

APACHE:

BIG_DATA

EUROPE

Nov 14, 2016, Melia Sevilla, Seville, Spain

Geospatial Track:

Crowd Learning for Indoor Navigation

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Chief Research Officer
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indoo.rs

indoor positioning and navigation for mobile apps



✓ **indoo.rs**

➔ Who we are, what we do, who our customers are.

✓ **Indoor localization**

➔ How we do it

✓ **Crowd learning**

➔ Better, scalable, big localization



indoo.rs

Who we are, what we do, who our customers are.

Who's talking?



✓ **Thomas Burgess**

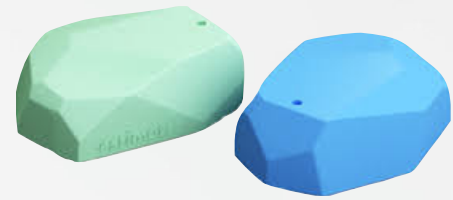
- ➔ Particle physics PhD
- ➔ Chief Research Officer
- ➔ At indoo.rs since 2013
- ➔ Swede living in Austria

✓ **indoo.rs GmbH**

- ➔ Technology startup since 2010
- ➔ ~20 people / ~5 researchers
- ➔ Based in Vienna, Austria

indoo.rs

Enabling location awareness.



✓ Proximity

➔ Rough, background, notifications

✓ Navigation

➔ Accurate, real time, foreground

✓ Asset tracking

➔ Track anything with a beacon

✓ Analytics

➔ Unified over all sorts setups

✓ Hardware

➔ Commodity mobile devices, WiFi/Beacons



Areas of Application.



Manufacturing



Mobile Games



Events



Museums



Public Safety



Social
e-Commerce



Enterprise



Travel



Retail



Entertainment

- ✓ Awareness of indoor navigation rising
- ✓ Numerous projects successfully deployed
 - ➔ From simple proximity notifications ...
 - ➔ ... to full navigation in large multi-story buildings

Who are our customers?



A few selected projects



Events



Museums



Travel



High Point Market.

HPMKT
HIGH POINT MARKET



✓Product

➔ Navigator for the world's largest furnishings trade show

✓Requirements

➔ 75,000 Visitors

➔ 950 iBeacons

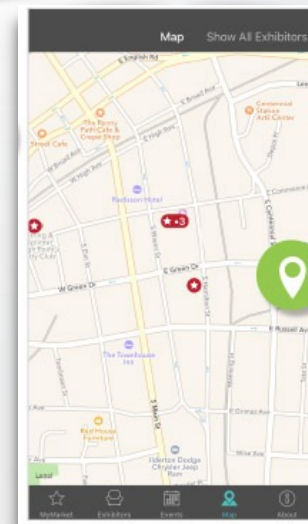
➔ 37,000 sqm, over 6 buildings and 11 floors!

✓Features

➔ Registration

➔ Positioning, navigation, routing

➔ Combine indoor & outdoor



✓ Product

➔ Tour guide of Art Museum

✓ App for changing exhibition

➔ Reusable for multiple exhibitions

➔ Proximity based messaging

➔ Information about each exhibit

✓ Results

➔ Self paced exhibition tour

➔ Audio guide

➔ Analyze interaction with exhibition





San Fransisco Airport.



✓Product

➔ Navigator for visually impaired

✓Requirements

➔ Blind UI

➔ Terminal wide coverage

✓Features

➔ Location aware guidance

➔ Personalized communication

➔ Proximity marketing

“ Both indoo.rs and SFO care about things that matter, and what matters is the freedom to move about one's environment independently with confidence and grace. With this solution, indoo.rs and SFO will change the way blind and low vision people travel.

LISA MARTINEZ, LIGHTHOUSE FOR THE BLIND AND VISUALLY IMPAIRED





Indoor Localisation

How we do it

Proximity.

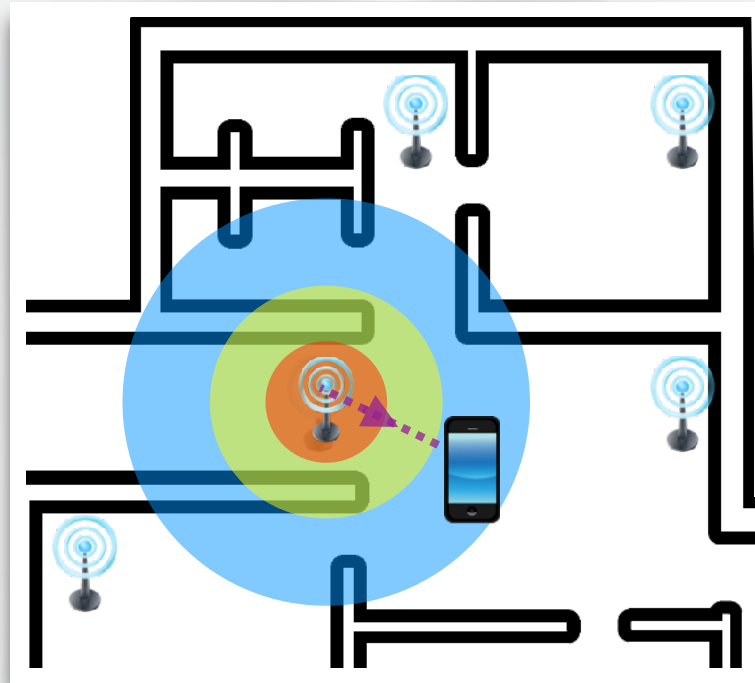


Installation

Configuration

Ready

Place beacons



- ✓ Operates in background
- ✓ Detected beacons trigger events

Navigation.

