Self-Localizing Sensor Network Architectures

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Outline

- Introduction
- System
- One-master architecture
- Three-master architecture
- Simulation and Results
- Discussion
- Reference

Introduction

- As technology advances, applications of sensor and monitoring networks are ample:inventory,smart home, warehouse inventory…etc
- As the number of sensors increases, it becomes more difficult to **configure and locate** them in space; moreover, the fault probability increases and power saving becomes more and more important.

Introduction

- To locate a node

  1.)simple triangulation

    (1)RSS(received signal strength)

    (2)AOA(angle of arrival of a signal)

    (3)TDOA(time distance of arrival)

  2.)some sensors with known location

  3.)GPS

Introduction

- To configure and communicate in a distributed sensor network
- Two architectures,one-master and three-master, which are discussed
- They are both fault tolerant and suitable for large number of sensors

Introduction

- Sensors are considered

  1.)to communicate

  with each other

  2.)can change position

  3.)are subject to failure

are supposed to be exactly identical and undistinguishable except for location in space

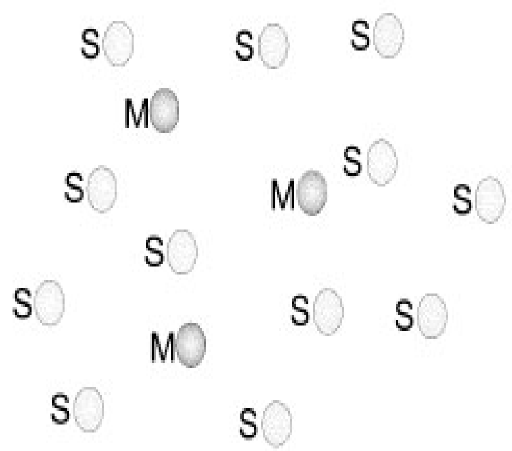


Fig. 1. Network topology. S: Sensor. M: Master.

System

- Distance Measurement

The correlation between power of transmitted and received signals can be derived from the Friis transmission formula

$$\frac{P_r}{P_t} = \frac{A_{er} A_{et}}{r^2 \lambda^2} \qquad (1)$$

System

P_r recived power, [W];

P_t transmitted power, [W];

A_{er} effective aperture of receiving antenna, $[m^2]$;

A_{et} effective aperture of transmitting antenna, $[m^2]$;

r distance between receiving and transmitting antennas, $[m]$;

λ wavelength, $[m]$.

System

- If the transmitter employs an isotropic source, (1) becomes

$$P_r = \frac{P_t A_{er}}{4\pi r^2}. \qquad (2)$$

- All constant parameters can be grouped into a constant

$$P_r = P_t \cdot K \cdot r^{-2}. \qquad (3)$$

One-master Architectures

- This architecture employs four different operations to locate and activate all the sensors of the network.

  A) single sensor identification

  B) imprecise sensor location map definition

  C) sensor location map refinement

  D) optimal communication path calculation between a sensor and the master.

single sensor identification

- 1) Identification of Sons(to assign ID)
  2) Identification of Parents(for position)
  3) Neighbor Identification
  (for communication and map refinement)

  time spent is proportional to

$$NUM_{sensors} \cdot (S + P + N). \quad (4)$$

Imprecsie Sensor Location Map Definition

- CC has received all information. It must translate all integer power measurement in a floating-point distance
- Then, a constellation map is created with the information about parents of each sensor by triangulation method

sensor location map refinement

- mass center of neighbors of each sensors is used to update the sensors' position
- Ex.

sensor location map refinement

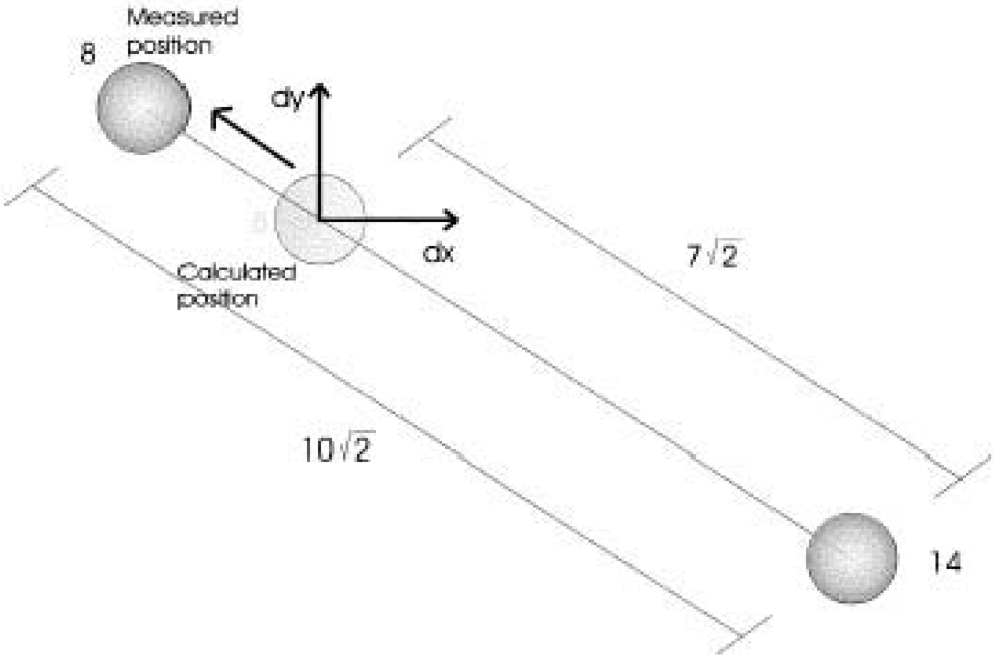


Fig. 2. Coordinate optimization.

