Exploiting Environmental Properties for Wireless Localization and Location Aware Applications

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Outline

- Introduction
- Related work
- Flex-EP
- Experimental evaluation
- Conclusion

Introduction

- The traditional approach for localization involves deploying enough landmarks with known positions to assist in localization.
- However, sometimes there may not sufficient landmarks in the area, e.g. due to cost limitations or environmental constraints.

Introduction

- The wealth of data may also be dual-used for additional purposes.
- The purpose of a sensor network is to provide sampling of a physical phenomena across a wide spatial distance.
- The close link between sensor data and location may assist applications involving localization.

Introduction

- This paper proposes the use of spatially varying environmental properties to support localization, without requiring the deployment of a localization infrastructure and additional APs.
- By using environmental readings plus the RSSI from one AP, it can achieve qualitatively the same performance as traditional localization schemes employing RSSI with at least four APs or landmarks.

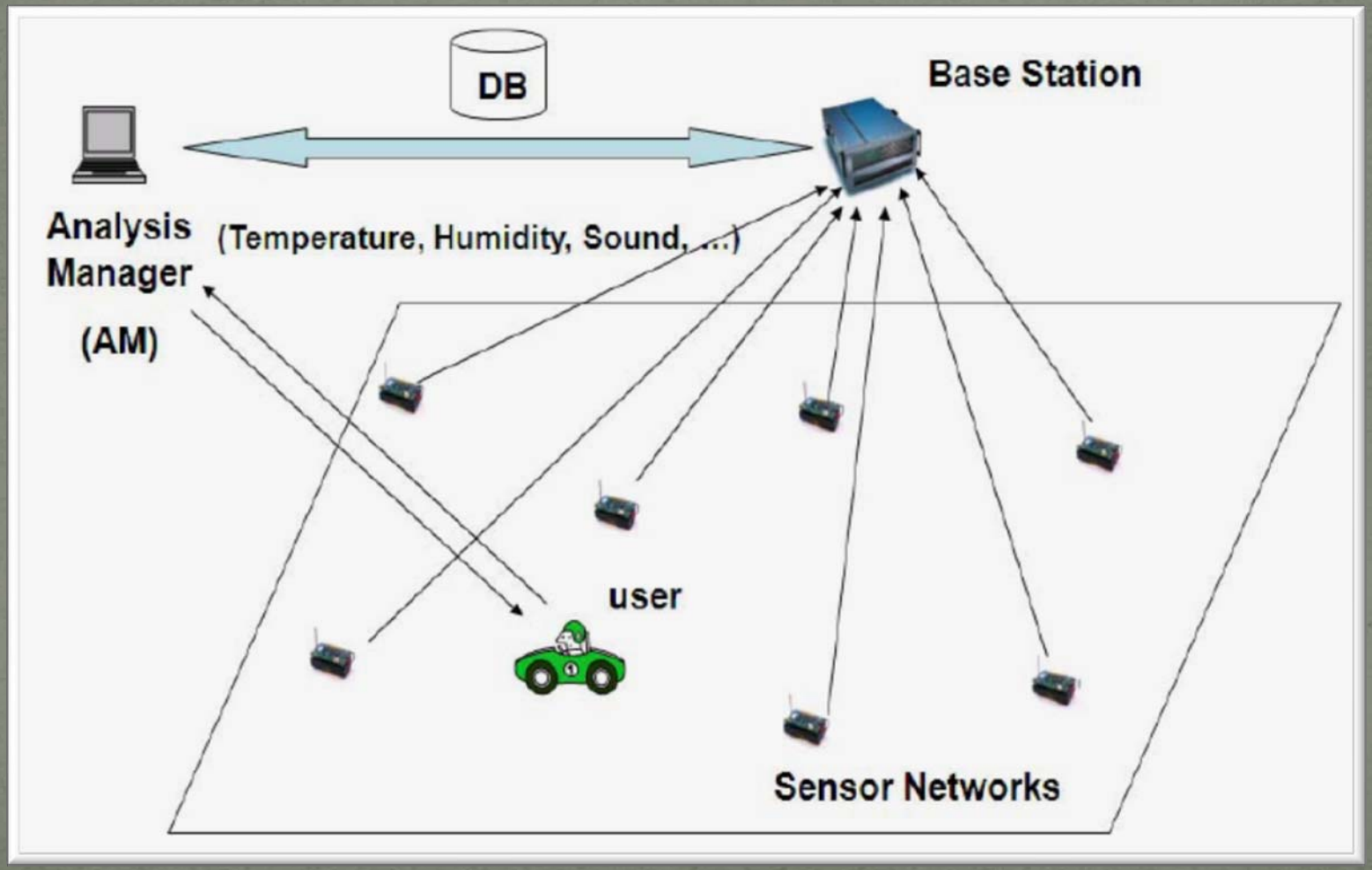
Related work

- Based on localization infrastructure：
  - Infrared
  - Ultrasound
- Reuse the existing wireless infrastructure：
  - Received Signal Strength Indication (RSSI)
  - Time Of Arrival (TOA)
  - Time Difference Of Arrival (TDOA)
  - Range-free

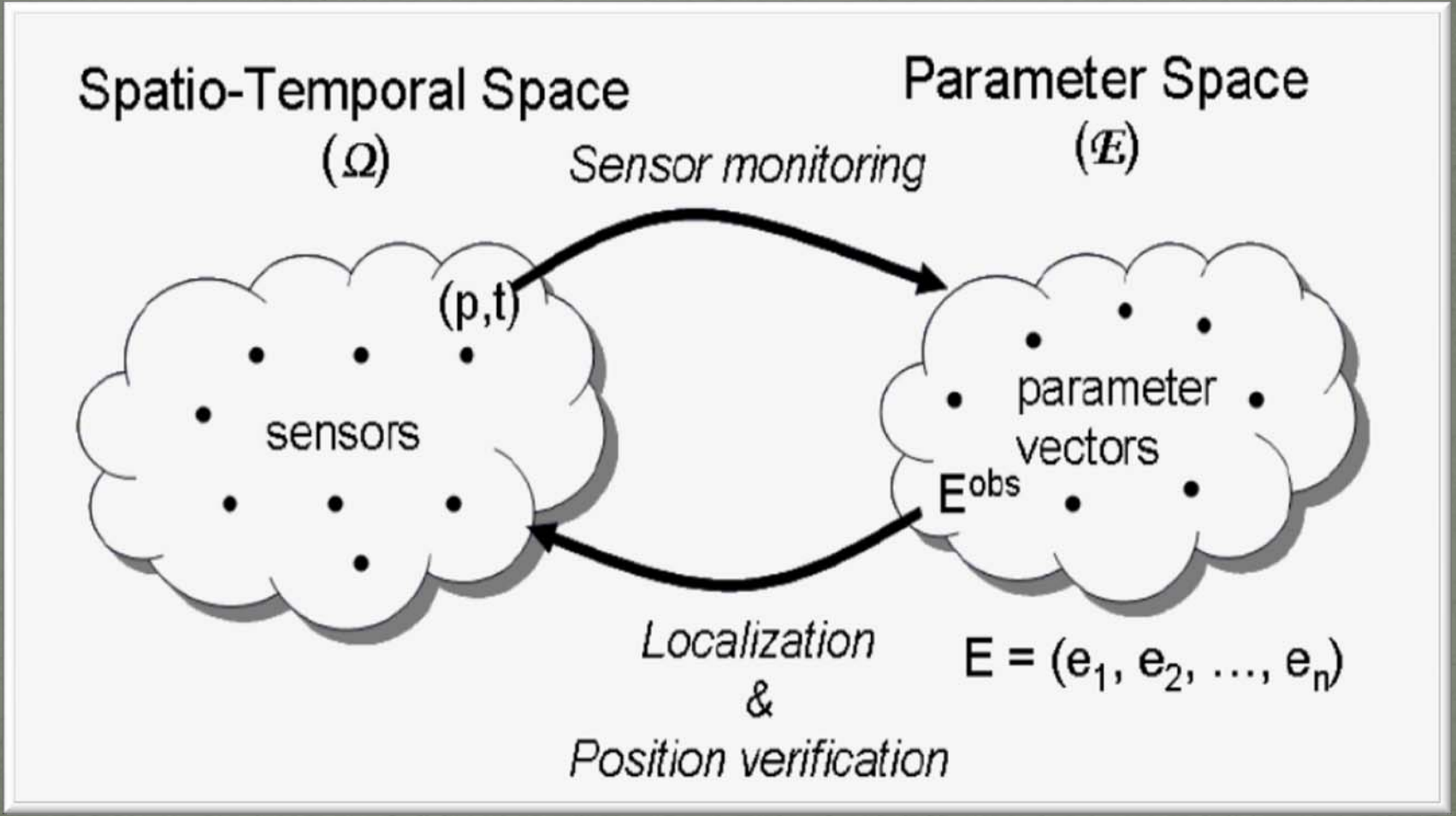
Flex-EP

- This paper proposes the Flexibly choosing Environmental Parameter (Flex–EP) algorithm.
- Flex – EP utilizes the parameter subset obtained from SCWM to determine a user's position based on it's environmental readings.
- But it has to collect environmental readings at the region of interest first.