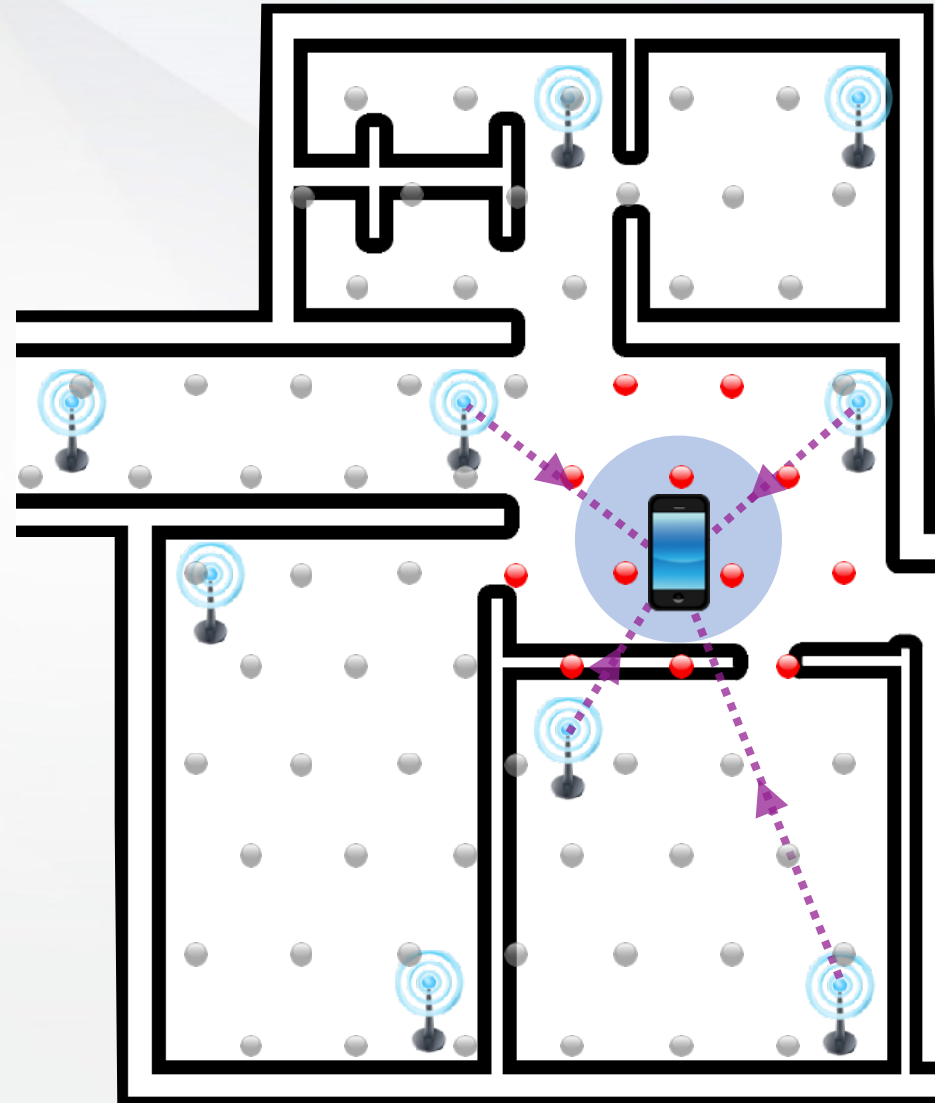


✓ Accurate real time localization

- ➔ Human scale: 2m within 2s
- ➔ On device calculation

✓ Calculation

- ➔ Use radio map: RSSI reference at each point
- ➔ Interpolate similar points
- ➔ Improve quality with motion sensors



Asset tracking.



✓ **Track any beacon**

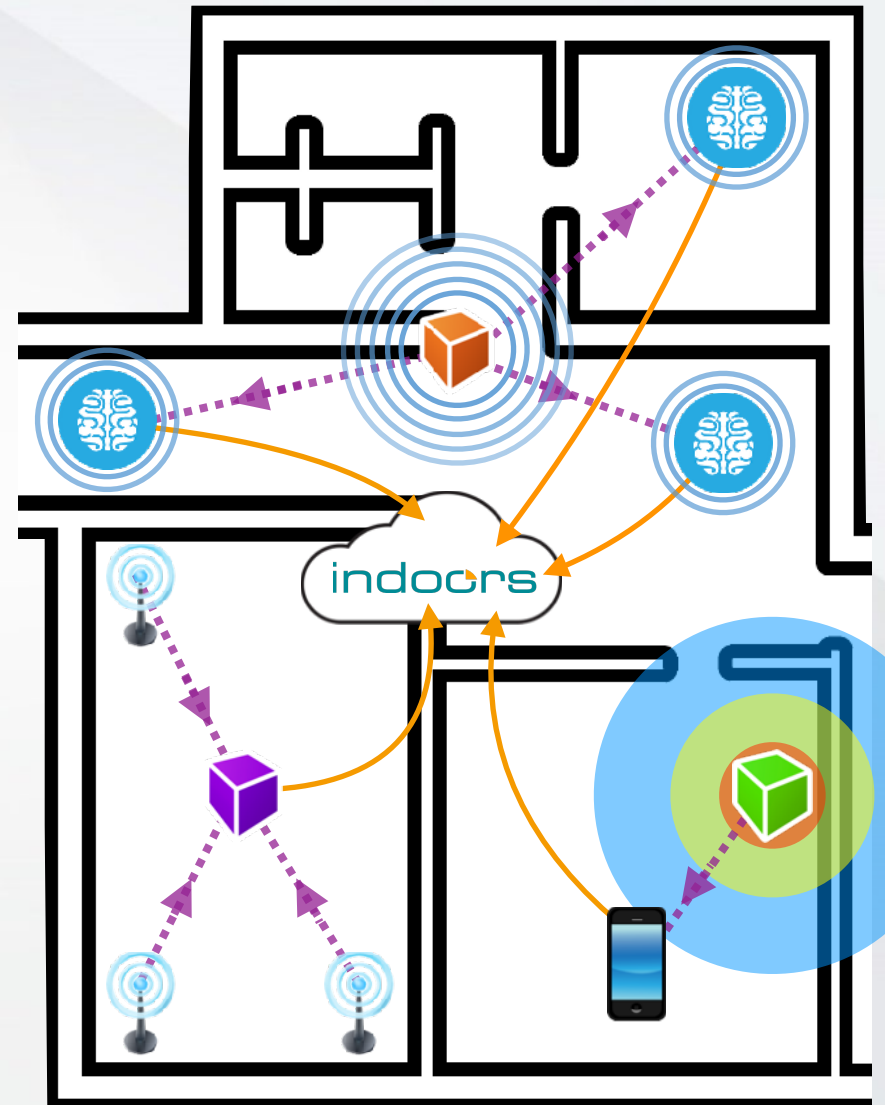
✓ **Reporting**

➔ Object report themselves

➔ Infrastructure report objects

➔ Passing phones report objects

✓ **Localization in cloud**



Analytics.



✓ Data types

➔ Instant - [db/Kafka]

- Asset locations
- Mobile locations
- Context: standing, walking...
- Additional beacon data

➔ Recordings - S3

- Require high quality data
- Radio data + trajectory



Analytics.

