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Tracking and Resource Allocation in Heterogeneous Sensor Networks

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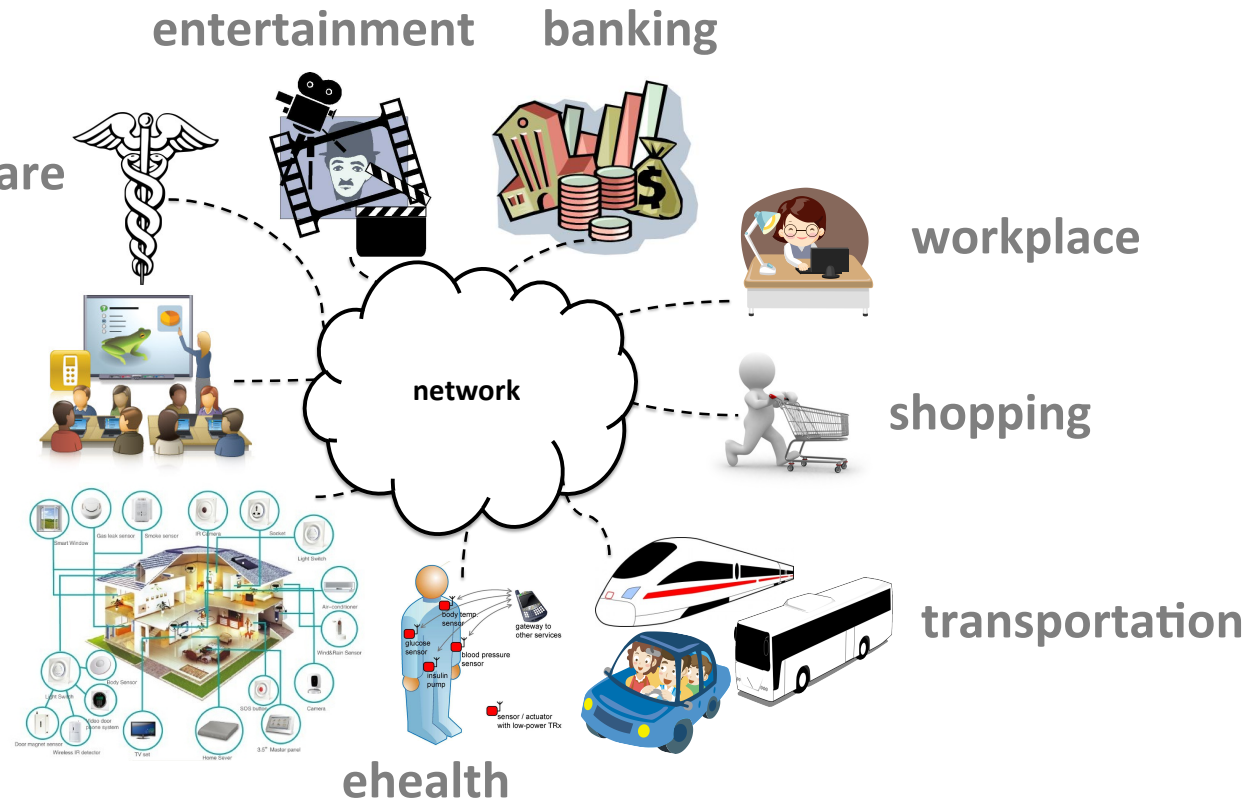
Motivation



- Efficient (e.g. accuracy, energy, time) and holistic management

How to **efficiently track** a **time-varying, unknown process** by adaptively exploiting **heterogeneous resources**?

How do we learn?

