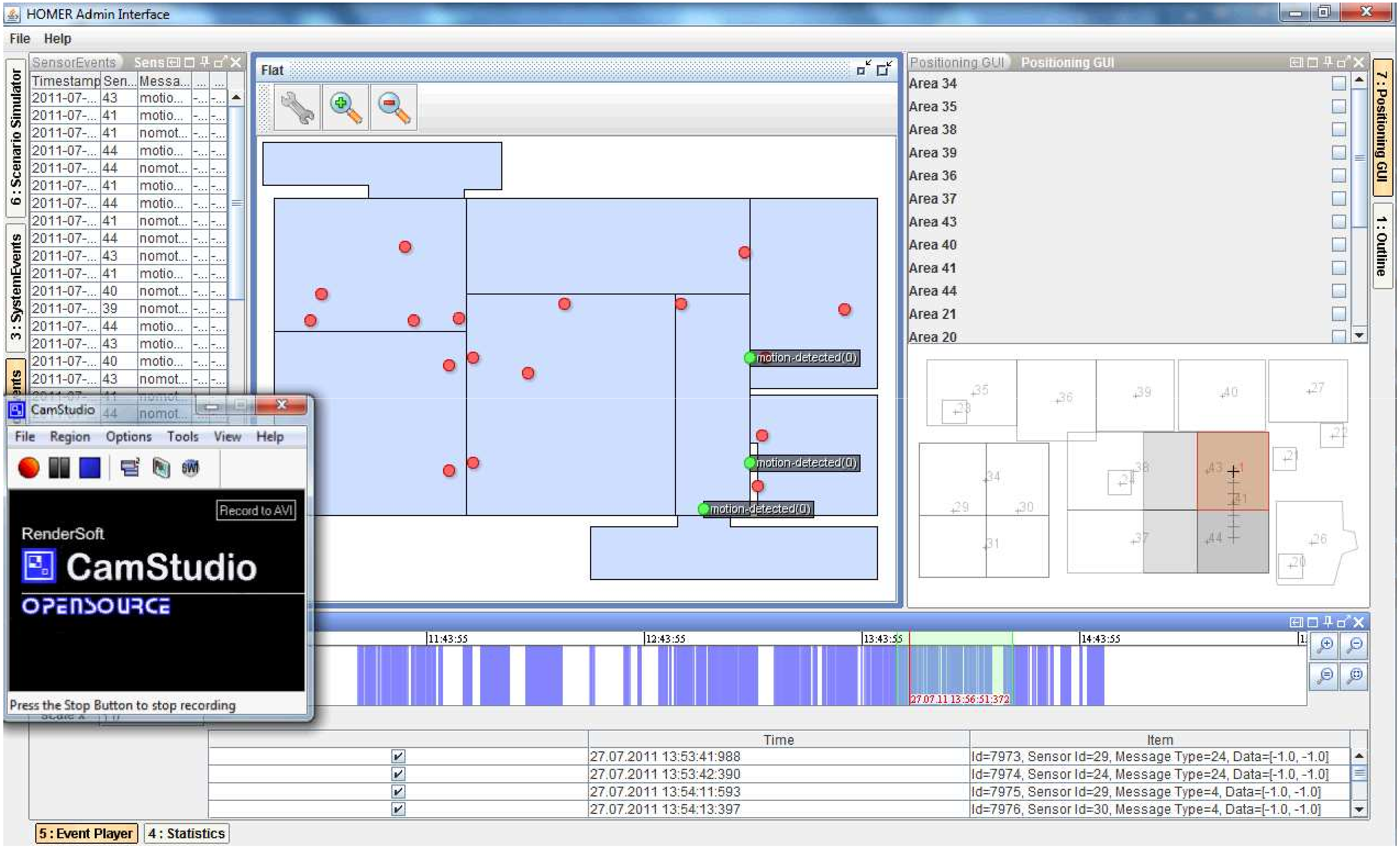
- Warnings on open doors or running devices
- Daily agenda
- Calendar and reminder

EvAAL competition – person tracking

- Set of 20 Passive Infrared Sensors (PIR) from Eaton
- Battery-powered and wireless data transmission (proprietary)
- USB gateway

EvAAL competition – person tracking II

EvAAL competition – person tracking III



HOMER Core is Open Source

- HOMER Core is a project incubated in AALOA association
- Download at http://homer.aaloa.org
- Including a template for integration of other sensor networks

- Contact: thomas.fuxreiter@ait.ac.at

1st evAAL Competition (2011): Report from preparity work

evAAL Workshop at AAL Forum 2011

Juan Pablo Lázaro TSB, Valencia

jplazaro@tsbtecnologias.es

http://www.tsbtecnologias.es

AGENDA

- Context of evAAL
- First Competition in 2011
  - Objective and call
  - Organizational aspects: committees and chairs
  - Living Lab requirements
  - The Reference Localization system
  - Tools:
    - Integration package
    - Evaluation software

CONTEXT of evAAL

- EvAAL (Evaluating AAL Systems Through Competitive Benchmarking) is an international contest
- Enable the comparison of different AAL solutions, by establishing suitable benchmarks and evaluation metrics that will be progressively refined and improved in the years. In particular, *EvAAL will focus not only on comparison of algorithms, but also of cost, deployment effort, time and costs, etc*.
- Open to all issues related to:
  - the test environment (living laboratories vs. into the wild),
  - the benchmarking (automatic vs. based on users' evaluations),
  - to the tools supporting the competition etc.
- Different tacks: this year localization, next year loc. + reasoning?

CONTEXT of evAAL
evAAL, AALOA and universAAL

- evAAL is a project in AALOA (evaal.aaloa.org)
- AALOA (www.aaloa.org): aaloa.org/manifesto

…our **mission, which is to:**

  - Bring together the resources, tools and people involved in AAL in a single forum that makes it much easier to reach conclusions on provisions needed to achieve AAL progress;
  - Make sure that all technology providers, service providers and research institutions involved in AAL are either directly involved in AALOA or (as a minimum) aware of decisions it promotes;
  - Involve end-user representatives in all work of AALOA;
  - Identify key research topics in AAL, and reach agreement on prioritization of these;
  - Design, develop, evaluate, standardize and maintain a common service platform for AAL.

- AALOA is currently funded by universAAL and individual contributions
- evAAL is currently funded by universAAL and individual contributions: CNR-ISTI, UPM-LST, ITACA, TSB S.A., FhG, AIT, RSD, SINTEF
- The future: stand-alone and sustainable competition with a wide community supporting its purpose.
- universAAL is a EU-FP7 IP Research project: http://www.universaal.org

2011 COMPETITION: Objectives and call for competitors

- From http://evaal.aaloa.org/current-competition/cfc:
  - The scope of this competition is to award the best indoor localization system from the point of view of Ambient Assisted Living (AAL) applications.
  - This competition is an opportunity to bring together both academic and industrial research communities to:
    - work together on challenging and open problems,
    - evaluate various approaches, and
    - to envision new research opportunities.
  - This competition is the first of several planned by universAAL to find good solutions to different challenges in the AAL domain.

2011 COMPETITION: Organizational aspects

EvAAL 2011 - Technical Program Committee **General Co-Chairs:**

- Dr. Stefano Chessa, Department of Computer Science, University of Pisa and ISTI-CNR, Italy
- Dr. Sergio Guillem, ITACA-UPV University of Valencia, Spain

Local Committee:

- Juan Pablo Lázaro (TSB Soluciones Tecnologicas, Spain)
- Dario Salvi (LST group at Polytecnic University of Madrid, Spain)
- Pilar Sala and Alvaro Fides (ITACA-UPV, Spain)

Publication chair: Dr. Reiner Wichert (Fraunhofer IGD, Germany)

Publicity Chairs: Casper Dahl Marcussen (Region Syddanmark ,Denmark); Dr. Francesco Potortì (ISTI-CNR, Italy)

Technical Program Committee Co-Chairs:
Dr. Rainer Mautz (ETH Zurich) - responsible for the reviewing process
Dr. Francesco Furfari (ISTI-CNR, Italy) - responsible for on site evaluation committee
Dario Salvi (Polytecnic University of Madrid, Spain) - responsible for benchmarking
Juan Pablo Lázaro (TSB Spain) - responsible for relationship and requirements with the hosting living lab

Technical Program Committee:
Bruno Andò (University of Catania, Italy); Paolo Barsocchi (ISTI-CNR, Italy); Philippe Canalda (University of Franche-Comté, France); Francesco Furfari (ISTI-CNR, Italy); Ivan Martinovic (University of Kaiserslautern, Germany)
Rainer Mautz (ETH Zurich)
Filipe M. L. Meneses (University of Minho, Portugal)
Adriano J. C. Moreira (University of Minho, Portugal)
Saied Tezari (Fraunhofer IGD, Germany)
Reiner Wichert (Fraunhofer IGD, Germany)

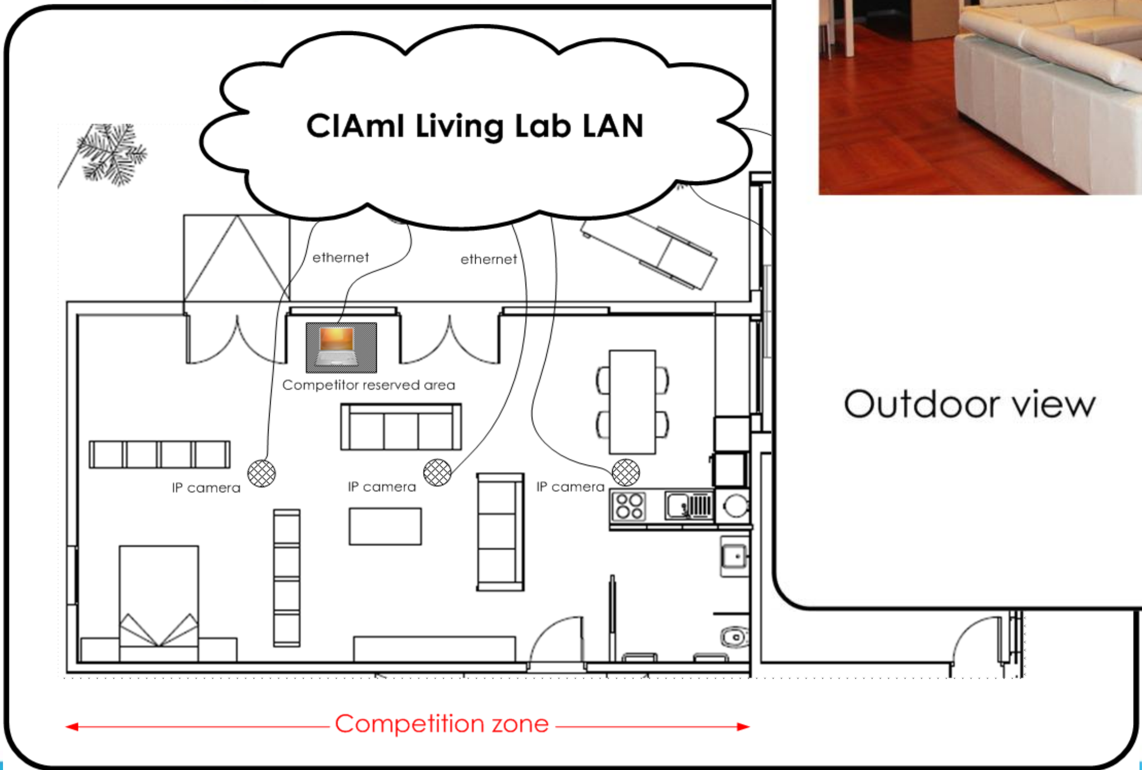
Collaborators and evaluators:
Ángel Martínez, Miguel Angel Llorente, Jose Blasco, Eduardo Montón, Elena Castellano (TSB, Valencia, ES); Juan Antonio (Universidad de Sevilla)
Jose Blasco y Eduardo Montón (TSB, Valencia, ES)
Claus Nielsen (Delta, DK); Patricia Gil (secretary)

2011 COMPETITION:
Living Lab and Local Committee

- Requirements:
  - A place that simulates a house. Not a laboratory.
  - If possible, with rooms.
  - Possibilility to easily host different technologies and devices:
    - Removable ceiling/floor
    - Ethernet, Wi-Fi, clean RF- environment (no interference)
    - Easy to attach devices.
  - Audio system
  - Continuous video recording system
  - Availability of supporting team
  - Availability of other meeting room
  - Screen to show paths in real time
  - Possibility to hide paths (painted on the floor)

2011 COMPETITION:
Living Lab and Local Committee

CIAMI Living-Lab



Indoor view

Outdoor view

ITACA and TSB in Valencia
http://www.ciami.es

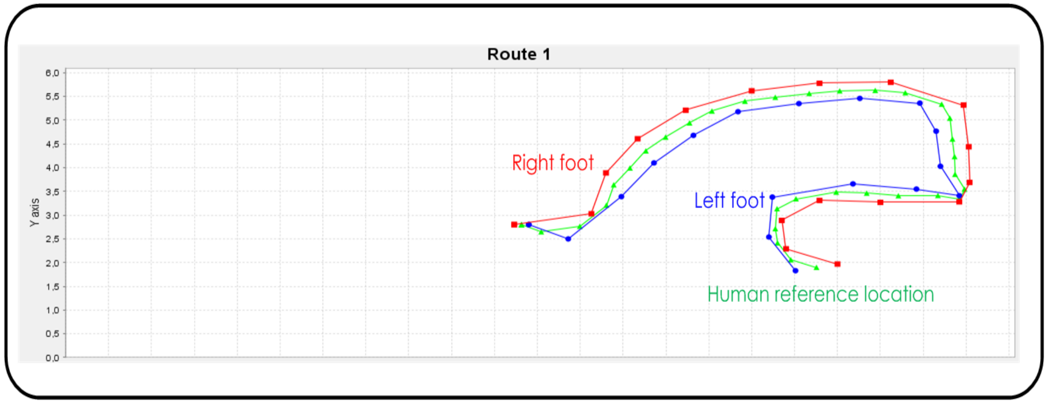
2011 COMPETITION:
Reference Localization System

- We needed a reference localization system to compare with competitor's samples.
- It should be the most precise localization system -> maybe expensive -> look for agreement/involvement in the competition (sponsor).
  - Technology based: Intelligent floor. German company (FutureShape).

- It was precise enough
- Could work together with other floor based systems (layers)
- We show it working in FZI Living Lab in Karlsruhe

2011 COMPETITION: Reference Localization System

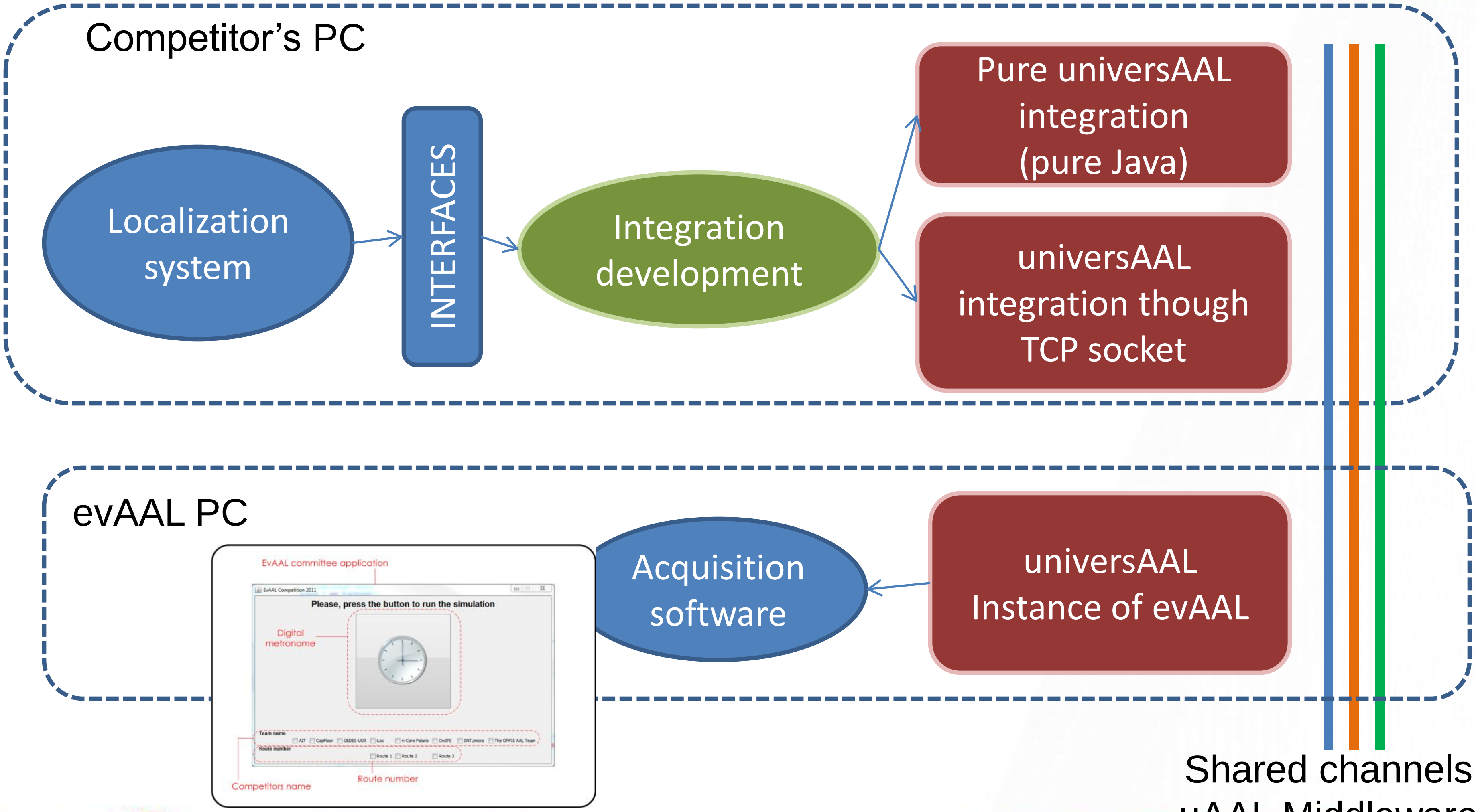
- <u>Human based:</u> trained actor to move in the same way. How?
  - Metronom and trained user.
  - Pre-defined paths (marks on the floor) with theoretical position.
  - Studies about antropometric
  - Verification tests + tolerance -> accuracy rules: 0,5m = 10/10 points.



