P5 REAL TIME ASSET TRACKING IN HOSPITALS USING QUUPPA INDOOR POSITIONING TECHNOLOGY

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TU Delft CGI Quuppa Rijnstate

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Description of the problem

Indoor localization of assets

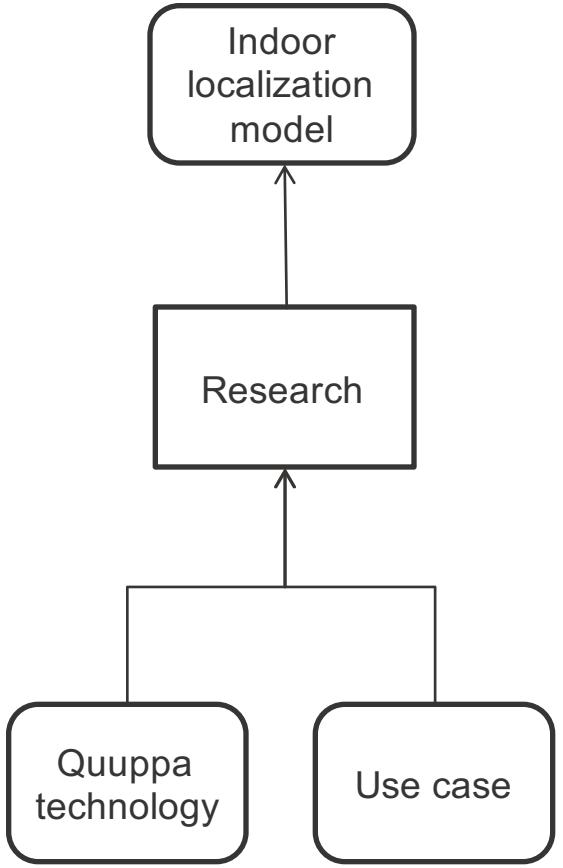
- Context (Complex buildings, indoor positioning, asset management)
- Develop a model for indoor localization to find certain assets

Quuppa

- Bluetooth indoor positioning system

Use case

- Monitor the whereabouts of medical equipment for asset management



Research Questions

Main research question:

"Does the technical and operational positioning performance of **Quuppa technology** meet the localization requirements for **asset tracking** in a hospital environment?"

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Research Questions

Sub research questions:

1. What are the possibilities and limitations of the Quuppa system?
2. What are the technical and operational performance parameters and how can they be measured?
3. What is the performance of the system based on the technical parameters?
4. What is the performance of the system based on the operational parameters?
5. How can the results of the test and analyses be put into a model for localization of assets using Quuppa technology?

Methodology

Positioning: Determining a point in a space represented by coordinates (x, y, z)

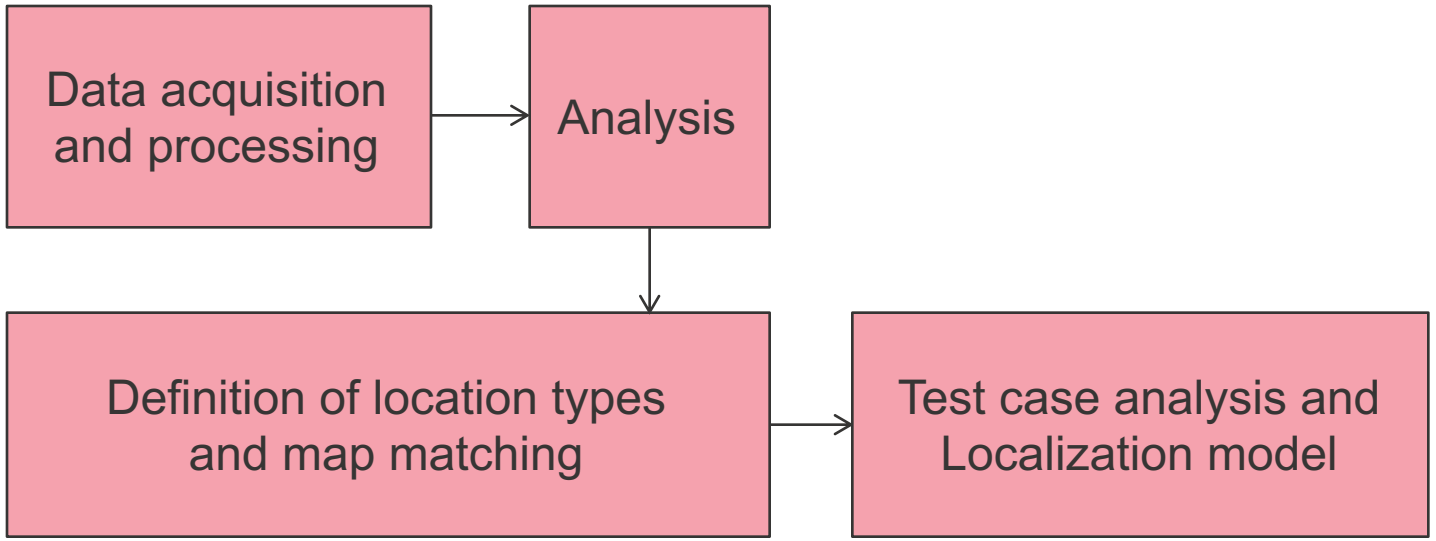
Localization: Determining a place with semantics and attributes about the identity added by human beings

Methodology

Research steps

Positioning

Localization



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Quuppa positioning technology

Specifications

- Bluetooth Low Energy (BLE) based
- Angle of Arrival (AoA) positioning method

- Accuracy up to sub-meter level (between 10m and 10 cm)
- Real-time data (between 1min and 100ms latency)