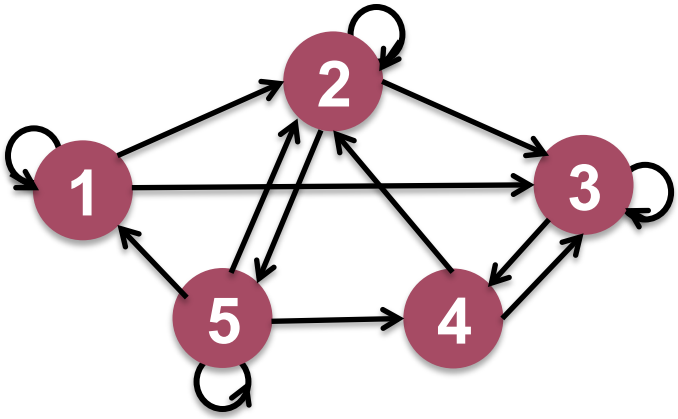
"Is the person wearing glasses?"

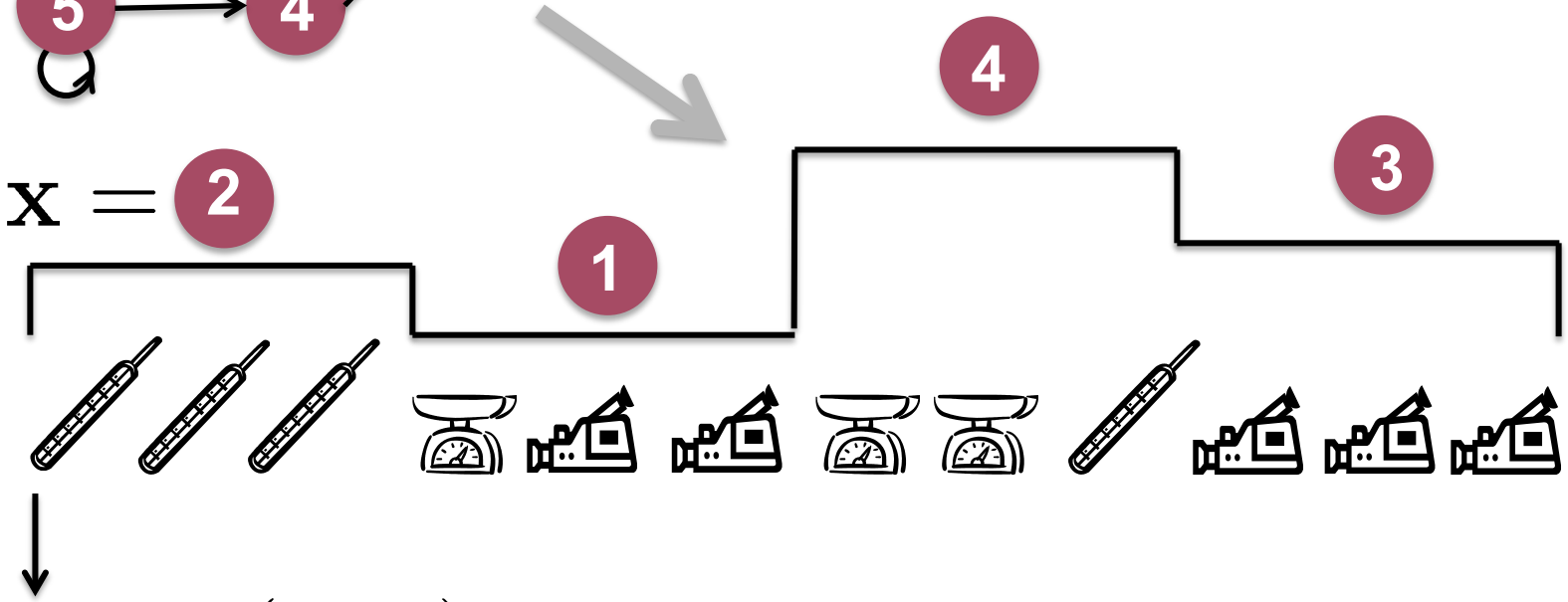
"Does the person have blue eyes?"

"Does the person have a beard?"