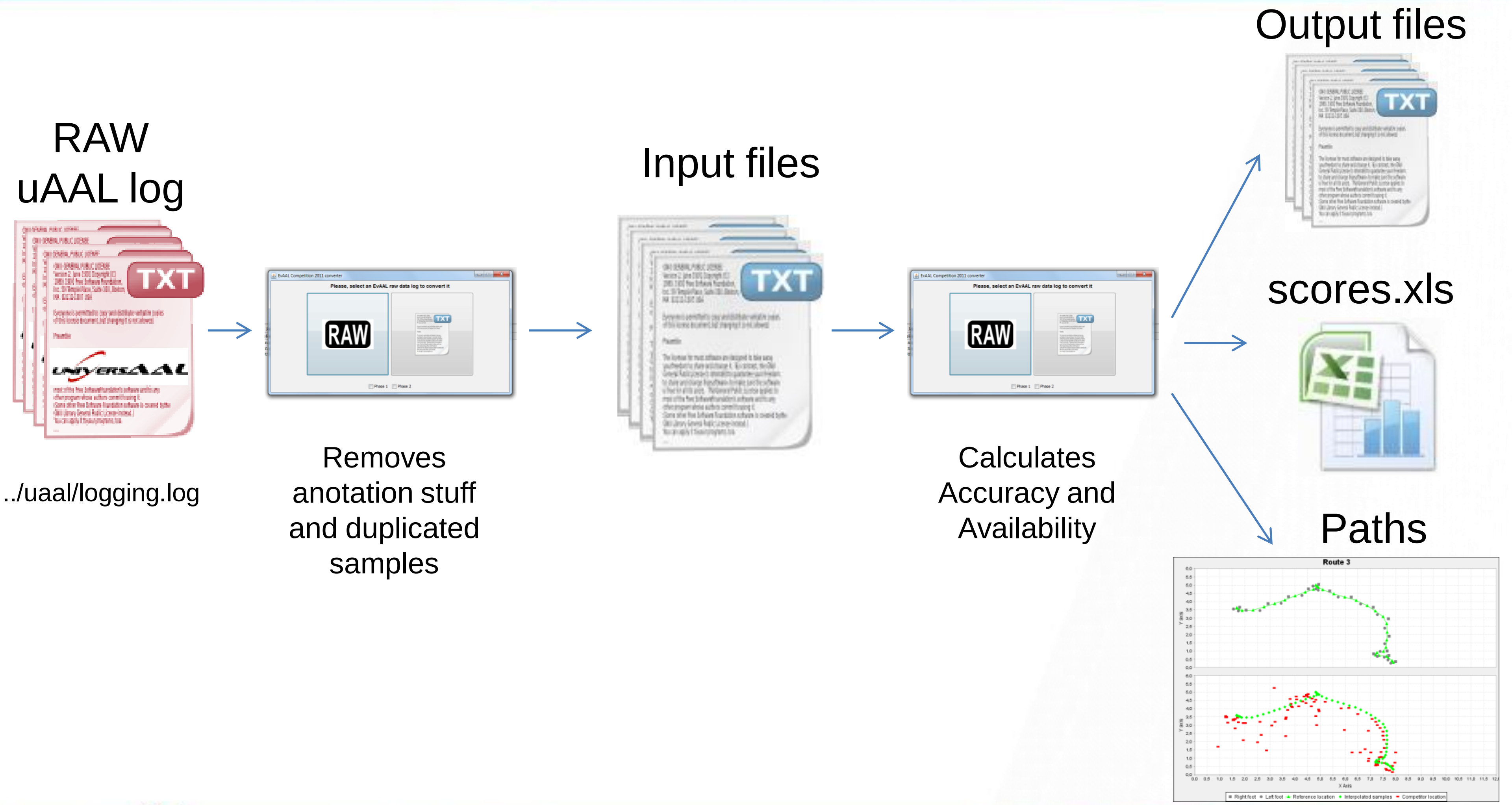
2011 COMPETITION:
Tools : Integration tool

- Integration of universAAL forced. Why?
  - Competing systems must demonstrate that they are able to integrate with external (not only standalone)
  - Offer our execution platform to external developers, together with tools that have been implemented within the project.
  - It is the easiest way for us to provide a system that captures the information is real-time thanks to the intrinsic capacity of universAAL platform.

2011 COMPETITION:
Tools : Integration tool



2011 COMPETITION:
Tools : Evaluation tool (accuracy and availability)



Now it is time to see our competitors

Thank-you!

TSB Soluciones Tecnológicas para la Salud y el Bienestar
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JUAN-PABLO LÁZARO & ANGEL MARTINEZ

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Sherlock : A Hybrid Positioning System based on Standard Technologies

EvAAL 2011

T. Ruiz-López, J.L. Garrido,
C. Rodríguez Domínguez, M. Noguera

Department of Software Engineering
University of Granada
September 2011

Overview

- Motivation
- Architecture of the System
- Implementation
- Conclusions

Motivation

- **Wide variety of technologies**
  - Ultrasounds, Infrarreds, Inertials, Radio Frequency...
- **Different positioning methods**
  - Triangulation, Proximity, Dead Reckoning, Scene Analysis
- **Various architectures**
  - Terminal-based, Network-based, Terminal-assisted
- **Different scopes**
  - Indoor / Outdoor
- **Non-functional Requirements**
  - Accuracy, Responsiveness, Privacy, Robustness, Scalability...

Architecture

Architecture

WiFi

ZigBee

Architecture

WiFi

ZigBee

BlueRose

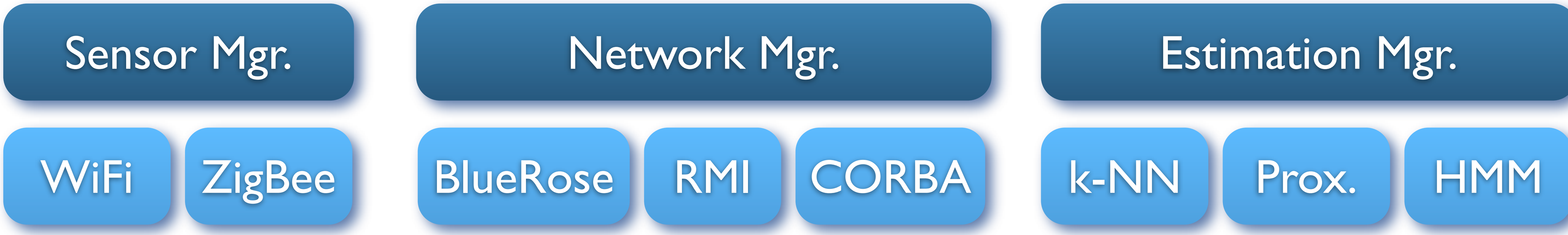
RMI

CORBA

Architecture

WiFi | ZigBee | BlueRose | RMI | CORBA | k-NN | Prox. | HMM

Architecture



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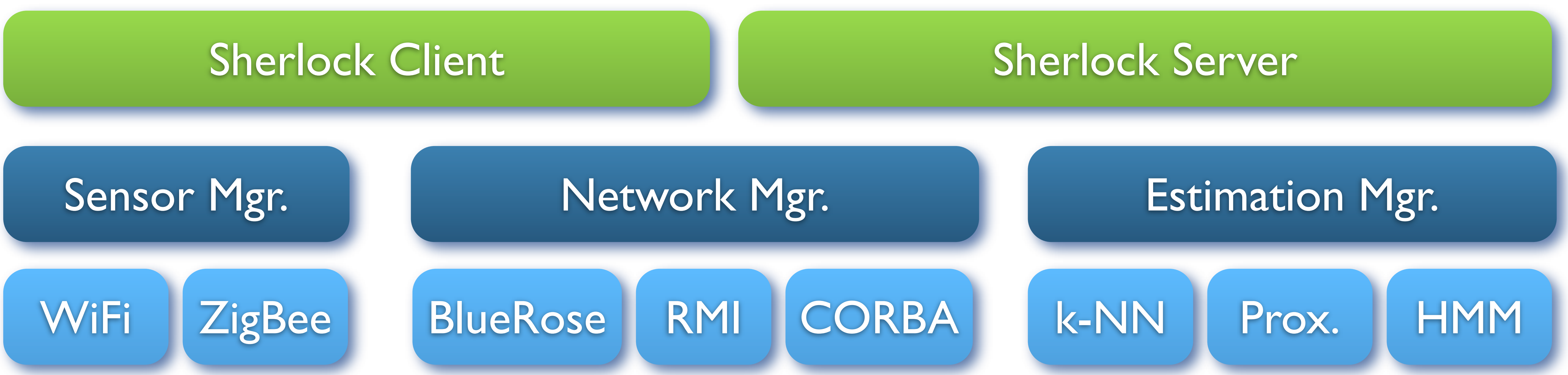

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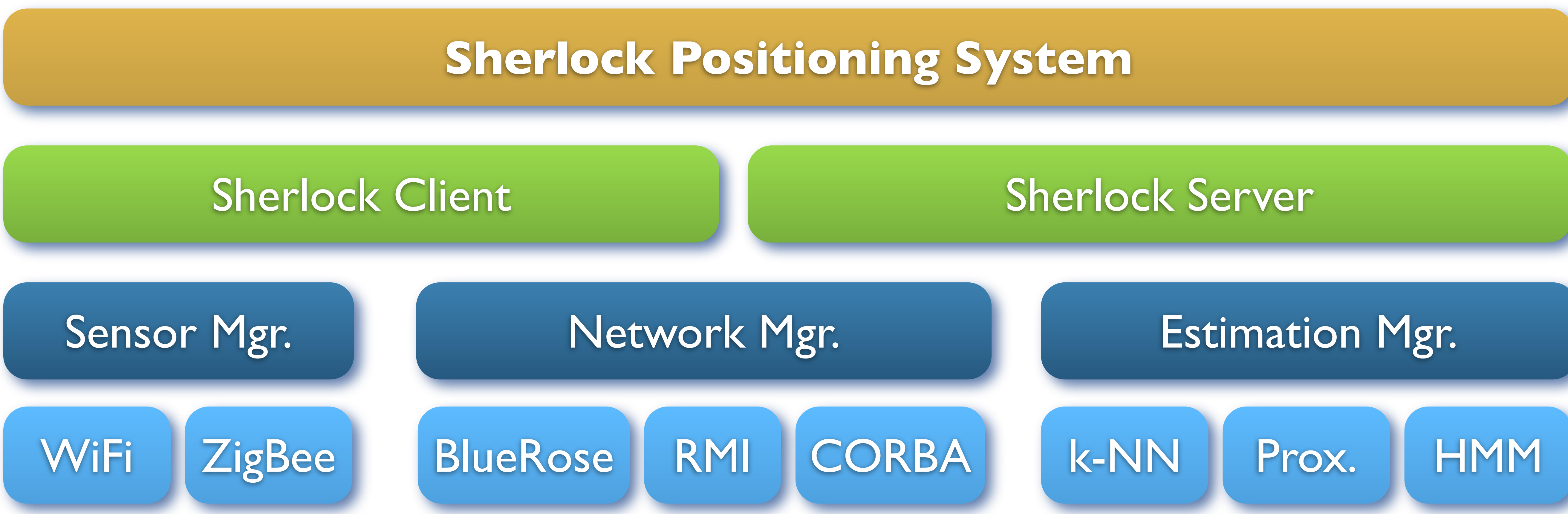

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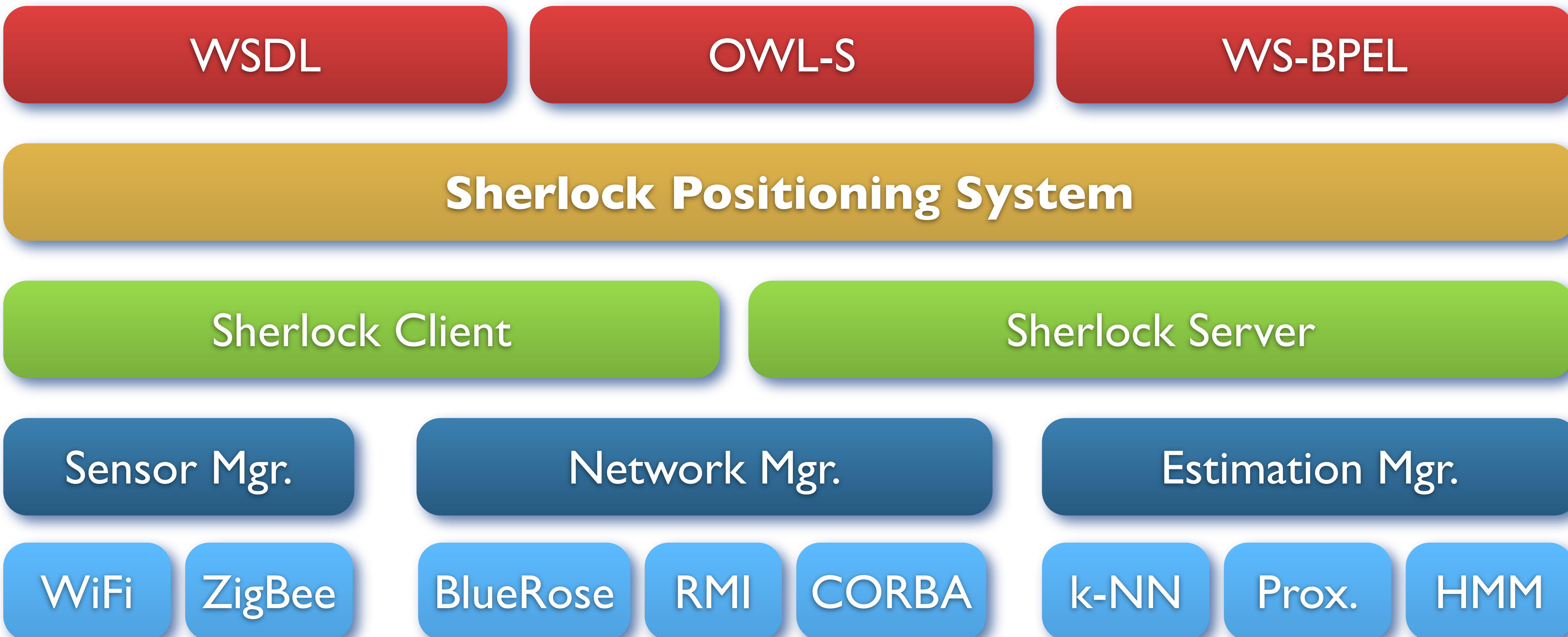

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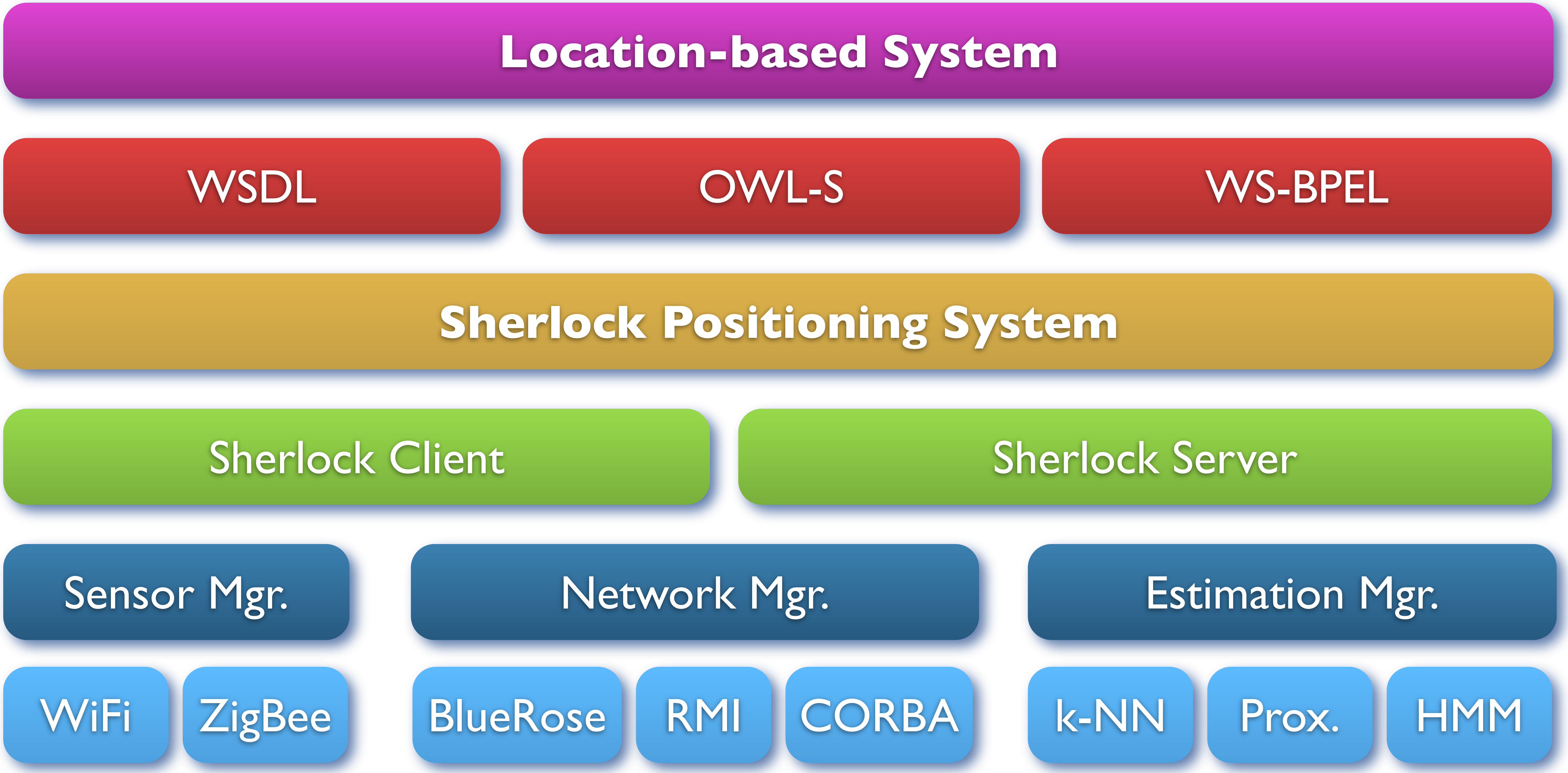

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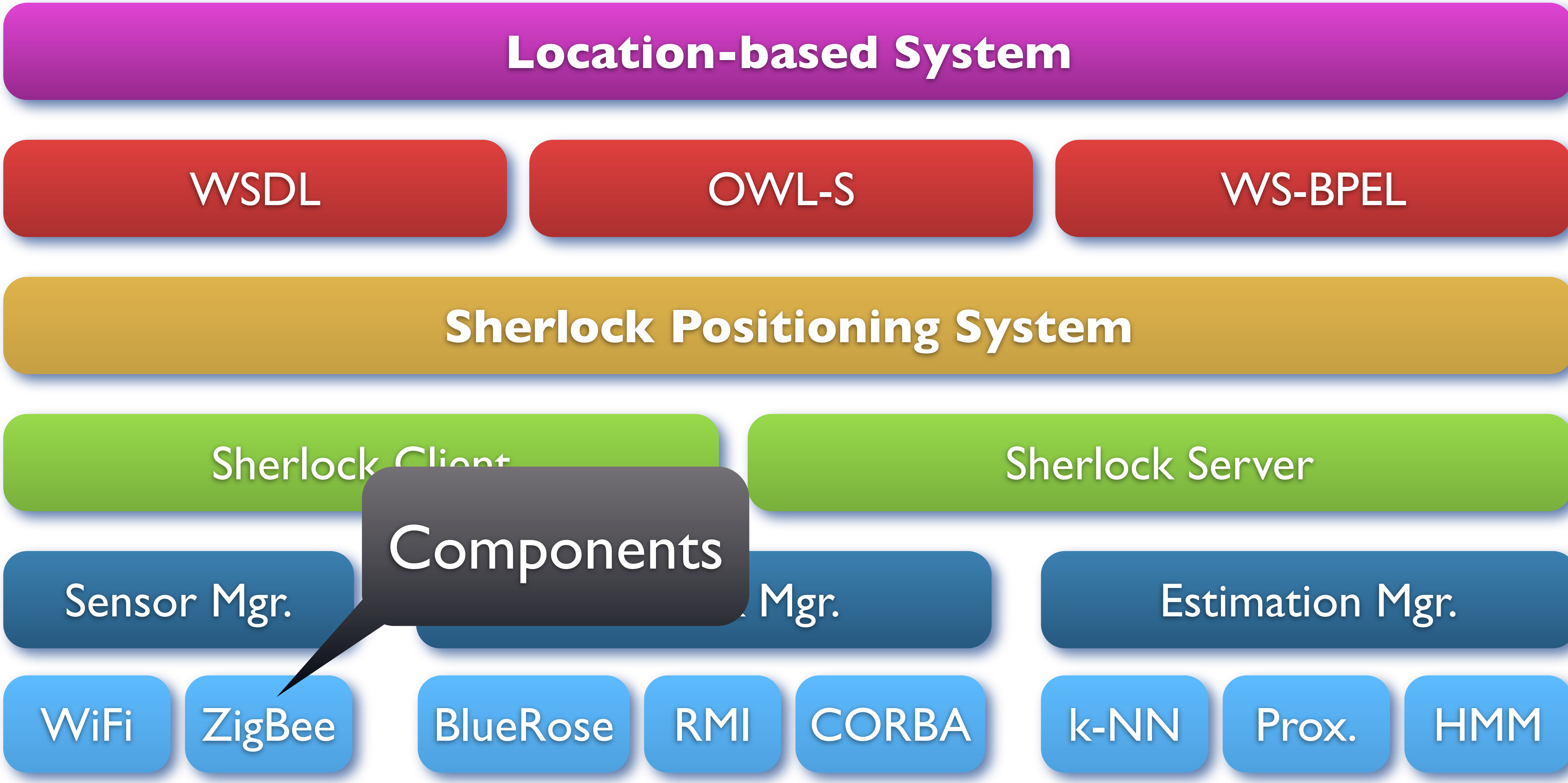