Tag

Locator

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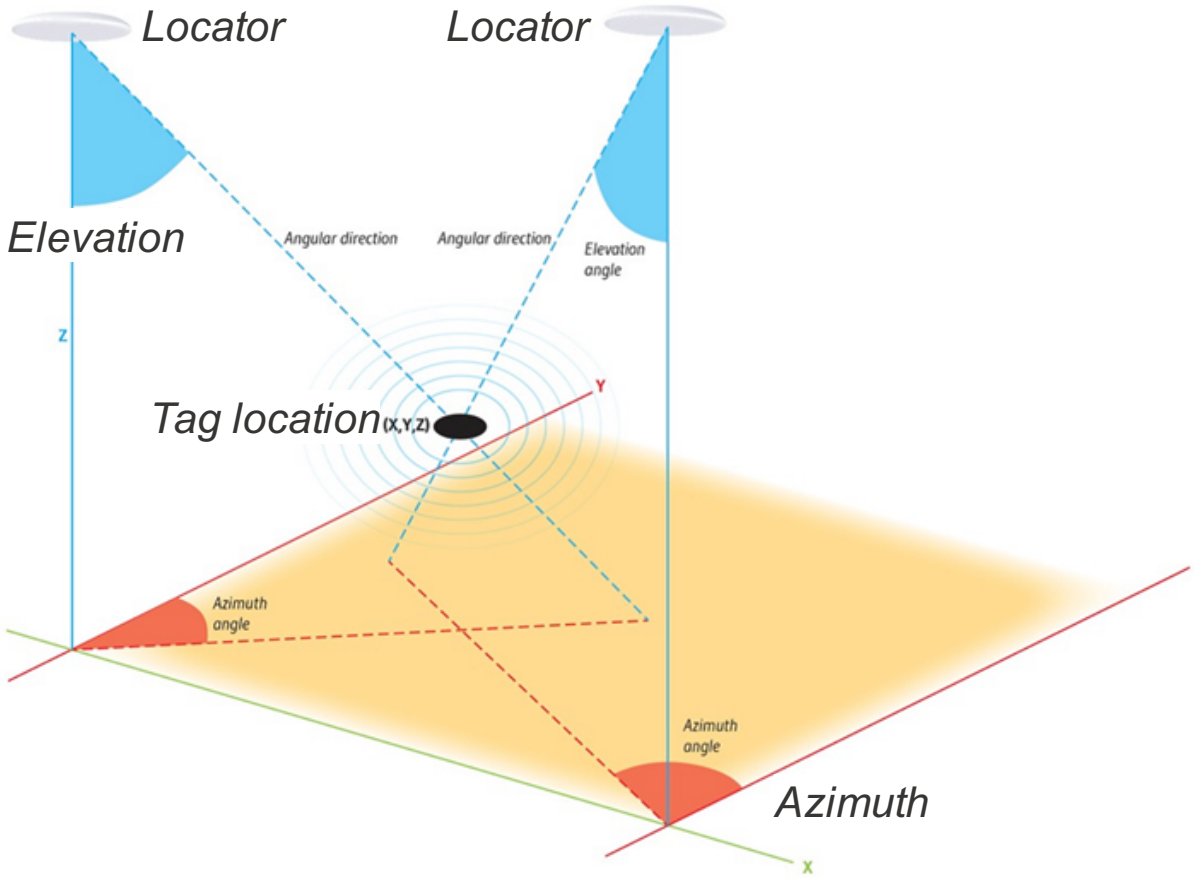
Quuppa positioning technology

Positioning method

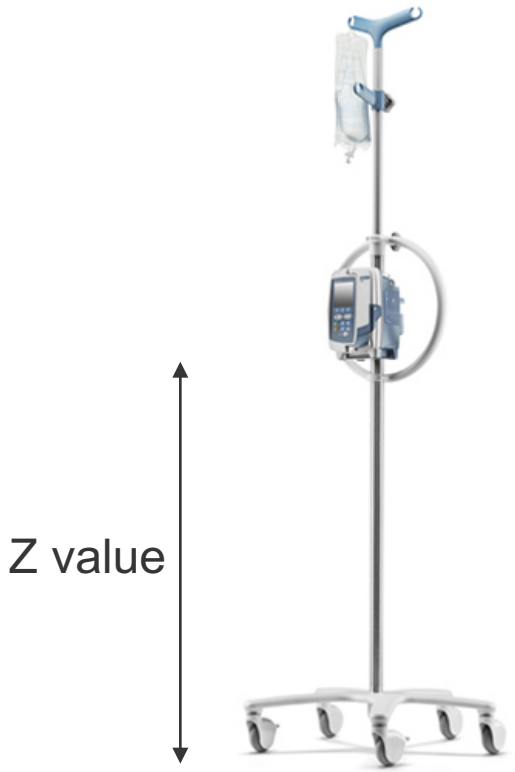
- Angle of Arrival (AoA)
- Measuring
  - Elevation angle
  - Azimuth angle
- in…
  - 2D (this research)
- or…
  - 3D



Use case for hospital

Requirements for localizing IV pumps

- Default height (Z value)
  Attached to stand (e.g. 1,2m)
- Area of Interest (AoI)
  Cupboard/Table/Open space
- Size
  0,20m
- Velocity
  Dynamic/static