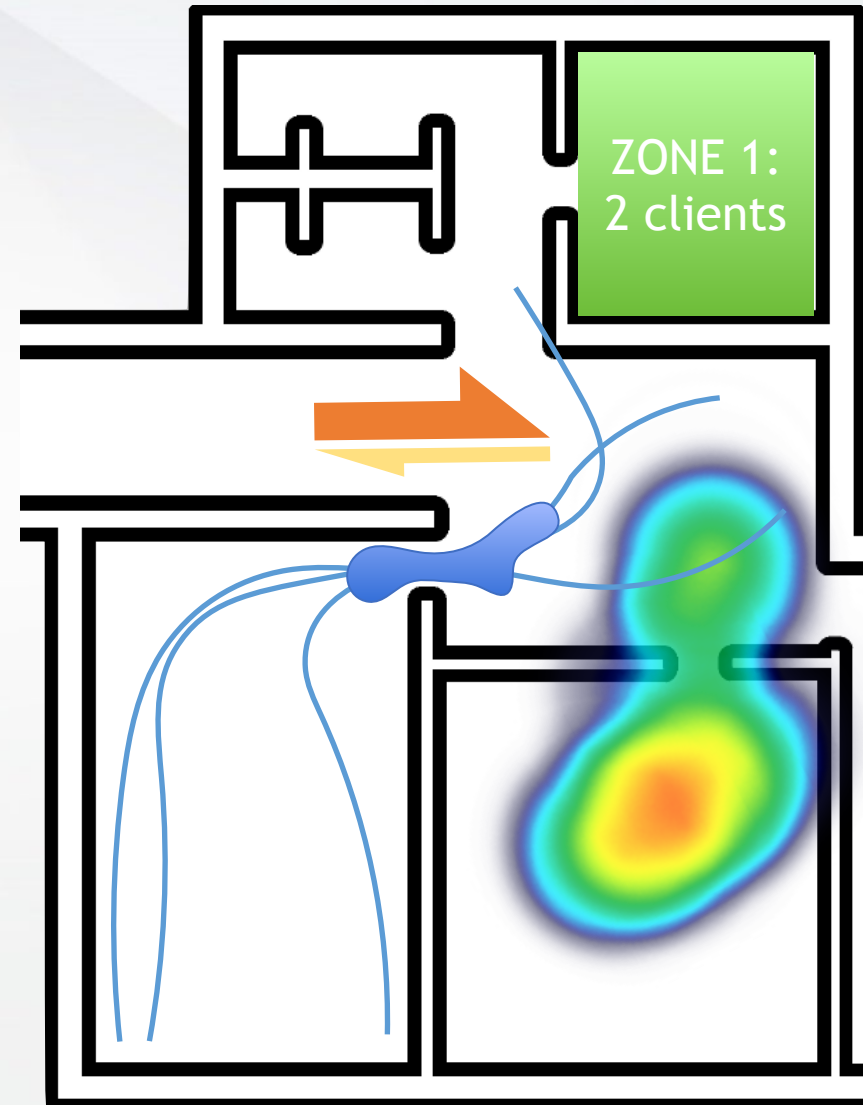


✓ Visual analytics

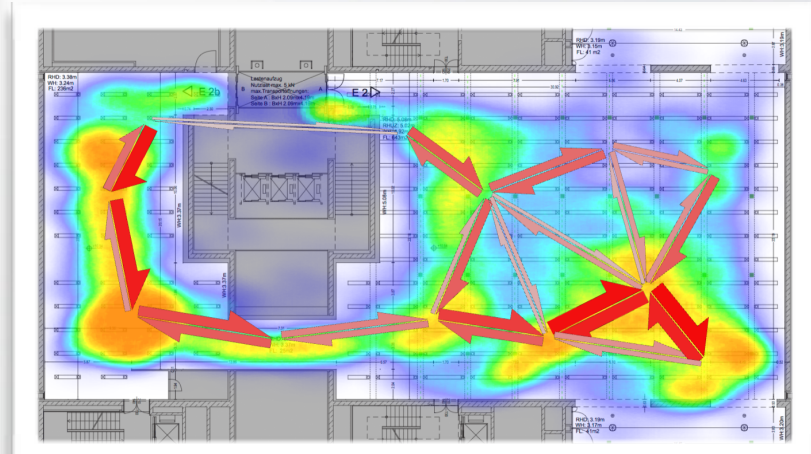
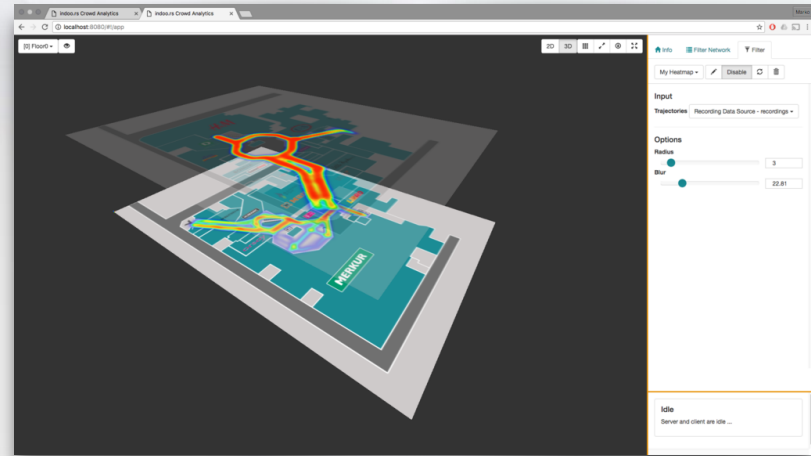
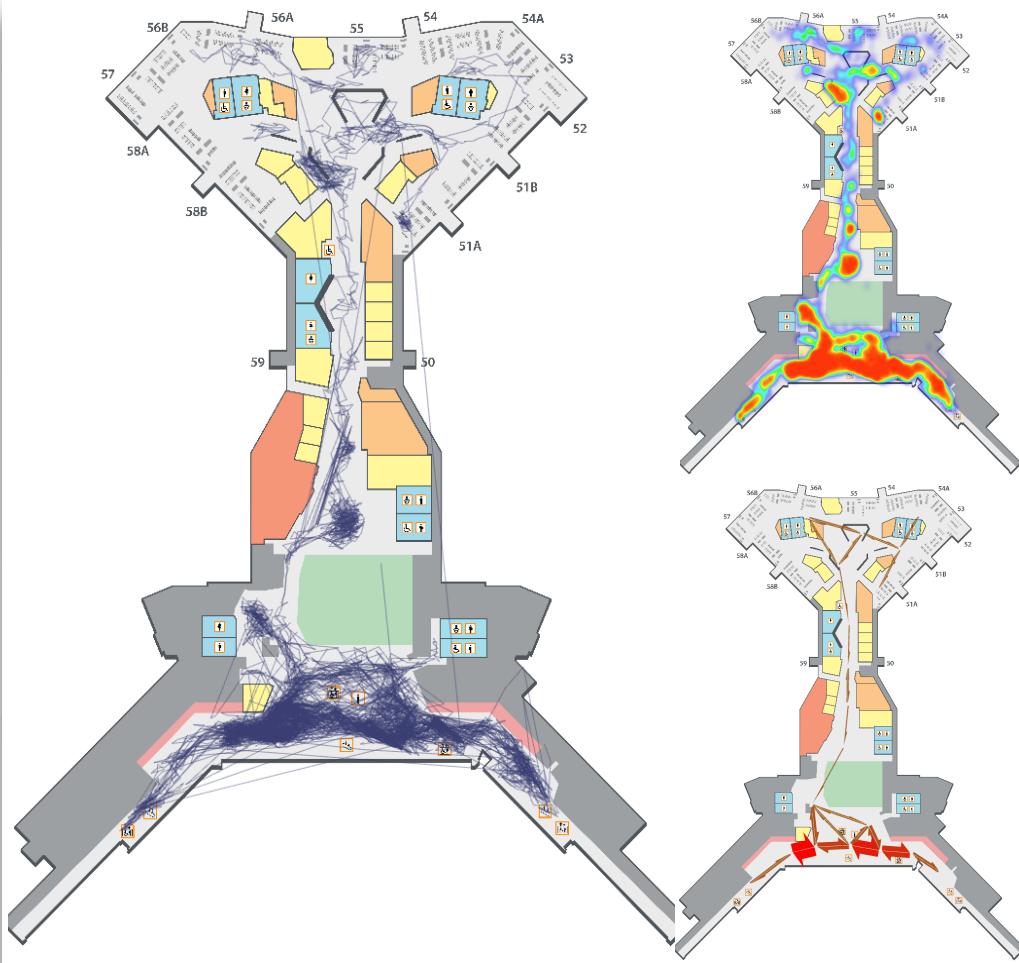
- ➔ Spatial/temporal queries
 - Occupancy - crowding
 - Dwell times
 - Congestion
 - Route popularity