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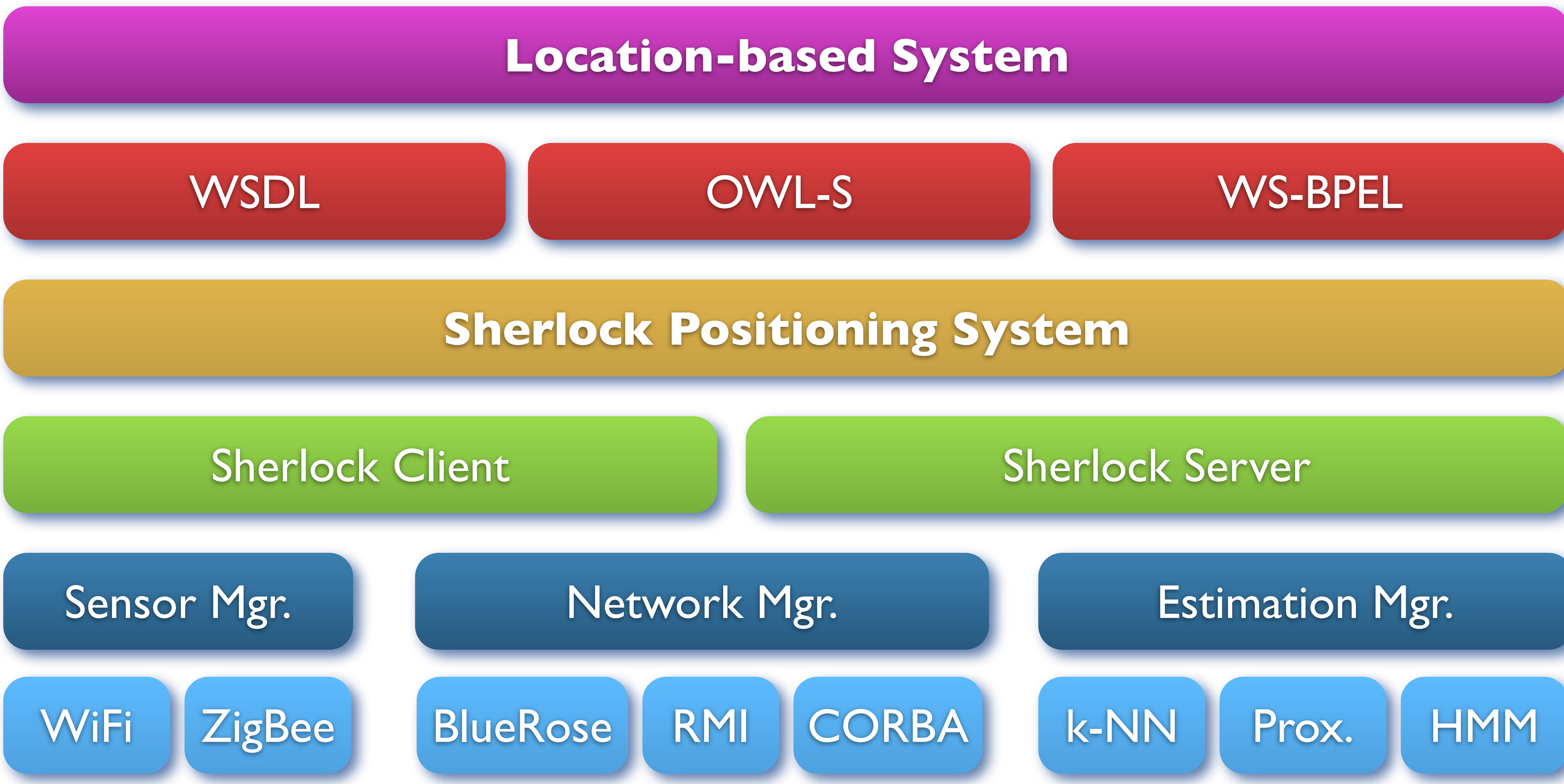

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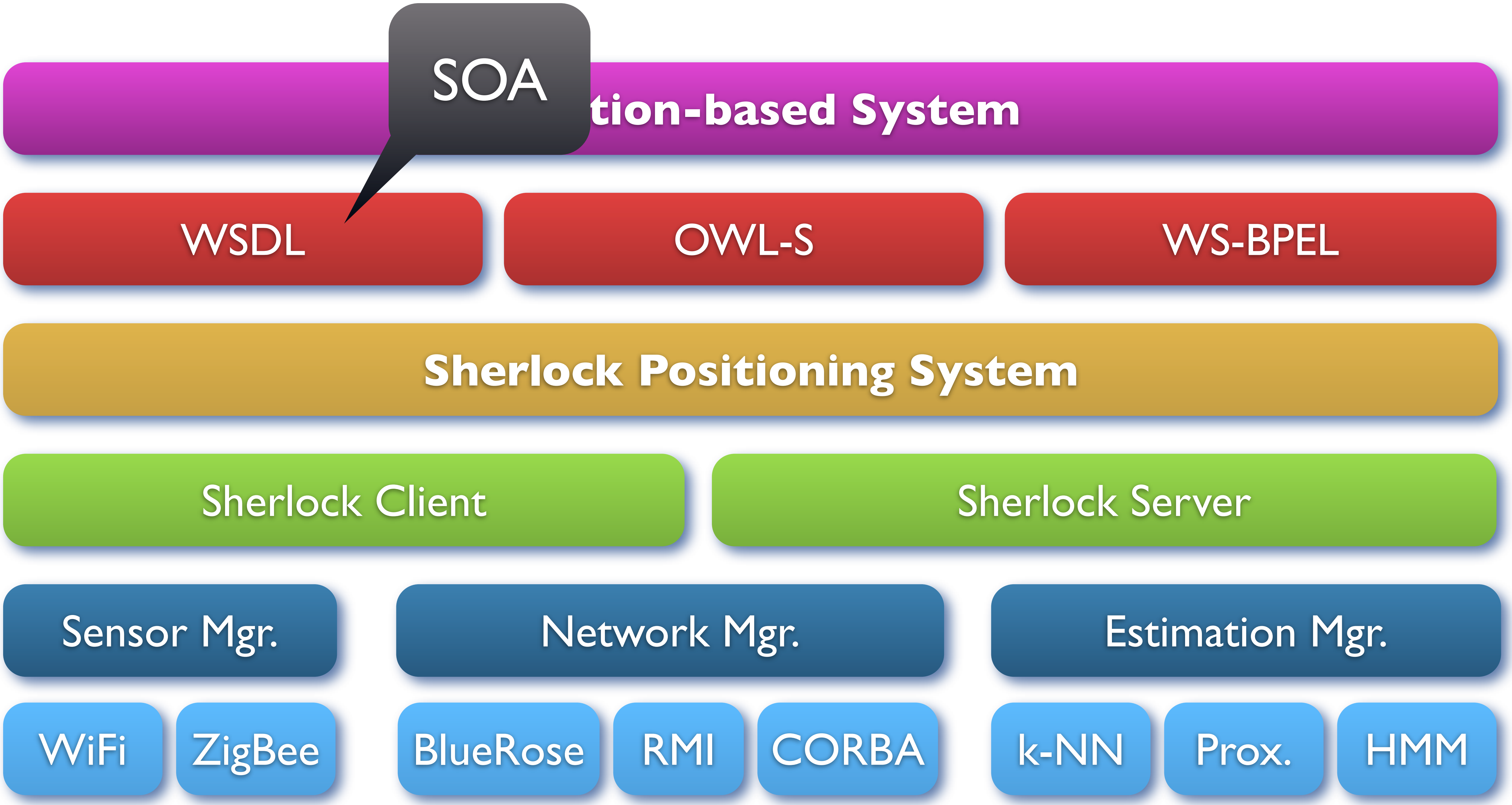

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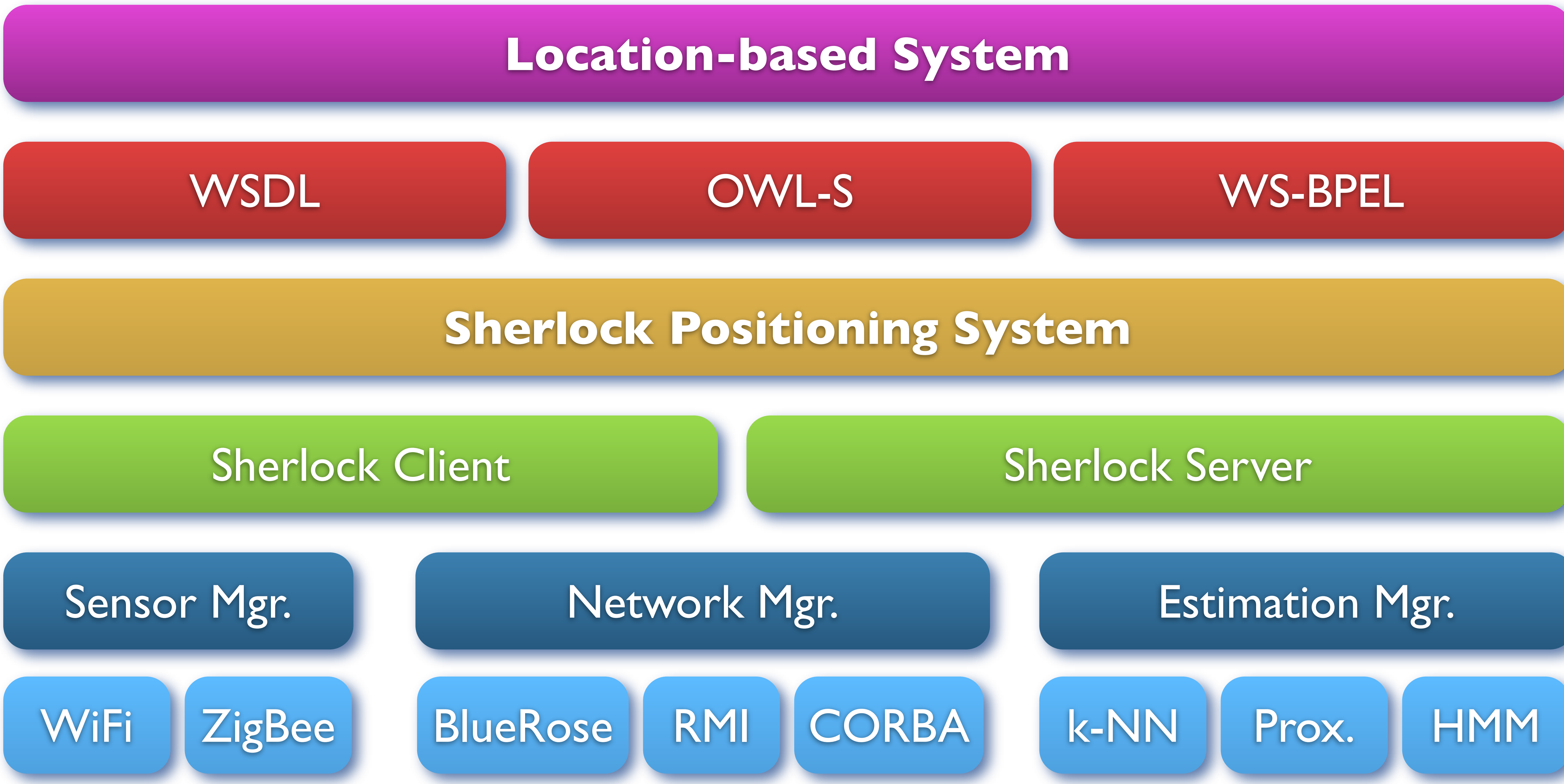

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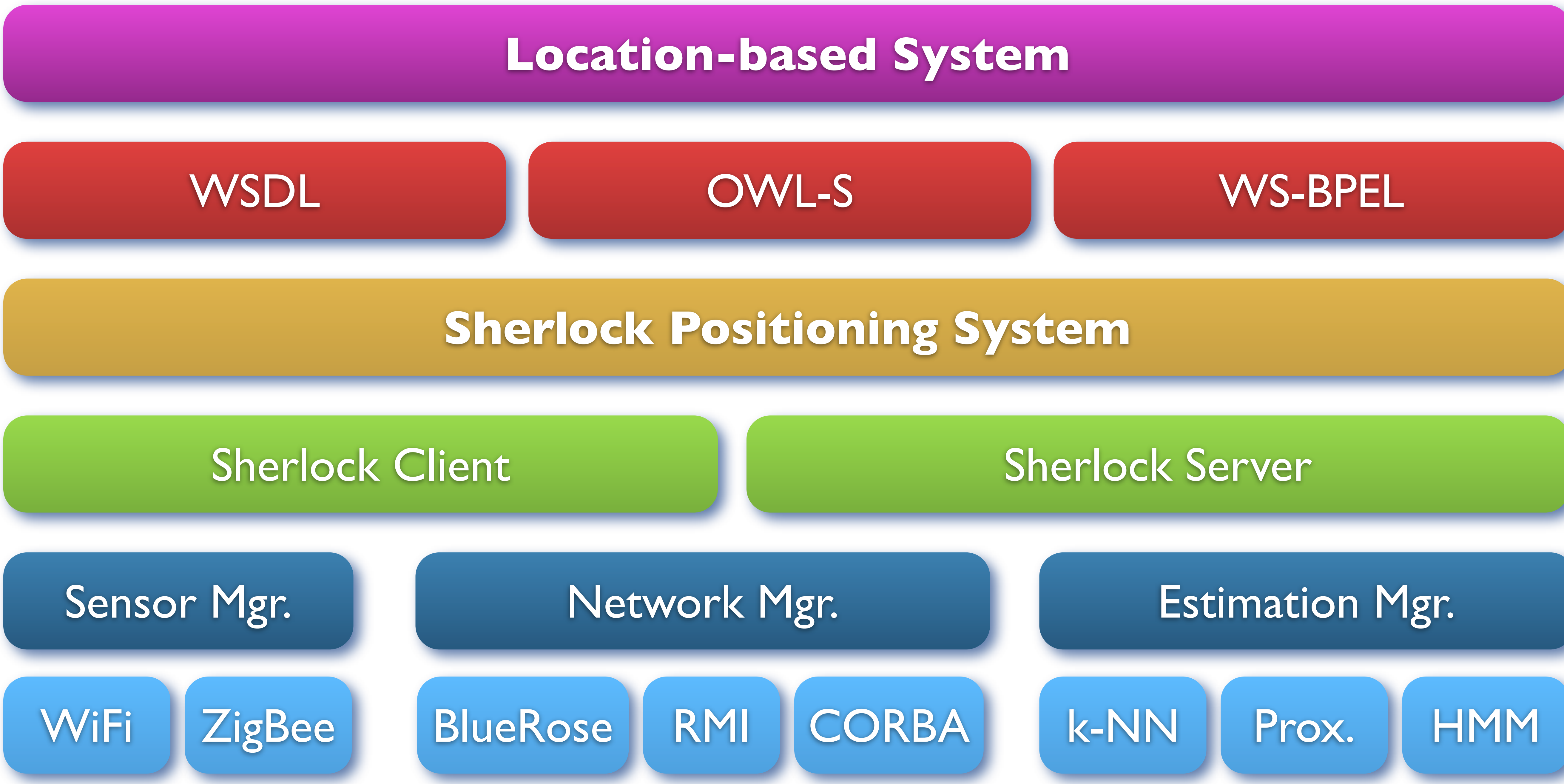

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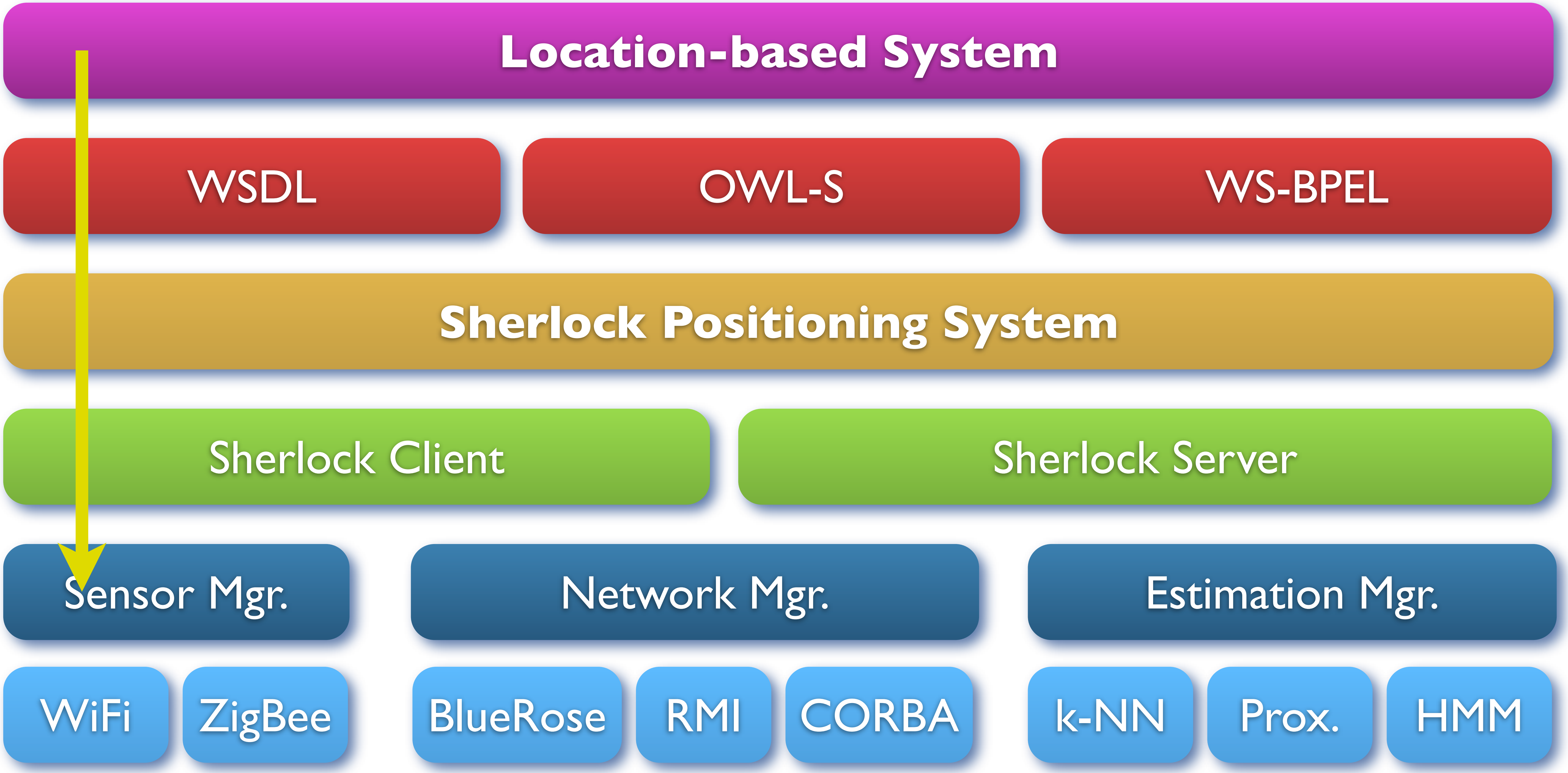

