Innovative approaches to achieve 9 dimensional positioning

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Internet of Things

In a world of machine-machine communications:

- Sensor-rich environment
- Location & position is important
- We potentially know everything about everything!
- This may be good or bad – public debate hosted by CW in London in November www.cambridgewireless.org.uk

Today I'm going say a little bit about location and positioning in this world of the future.

Short introduction

I am CTO and co-founder of Omnisense

- We have developed a unique WSN solution for positioning sensors in a network using a combination of radio signals exchanged between peers and motion sensors in the devices. The system operates without the need for pre-installed fixed infrastructure of readers or access points.
- We are a young company based in Cambridge UK but our products have global applicability and reach.
- I am also Location Special Interest group co-champion at Cambridge wireless, a networking organisation for the wireless industry with links to like-minded groups around the world.
- I have worked in the field of location and positioning for more than 25 years including: AVI, RFID, GPS, TDOA, SLAM - using radio signals, acoustics, optical and motion sensors.

Evolution of RTLS

1st generation (RFID)

- Pinch point proximity

2nd generation

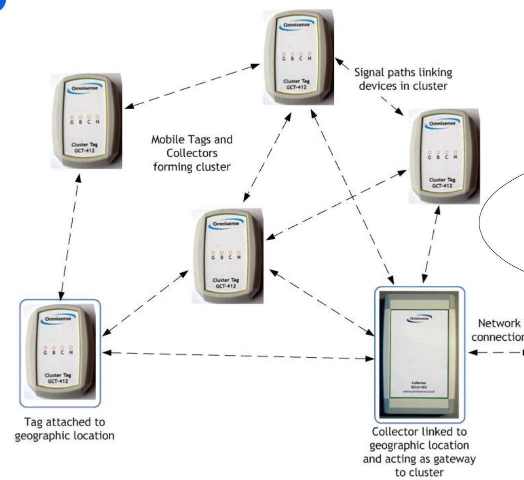
- Zonal bounded

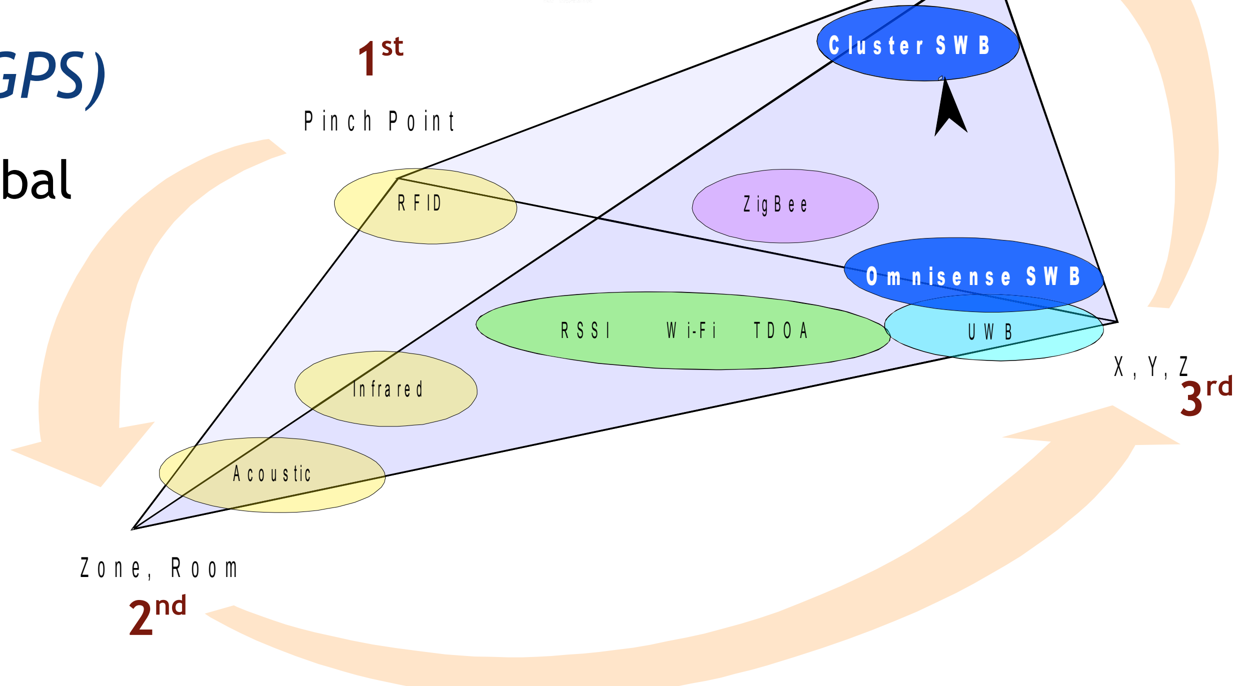
3rd generation (GPS)