✓ Custom analytics

- ➔ Zeppelin notebook
- ➔ Export API



Visual Analytics.





Crowd learning

Better, Scalable, BIG Localization

Creating radio maps.



✓ Radio map requirements

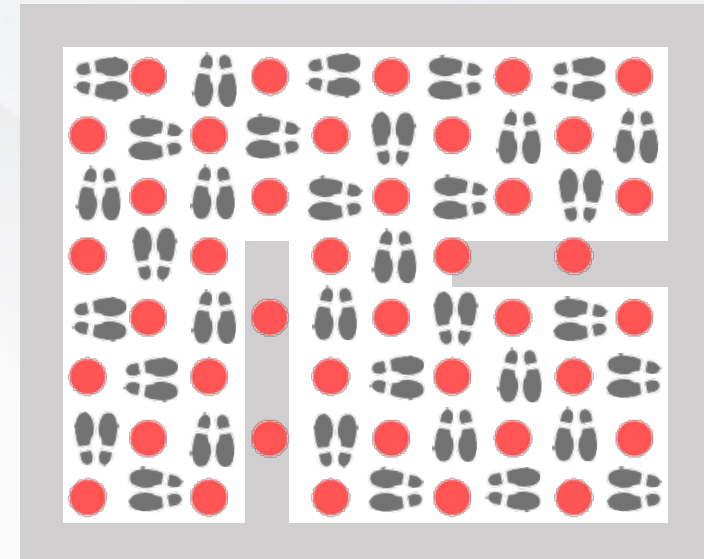
- 1-5m between points
- ~10 radio scans per point
- Needs regular updates

✓ Manual measurements

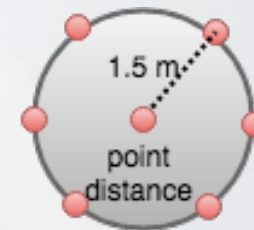
- Walk to a point, enter location, measure 60s, repeat

✓ Problems

- Partial updates difficult
- No one enjoys this task
- Sensitive shadowing by measurer



60s/point



6 months
validity



5-100
sources/point



1-100 MB

SLAM Engine.



✓ Procedure

- ➔ Dedicated recordings with occasional ground truth
- ➔ Calculate map in cloud

✓ Improvement

- ➔ 20x faster than manual measurements

✓ Problems

- ➔ Computationally intensive
- ➔ On site work still required

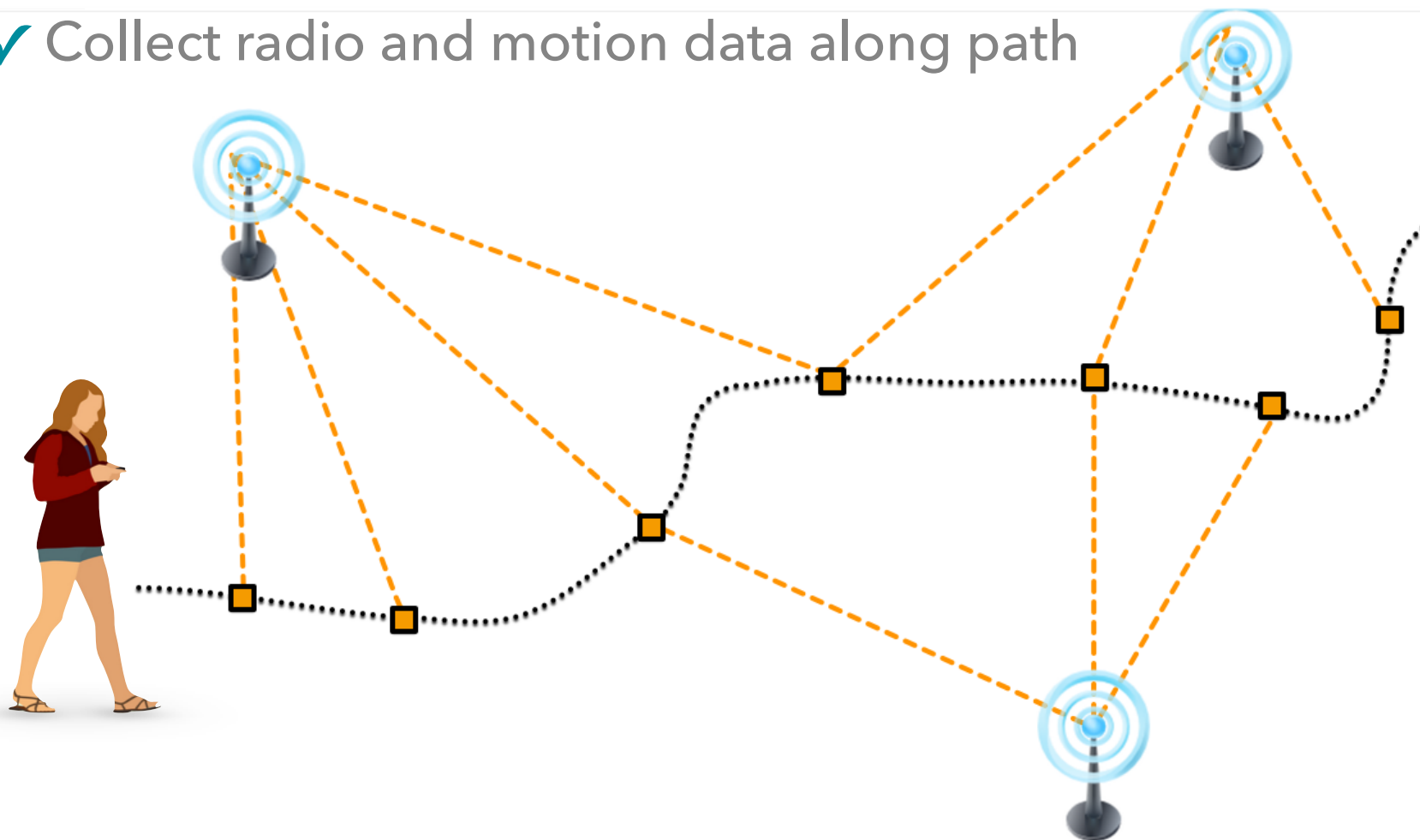


SLAM 1/4.