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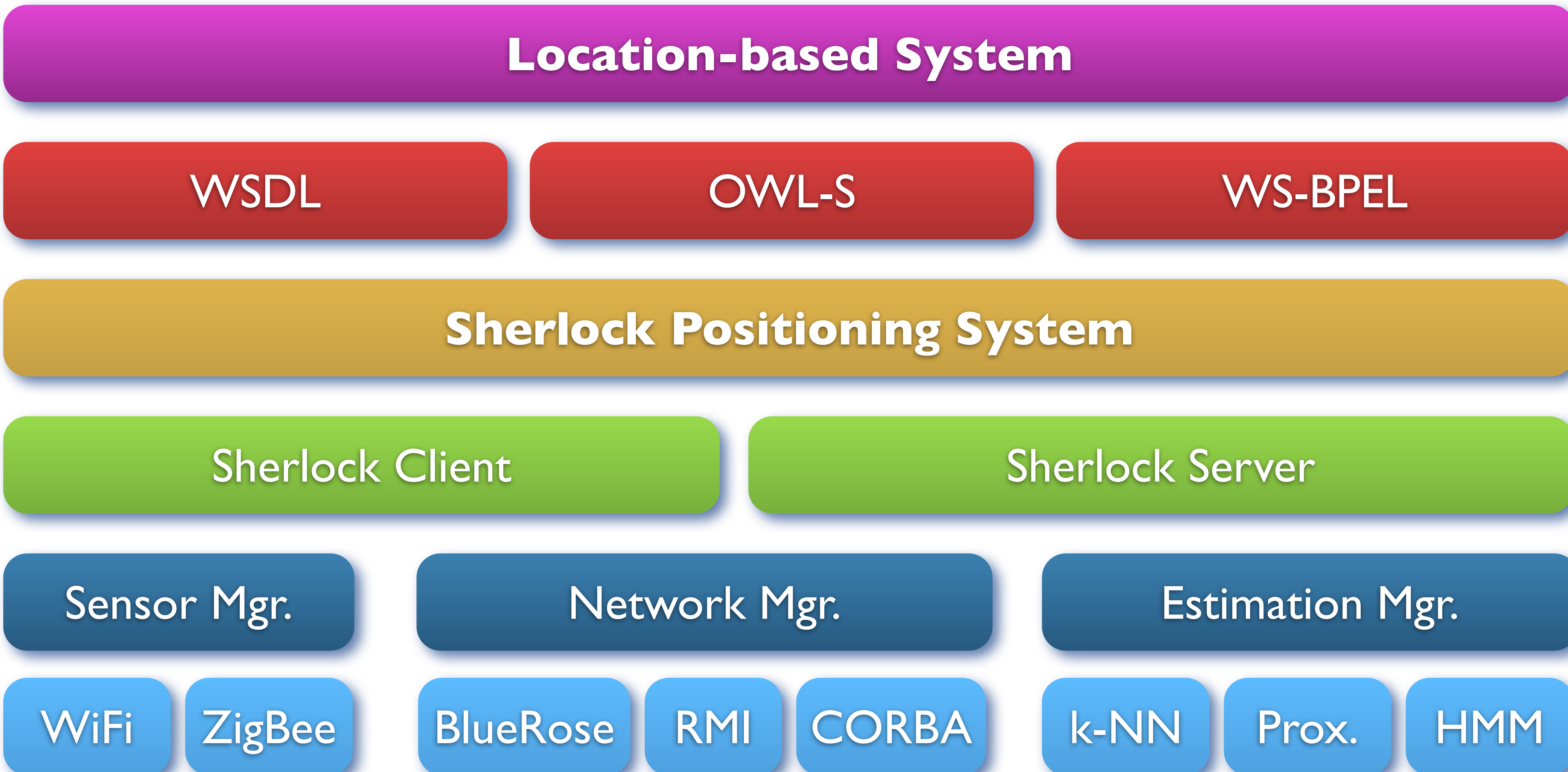

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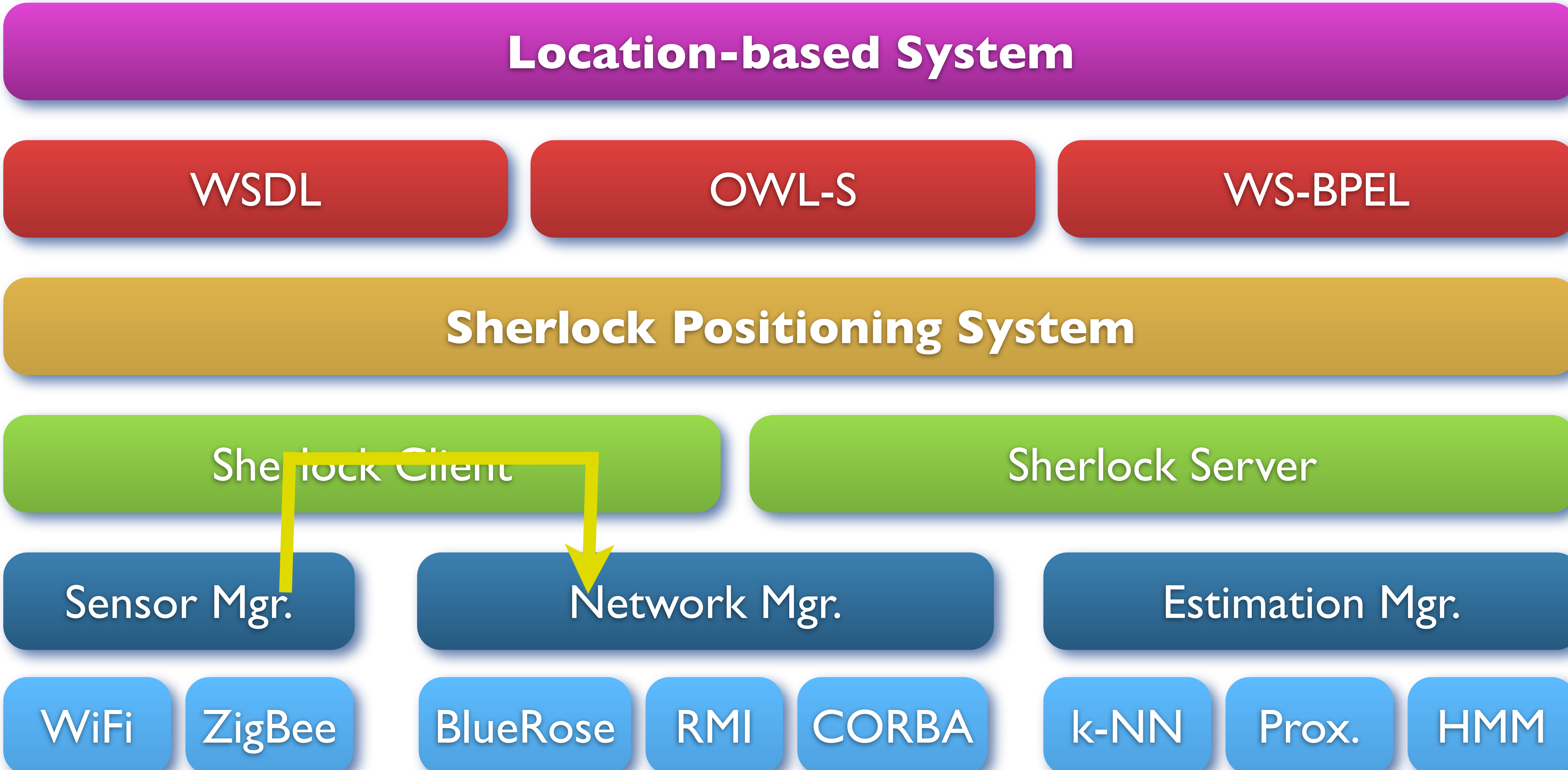

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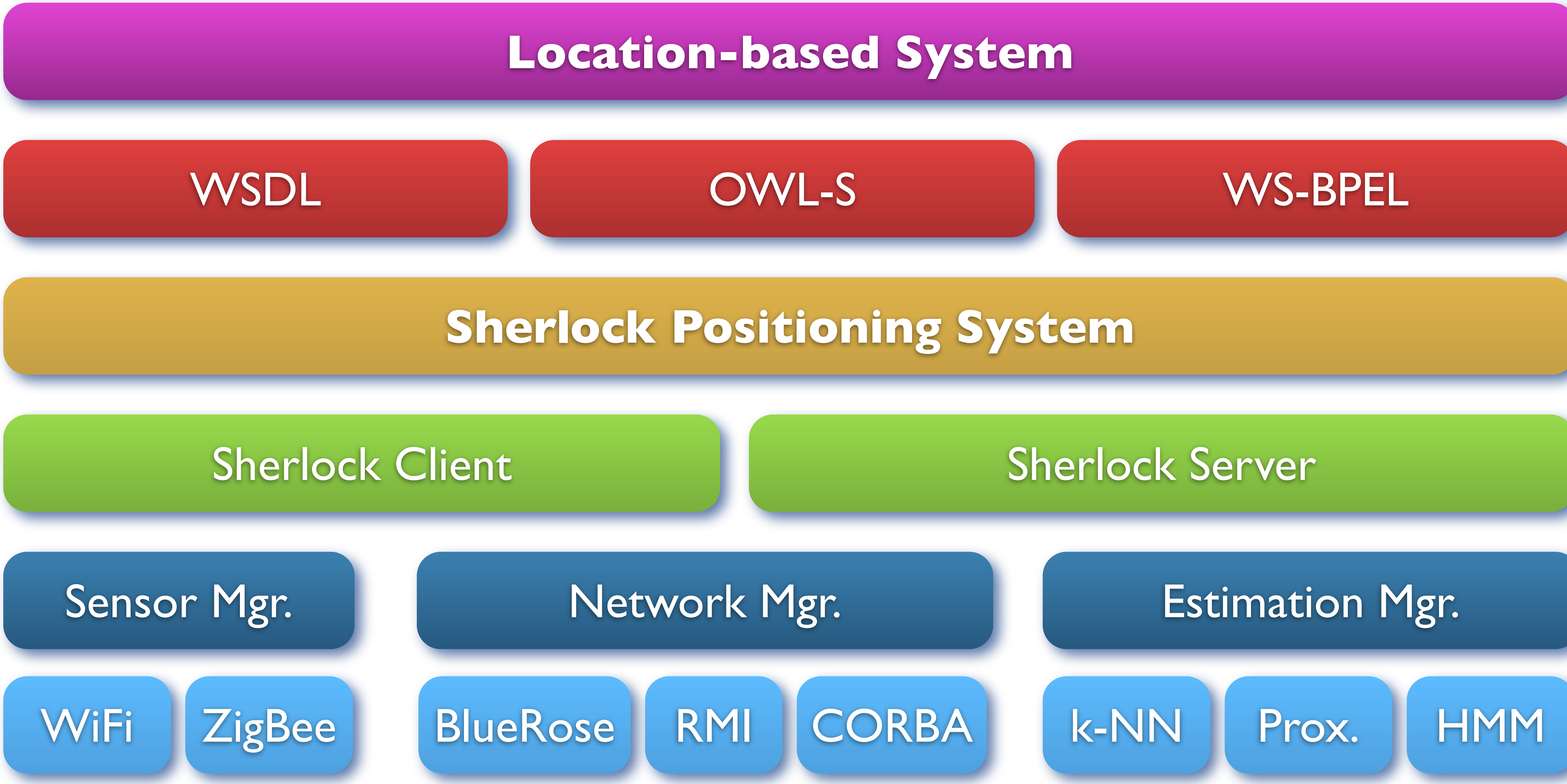

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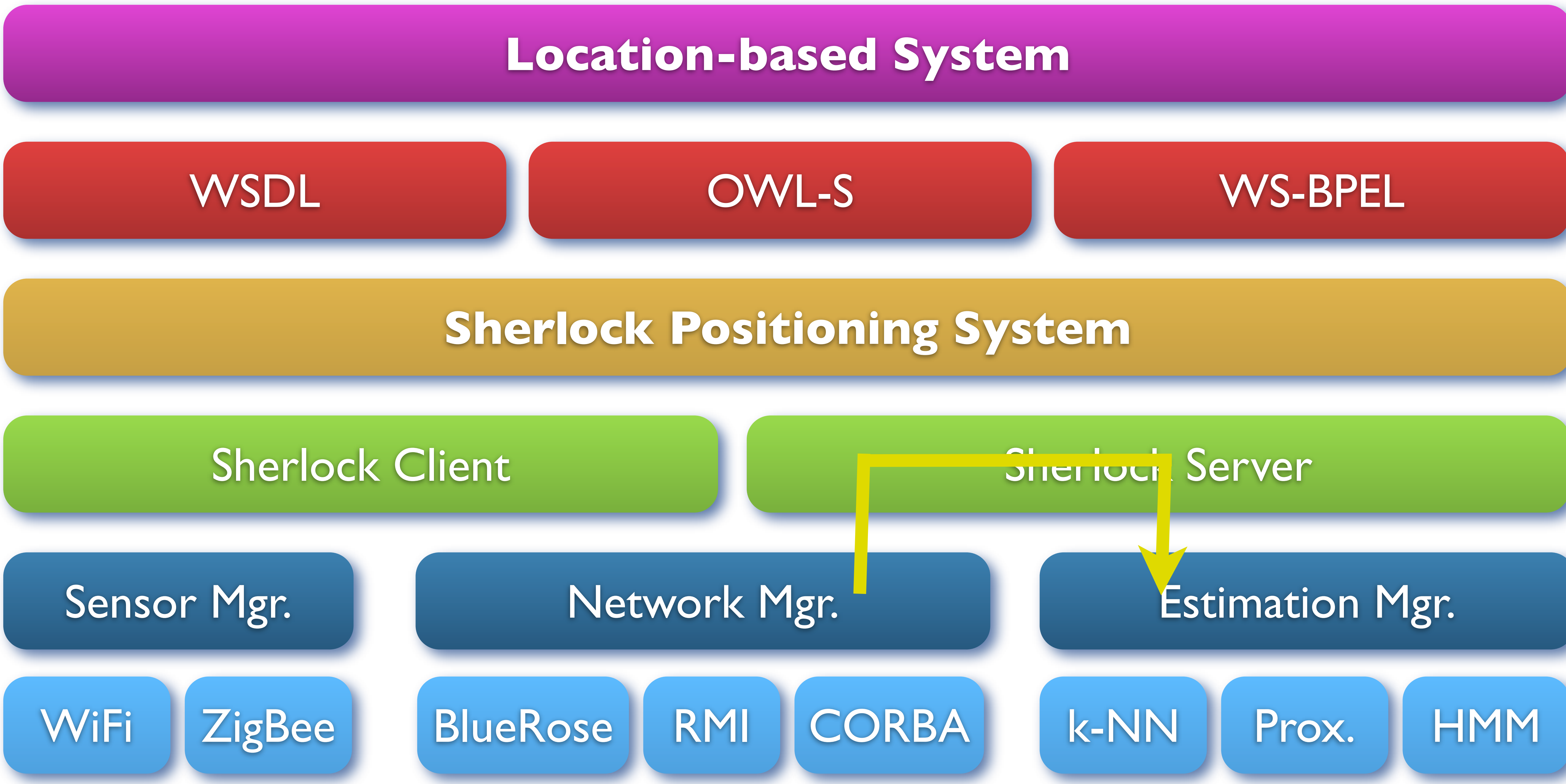

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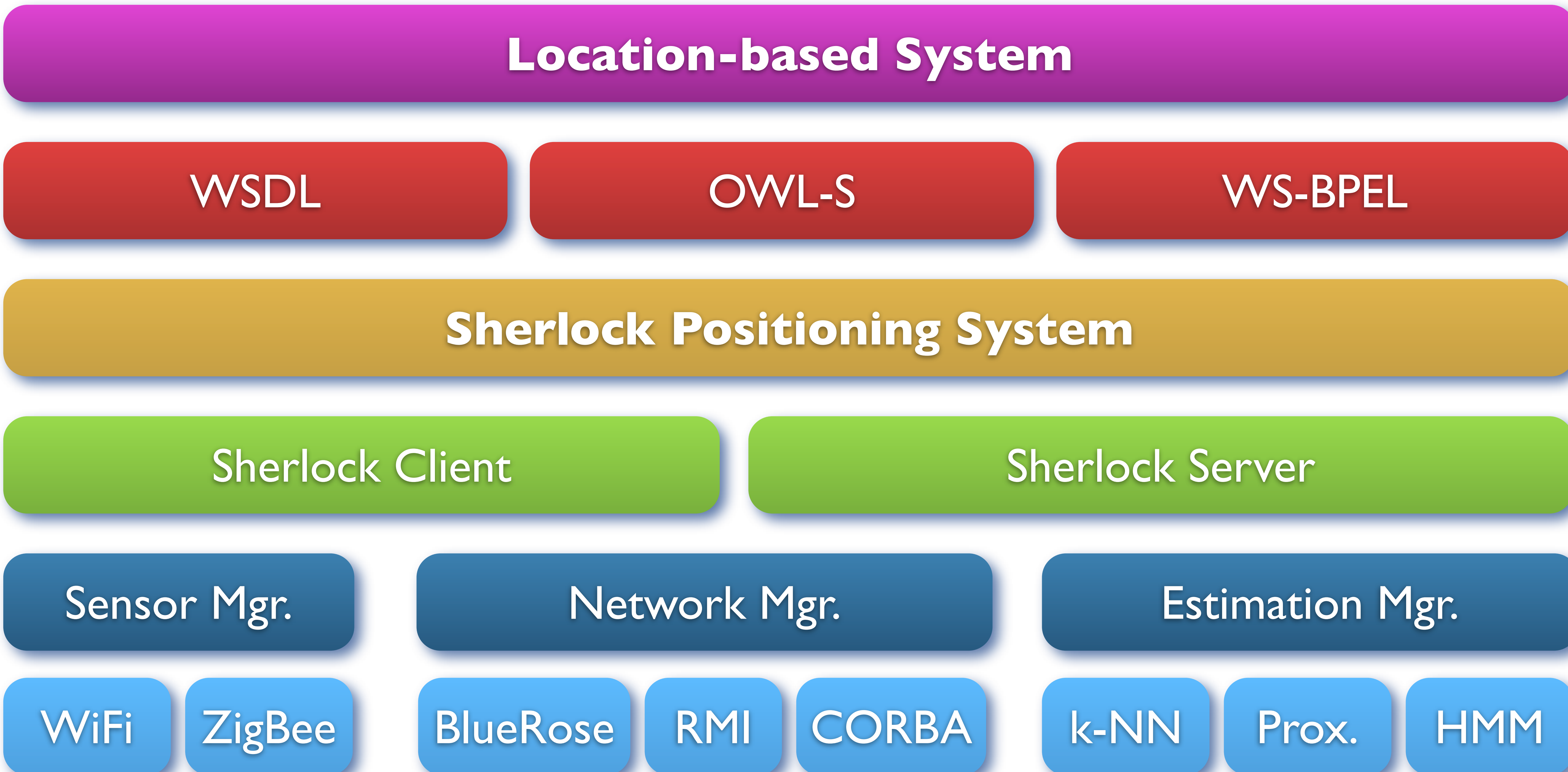

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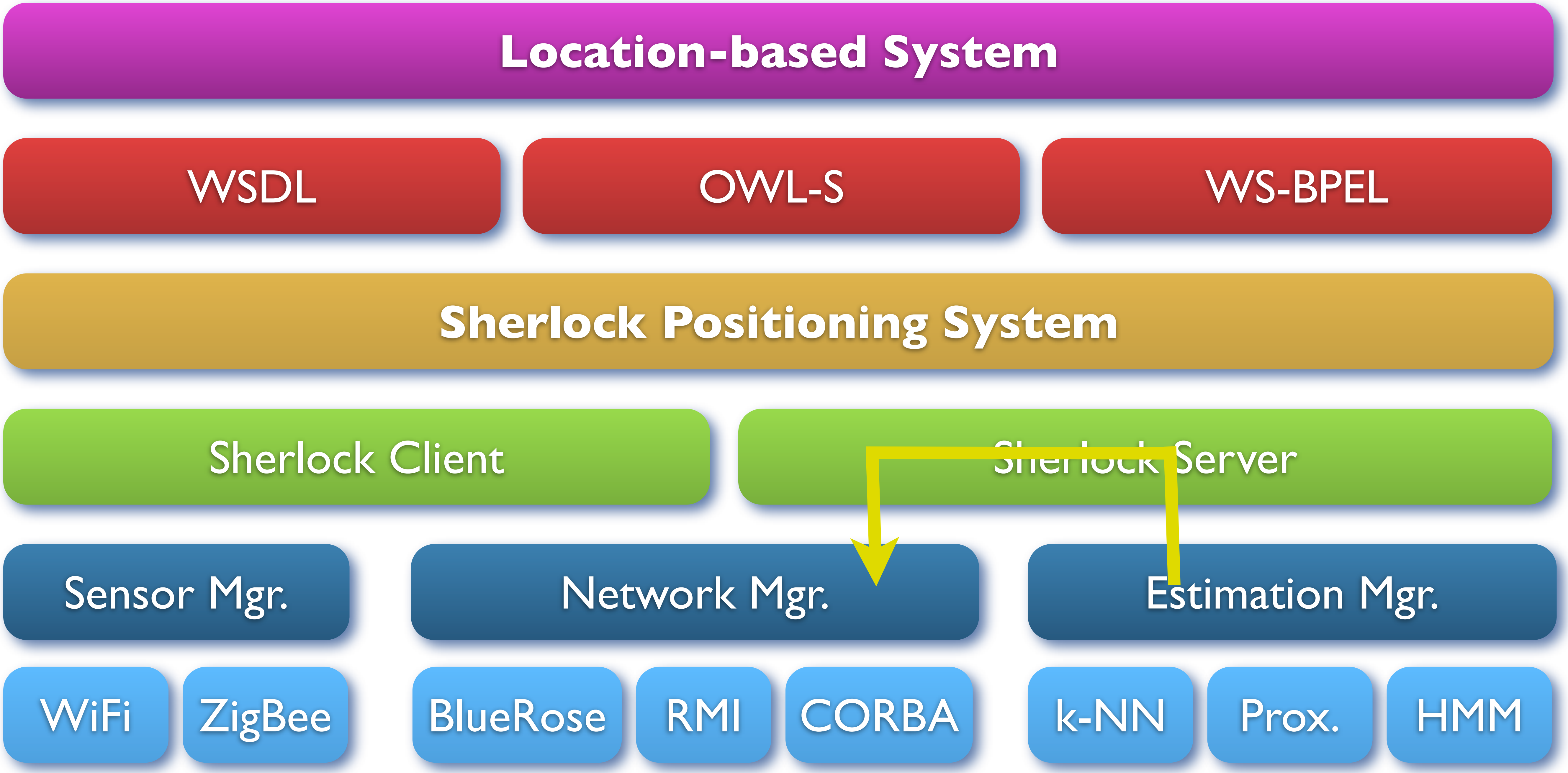