- X,Y,Z, local or global

4th generation

- X,Y,Z and
- Orientation
- Behaviour aware
- The future...





9-dimensional positioning?

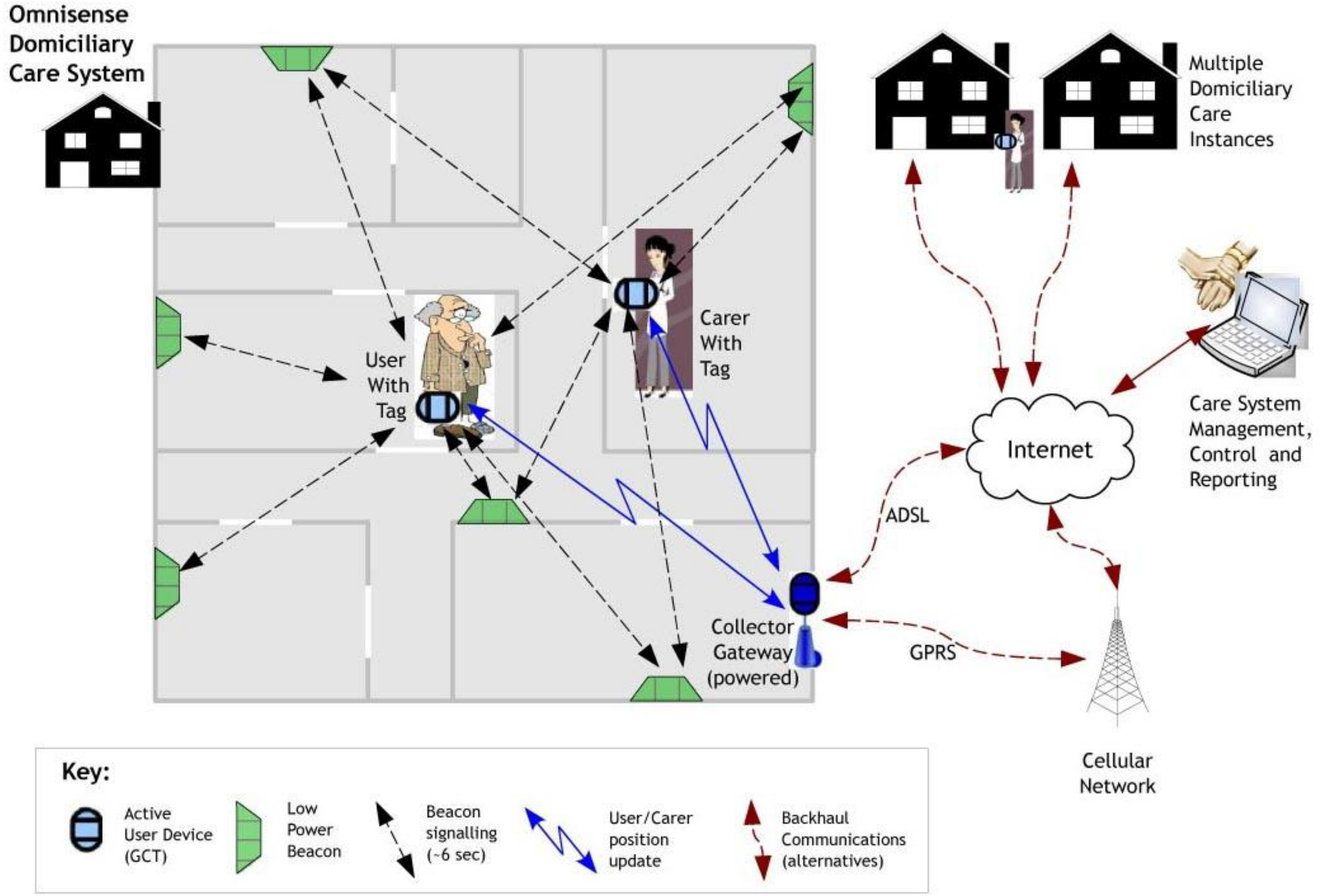
Position (location) is far more than an (x,y,z) point in space.

