Tracking as a canonical problem for studying collaborative processing

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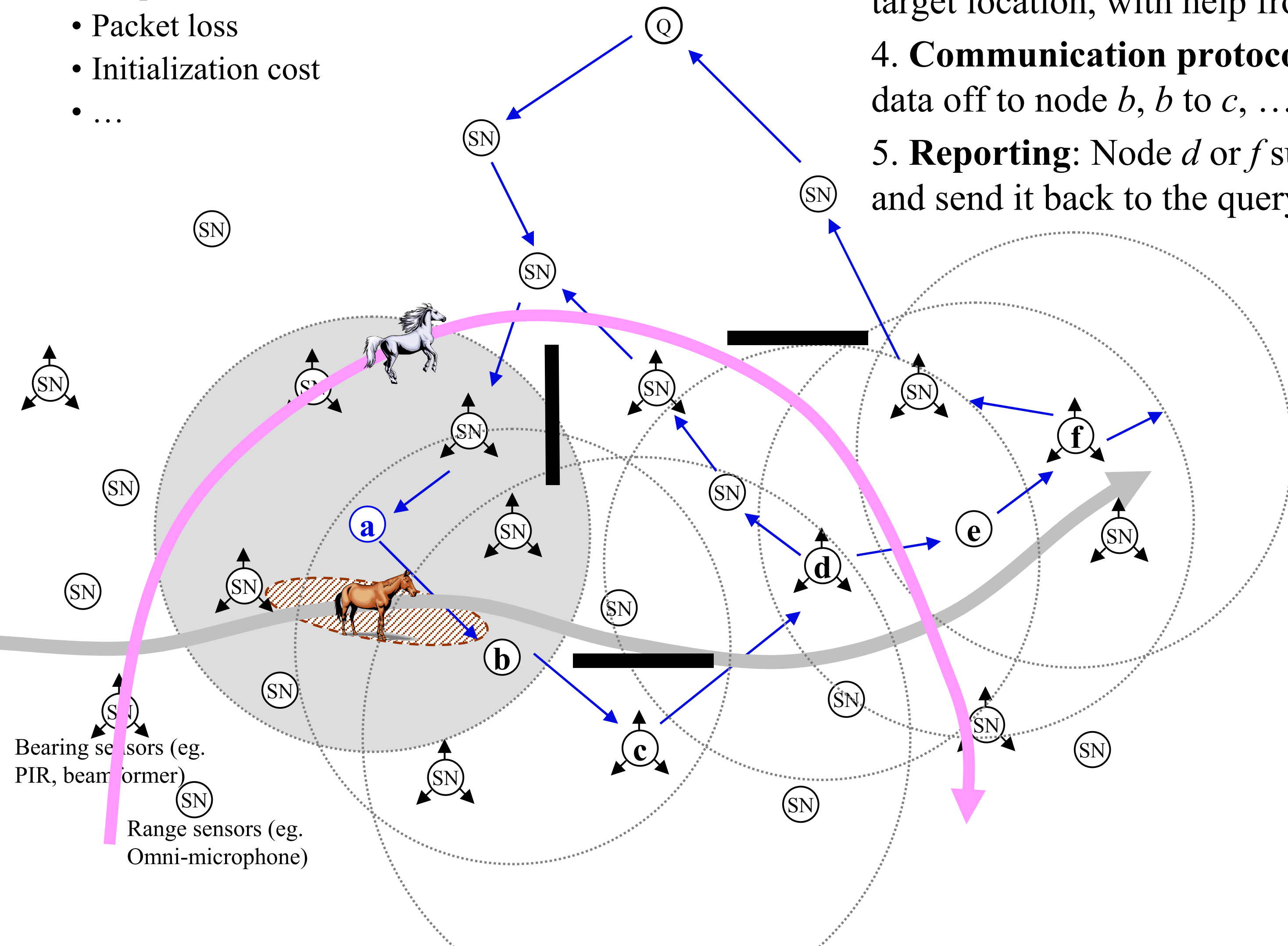
Recall the tracking scenario

Constraints:

- Node power reserve
- RF path loss
- Packet loss
- Initialization cost
- …

1. **Discovery**: Node *a* detects the target and initializes tracking
2. **Query processing**: User query *Q* enters the net and is routed towards regions of interest
3. **Collaborative Processing**: Node *a* estimates target location, with help from neighboring nodes
4. **Communication protocol**: Node *a* may hand data off to node *b*, *b* to *c*, …
5. **Reporting**: Node *d* or *f* summarizes track data and send it back to the querying node



What if there are other (possibly) interfering targets?

What if there are obstacles?