- The learning process is **sequential** and **adaptive/active**
  - The answers may not be entirely reliable (**noisy observations**)
  - The phenomenon may change with time

What is my problem?





$$\mathbf{y} = f(\mathbf{x}, \mathbf{u}) \rightarrow \hat{\mathbf{x}}$$

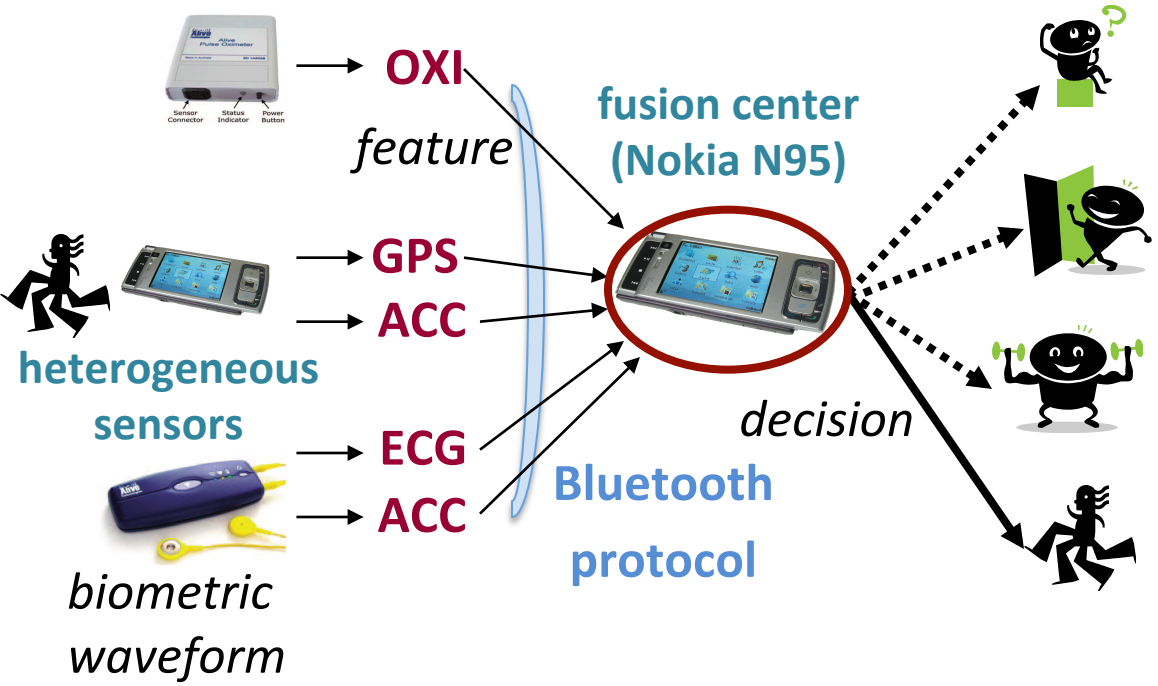
observation state, control

this is **active hypothesis testing** for a **time-varying process**

Case Study: Activity Detection in WBANS

our Wireless Body Area Network (WBAN)