Flex-EP


DB
Base Station
Analysis
Manager
(AM)
(Temperature, Humidity, Sound, ...)
user
Sensor Networks

Flex-EP

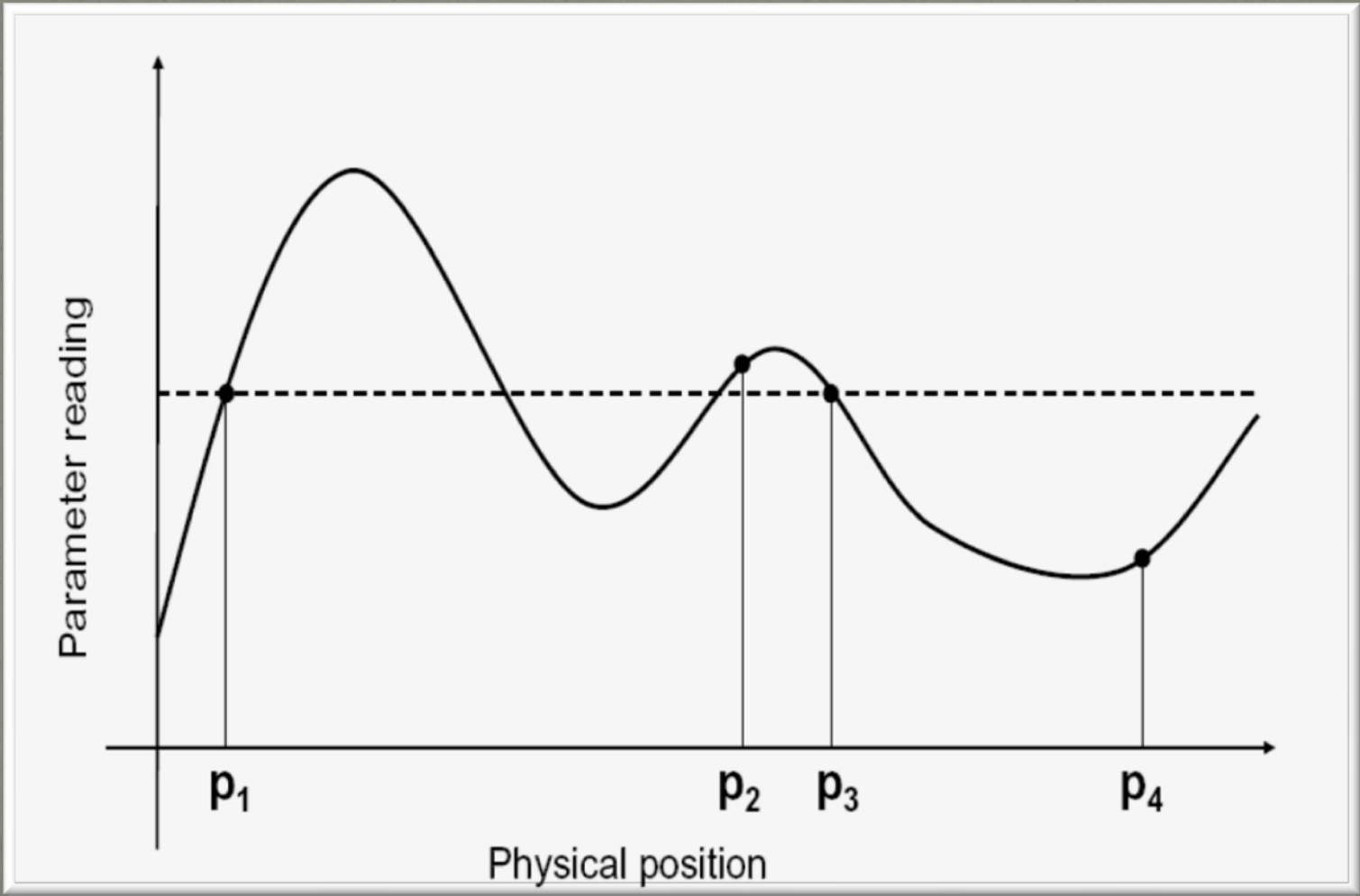

Spatio-Temporal Space
(Ω)
Sensor monitoring
Parameter Space
(E)
(p,t)
sensors
parameter
vectors
E^obs
Localization
&
Position verification
E = (e1, e2, …, en)