- To dully describe position at least 9 parameters are needed:
  - (x,y,z) – the position at a point in time
  - (v_x,v_y,v_z) – velocity
  - (Φ,θ,ψ) - orientation
- Actually additional secondary parameters may also be useful:
  - Acceleration
  - Rate of rotation
  - Behaviour descriptions

In many respects the very last point, behaviour, is the most important although it is application specific.

Behaviour – healthcare example

- Elderly care for people with dementia
- Actions and proximity of carer matters
- Behaviour of person with dementia
- (x,y,z), which room at which time
- Mobility relates to activity level, step count
- Orientation: stand, sit, fall etc.

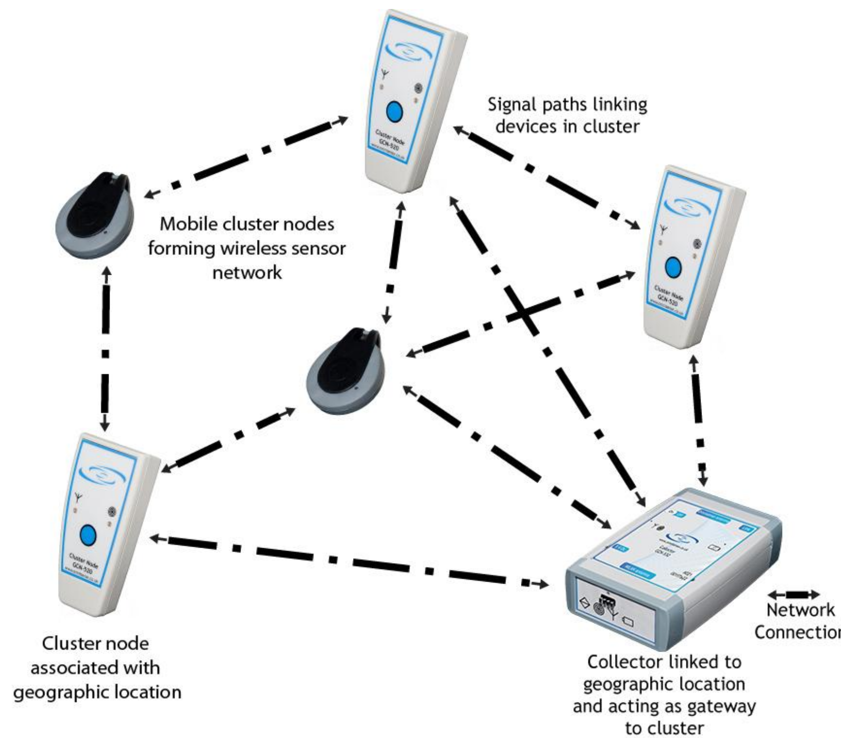


Calculating (x,y,z)

Several methods

- RFID gives proximity to reader
- Infrared, acoustic give room based positions
- GPS: receiver knows latitude and longitude
- Omnisense system uses a novel peer-peer communications between sensors to position them relative to one another