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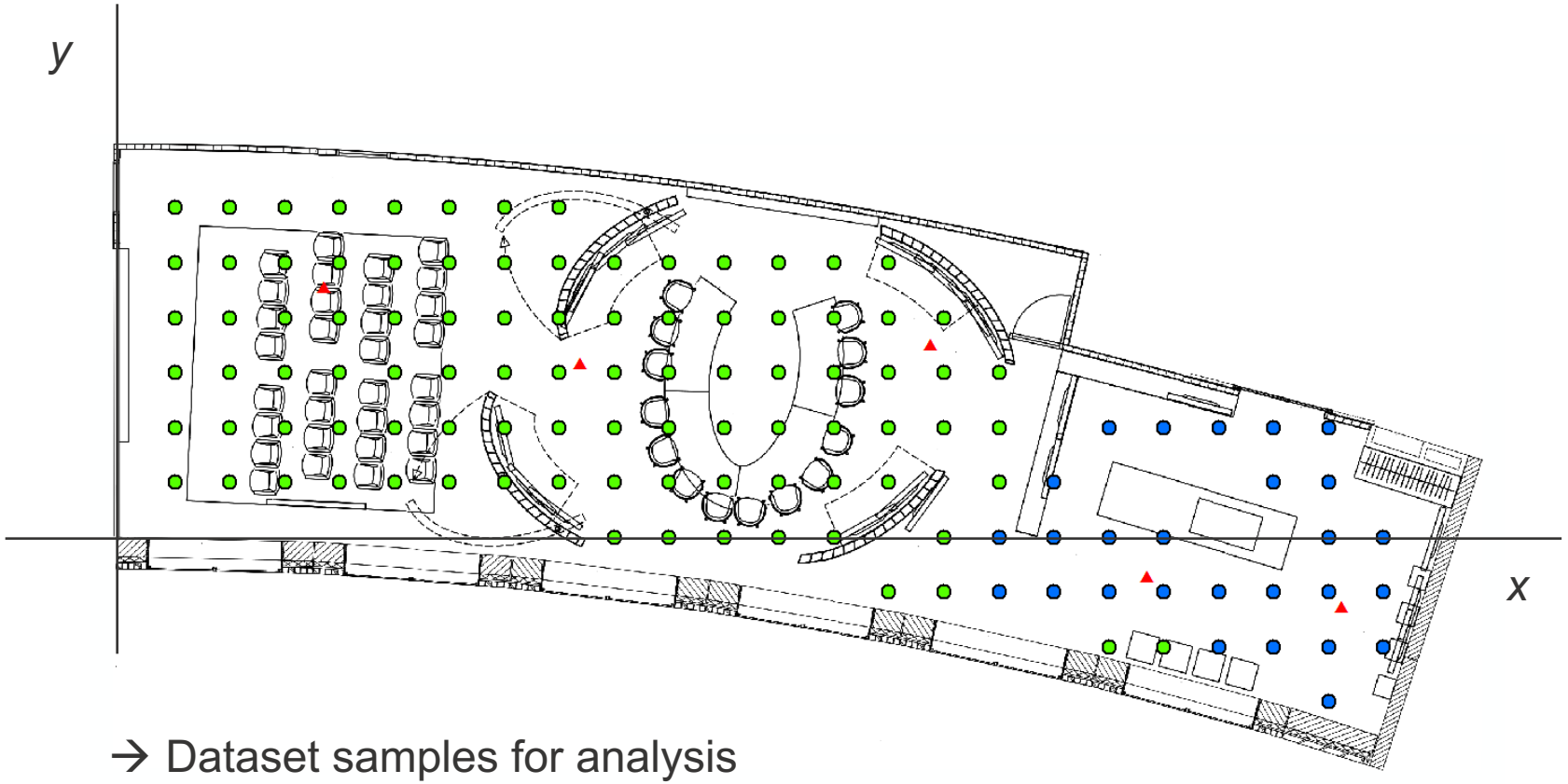
Test set up in Spark Centre

Test set up in Spark Centre

Definition of test grid in Spark Centre *(1m x 1m)*



→ Dataset samples for analysis

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Processing

Processing steps

- Mean
- Median
- Standard Deviation (SD)

	Test 1	Test 2	Test 3
Z value [m]	0	0,8	0,8
Transmit rate [Hz]	2	5	5
Latency [s]	0,1	0,1	0,1
Logging	CSV	CSV	JSON
Time span [s]	± 60	10/30/60	1/5/10
Tracking area	Spark	no	Spark/no