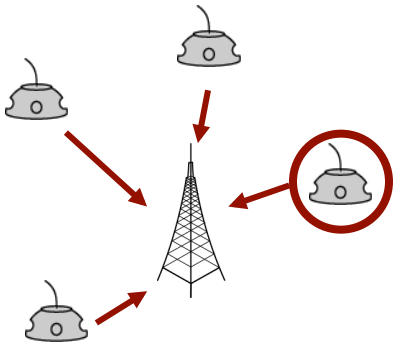
optimize energy resources at N95



traditional sensor network

optimize energy resources at sensor

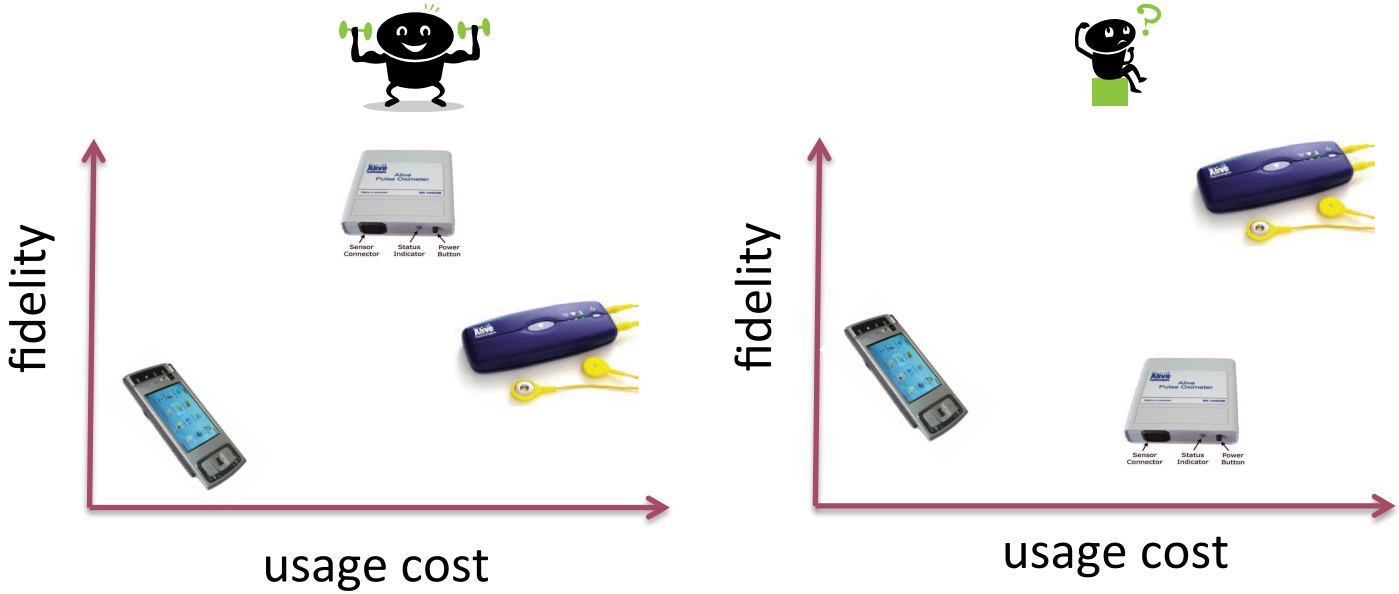
vs.



Listening via Bluetooth is expensive!!!

*If **data are collected from all sensors** (ECG, OXI, ACC, GPS) and written to a local flash drive on the N95 without buffering, **the battery life is 4h**. This is in sharp contrast to the N95's 10h of rated talk time and 200 standby hours.*

Sensors are Heterogeneous!