Relative positions often more important than absolute



Calculating velocity

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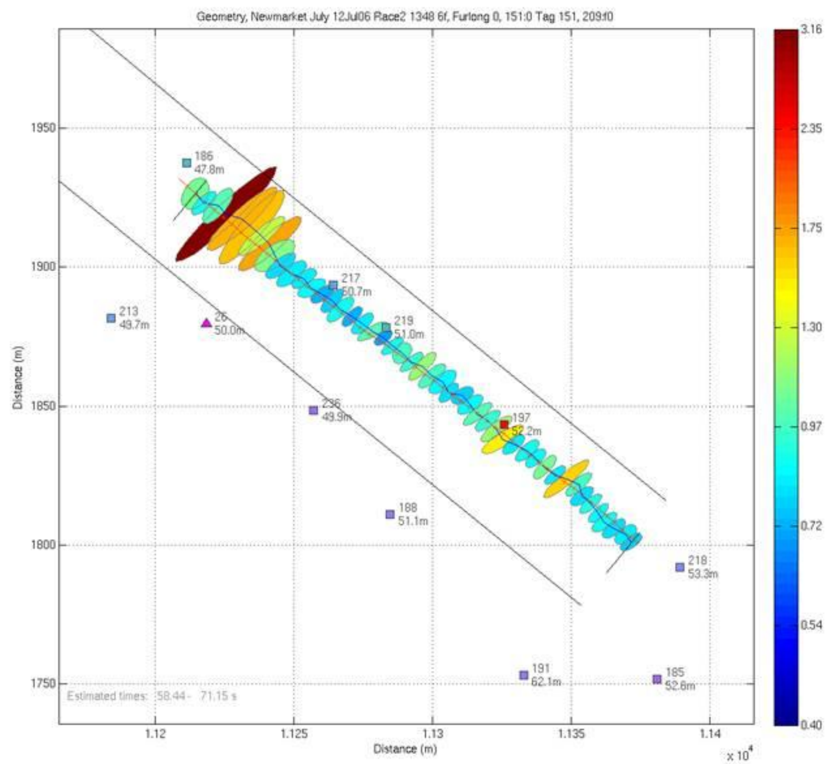
Velocity is more difficult

- Dopplers from radio signals
- Inertial navigation using accelerometers and rate gyroscopes
- Dead reckoning using step counts, odometer, wheel counters
- Differencing (x,y,z) positions not recommended.



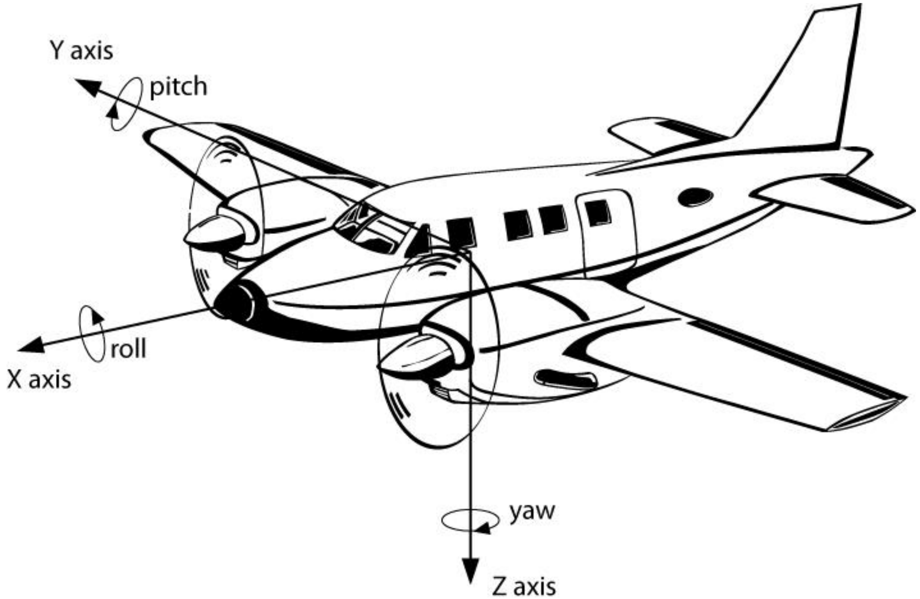
True velocity using the first two methods lead to more precise problem solution

Calculating orientation

Orientation is easier

- Angle of arrival of radio signals using antenna array
- Magnetometer to measure compass bearing
- Using inertial navigation system of accelerometers and rate gyroscopes.