Flex-EP

- Parameter selection：
  - Data normalization：
    - Different environmental parameters have different units and different range of values.
  - Spatio-Correlation Weighting Mechanism (SCWM)：

$$
\begin{aligned}
W(K) &= \sum_{p_i,p_j,\,i\neq j} w_{i,j}\cdot d_{i,j} \\
&= \sum_{p_i,p_j,\,i\neq j} w_{i,j}\cdot \|p_i-p_j\|^2 \qquad (2) \\
with\ w_{i,j} &= \frac{1}{1+\tau\cdot\|e_{k\in K}(p_i)-e_{k\in K}(p_j)\|^2}
\end{aligned}
$$

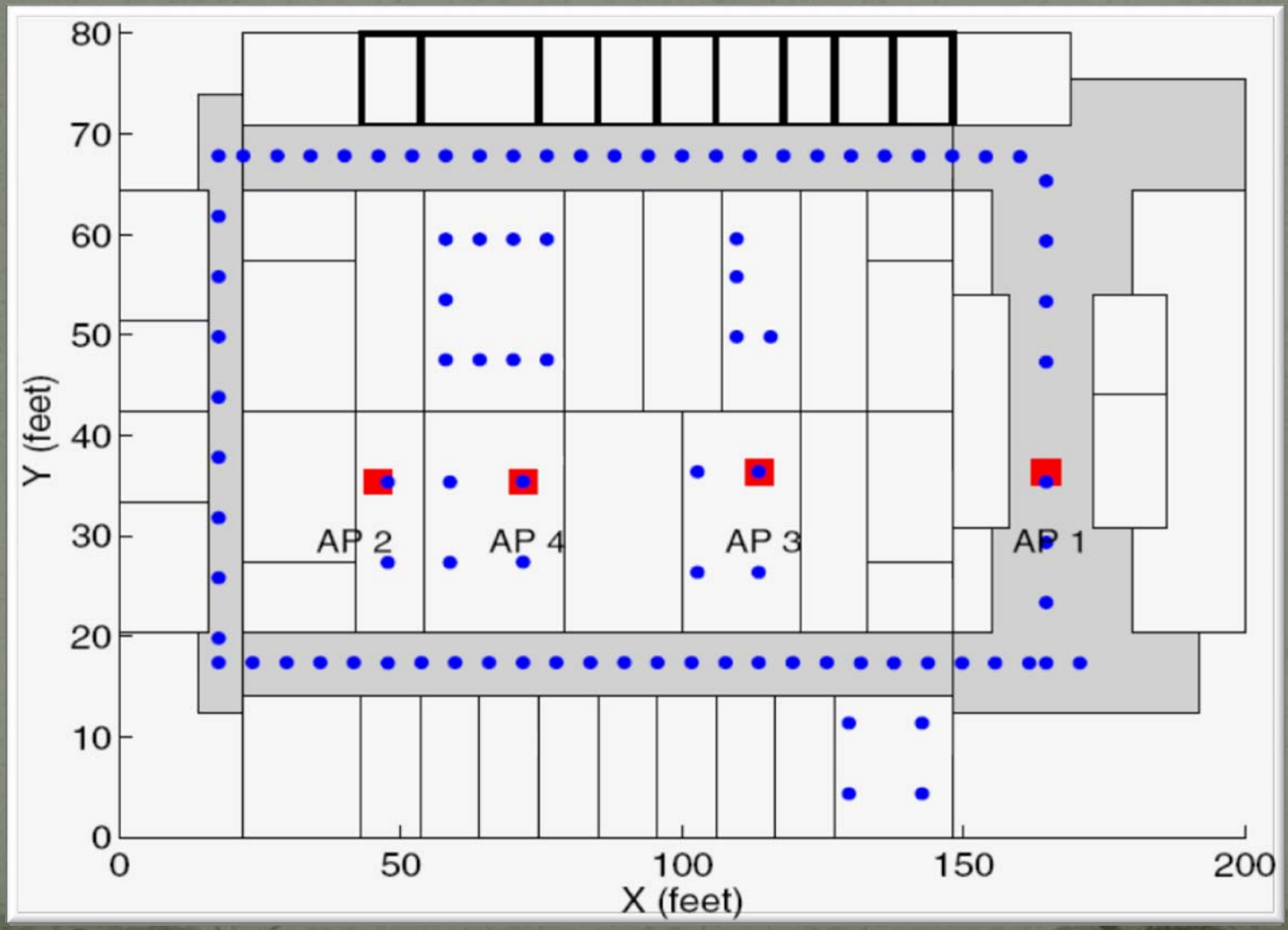
Flex-EP



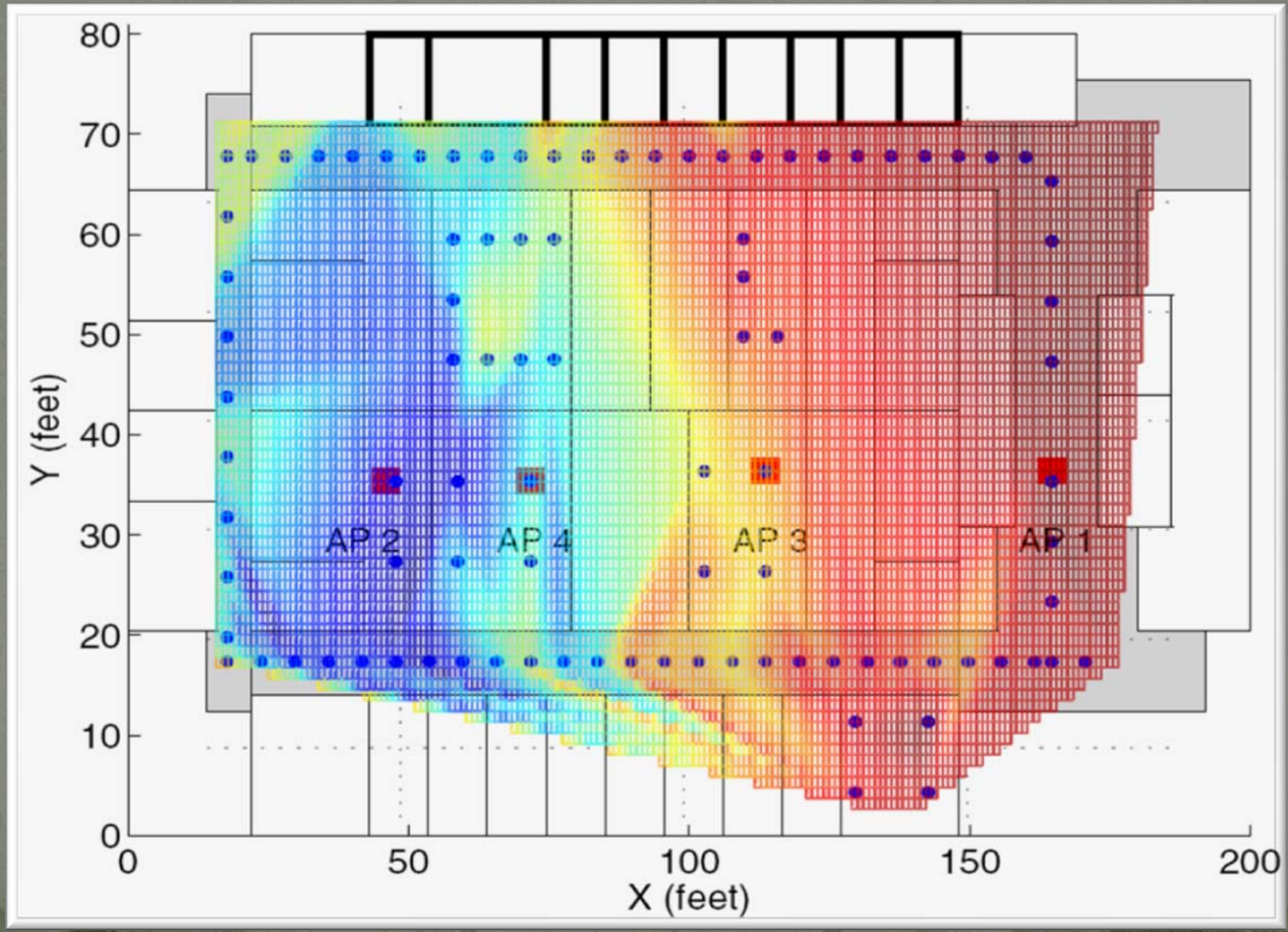
Flex-EP

- The parameter subset that results in the minimum value of W(K) is the optimal parameter combination that contains the highest discriminative power for performing localization.
- SCWM can sort all the possible combination of parameters under a fixed size parameter subset in the ascending order for localization.