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Analysis

Parameters for analysis

Technical

- Accuracy
- Precision
- Coverage
- Latency
- Update rate

} *Reliability (R)*

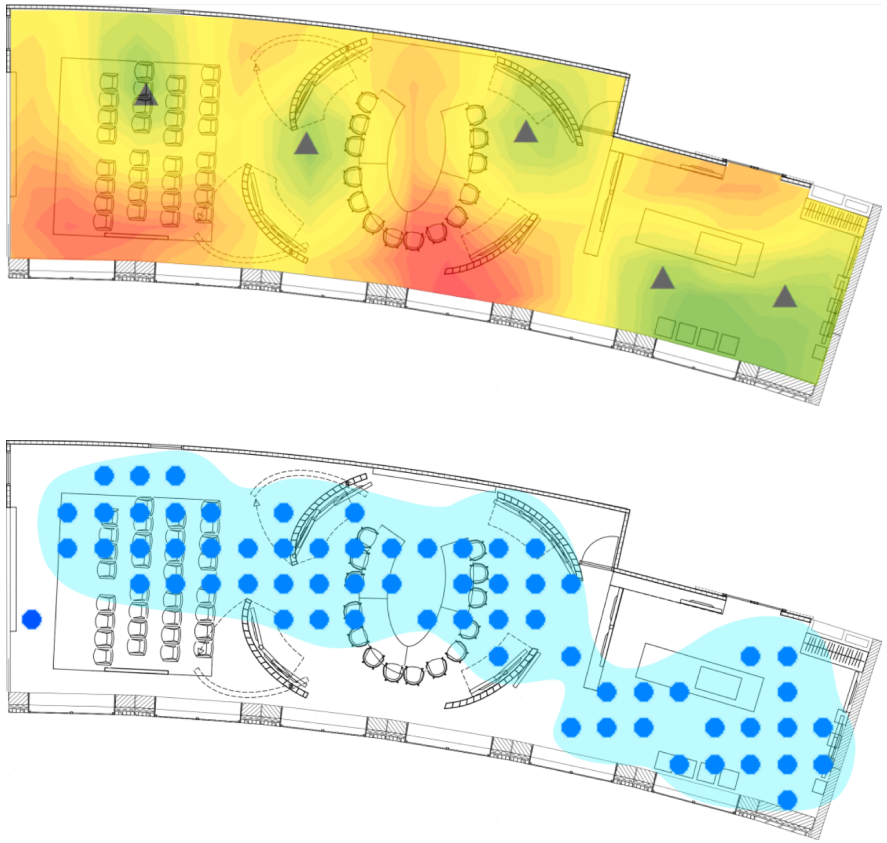
Operational

- Clustering
- Indoor environment
  - Material
  - Lay out
  - Obstacles

Analysis

Conclusions for positioning

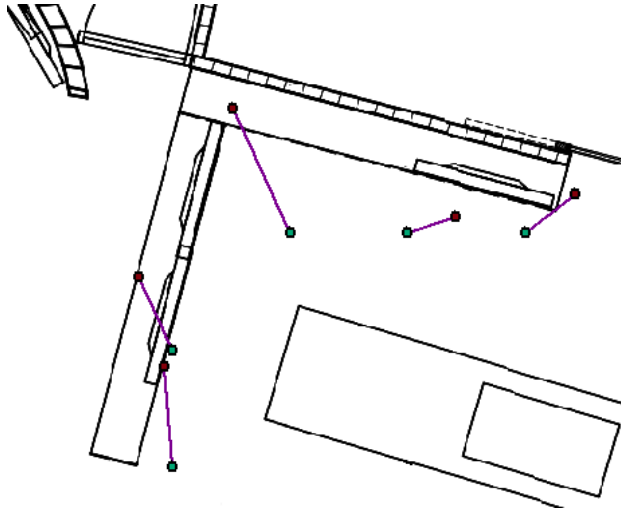
- Influences of the indoor environment are significant
- Strong relation between range and reliability
  - Accuracy <0,5 m
- Reliability is not time dependent