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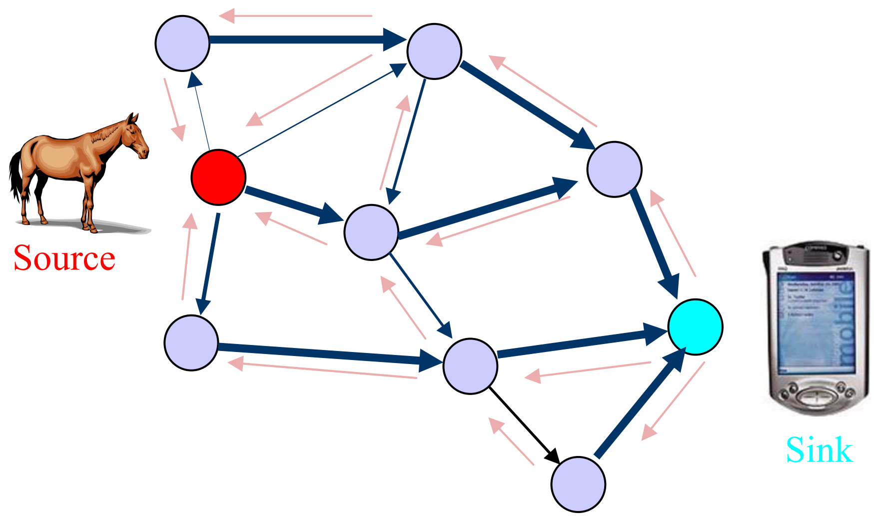
Where is the data and how to move it to where it will be needed?



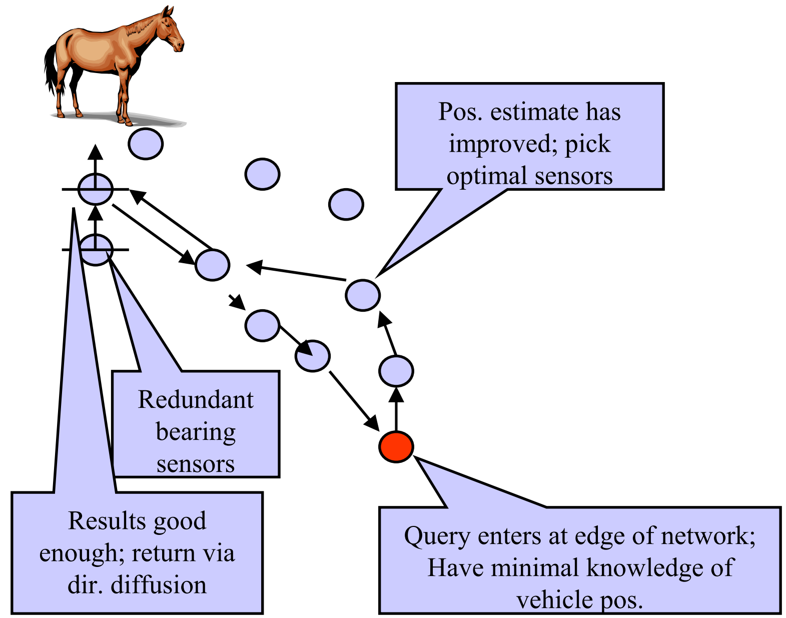
For example, use directed diffusion routing (Estrin et al)

- Publish and subscribe
  - Interest from user/data attribute from source => gradient
  - Finding shortest paths in graph

But we must also consider the information content of the data …

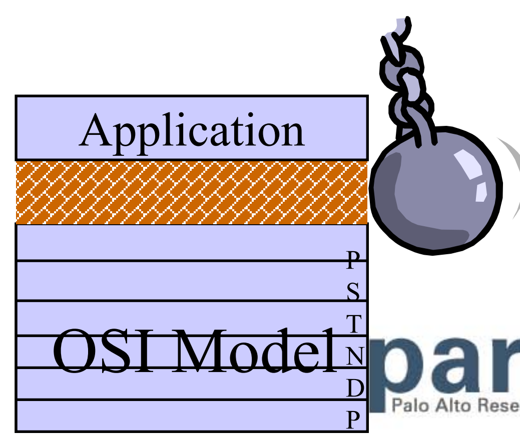
Actively Seek Out Information

"Find and track the animal" (minimize energy usage)



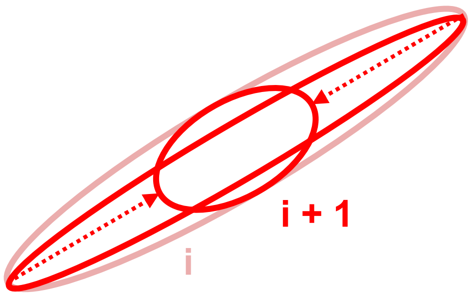
Break the barrier between *application* layer and *routing*

- Pick best info source considering network cost and information utility
- Implement selection in network, via routing decision.



Information Optimization in Sensor Networks [Byers00, Zhao02]

Example: target localization



Challenge:

Not all sensors provide useful information. Some are useful, but redundant. Select next sensor to query to **maximize information** return while **minimizing latency & bandwidth** consumption

Questions:

- What is an appropriate measure of **information utility** and **cost**?
- How does one compute the utility? in the expected sense?
- How does each sensor node balance the information gain with cost and make a local decision about sensing, aggregation, and routing?

