

## Localization in the Swarm

Marauder's Map

Mobile devices can locate people indoors. The result is akin to the Marauder's Map (right) from Harry Potter.

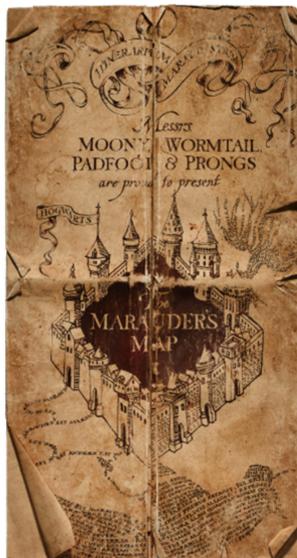


Image from [http://harrypotter.wikia.com/wiki/Marauder's\\_Map](http://harrypotter.wikia.com/wiki/Marauder's_Map)

Localization matters for swarm infrastructure too:

- A projector should only display the desktop of a computer in the same room.
- A smart HVAC system must know where sensors and actuators are in relation to each other.

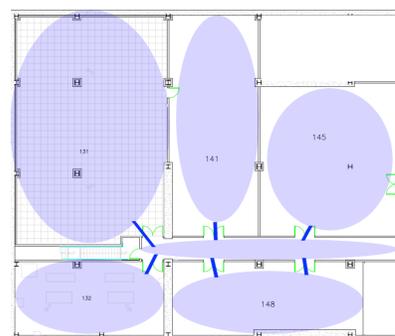
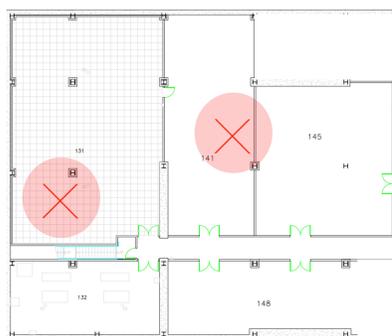
Use both to identify people and swarm capabilities at their locations.

## Semantic Localization

Localize by significance rather than absolute position in space.

Geographic

Semantic



Sutardja Dai Hall Floorplan

Why? Error in the geographic approach may localize to the wrong room

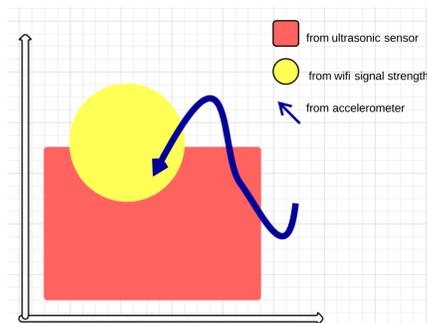
## Heterogeneous Data

Localization data is diverse but intrinsically geometric.

Localization Resources:

- Ultrasonic beacon
- WiFi signal strength
- Mobile device accelerometer
- Smart video camera
- Barometric pressure
- Range-finder
- iBeacon (Bluetooth LE)
- Etc.

### Geometric Localization Framework



Develop a common geometric reporting framework, then integrate available data into localization algorithm. Potentially:

- Simultaneous Localization and Mapping (SLAM)
- Satisfiability Modulo Theory (SMT) Solving
- Particle Filtering

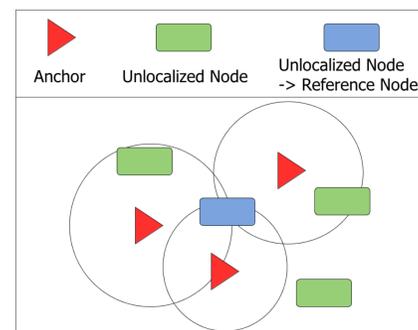
## Self-Organization

Devices in the swarm may:

- Enter or leave the network spontaneously
- Have a variety of owners
- React to a changing environment.

Potential Approaches:

Decentralized Trilateration, as used in Underwater Sensor Networks [1]



Kohonen Network: Self-Organizing Map [2]

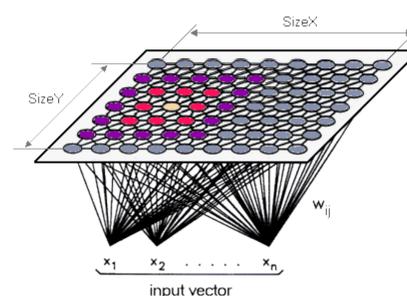


Image from [http://www.lohninger.com/helpsuite/kohonen\\_network\\_-\\_background\\_information.htm](http://www.lohninger.com/helpsuite/kohonen_network_-_background_information.htm)

## Application: Location Based Addressing

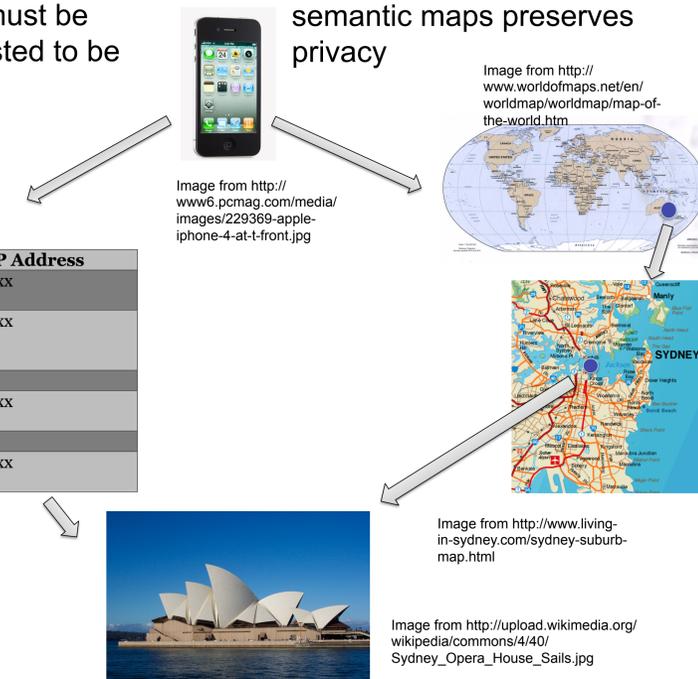
A world with a trillion nodes has an addressing problem. How should a device communicate with a new sensor or actuator in the swarm?

### DNS style

- Lookup target in large database
- Entries are quickly out-of-date
- Devices must be publicly listed to be reachable

### Semantic Localization

- Route to a semantic location and ask if target exists
- Self-Organized
- Hierarchical structure of semantic maps preserves privacy



## References

- [1] S. S. Naik and M. J. Nene, "Self organizing localization algorithm for large scale Underwater Sensor Network," in *Recent Advances in Computing and Software Systems (RACSS), 2012 International Conference on*, 2012, pp. 207–213.
- [2] Y. Takizawa, "Node localization for sensor networks using Self-Organizing Maps," in *Wireless Sensors and Sensor Networks (WiSNet), 2011 IEEE Topical Conference on*, 2011, pp. 61–64.