Collect scans while walking

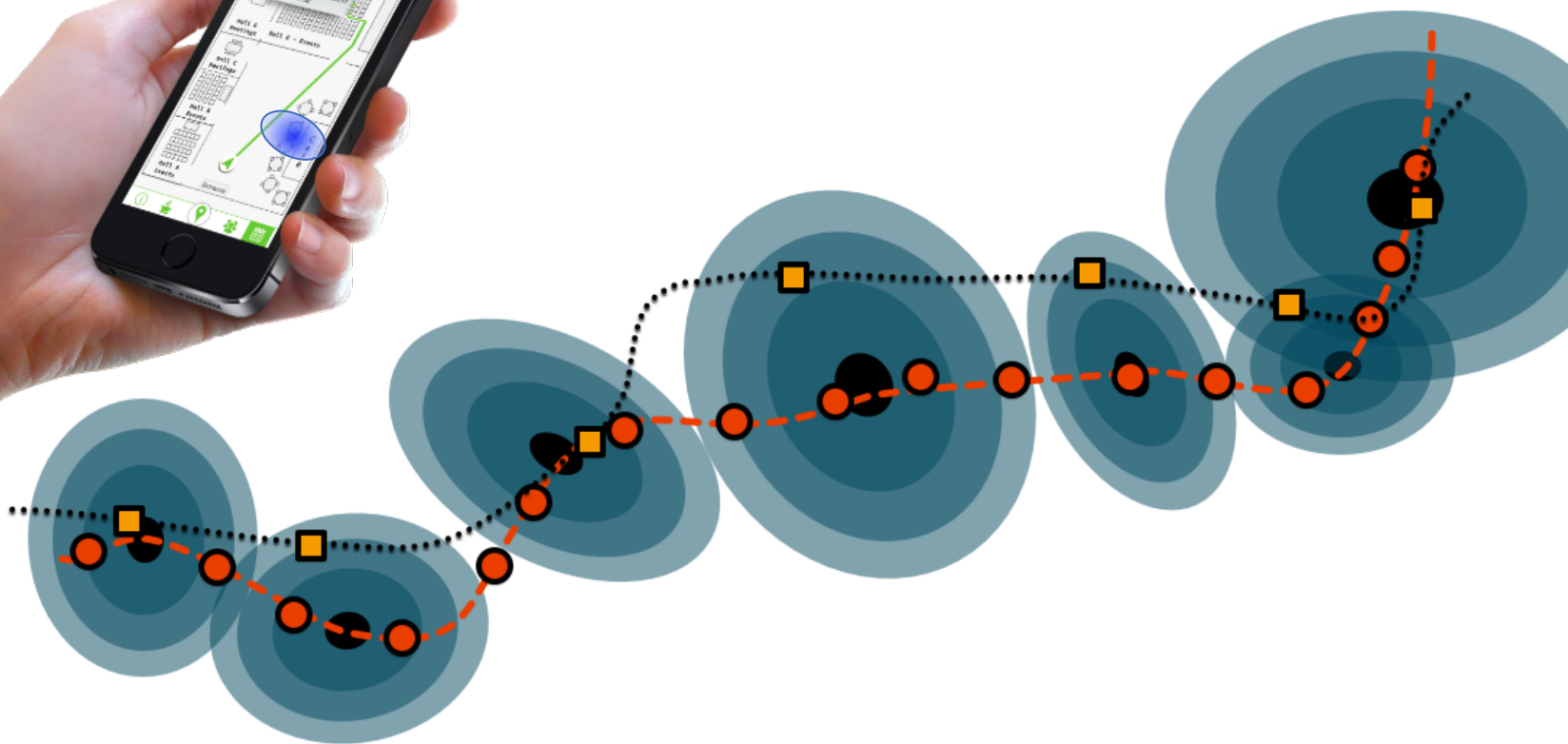


✓ Collect radio and motion data along path



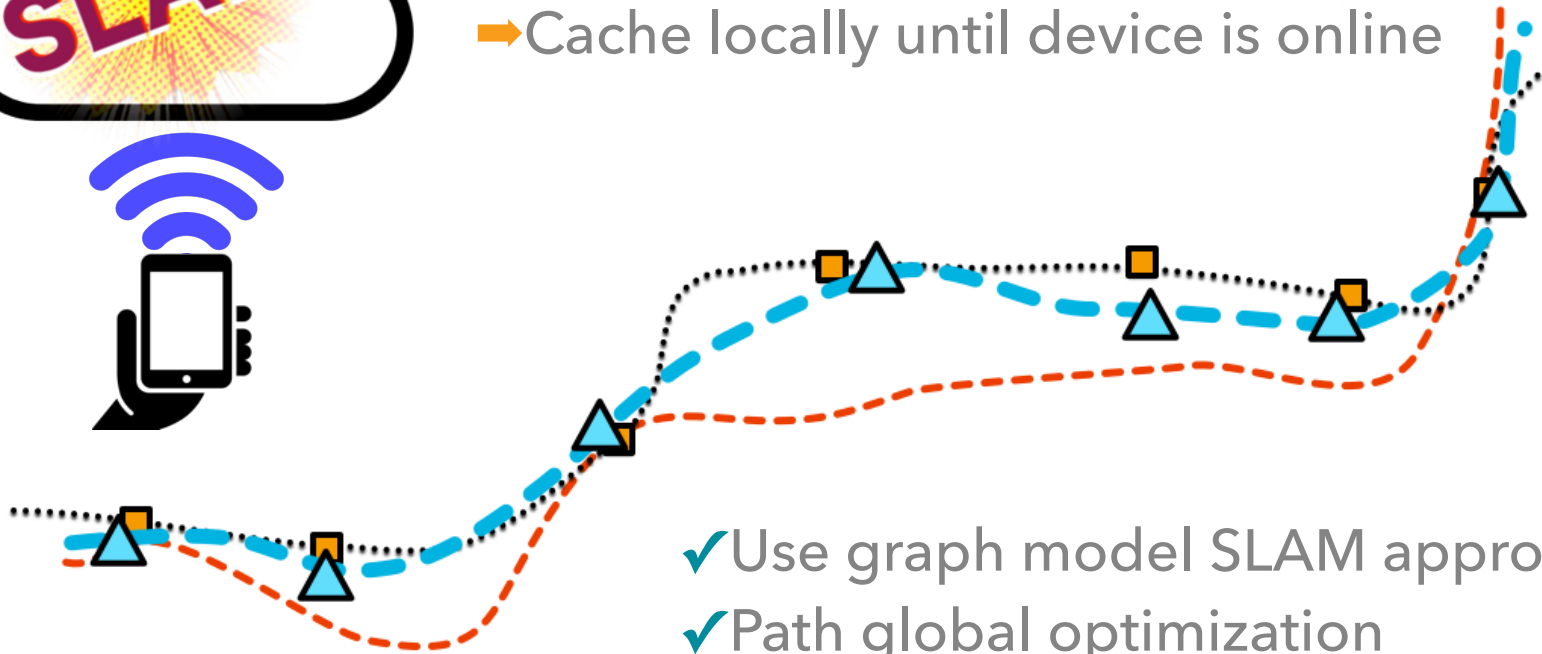


- ✓ Use localization engine to show blue dot
- ✓ Identify usable path segments





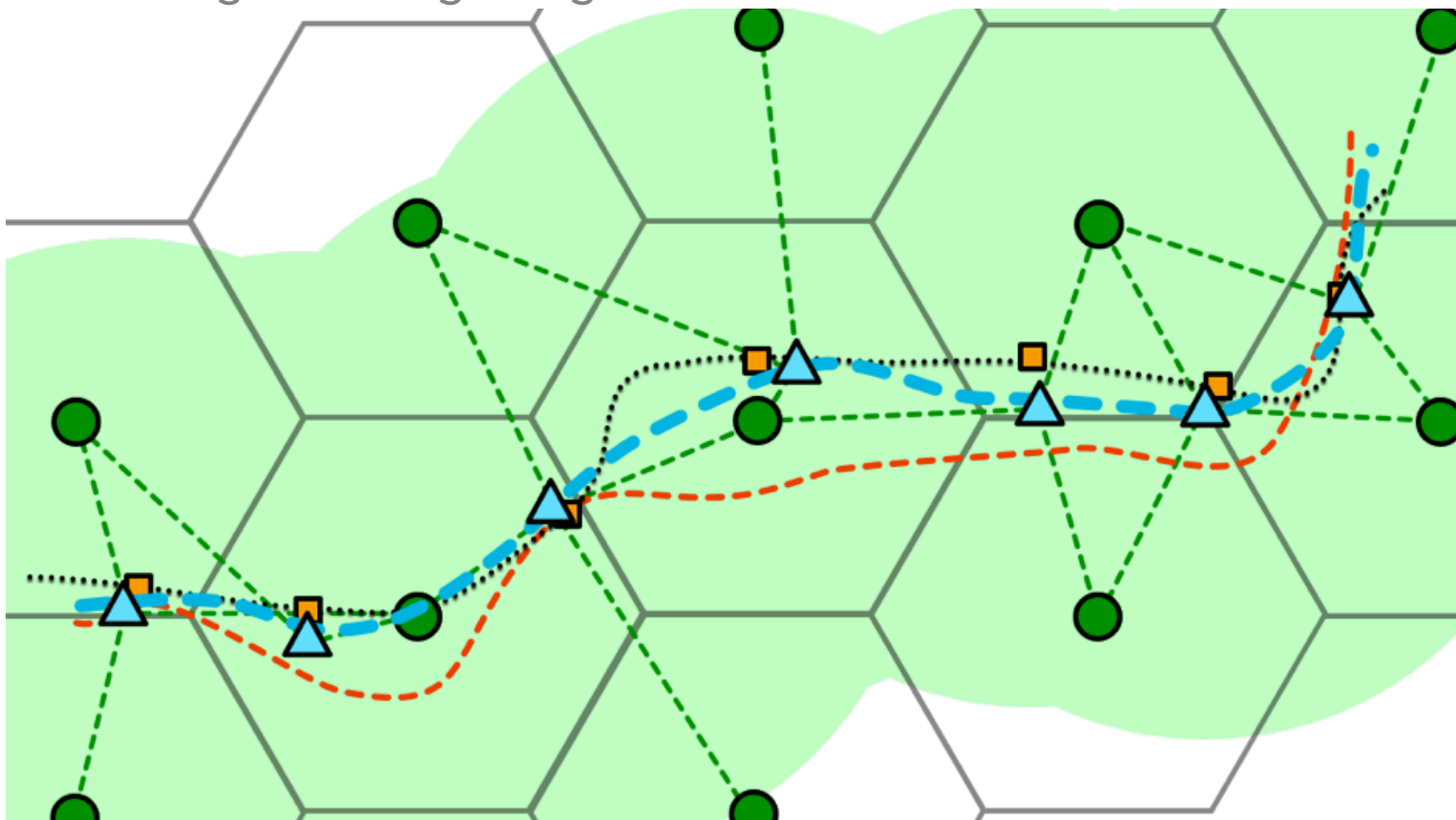
- ✓ Upload selected data
 - ➔ Radio, steps & locations
 - ➔ Cache locally until device is online



- ✓ Use graph model SLAM approach