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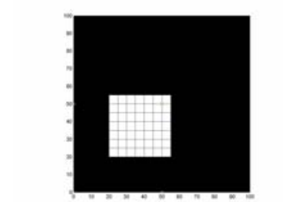
Bayesian Estimation

Initial Distribution $p(x_0)$

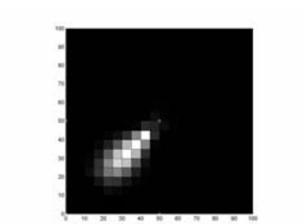


Posterior at time *k-1*

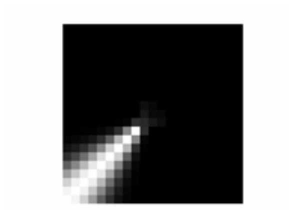
Dynamic Model

$$p(x_k \mid \bar{z}_k) \propto p(\bar{z}_k \mid x_k) \cdot \int p(x_k \mid x_{k-1})\, p(x_{k-1} \mid \bar{z}_{k-1})\, dx_{k-1}$$

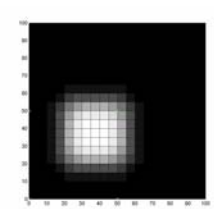
Posterior at time *k*



Observation at time *k*

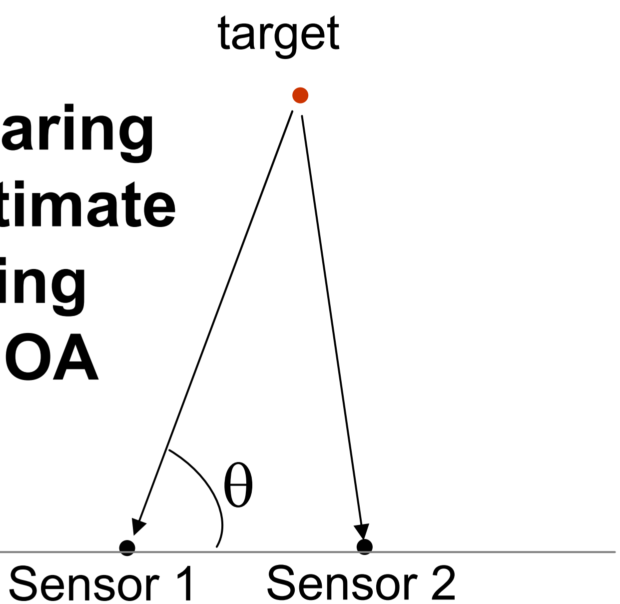


Prediction at time *k*



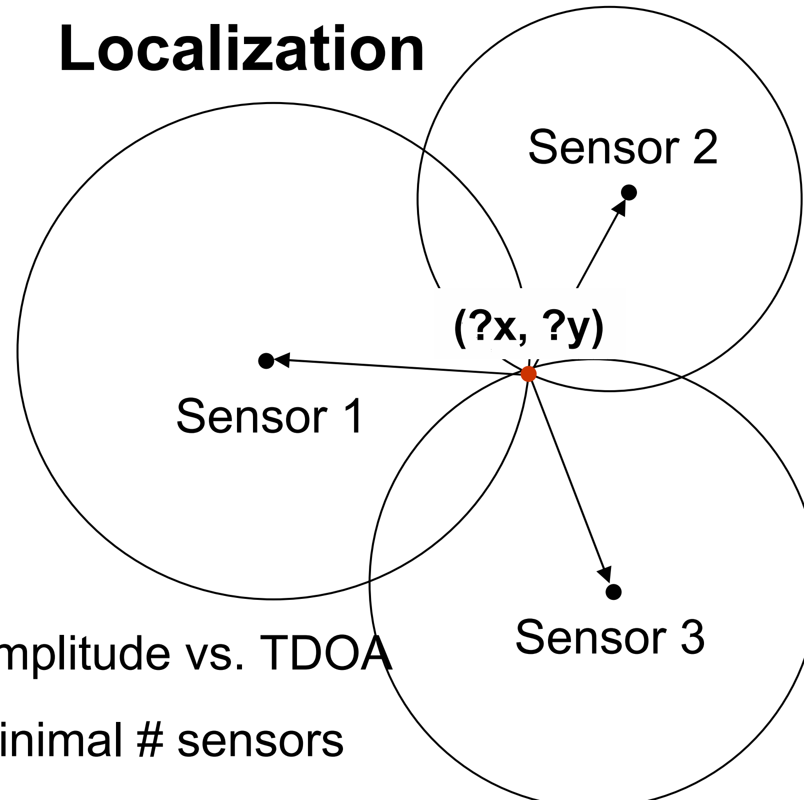
DOA and Location Estimation [Chen02, Hegazy03]

Bearing estimate using TDOA



- Far-field vs. near field
- Node time synch
- Single v.s. multiple sources

Localization



- Amplitude vs. TDOA
- Minimal # sensors
- Optimal sensor placement

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