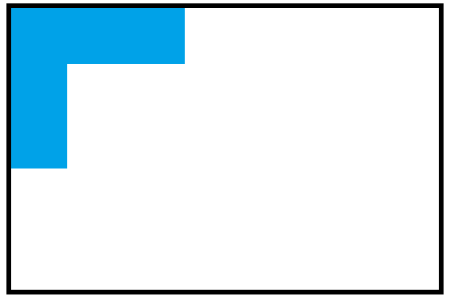


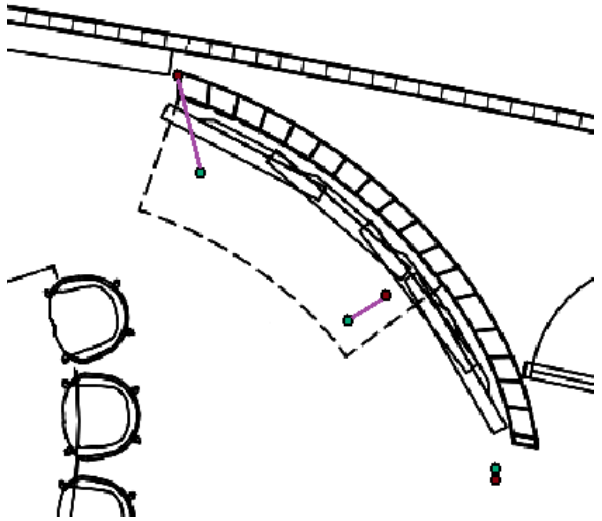
Map matching

Test cases

Cupboard







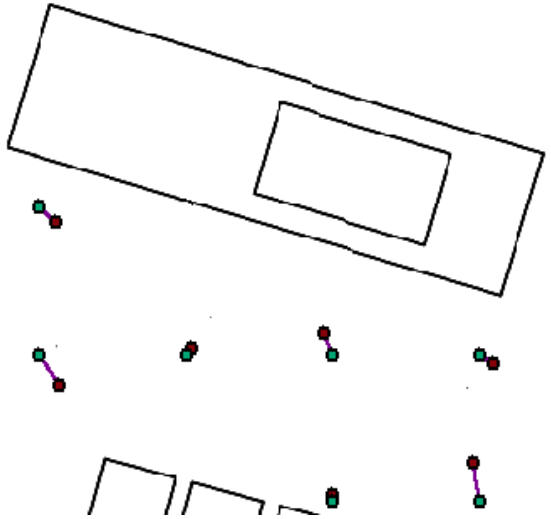
R = 16%

R = 67%

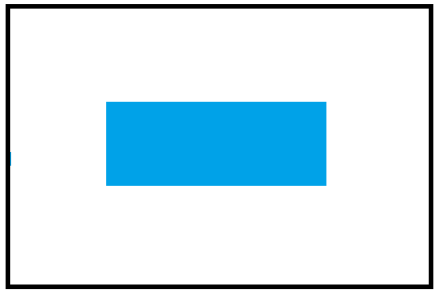
Map matching

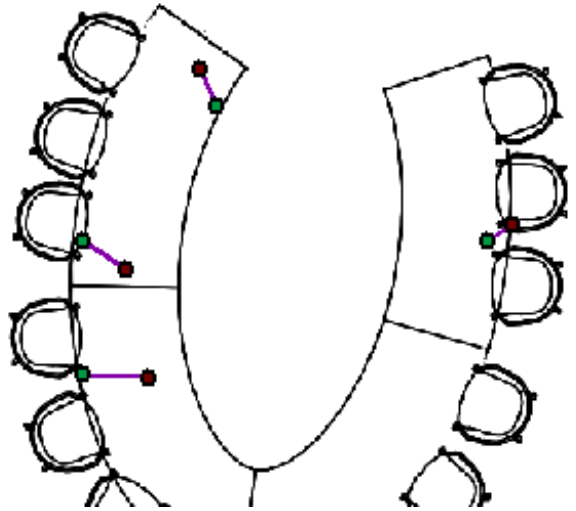
Test cases

Table



R = 100%



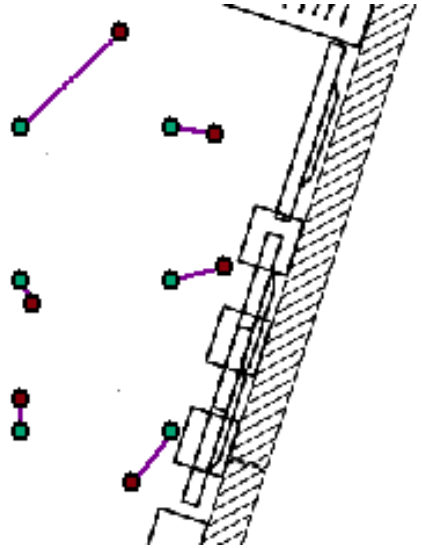


R = 75%

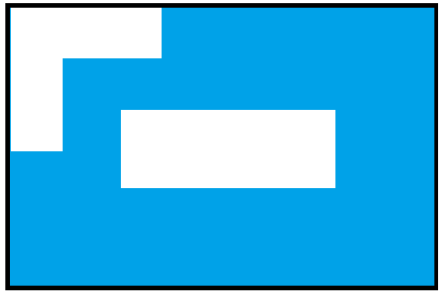
Map matching

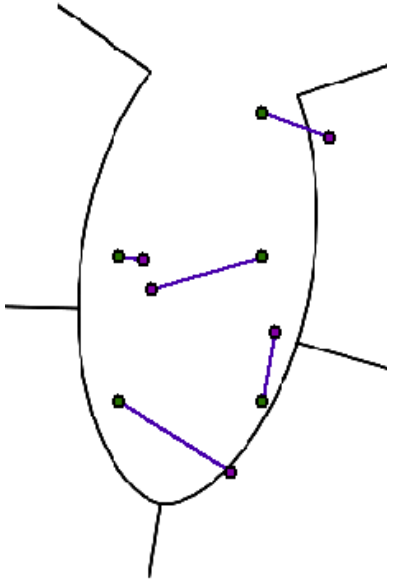
Test cases

Open space



R = 80%





R = 25%

Map matching

Summary

PointInPolygon

- Threshold
  - Accuracy: 0,5m
  - Precision: 0,2
- Decreased reliability around borders

Test case *Name*	**Accuracy**	**Precision**
Cupboard along the wall	0,74	0,27
Table in the storage room	0,17	0,05
Walking space around table	0,39	0,03
Cupboard in the corner	0,39	0,02
Patient's bed	0,35	0,09
Walking space around bed	0,57	0,09

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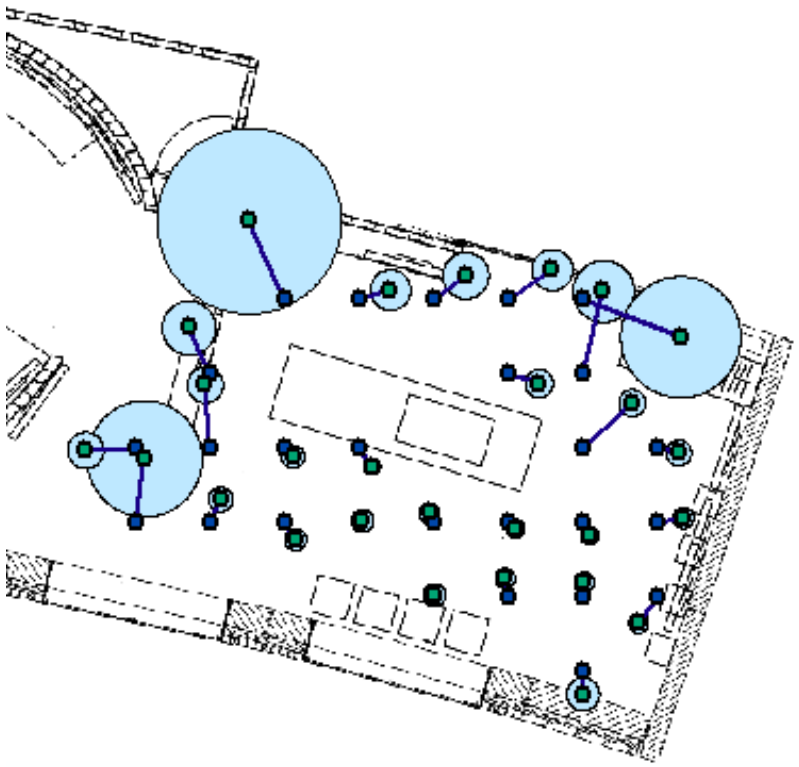
Localization model