- ✓ Path global optimization
 - ➔ Key advantage over Kalman filter
- ✓ Signal based path closure



- ✓ Local gaussian process interpolation
- ✓ Fixed regular hexagonal grid



SLAM Crowd Engine.



✓ Procedure

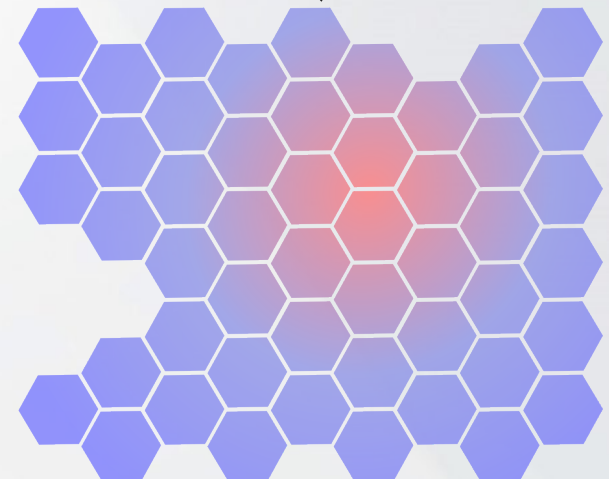
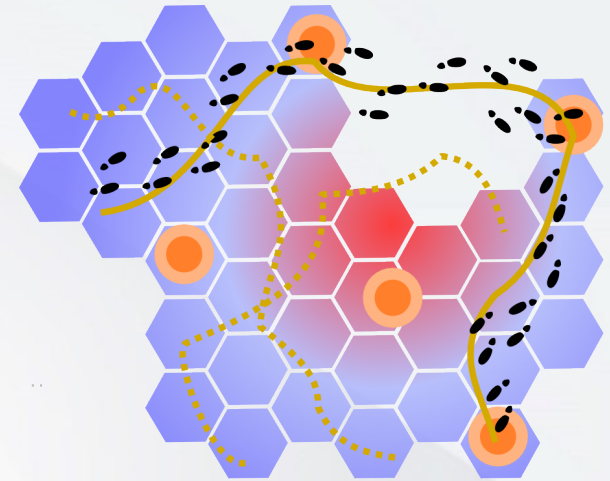
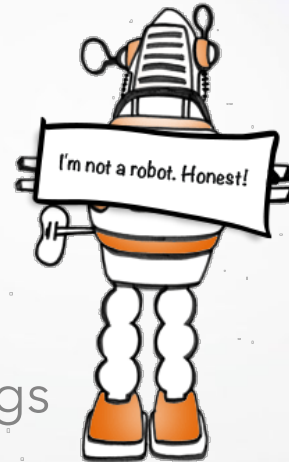
- ➔ Maintain map with analytics data
- ➔ Use estimated locations and steps
- ➔ Parallelize SLAM with Spark

