Non-Inverse Architecture (NIA)

DSP Beacon 1

Stationary beacons:
- Mounted on walls or ceilings
- Users have to measure distances between stationary DSP beacons manually
- Communicate with router wirelessly in ISM band

DSP Beacon 2

Key requirement for the system to work well: **unobstructed sight** by a mobile beacon of 2 or more stationary beacons simultaneously (like in GPS)

Mobile beacon:
- Installed on robot and interacts with it via UART or SPI or I2C or USB
- Receives location update from router up to 45 times per second
- May contain IMU (accelerometer + gyroscope + compass module)

Submaps:
- Advanced feature that allows building independent maps/clusters of beacons in separate rooms and thus covering large buildings (with area of thousands of m2) similar to cellular network coverage

Indoor Navigation System consists of:
- 2 or more DSP beacons
- 1 or more mobile beacons
- 1 central router

DSP Beacon N

Distance between beacons-neighbors is up to **30 meters**.

DSP Beacon 3

Router/modem:
- Central controller of the system
- Calculates position of mobile beacon up to **45 Hz**
- Communicates via USB/virtual UART with Dashboard or robot

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Inverse Architecture (IA)

Beacon 1 (19KHz)

Stationary beacons:
- Mounted on walls or ceilings
- In inverse system beacons belonging to the same submap should have different ultrasound frequencies (19 & 25kHz or 25 & 31 kHz, for example)
- Communicate with router wirelessly in ISM band

Beacon 2 (25KHz)

Key requirement for the system to work: **unobstructed line of hearing/sight** by a mobile beacon to 2 or more stationary beacons simultaneously (like in GPS)

Mobile DSP beacon(s):
- Installed on robot (human) and interacts with it via virtual UART over USB
- Contains 3D IMU (accelerometer+gyroscope)
- Beacon's update rate doesn't directly depend on the number of mobile beacons unlike in Non-Inverse Architecture
- Calculates its location by itself – not by modem
- Recommended distance from mobile beacon to stationary ones up to 30m

Submaps:
- Advanced feature that allows building independent maps/clusters of beacons in separate rooms and thus covering large buildings (with area of thousands of m2) similar to cellular network coverage
- In Inverse Architecture every submap must have beacons with non-repeating ultrasound frequency
- Available frequencies: 19, 25, 31, 37, 45, 56 KHz

Indoor Navigation System consists of:
- 2 or more stationary beacons
- 1 or more DSP beacons
- 1 central router

Beacon N (19, 25, 31, 37, 45, 56 KHz)

Distance between beacons-neighbors is up to **30 meters**.

Beacon 3 (31KHz)

Router/modem:
- Central controller of the system
- Communicates via USB/virtual UART with Dashboard or robot
- Get location data from Mobile DSP beacons
- Supports up to 250 beacons

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Architectures comparison

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	Non-Inverse (NIA)	Inverse (IA)
Typical usage	- 1-4 autonomous robots/drones - supports up to 250 beacons - When mobile beacon shall be installed on a noisy vehicle, but stationary beacons are in relatively quieter places	- Many mobile users (people, robots, VR) - supports up to 250 beacons - When mobile beacons are in quieter places
Not recommended	- In applications, where emitting ultrasound of mobile beacon is undesirable	- For drones – because mobile beacon is receiving. The range may be limited to just 2-5m. May be improved with future SW releases
Precision	- ±2cm or better with more averaging	- Targeted - ±2cm - It will be on par with Non-Inverse Architecture, eventually. Currently, Non-Inverse SW is more polished, more stable and shows better precision than the Inverse one
Update rate	- Depends on the number of mobile beacons (n) as 1/n –TDMA is used - Slightly depends on the radio protocol - Depends on the sizes of submaps - IMU fusion is HW and SW supported	- Does not depend on the number of mobile beacons, because they are receiving - Slightly depends on the radio protocol (the same as NIA) - Depends on the sizes of submaps (the same as NIA) - IMU fusion is HW supported. SW support is coming
Range	- Can cover as large territory as you wish using submaps - Up to 30m in real life and up to 50m in lab conditions within a submap, i.e. stationary beacons shall be placed every 30m or closer	
Map building	- Can build a map automatically, if HW v4.9 beacons are used. Mini-beacons cannot build the map, because they are TX-only	- Manual entry of stationary beacons' location or distances between them is required

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