Map matching

PositionAccuracy

- Quuppa parameter
  - Value indicating the quality of the measurement

- No direct relation to SD
- Measure for on-the-fly accuracy estimation

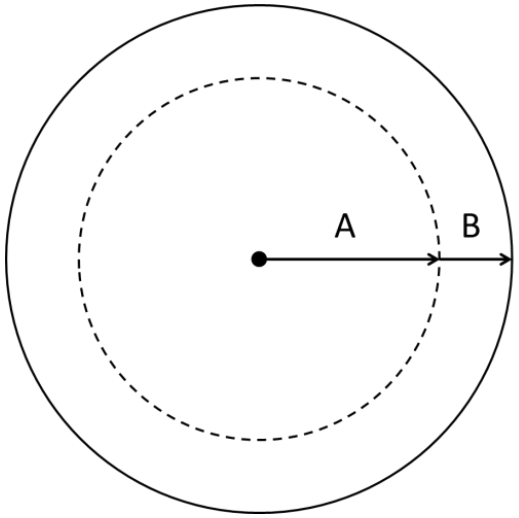


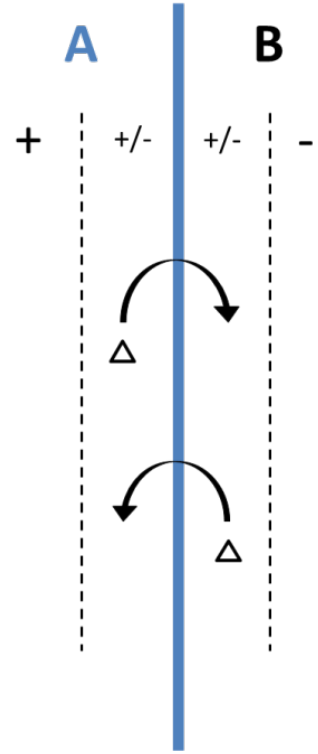
Localization model

Map matching

ShapeRelatedProbability

- Chance of being located ‘across the border’ is larger near the border of the polygon
- Based on accuracy of measurements
- Decreased reliability in zone B