✓ Improvement

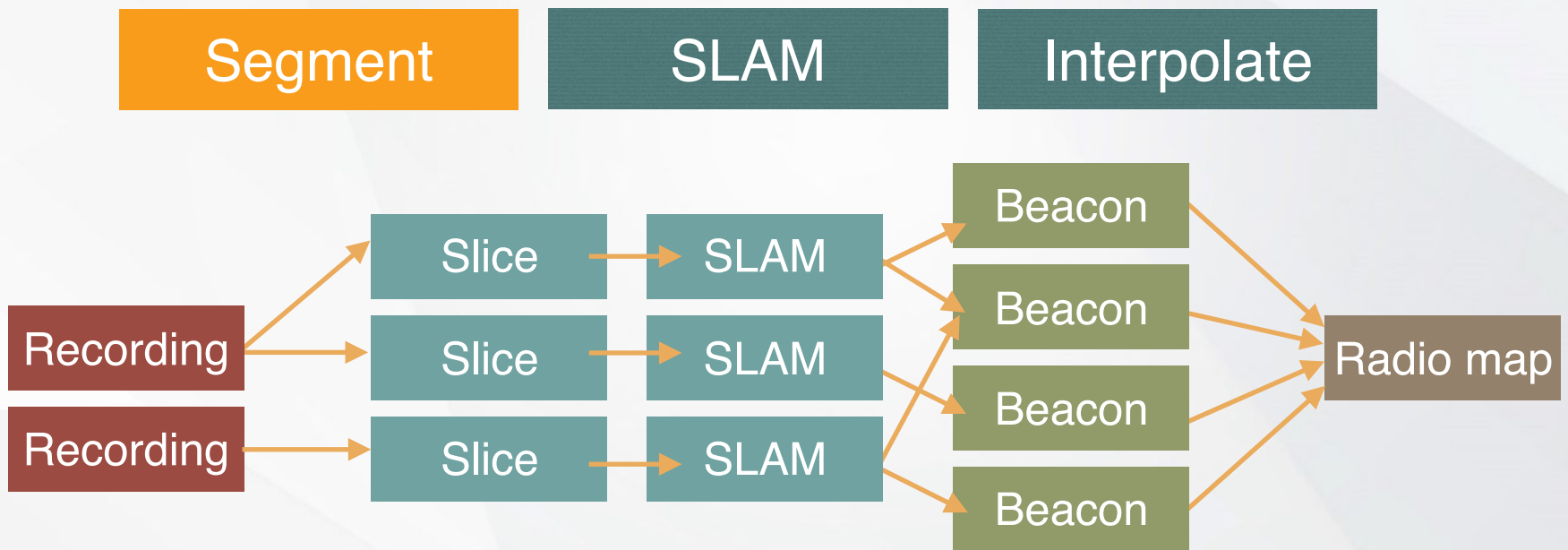
- ➔ Expands and heal maps!
- ➔ Yield high quality trajectory

✓ Problems

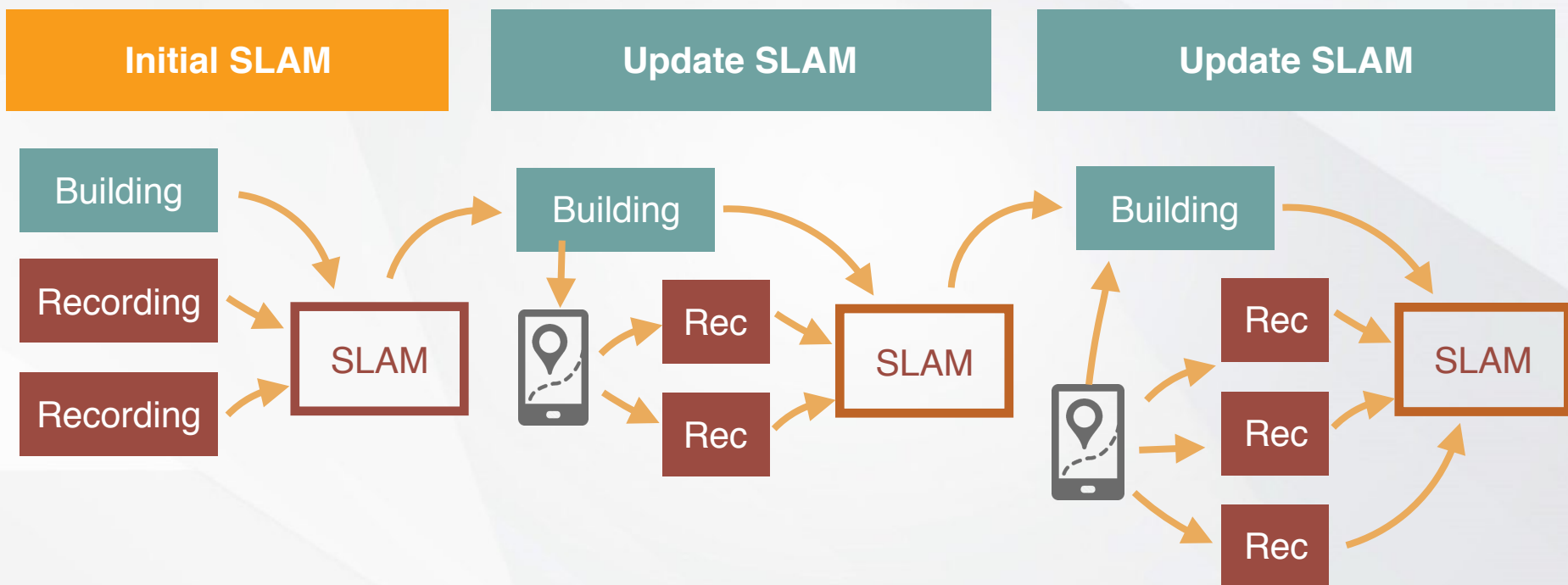
- ➔ Initial dedicated on site recordings
- ➔ A lot of data needed
- ➔ No automatic update trigger
- ➔ SLAM made for robots - humans won't always close loops!