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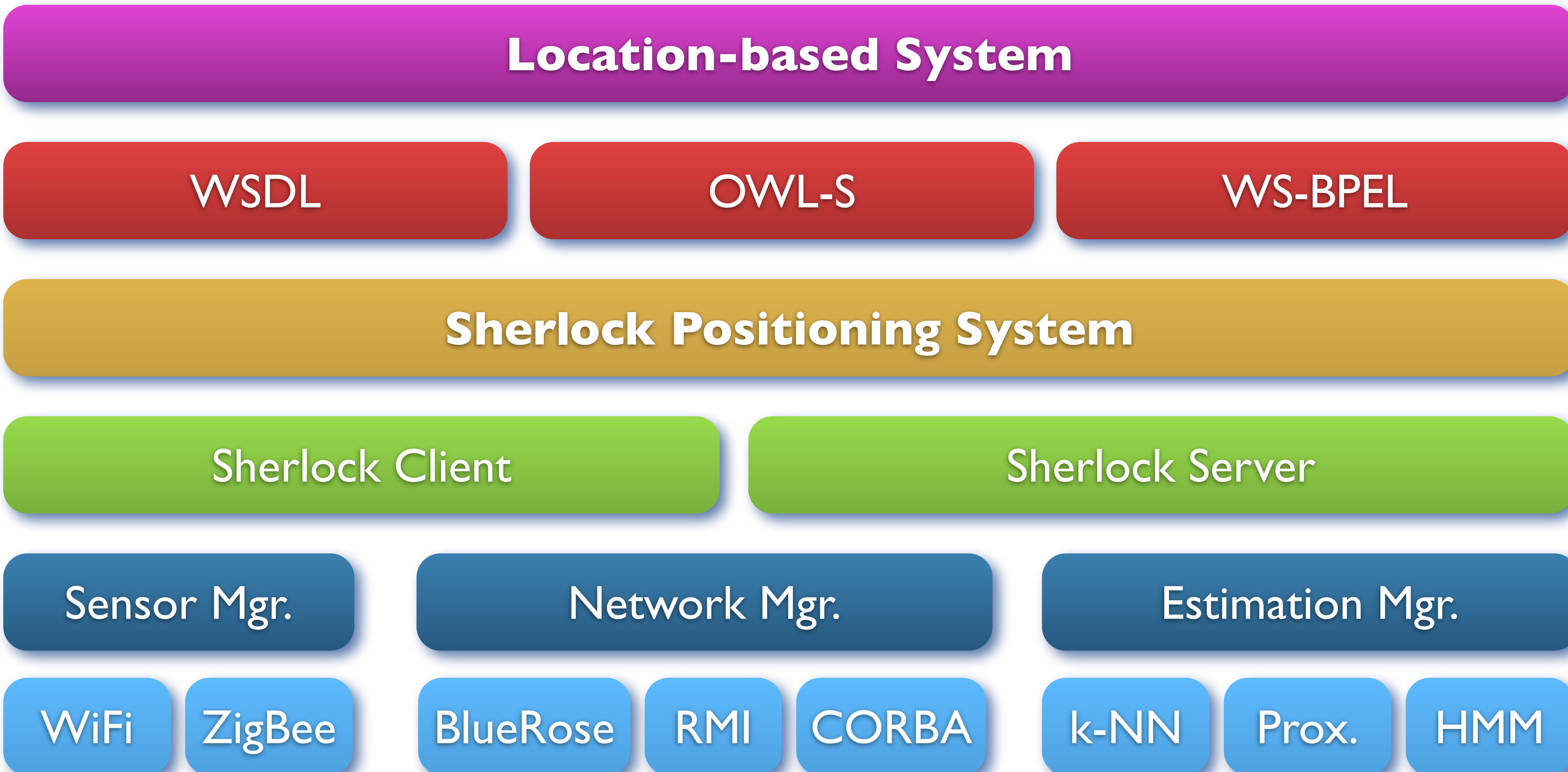

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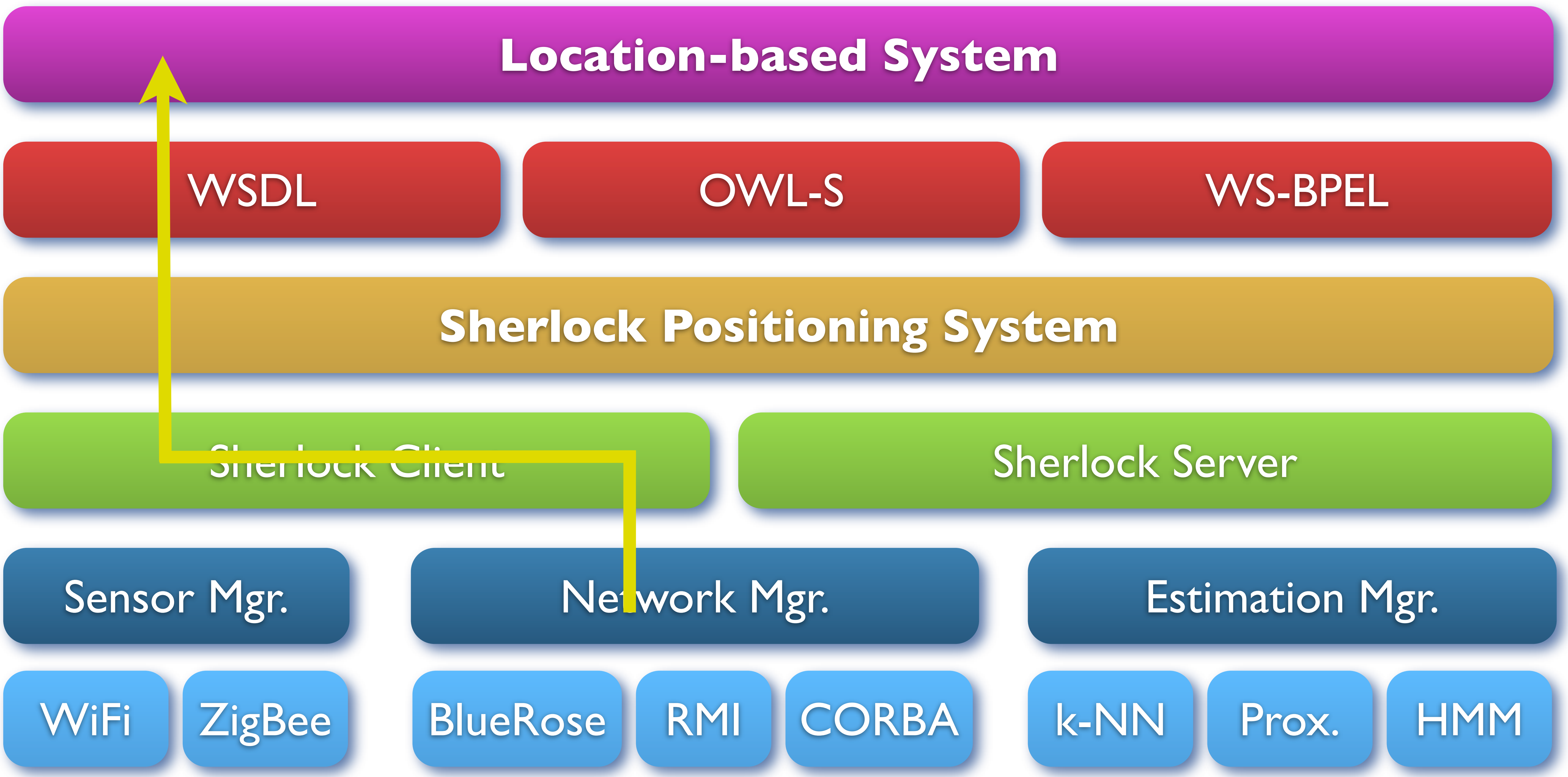

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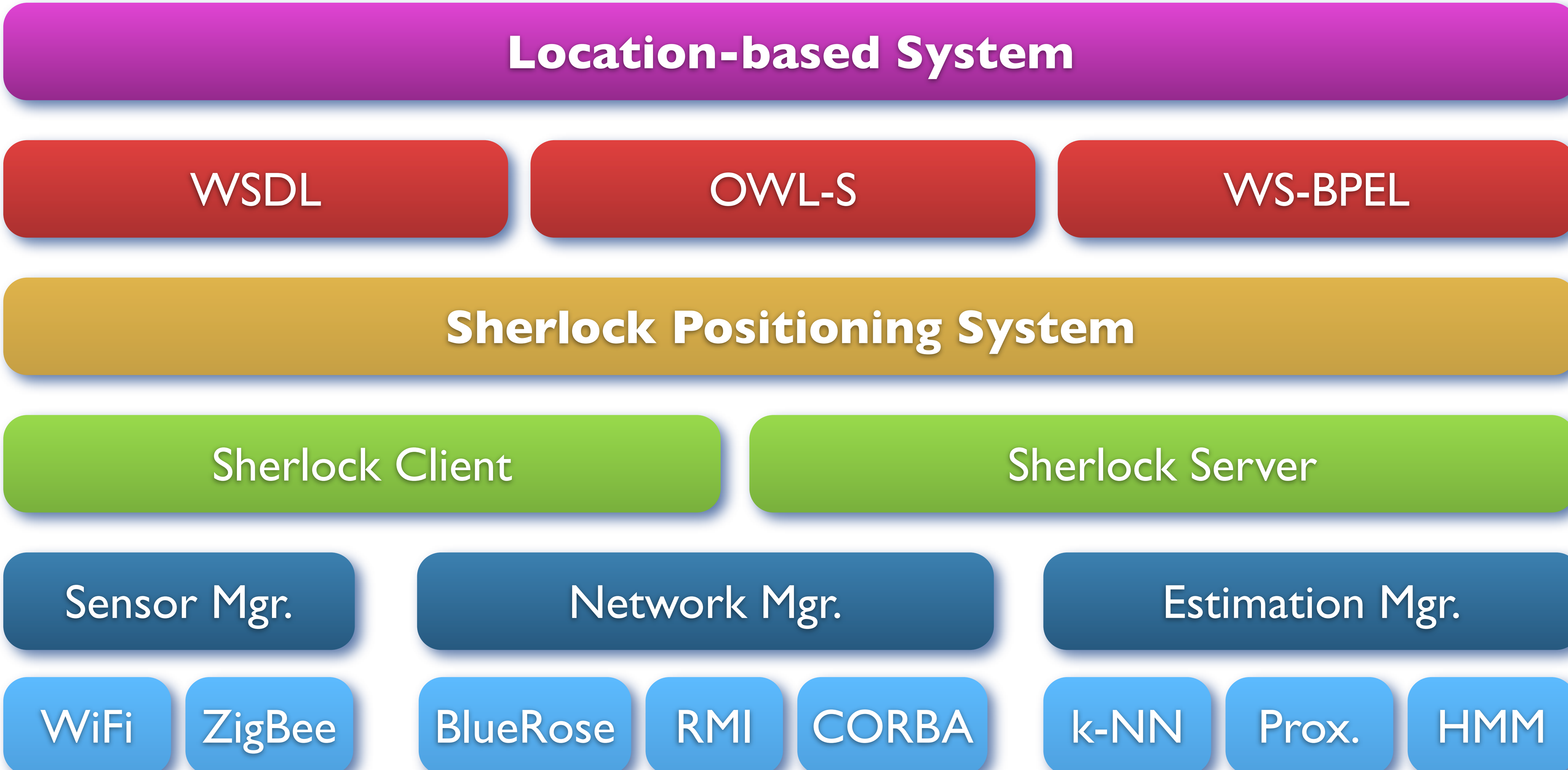
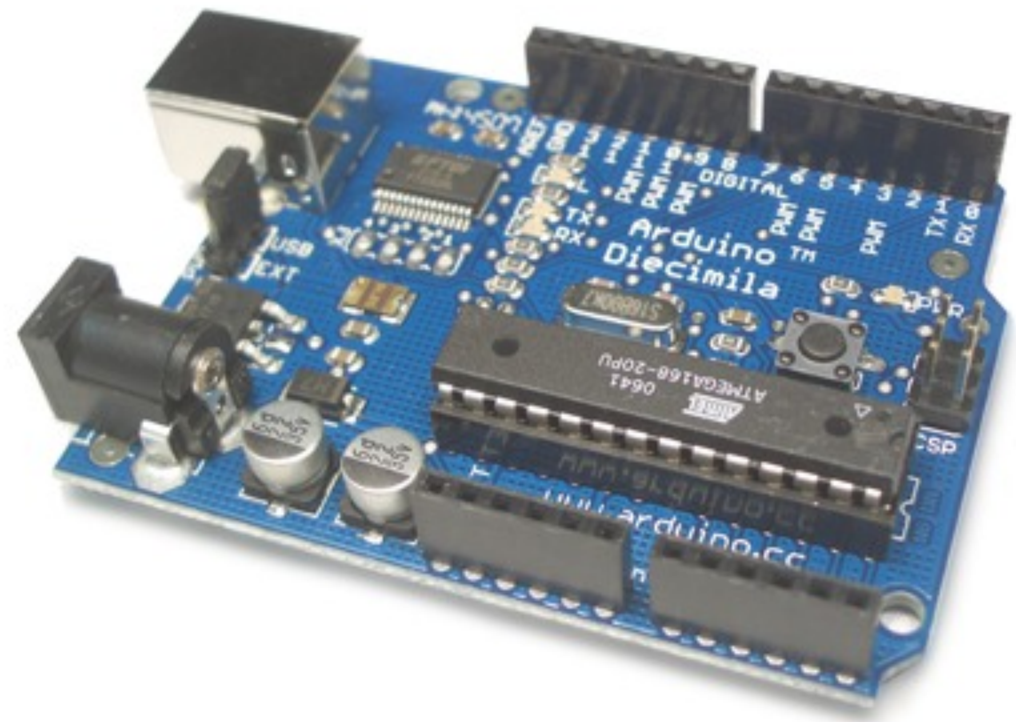
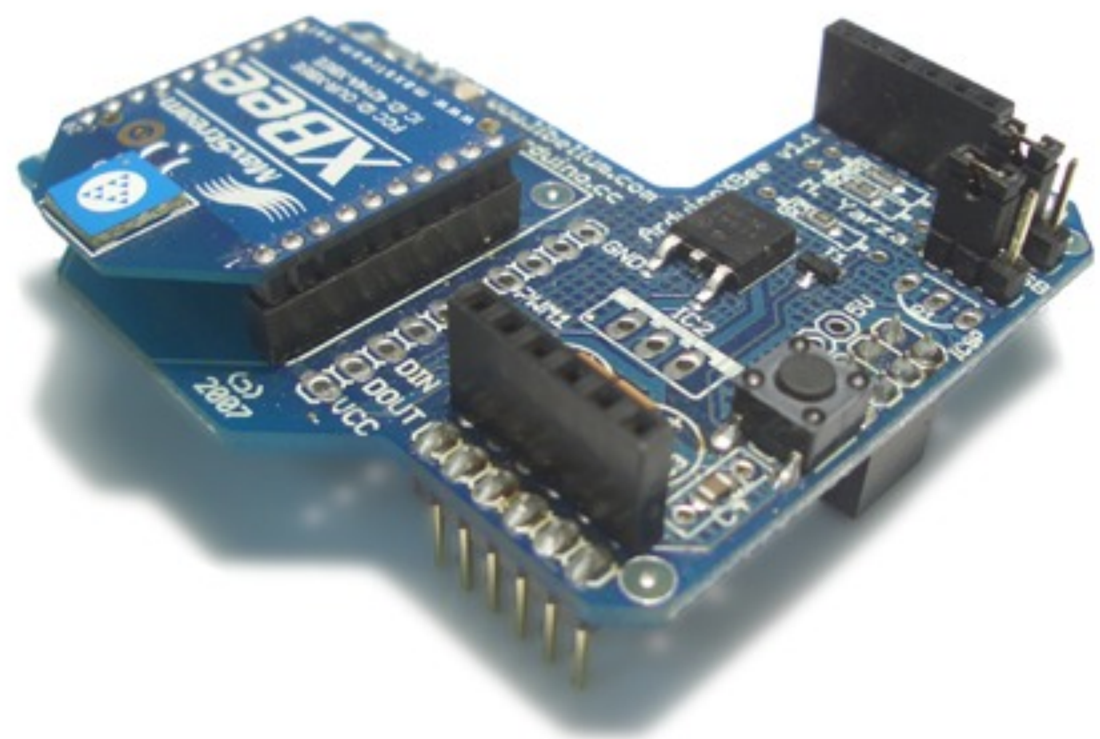