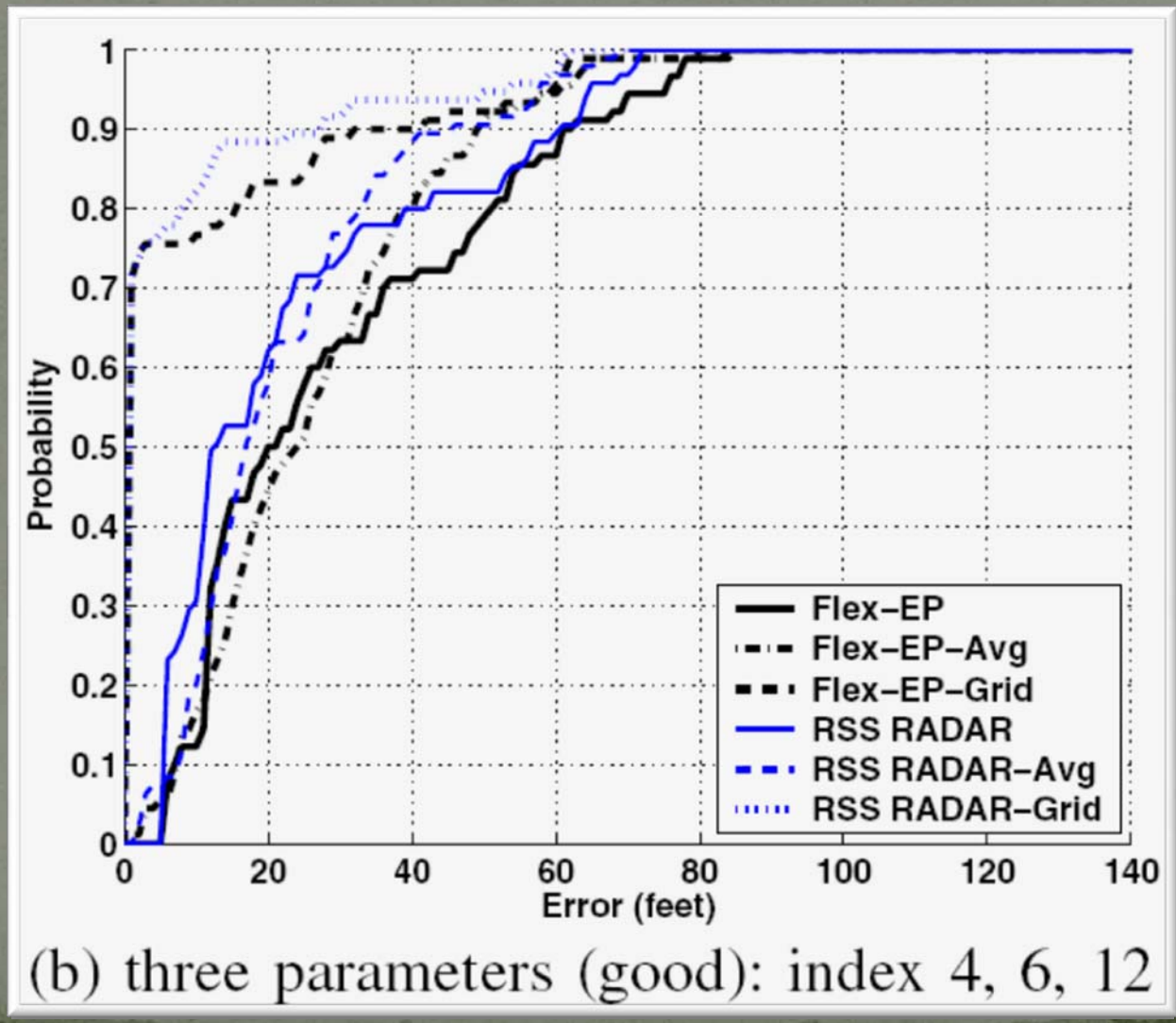
Experimental evaluation



Experimental evaluation

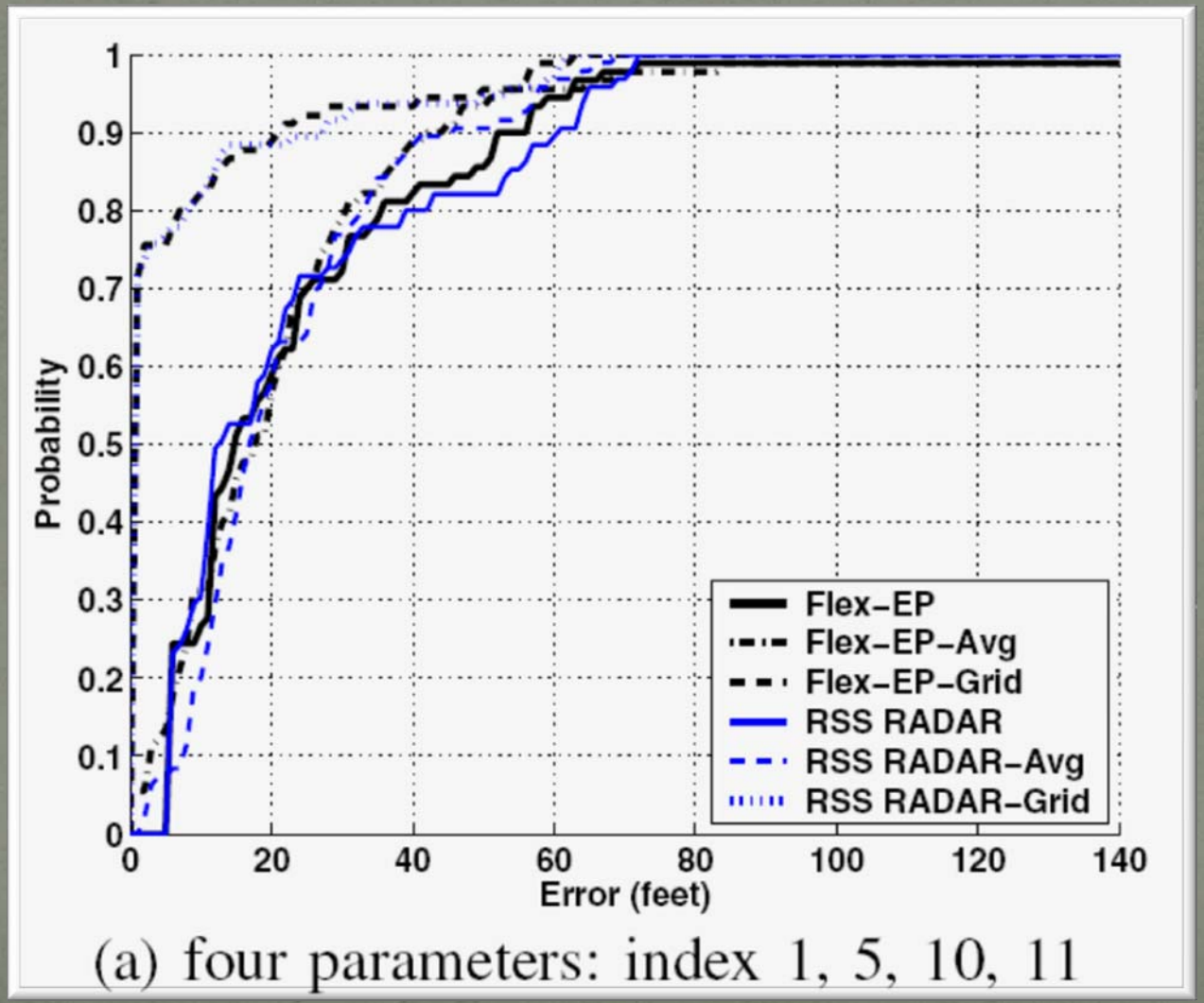


Experimental evaluation



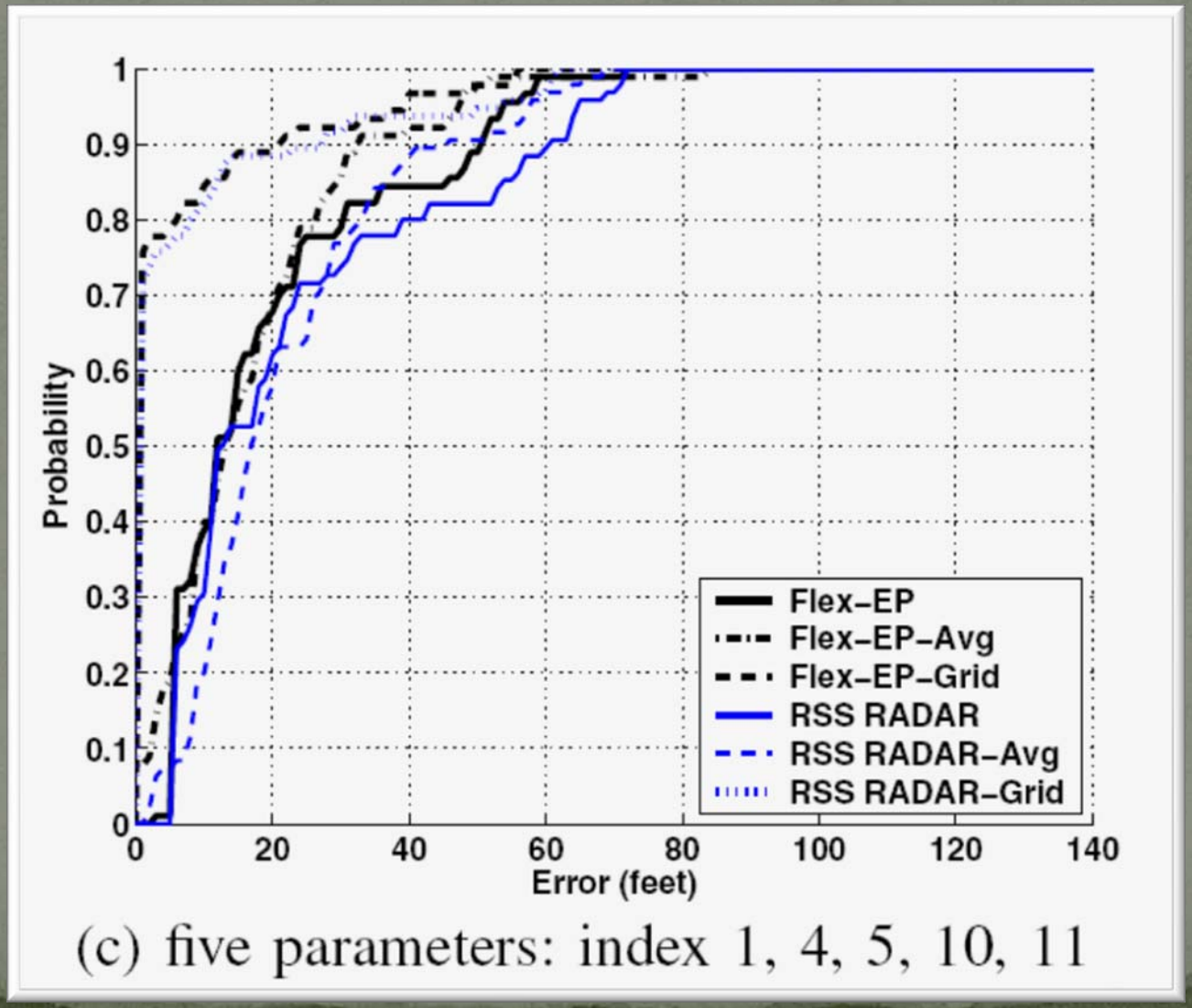
(b) three parameters (good): index 4, 6, 12

Experimental evaluation



(a) four parameters: index 1, 5, 10, 11

Experimental evaluation



(c) five parameters: index 1, 4, 5, 10, 11

Conclusion

- This paper proposes Flex-EP to use the inherent spatial variability in physical phenomena recorded by sensor networks to support wireless localization and position verification.
- By increasing the number of parameters with high discriminative power in a subset, we can further refine the localization accuracy and obtain better performance than conventional localization results.