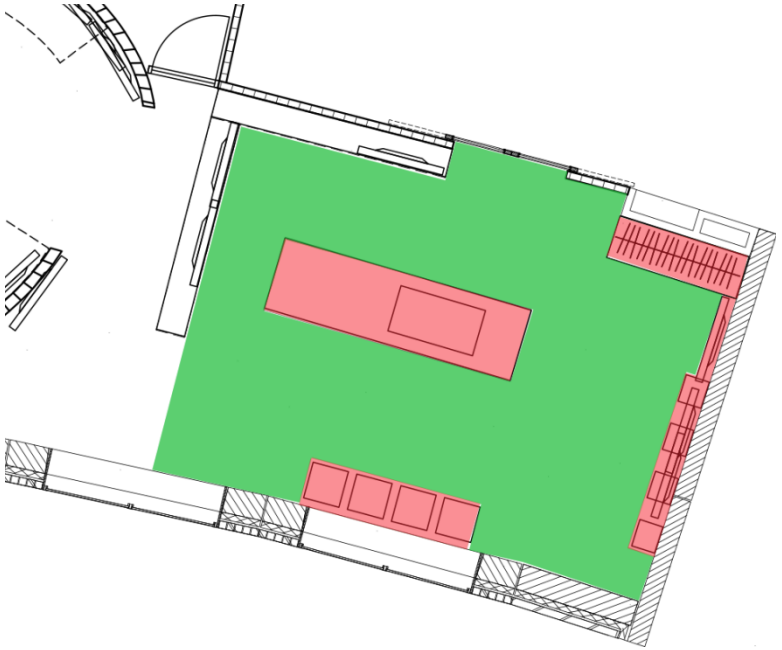


Localization model

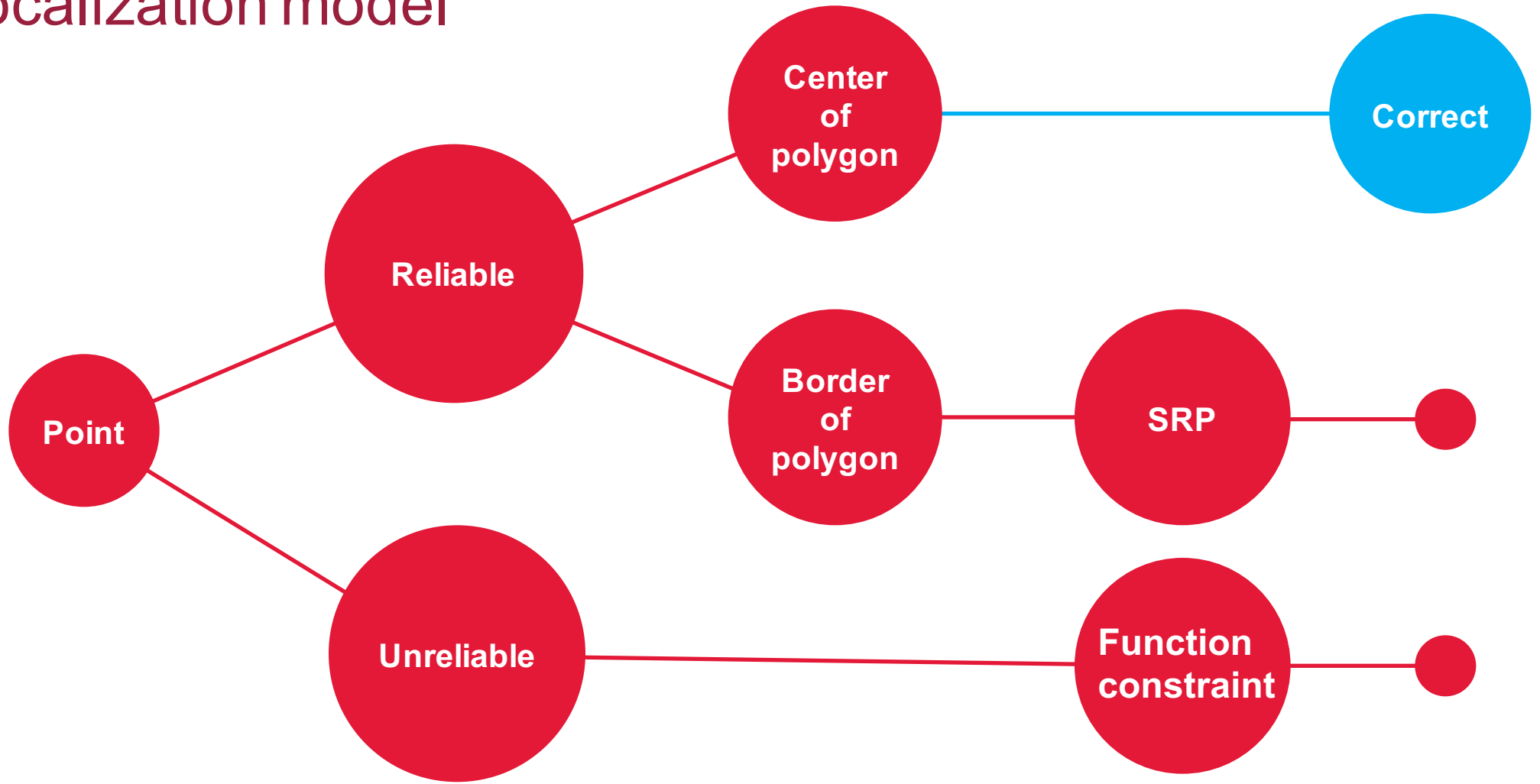
Map matching

FunctionalConstraints

- Define areas where:
  - asset **can** be positioned
  - asset **cannot** be positioned



Localization model



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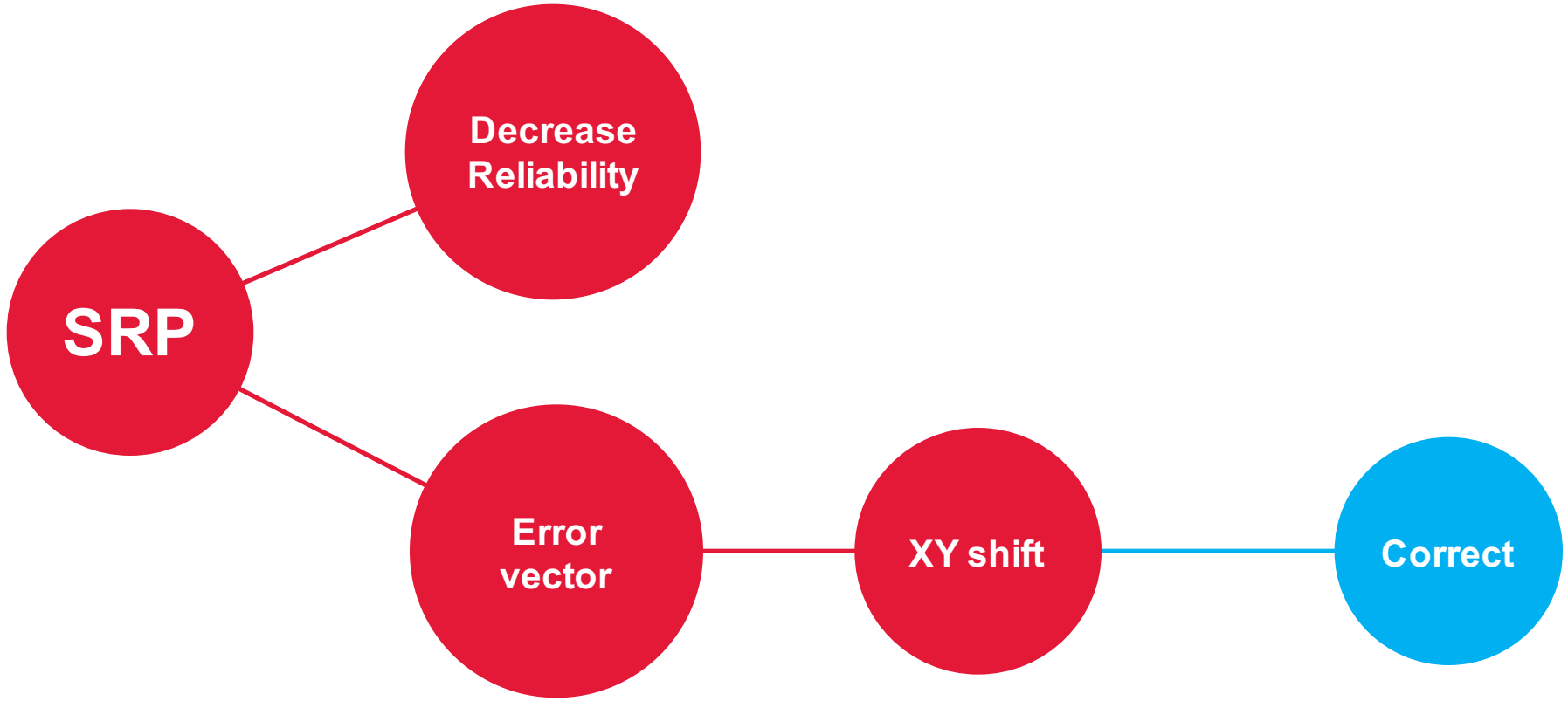