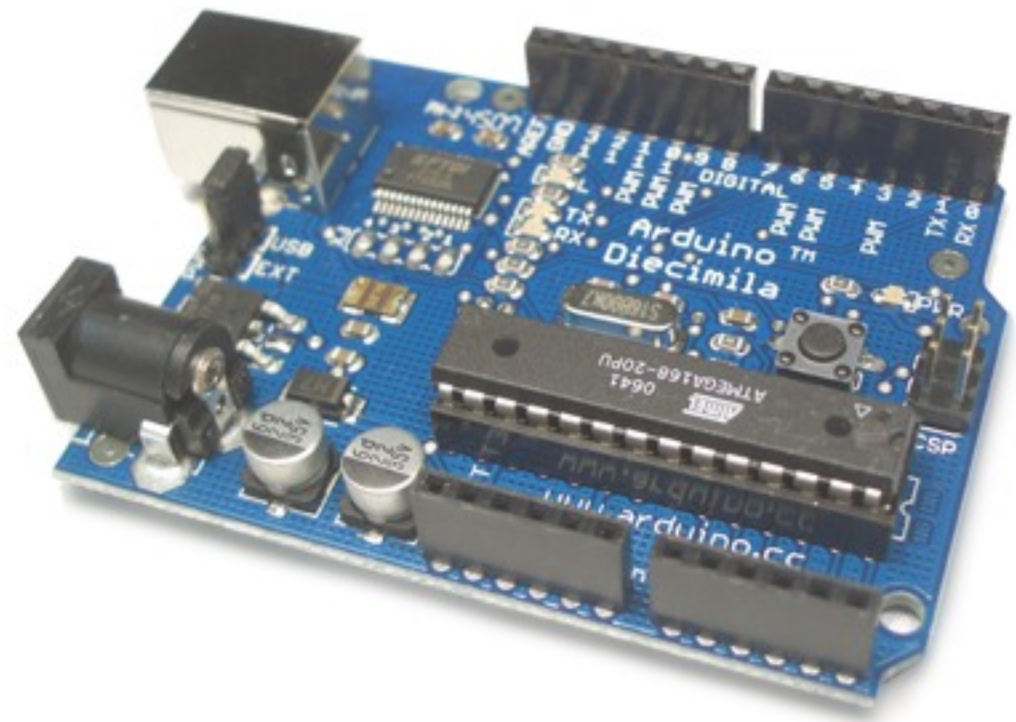
Implementation

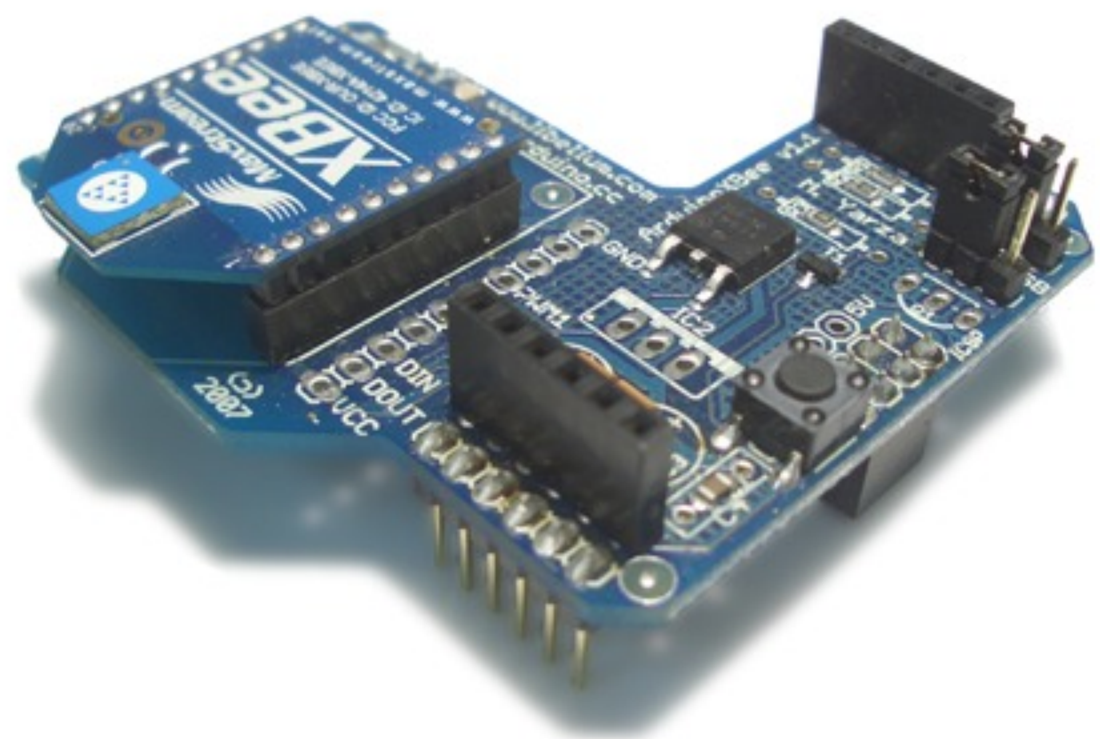




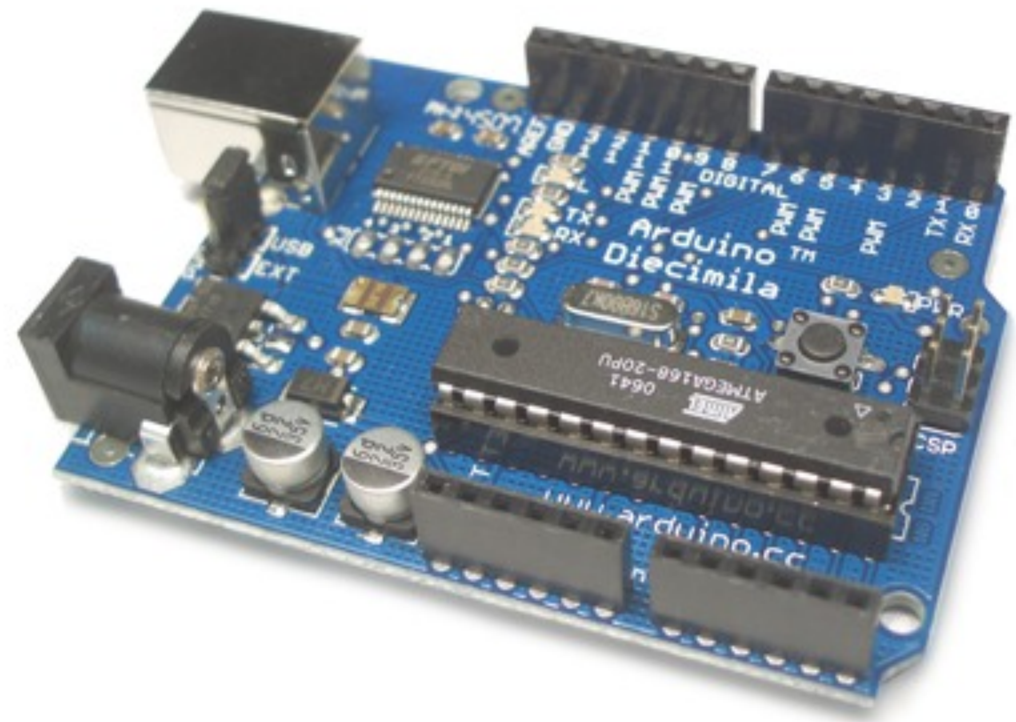
Implementation

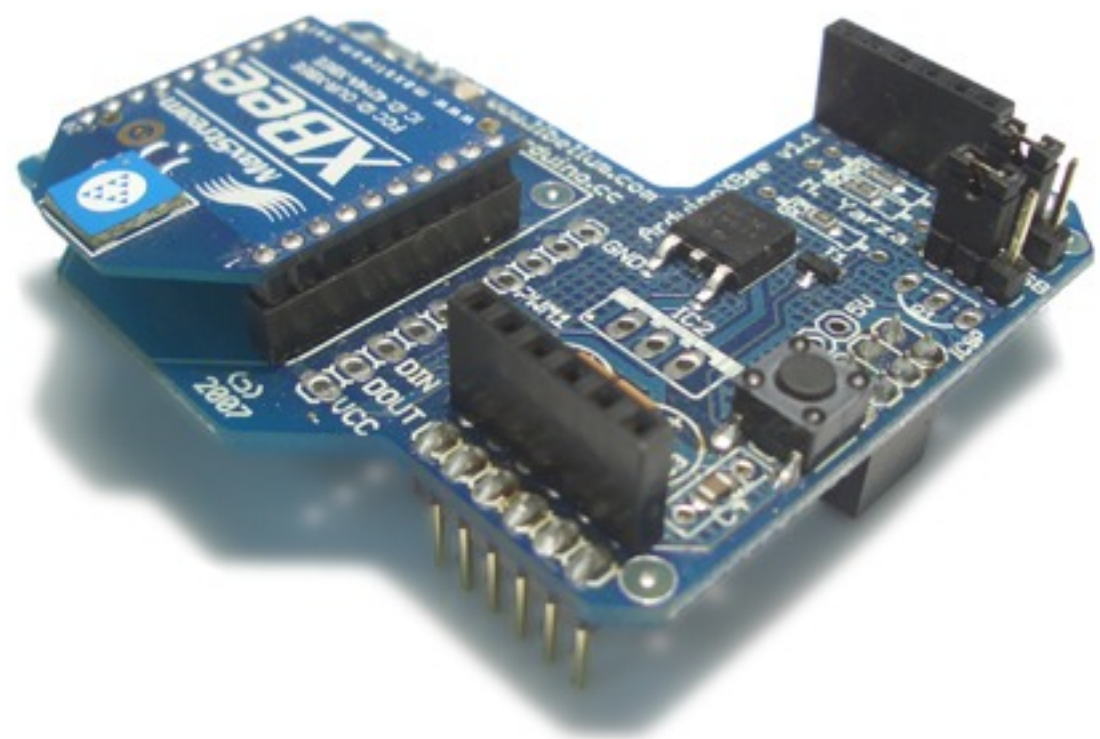
WiFi
Bluetooth
GPS



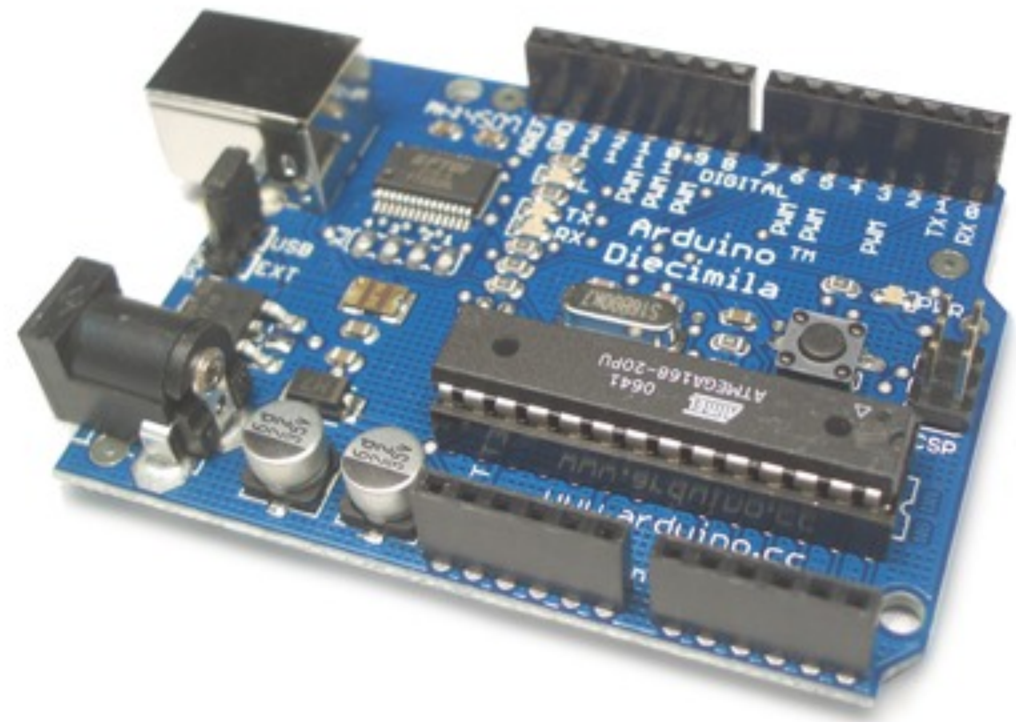


Implementation

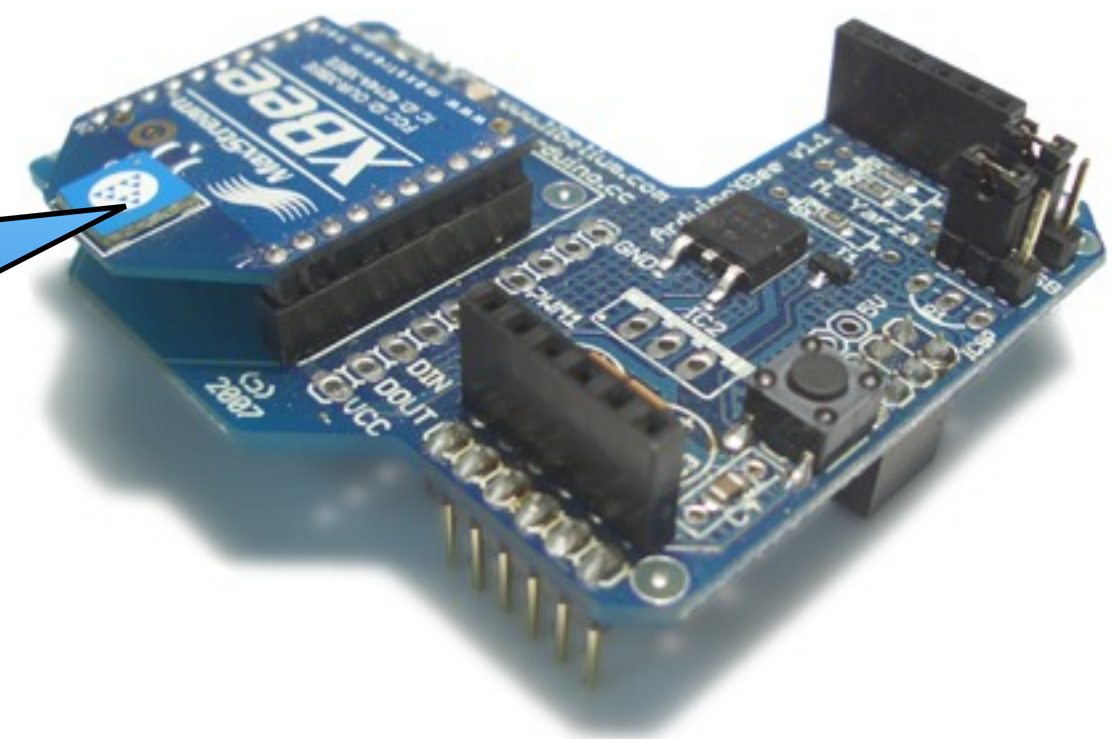




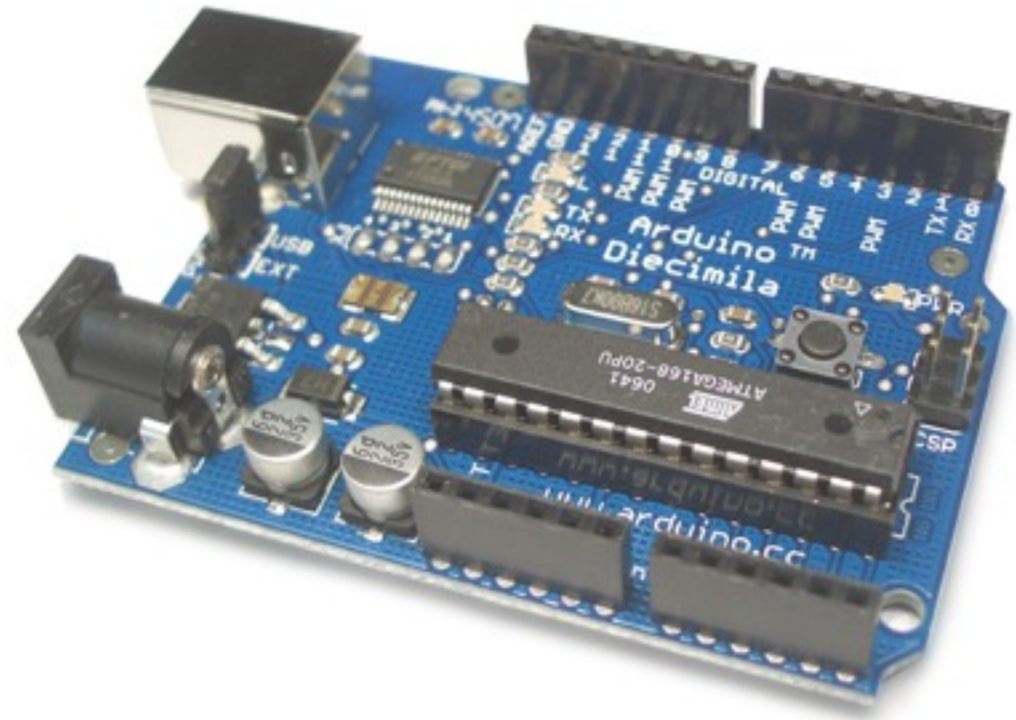
Implementation

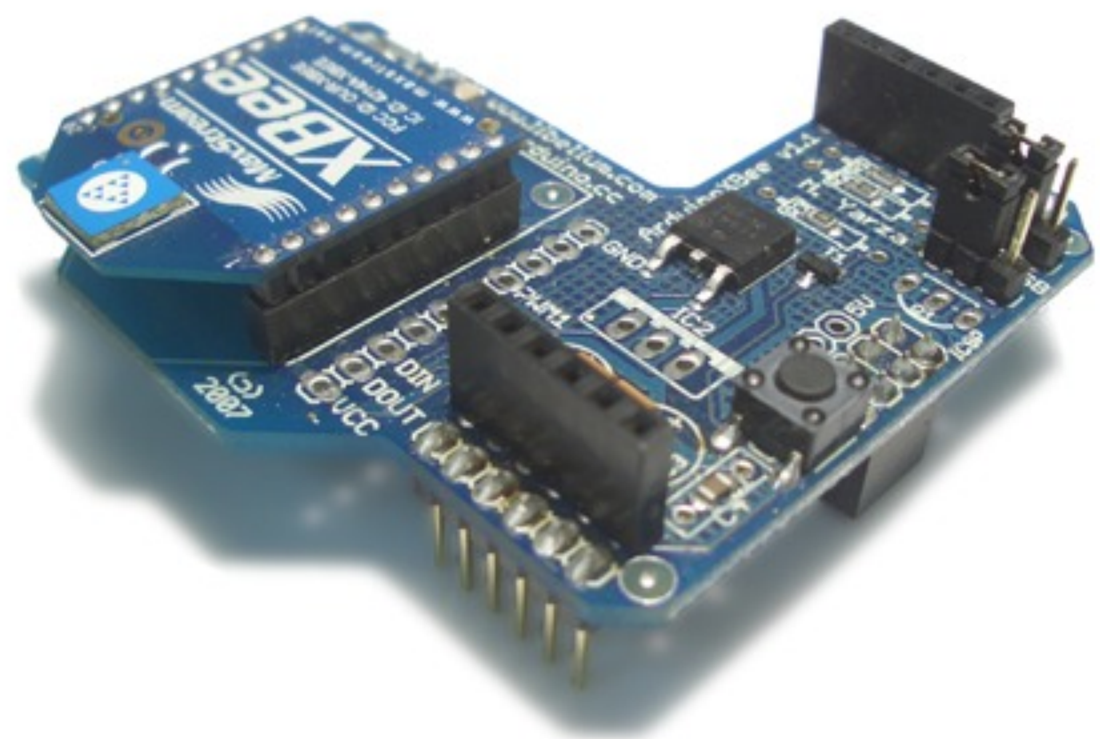


ZigBee Sensors



Implementation





Implementation

- k-Nearest Neighbors, measuring RSS
  - Manhattan distance
  - Euclidean distance
  - k = 3, 5

$$L_p = \frac{1}{N} \left(\sum_{i=1}^{N} \frac{1}{w_i} \cdot |x_i - x_i'|^p \right)^{\frac{1}{p}}$$

- Symbolic location indoors (Regions of interest)
- Absolute location outdoors

Conclusions

- Hybrid and adaptable Positioning System
  - Indoors / Outdoors
  - Technologies
  - Positioning algorithms
  - Positioning architectures
- Extensible
- Reusable support to LBS
- Satisfaction of Non-Functional Requirements

Thanks for your attention

Tomás Ruiz-López
tomruiz@ugr.es

Sherlock: A Hybrid Positioning System based on Standard Technologies

EvAAL 2011

T. Ruiz-López, J.L. Garrido,
C. Rodríguez Domínguez, M. Noguera

Department of Software Engineering
University of Granada
September 2011

Evaluating AAL Systems Through Competitive Benchmarking (EvAAL)

Technical (and less technical) aspects of the first competition

Stefano Chessa

Lecce, 26th September 2011

EvAAL : motivations

- Ambient Assisted Living (AAL) seeks for technical solutions for the improvement of the quality of life of elders and disabled.
- EvAAL aims at giving an impulse to research in AAL:
  - by identifying research challenges relevant to AAL
    - The **long term research challenge** of EvAAL is the evaluation of complex platforms for AAL
    - Short term research challenges are the evaluation of components/services of AAL systems
  - by making available to researchers the datasets obtained during the competition;
  - by contributing to the construction of a community of people interested in AAL.

The EvAAL 2011 team

- Steering board (9 members)
  - Italy (3), Spain (3) Germany (2) Denmark (1)
- Program committee (17 members from Spain and Italy)
- Local and evaluation teams
  - You already know them

Competitors selection process

- Managed by the Technical Program Committee
  - Each submission was reviewed by two TPC members
- Selection of competitors among 10 submissions
  - 1 rejected because not suitable to AAL
  - 2 widthdrew
  - 1 admitted as guest
  - 6 admitted as competitors

Competitors

- 7 teams in Valencia
  - one was admitted as guest
- Teams and nationalities:
  - AIT – Austria
  - CapFloor – Germany (guest)
  - GEDES-UGR – Spain
  - iLoc – Germany / Switzerland
  - nCore Polaris – Spain
  - OwIPS – France
  - SNTUmicro – Ukraine

Financing of EvAAL

- The ideal plan was to find sponsors
  - … not easy : this was the first edition, EvAAL was not known
- The CIAMI Living Lab was offered for free (THANKS to TSB in Valencia)
- All the organization members were volunteers
- Some partners of the universAAL consortium offered to refund travel expenses to competitors
  - ISTI-CNR (IT)
  - Fraunhofer (GE)
  - Univ. Politecnica of Madrid (SP)
  - ITACA (SP)

Evaluation criteria

- Accuracy
  - This is the main purpose of a localization system
  - The score is attributed in a range of errors between 0 and 4 meters
    - An average error above 4 meters would mean that the system does not really know in which room the user is…
- Availability
  - …nobody wants a system that does not responds…

Evaluation criteria

- Installation complexity
  - Measure the invasiveness of the system installation in the home of the final user
  - Think whether if you would be happy to install these systems in your home…
- Integrability in AAL systems
  - How easy is to use your system from the point of view of AAL applications programmers

Evaluation criteria

- User acceptance
  - Would you use your system in your daily life?
  - More advanced and better engineered systems where advantaged against research prototypes…
  - … but we considered also your system in the perspective of an engineering
  - Each evaluation committee member gave his own opinion and score
  - There’s room for improvements here…

What's next?