Inertial navigation systems need to be calibrated because they drift with time, low cost sensors are particularly problematic.



Inertial navigation

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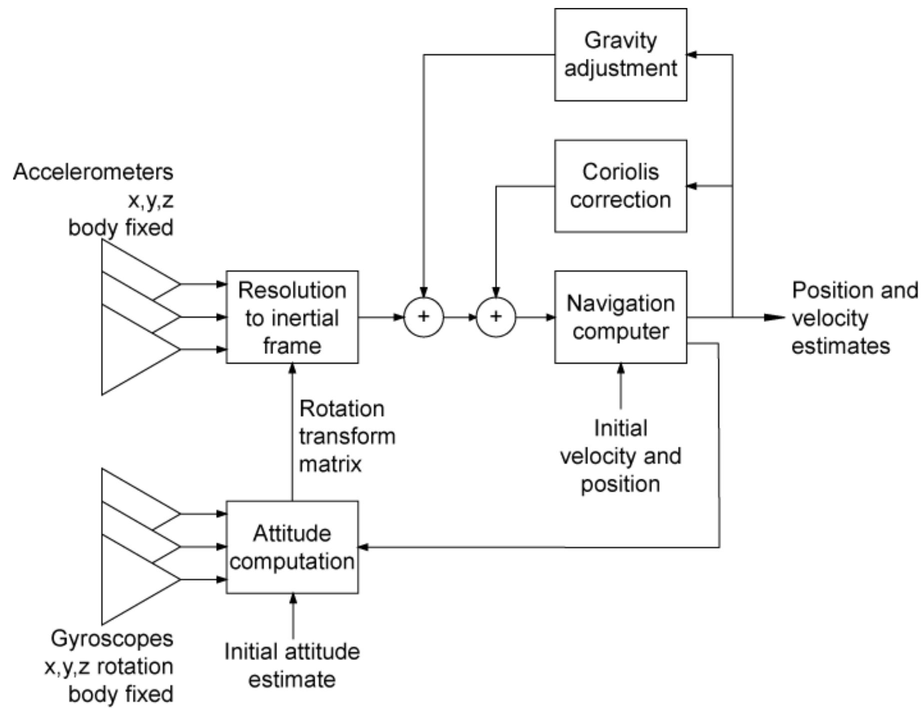
Strap-down inertial navigation using low cost MEMs sensors may be possible

- Acceleration and rotation rate must be integrated to give velocity and orientation.
- Initial conditions and sensor errors need to be computed
- Measurements are in inertial space which is not same as navigation coordinates

But difficult



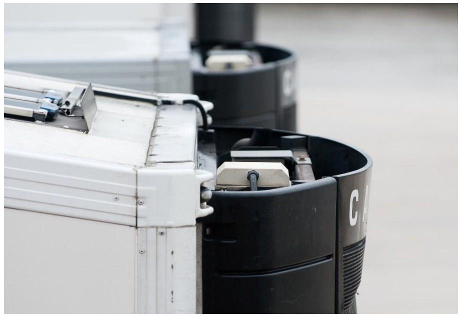
$$v = \int a.dt + v_0$$

$$d = \int v.dt + d_0$$

Conclusions

By using the right combinations of sensors full 9-dimensional positioning can be achieved.

- Low cost low performance systems can be built using simple radio location combined with accelerometer and magnetometer
- Higher performance systems can be built using the combination of radio location and inertial navigation sensors
- Relative positions are often more important than absolute positions
- Derived behaviours are often most valuable, but they usually need 9-dimensional+ position parameters to characterize!



Thank You

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