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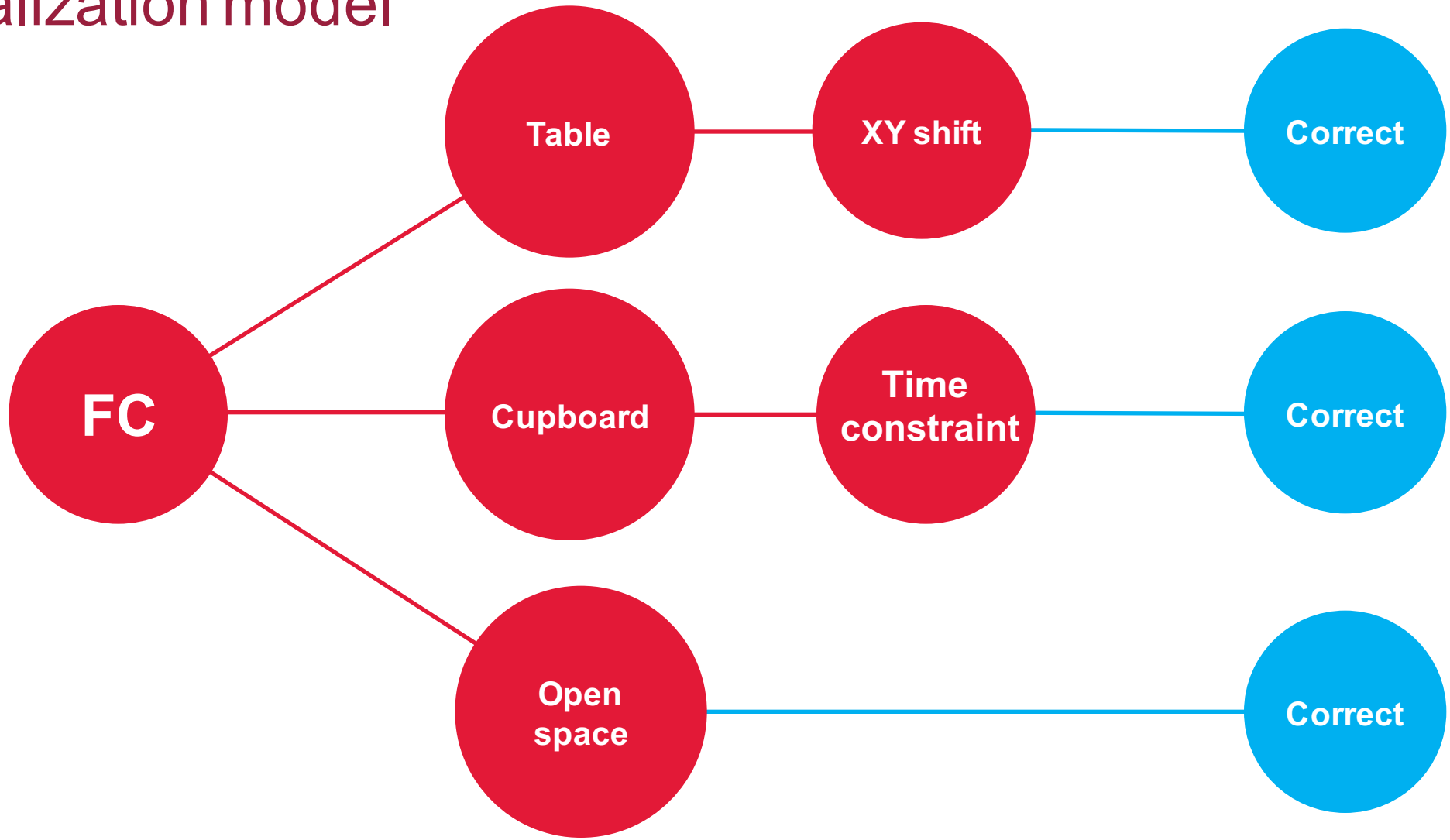

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Answering the sub research questions

1. What are the possibilities and limitations of the Quuppa system?

\+ High accuracy
\+ Designed for positioning

\- Availability of hardware

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Answering the sub research questions

2. What are the technical and operational performance parameters and how can they be measured?

- Subjects for positioning analysis cover technical parameters
- Locations types take into account the operational parameters

Answering the sub research questions

3. What is the performance of the system based on the technical parameters?

+ Accuracy and precision values are influenced by distance to locator and obstructions
+ Update rate can be relatively low for this kind of application

- Coverage is subject to environmental issues, range and obstructions
- Latency only affects high speed movements

Answering the sub research questions

4. What is the performance of the system based on the operational parameters?

- Reflective surfaces have a large influence on performance
  - TV screens
  - Metal objects
- Obstructions and interior elements affect reliability

Answering the sub research questions

5. How can the results of the test and analyses be put into a model for localization of assets using Quuppa technology?

- Accuracy is key
  - Localization depends highly on reliability of the position

- In addition to Point-In-Polygon method (> 75%):
  - Position accuracy
  - Shape related probability
  - Functional constraints

Answering the main research question

MQ: Does the technical and operational positioning performance of Quuppa technology meet the localization requirements for asset tracking in a hospital environment?

- Accuracy of the measurements is not time span related and not related to precision
- Area of Interest is main driver of locator constellation
- Localization can be optimized by on-the-fly correction of map matching using PA and covariance

Recommendations

Future Research

- Correction grid (vectors) for improved positions and thus localization
  - Based on error vectors covariance matrix

- Performance of Quuppa in 3D for localization and FunctionalConstraints

References

Figures

p11/12/13: Quuppa (2015a). Quuppa – enabling sub-meter positioning and real-time asset management. Quuppa%20company%20presentation%20January%202015-JC.pdf.

p14: http://www.ortusgroupbv.com/data/news/957c0fca1231dbb0c191aaa6a0321522.jpg

http://www.modocarts.com/images/work/CareFusion-Alaris-CareStand-IVPole-2.jpg

Literature

p12/13: Quuppa (2015a). Quuppa – enabling sub-meter positioning and real-time asset management. Quuppa%20company%20presentation%20January%202015-JC.pdf.

Thank you for your attention!

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