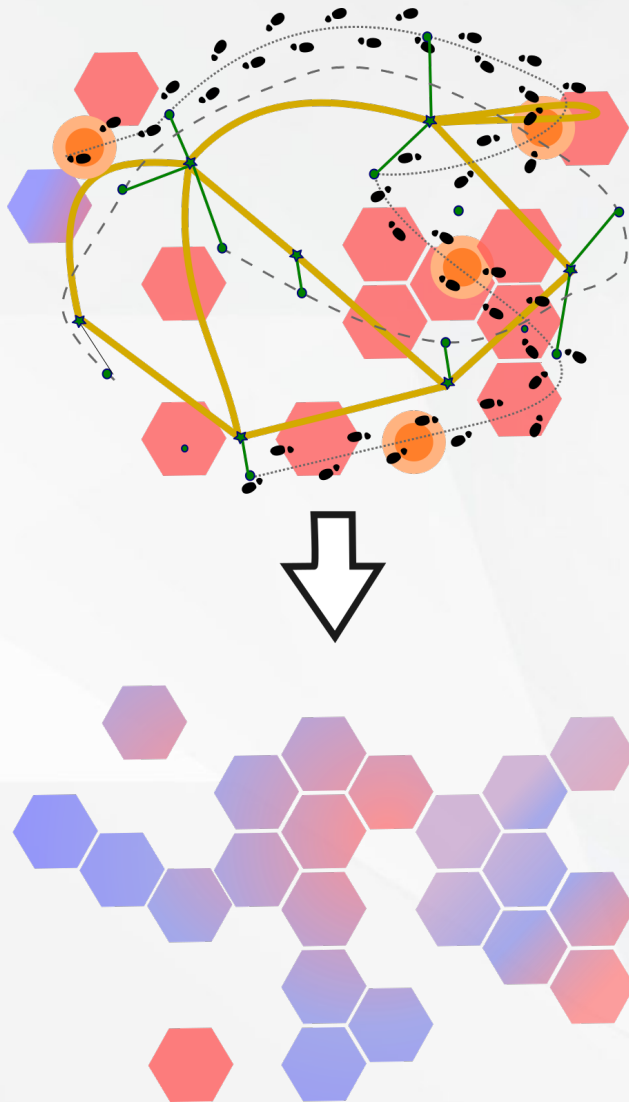
Parallel SLAM.



Incremental updates.



Crowd Learning.



✓ Grow map from seeds

➔ Initially only basic navigation

➔ Seed sources

- GNNS, ray-tracing, proximity, partial map

✓ Crowd only based SLAM

➔ Join paths to close loops

✓ Grow and maintain map

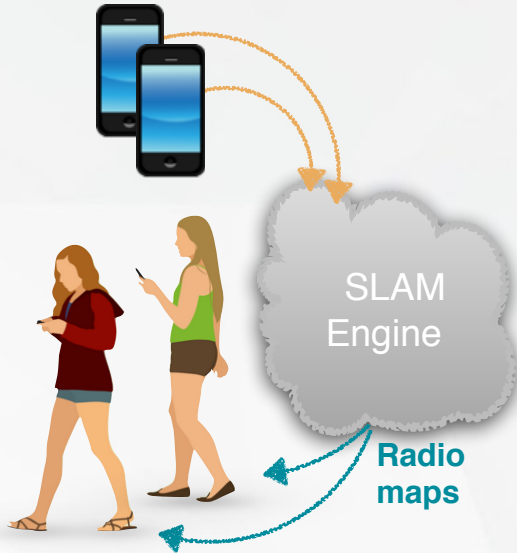
➔ Reinforcement learning

➔ Fully automated

indoo.rs SLAM evolution.

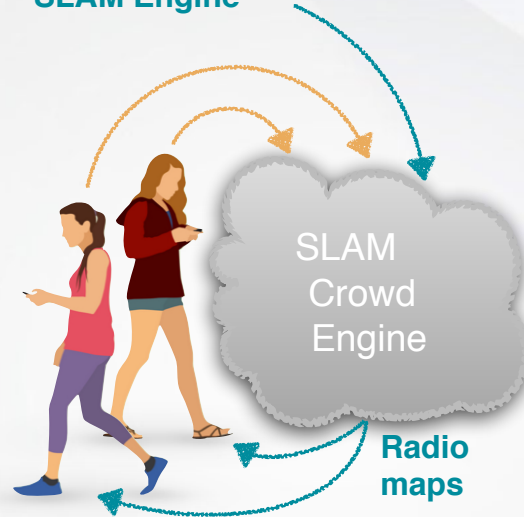


On site survey



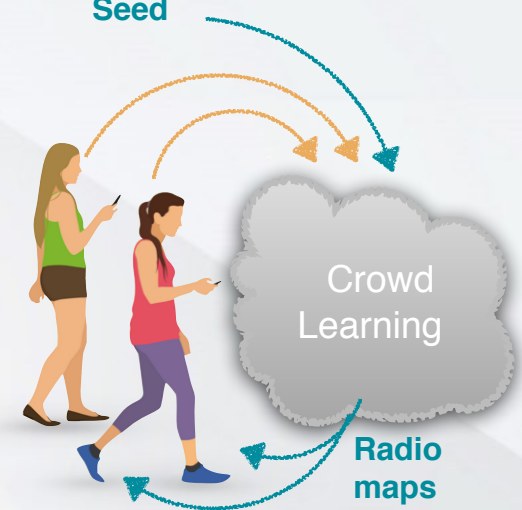
- ➔ Predefine path
- ➔ Walk path
- ➔ Repeat 10x

SLAM Engine



- ➔ Walk around
- ➔ Update maps
- ➔ Triggered

Seed



- ➔ Walk around
- ➔ Create maps
- ➔ Automatic



Conclusions.

Summary.



✓ indoo.rs

- ➔ Enables location awareness!
- ➔ Lots of successful deployments world wide

✓ Solution

- ➔ Using radio (WiFi/BLE Beacons)
- ➔ Proximity, Navigation, Asset tracking
- ➔ Analytics

✓ SLAM - journey into big data

- ➔ Simplify **deployment** and **maintenance**
- ➔ 20 x speedup → Free maintenance → Automatic mapping
- ➔ Using crowd data to improve scalability
- ➔ Only made possible with Apache toolset

Conclusions.



✓ Still early phase for our big data

- ➔ Finding optimal tool set
- ➔ Calculation load more challenging than data volume

✓ Crowd mapping

- ➔ Promising results for radio maps
- ➔ Technique not limited to radio (magnetics, contexts, ranging)

✓ Analytics

- ➔ Big data of increasing importance
- ➔ Challenging to provide easy secure data access
- ➔ Connections to other geospatial data very exciting
 - Requires open formats/standards/tools

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