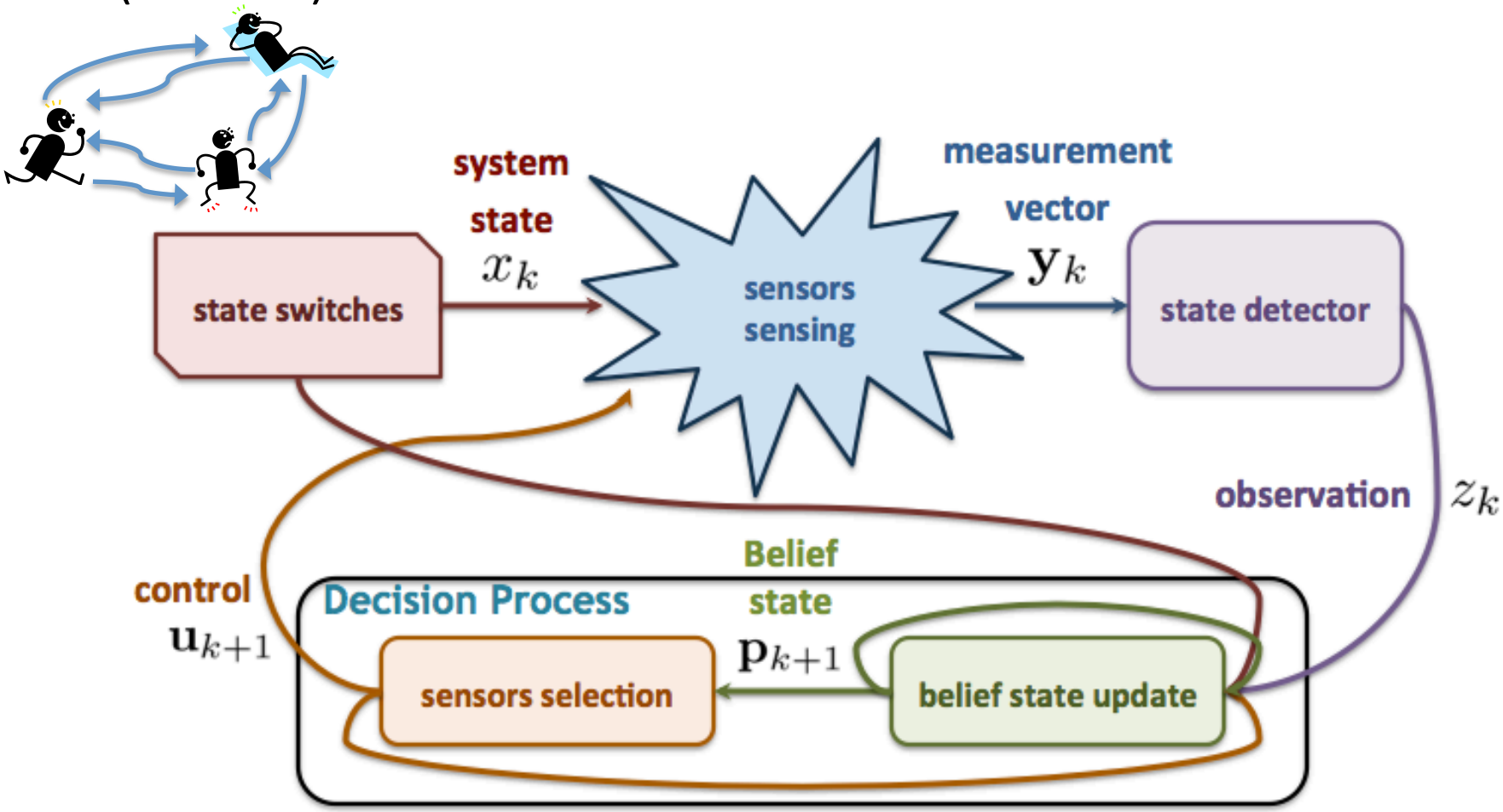


- Different sensors are good at discriminating different states
- Sensors do not have the same usage cost