EvAAL 2011 had been a great experience for us

- We are now planning EvAAL 2012
  - You already received the call for ideas
- We need involvement of people in terms of:
  - Ideas (new tracks?)
  - Participation to committees
  - Hosting and organization
  - In perspective, people willing to continue EvAAL in the years to come

CapFloor - Indoor localization using capacitive proximity sensors

Andreas Braun, Henning Heggen

Fraunhofer Institute for Computer Graphics Research - IGD, Darmstadt, Germany

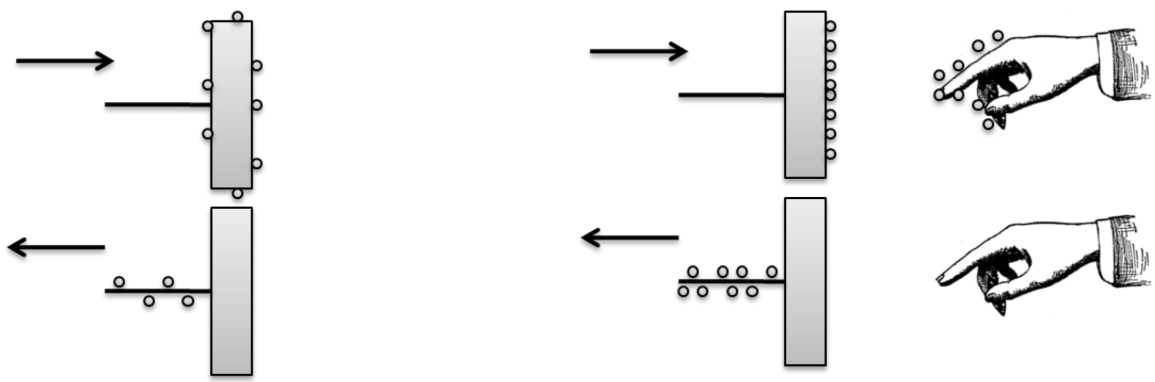
Fraunhofer IGD

Topics

- **Capacitive proximity sensing**
- Indoor localization
- Prototype
- Conclusion

Capacitive proximity sensing

Capacitive proximity sensing



1. Charge – small amount of energy stored
2. Discharge – low voltage

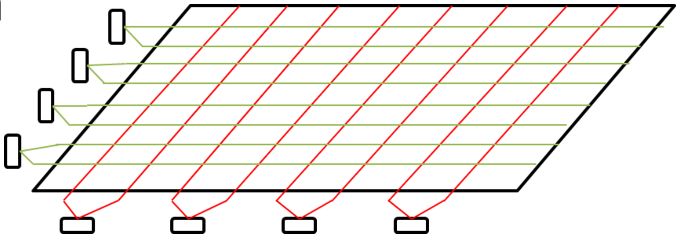
1. Charge – higher amount of energy stored
2. Discharge – higher voltage

Topics

- Capacitive proximity sensing
- **Indoor localization**
- Prototype
- Conclusion

Indoor localization

- Electrodes as wires in floor
- Grid placement allows two-dimensional detection
- Detect the presence of bodies on the floor
- Measurement system placed on the edges only



Indoor localization

- System capacitance depending on proximity and size of body

$$C = \varepsilon_0 \varepsilon_r \frac{A}{d}$$

- Distinguishing between lying/sitting/standing using thresholds
- Detecting position using interpolation between sensors and their position in room – currently weighted average in two dimensions

$$\bar{e} = \frac{\sum_{i=1}^{n} w_i e_i}{\sum_{i=1}^{n} w_i}$$

Indoor localization

- Example

- Reading Wire 1 – 1000, Reading Wire 2 – 300

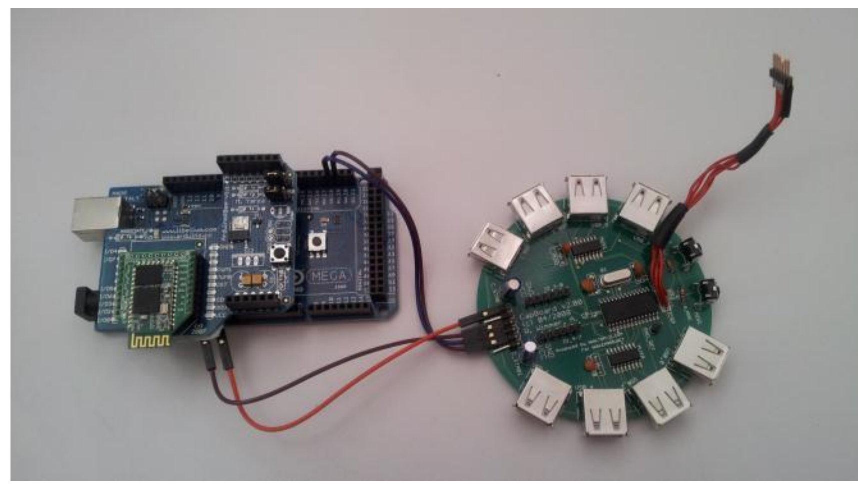
$$pos = \frac{1 \cdot 1000 + 2 \cdot 300}{1000 + 300} \approx 1{,}23$$

Topics

- Capacitive proximity sensing
- Indoor localization
- **Prototype**
- Conclusion

Prototype

- Electrode Mat
  - Two layers of insulated wires
  - Two/three wires on each sensor
- Open Source Sensors
  - CapToolKit
  - 8 channels
- Arduino Bluetooth transmission
  - Arduino Mega
  - Bluetooth Bee



Prototype

- EvAAL setup
  - Three mats with different electrode configuration
  - Three mini-mats for AOI detection with different sensor
  - Coverage around $25m^2$ - a third of area
- Software
  - XML based configuration of the different mats
  - Interfacing different types of sensors
  - Supporting different mat types
  - universAAL-by-socket

Fraunhofer IGD

Topics

- Capacitive proximity sensing
- Indoor localization
- Prototype
- **Conclusion**

Conclusion

- Ability to detect one person with a resolution of approximately 40cm
- Support of multiple sensor types
- Detection of falls possible
- System working through different types of floor covering
- Electrodes can be cut to fit rooms – different response can be compensated

Future Work

- Get enough hardware!
- Large scale installation
- Detection of multiple persons, pets through historical data

Thank you for listening

Andreas Braun
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Fraunhofer IGD

OwlPS: a Wi-Fi-based positioning system

Open WireLess Positioning System

Matteo Cypriani – matteo.cypriani@univ-fcomte.fr
University of Franche-Comté, France
Computer Science Laboratory (LIFC)

Monday 26 September 2011

Outline

Overview

Architecture

Algorithms

Hardware

Outline

Overview

Architecture

Algorithms

Hardware

Overview of OwlPS

- Wi-Fi signal strength-based positioning system.
- Mainly indoor.
- Infrastructure-centred.
- Emphasis on:
  - fast & easy deployment;
  - low cost.

Outline

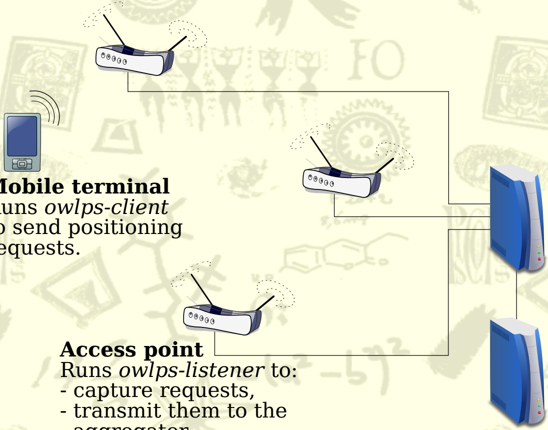
Overview

Architecture

Algorithms

Hardware

Architecture



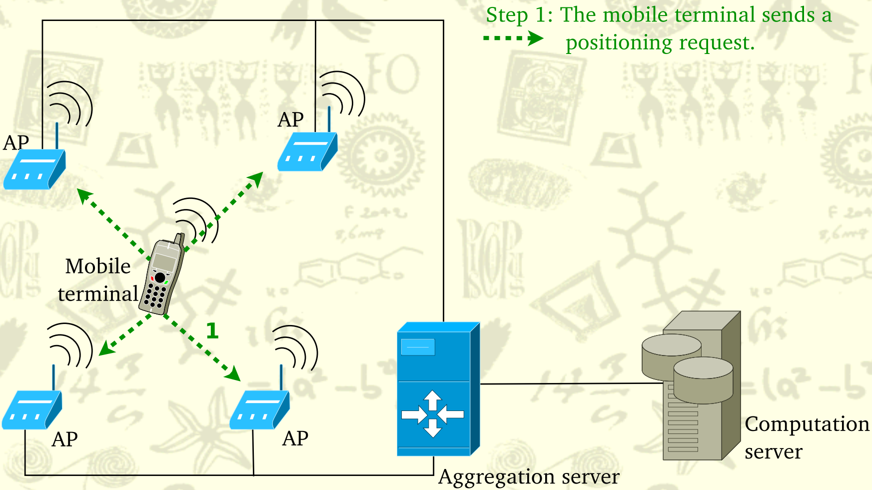
Mobile terminal
Runs *owlps-client* to send positioning requests.

Access point
Runs *owlps-listener* to:
- capture requests,
- transmit them to the aggregator.

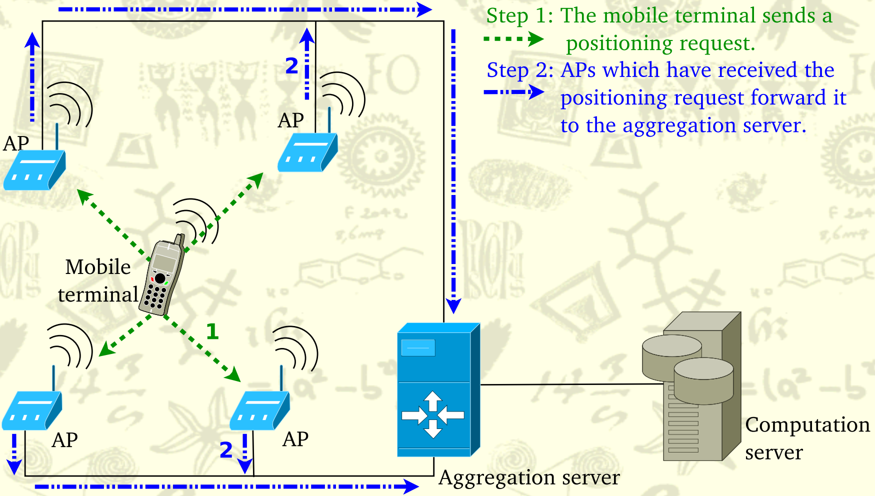
Aggregation server
Runs *owlps-aggregator* to:
- get requests from APs,
- aggregate identical requests sent by several APs,
- send aggregated requests to the positioning server.

Positioning server
Runs *owlps-positioning* to:
- get aggregated requests from the aggregator,
- run positioning algorithms,
- provide results.

Operating process



Operating process

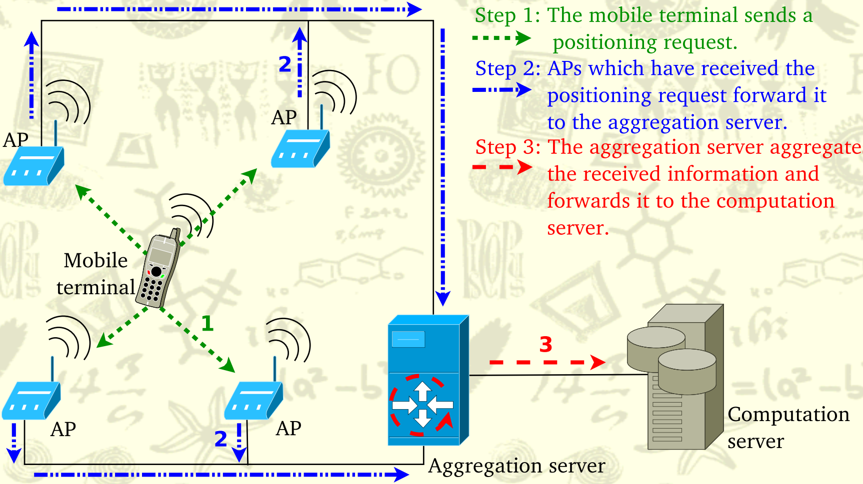


Operating process

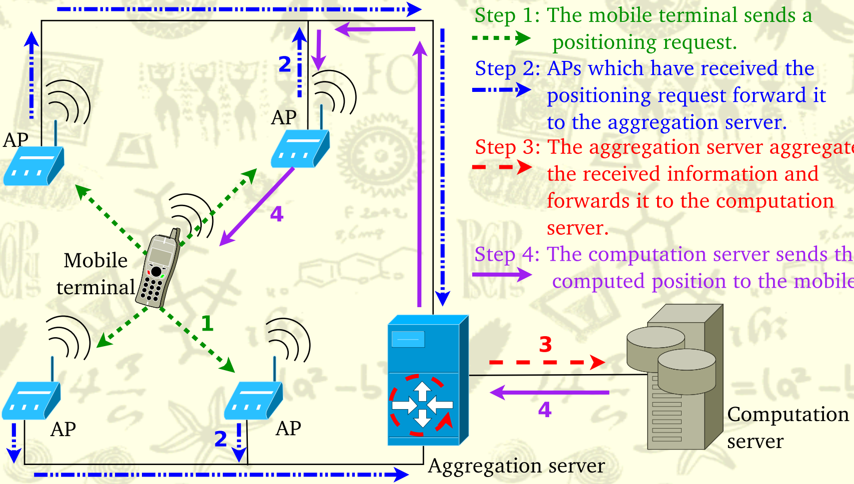
Step 1: The mobile terminal sends a positioning request.

Step 2: APs which have received the positioning request forward it to the aggregation server.

Step 3: The aggregation server aggregates the received information and forwards it to the computation server.



Operating process



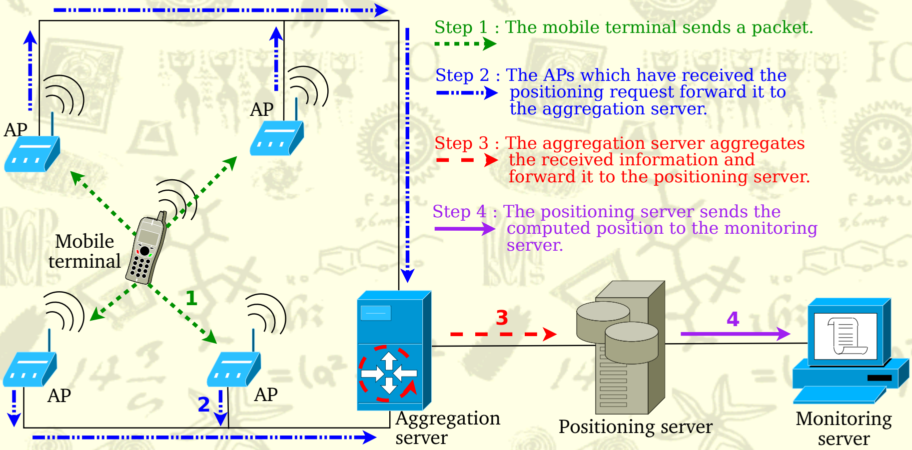
Step 1: The mobile terminal sends a positioning request.

Step 2: APs which have received the positioning request forward it to the aggregation server.

Step 3: The aggregation server aggregates the received information and forwards it to the computation server.

Step 4: The computation server sends the computed position to the mobile.

Operating process



Step 1 : The mobile terminal sends a packet.

Step 2 : The APs which have received the positioning request forward it to the aggregation server.

Step 3 : The aggregation server aggregates the received information and forward it to the positioning server.

Step 4 : The positioning server sends the computed position to the monitoring server.

Outline

Overview

Architecture

Algorithms

Hardware

Algorithms

- Several algorithms implemented:
  - fingerprinting location,
  - trilateration,
  - hybrid fingerprinting-trilateration.
- Auto-calibration implemented for fingerprinting-based algorithms.
- Algorithm used for EvAAL:
  simple nearest neighbour with auto-calibration.

Auto-calibration

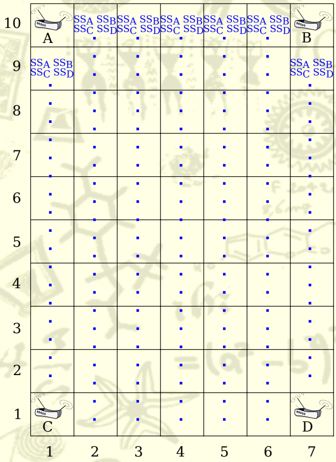
- Matrix of the SS received by any AP from each other.
- Geographical matrix, each element represents a coordinate and contains: $\{SS\ AP_A; SS\ AP_B; \ldots; SS\ AP_n\}$ as received from a virtual mobile.

Rx \ Tx	AP_A	AP_B	AP_C	AP_D
AP_A		-21	-60	-51
AP_B	-23		-52	-73
AP_C	-64	-55		-17
AP_D	-49	-70	-19	

Auto-calibration

- Matrix of the SS received by any AP from each other.

- Geographical matrix, each element represents a coordinate and contains:
  $\{SS\ AP_A; SS\ AP_B; \ldots; SS\ AP_n\}$
  as received from a virtual mobile.



Outline

Overview

Architecture

Algorithms

Hardware

Hardware

- 4 Fonera 2.0g:
  - Atheros AR2315 (180 MHz),
  - 16 Mo RAM, 8 Mo flash,
  - Wi-Fi Intel BG2200,
  - 5 or 1.8 dBi antenna,
  - OpenWrt.
- one more Fonera (mobile terminal).
- 1 PC (aggregation & positioning server).

→ Total cost < 1000 €.

Old vs. new hardware

Conclusion

OwlPS: a Wi-Fi indoor positioning system:

- flexible, modular,
- self-calibrated, quick deployment,
- low-cost.

OwlPS: an experimental platform for research:

- several algorithms implemented, new ones can easily be added;
- evaluation of localization techniques in identical conditions
  $\rightarrow$ we can compare the results objectively.

Future work

Weaknesses:

- mediocre accuracy (nearest neighbour similarity function),
- poor fault tolerance,
- 2-D only with the self-calibration (goal: 2.5-D),
- no handling of mobile terminals' characteristics.