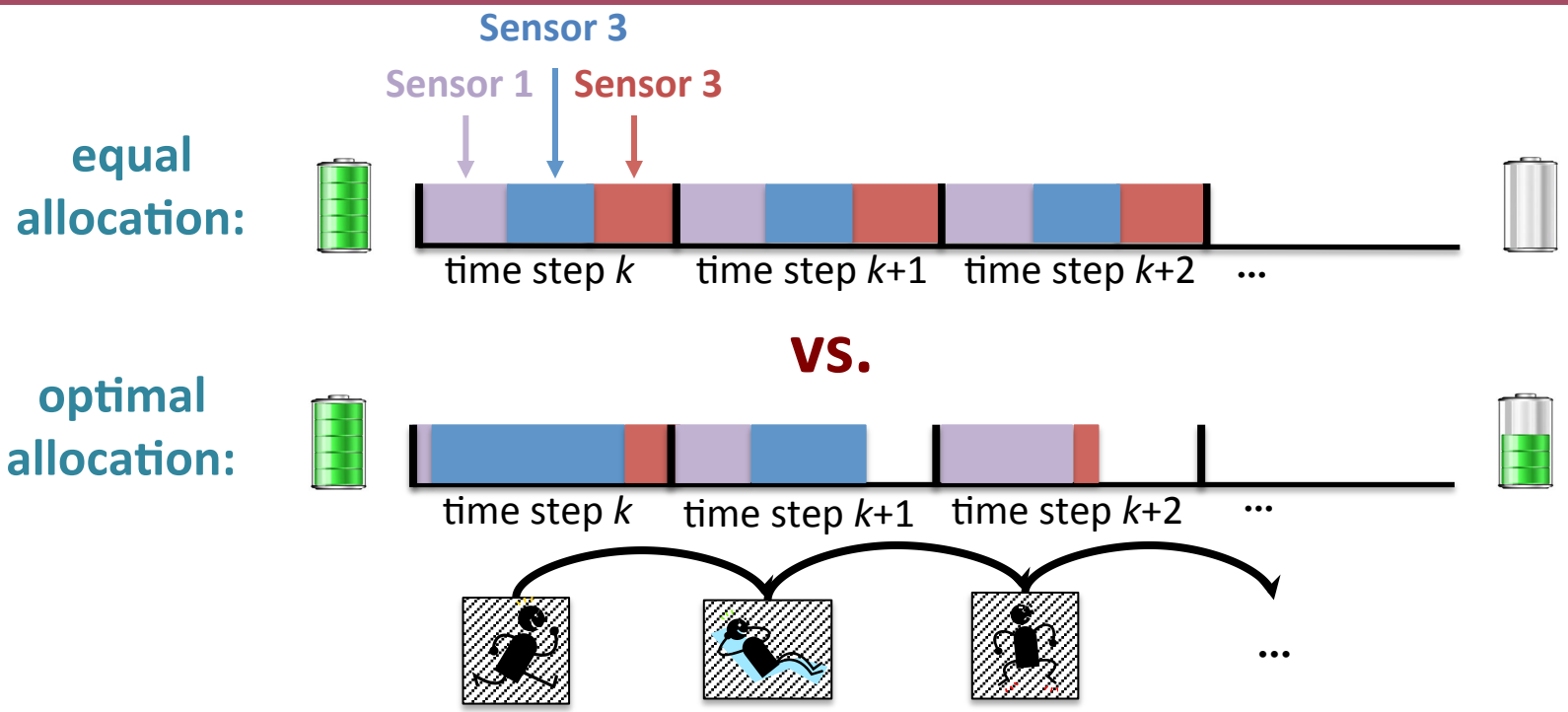
Q: Which sensor to listen to and for how long?

Proposed Framework

- Proposed a Partially Observable Markov Decision Process (**POMDP**) model



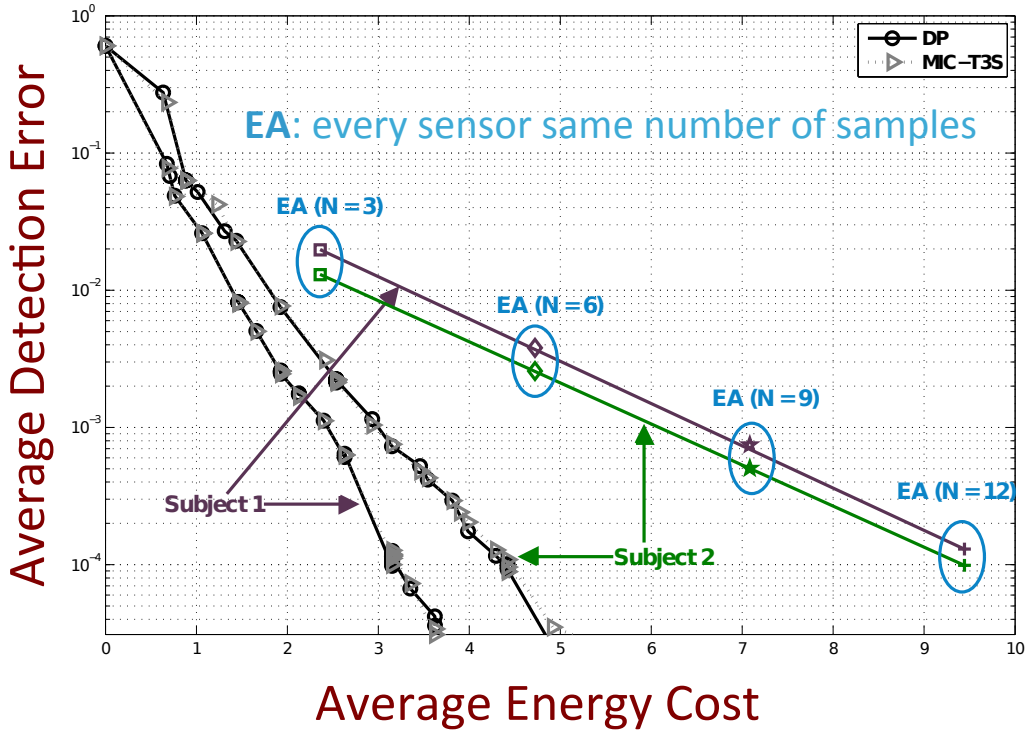
Sensor Selection Strategies



- Derived optimal sensor selection strategy via dynamic programming (**DP**)
- Derived three approximation schemes
  - Time Sharing Sensor Selection (T3S) algorithm
  - Maximal Belief Sensor Selection algorithm
  - Greedy Minimum Error Probability algorithm

Lower complexity than optimal solution

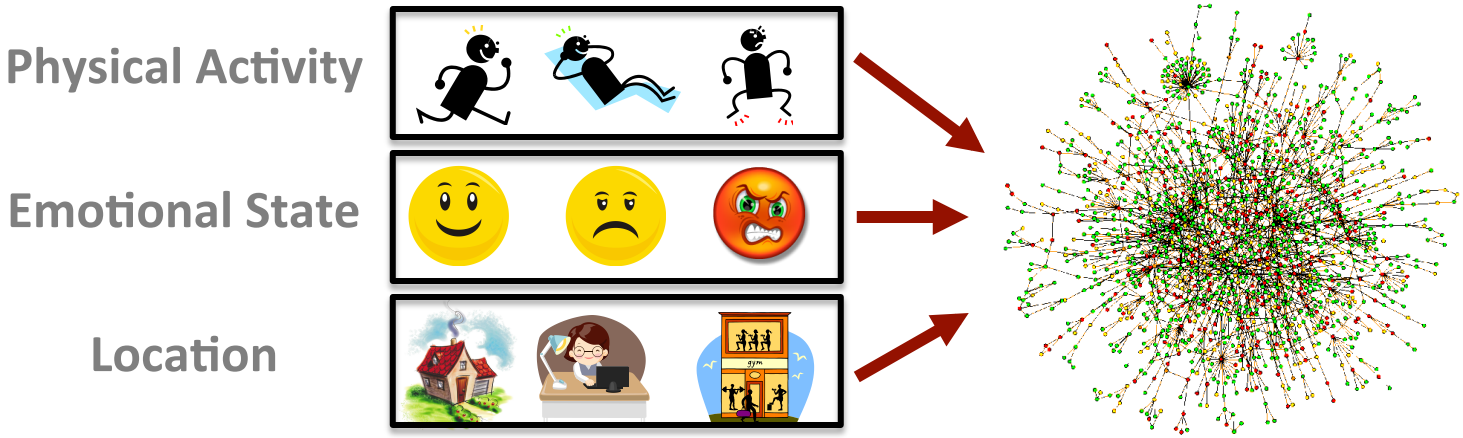
Trade-off Curves



evaluation on real data

- Energy gains as high as **68%** with **99%** detection accuracy!!!
- *Near – optimal performance* of approximate schemes
- *Very few resources* used

Current Efforts: Scalability



- **Fine-grained characterization of physical activities**: state space explosion
  - new state estimation techniques ✓
  - accelerate detection & control tasks ➔ exploit underlying structure

Thank you!

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