Perspectives:

- full-automated deployment,
- outdoor positioning, combining positioning systems (Wi-Fi + GNSS, etc.)…

OwlPS: a Wi-Fi-based positioning system

Open WireLess Positioning System

Matteo CYPRIANI – matteo.cypriani@univ-fcomte.fr

University of Franche-Comté, France
Computer Science Laboratory (LIFC)

Monday 26 September 2011

Precision Indoor Objects Positioning based on Phase Measurements of Microwave Signals

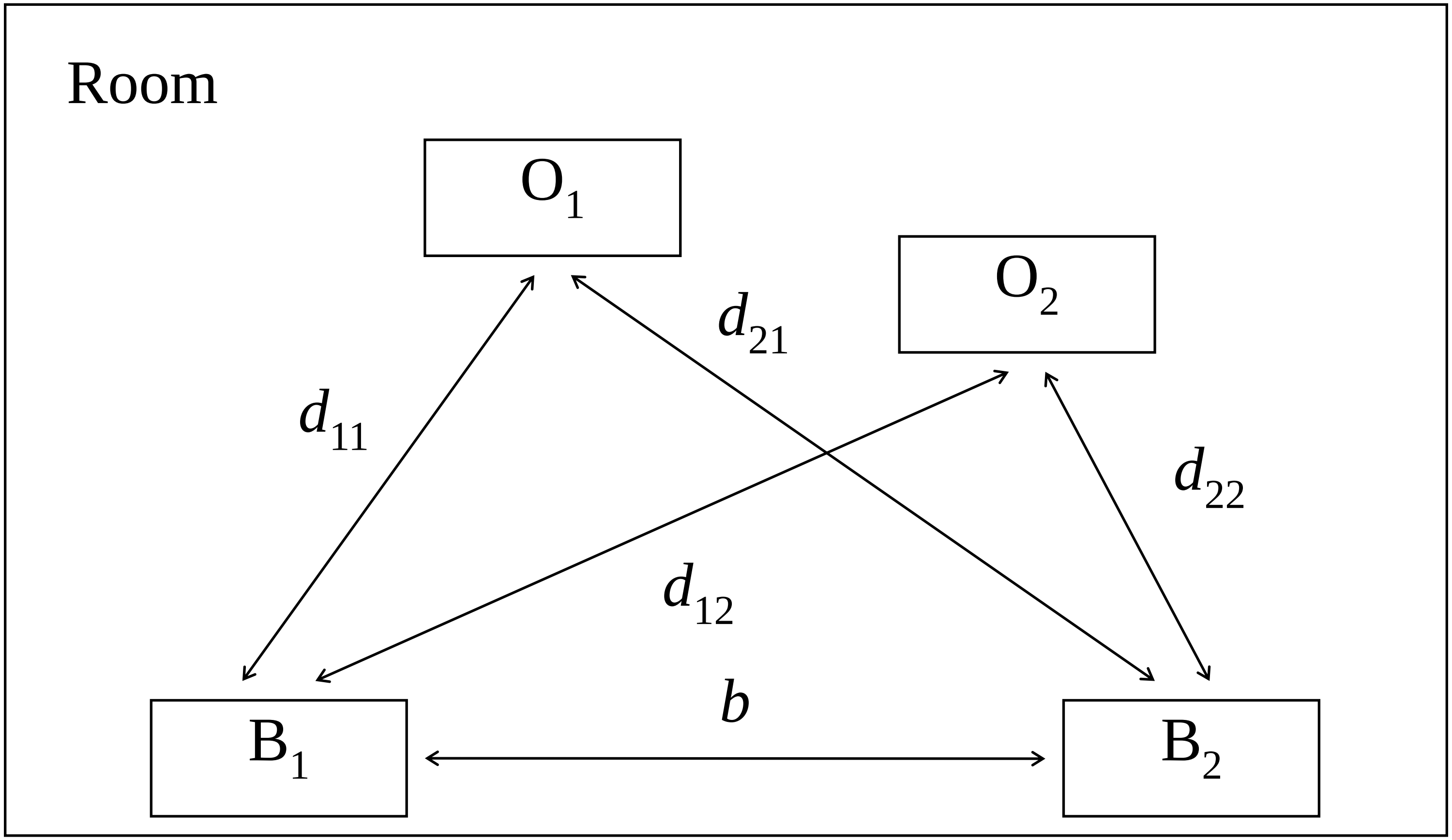
Igor B. Shirokov

Sevastopol National Technical University

Outline

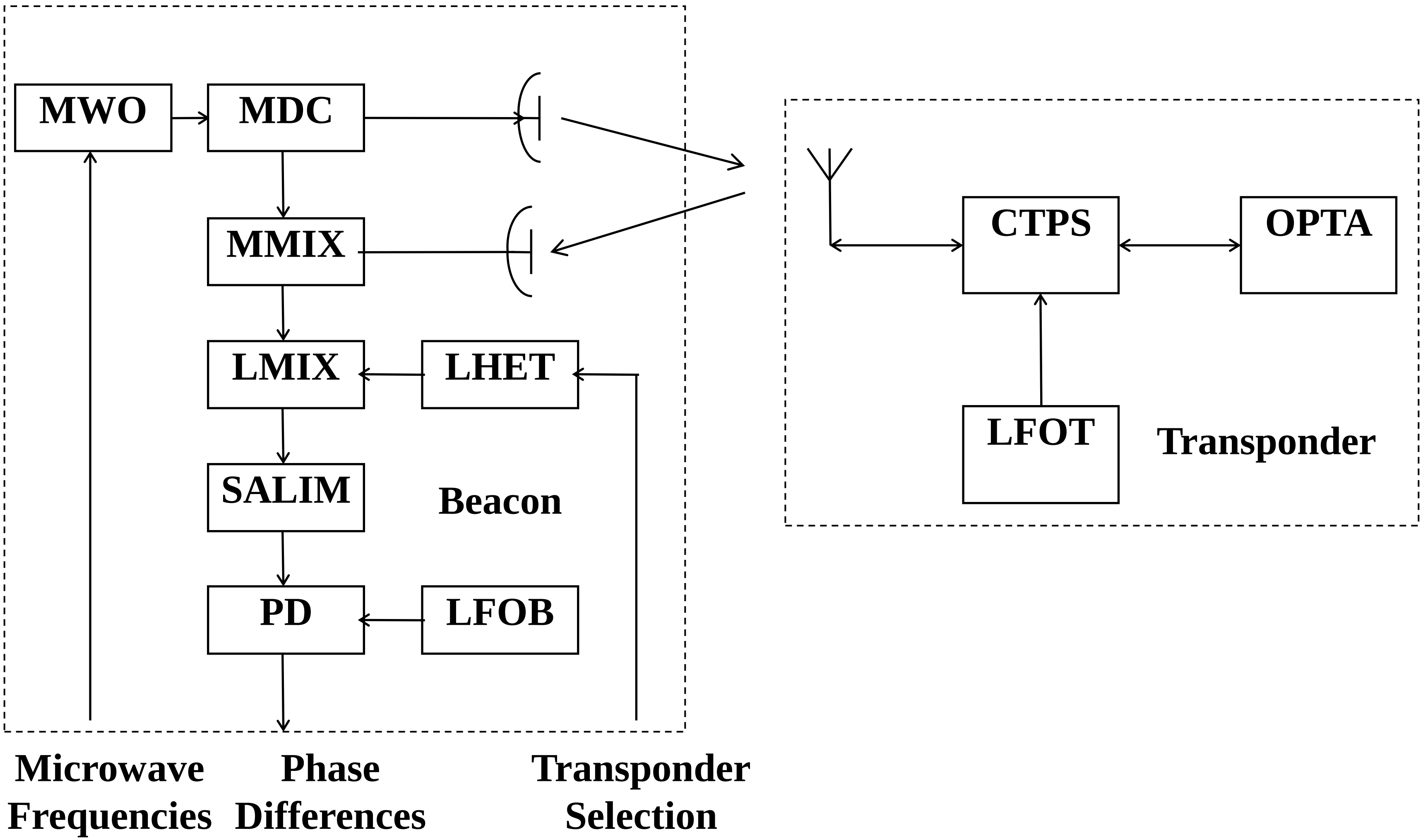
- Introduction
- Approach to a Problem
- Base equation
- The System Implementation
- Conclusion

Approach to a Problem



Placing the beacons and the objects in the room

The block diagram of each beacon and each transponder



Base equation

$$u_{i1}(t) = U_{i0}\sin\left[\omega_{i0}t + \varphi_{i0}\right]$$

$$u_{ij2}(t) = A_{ij}U_{i0}\sin\left[\omega_{i0}t + k_{i0}d_{ij} + \varphi_{i0}\right]$$

$$u_{ij3}(t) = A'_{ij}\,U_{i0}\sin\left[\left(\omega_{i0} + \Omega_{j}\right)t + k_{i0}d_{ij} + \varphi_{i0} + \varphi_{jL}\right]$$

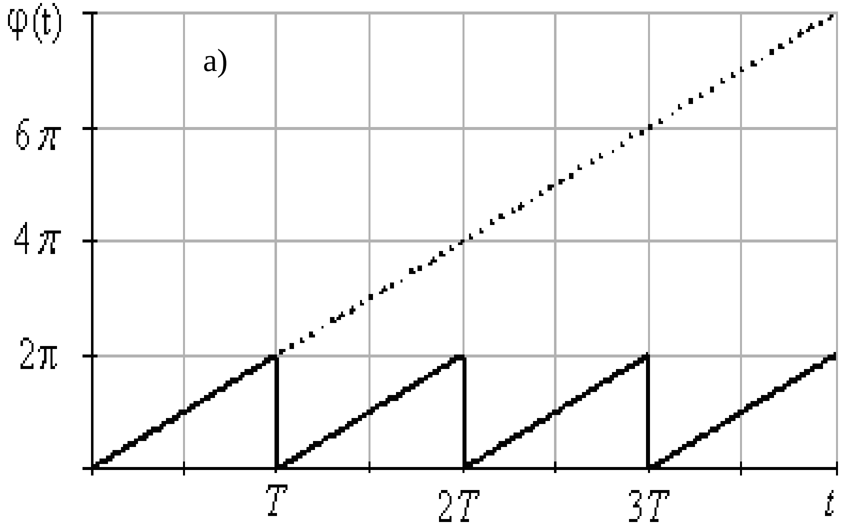
$$u_{ij4}(t) = A^{2}_{ij}U_{i0}\sin\left[\left(\omega_{i0} + \Omega_{j}\right)t + k_{i0}d_{i} + k'_{i0}d_{ij} + \varphi_{i0} + \varphi_{jL}\right]$$

$$u_{ij5}(t) = A^{2}_{ij}U_{i0}\sin\left[\Omega_{j}t + 2k_{i0}d_{ij} + \varphi_{jL}\right]$$

$$u_{ij6}(t) = U_{0}\sin\left[\Omega_{ij}t + 2k_{i0}d_{ij} + \varphi_{jL} - \varphi_{iH}\right]$$

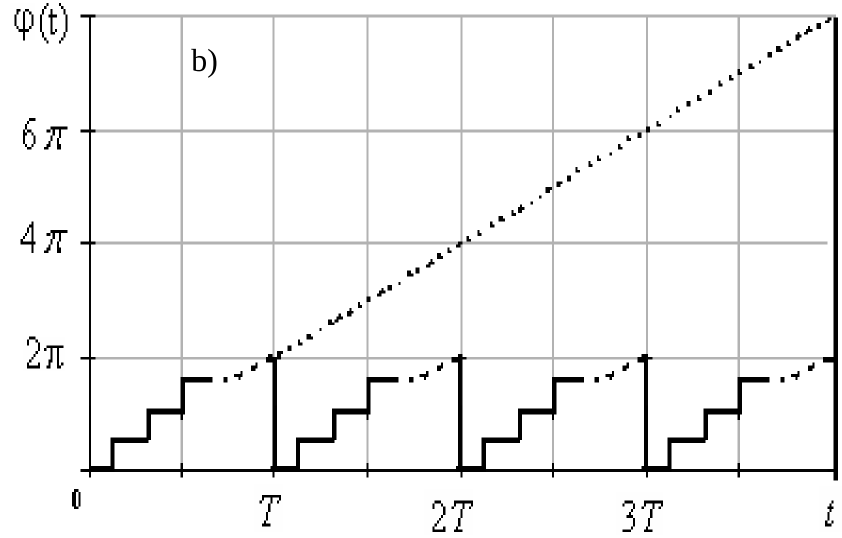
$$\Psi_{ij}\ :\ \ 2k_{i0}d_{ij} + \Delta\Omega t + \varphi \qquad\qquad D = \frac{\Delta\varphi\cdot c}{4\pi\left(f_1 - f_2\right)}$$

Frequency transformation



The law of microwave signal phase changing

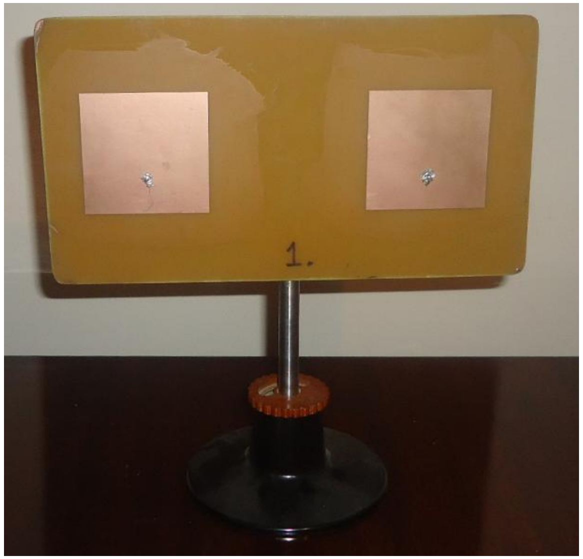
$$\Omega_j = 2\pi / T_j$$

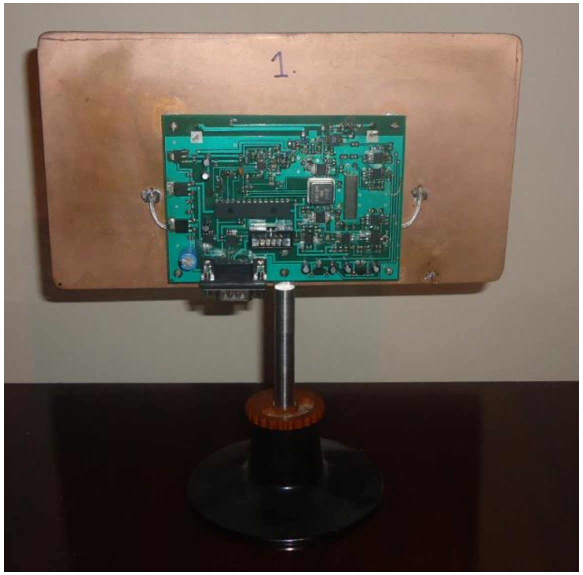


$$F_j = \Omega_j / 2\pi = 10\,\text{kHz}$$

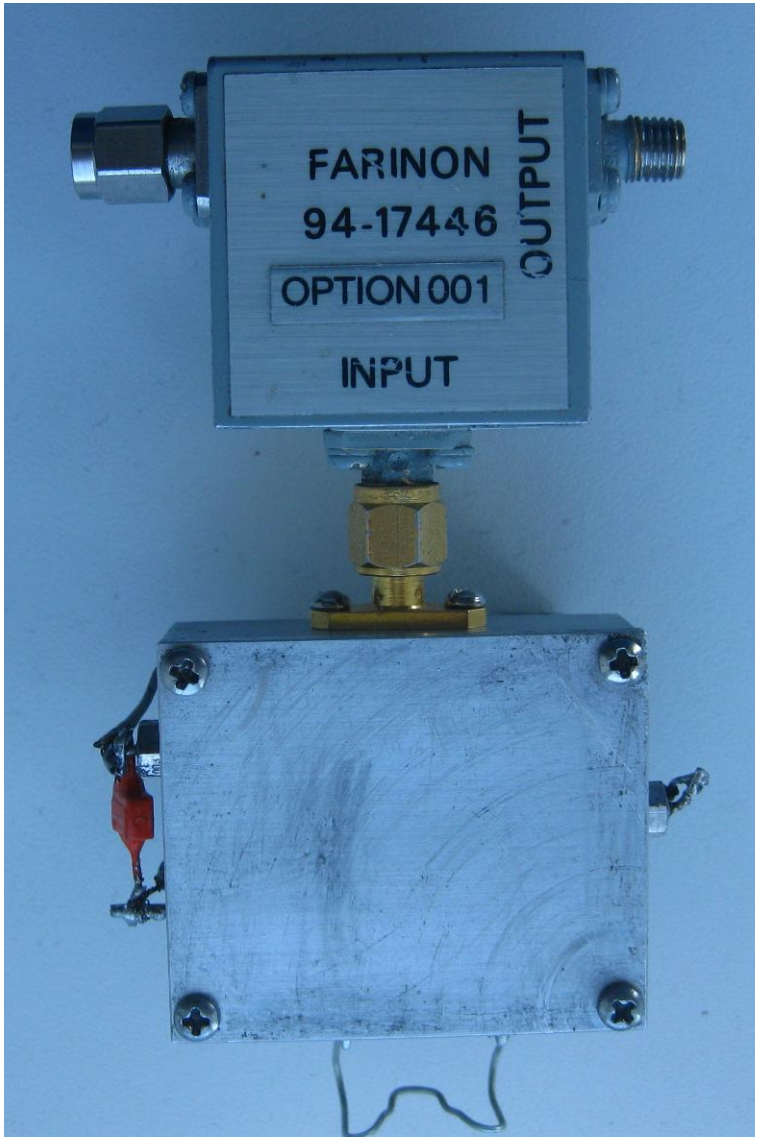
$$f_{i0} = \omega_{i0} / 2\pi = 1.5\,\text{GHz}$$

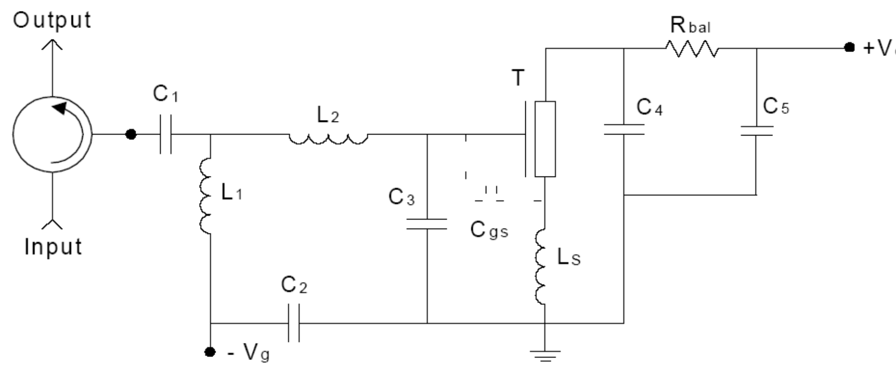
The System Implementation

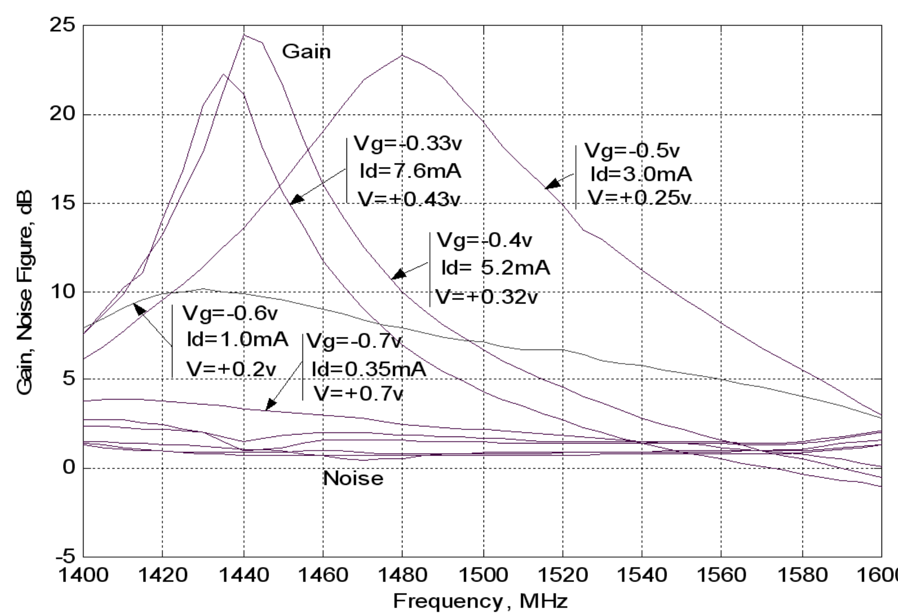




OPTA Design


FARINON
94-17446
OPTION 001
OUTPUT
INPUT


Output
Input
C1
L1
L2
C2
C3
Cgs
T
Ls
C4
C5
Rbal
+Vd
- Vg


Gain
Noise
Vg=-0.33v
Id=7.6mA
V=+0.43v
Vg=-0.5v
Id=3.0mA
V=+0.25v
Vg=-0.4v
Id= 5.2mA
V=+0.32v
Vg=-0.6v
Id=1.0mA
V=+0.2v
Vg=-0.7v
Id=0.35mA
V=+0.7v
Gain, Noise Figure, dB
Frequency, MHz

Conclusion

- The considered equipment possesses the simplest design and the lowest cost
- The metrological features are high
- The calculation routines are quite realized
- The equipment installation does not demand the extended manpower
- The transponder does not generate any radio signals

Thank you for attention

Igor Shirokov

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