$$x_8 = 3, \qquad y_8 = 7, \qquad x_{14} = 10, \qquad y_{14} = 0.$$

sensor location map refinement

- The position of sensor8 measured by sensor 14 is

$$x_8^1 = 0, \qquad y_8^1 = 10, \qquad dx = -3, \qquad dy = 3.$$

- By the method, the new location of sensor 8 is given by

$$x_8 = \frac{\sum_{i=1}^{N} x_8^i}{N}, \qquad y_8 = \frac{\sum_{i=1}^{N} y_8^i}{N}. \qquad (5)$$

optimal communication path

- CC has all information that can communicate with each of sensors through the master
- The next step is making communication efficient.
- Ex.

optimal communication path

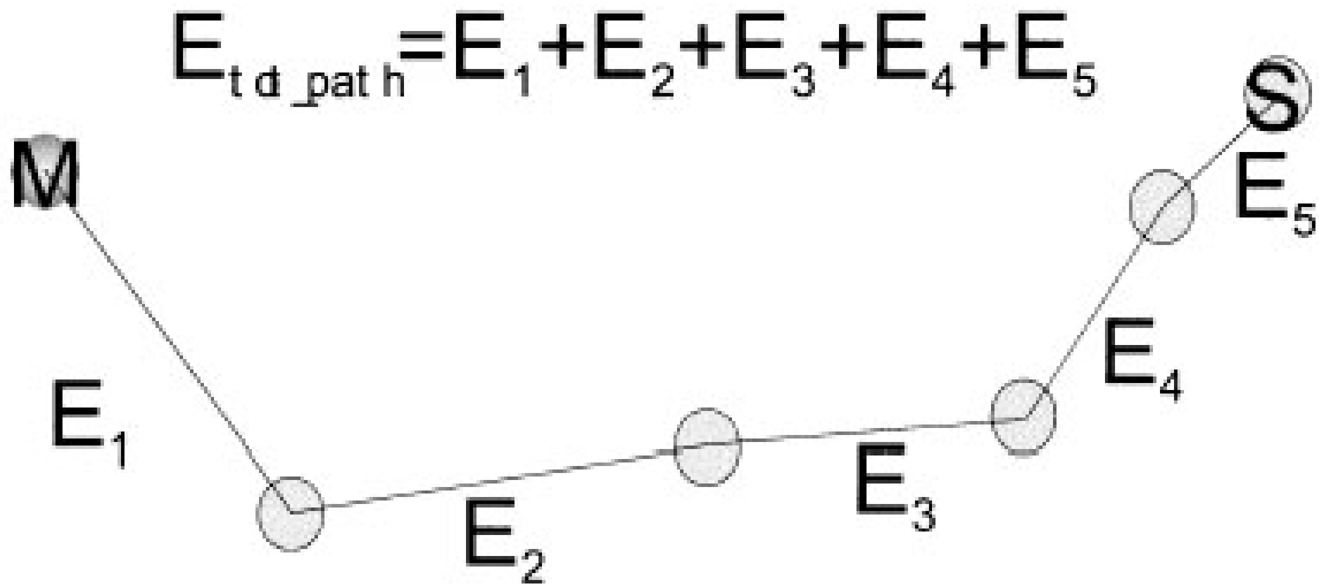
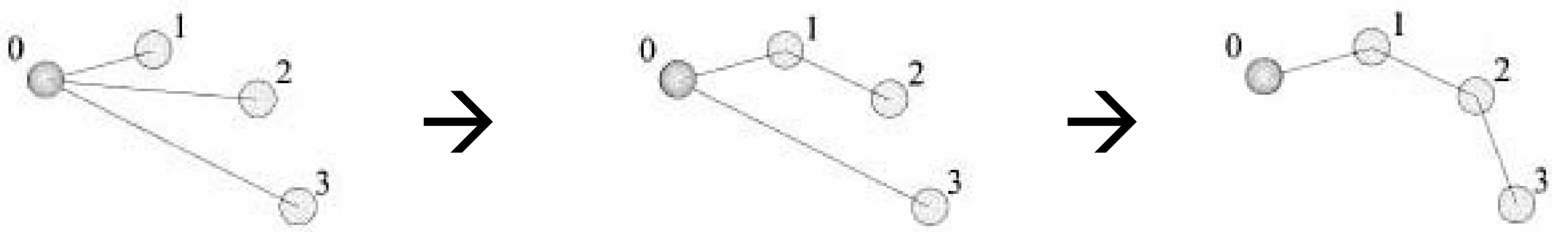


Fig. 3. Energy computation over a path.

optimal communication path



3-master architecture

- it is not necessary to identify the individual sensors
- when a sensor transmits data to the masters it is located by triangulation.
- the accuracy and precision of the power measurement is important

3-master architecture

- simpler operations in the three-master
  1) Masters do not need to collect data
  2) Sensors do not do complicated calculation

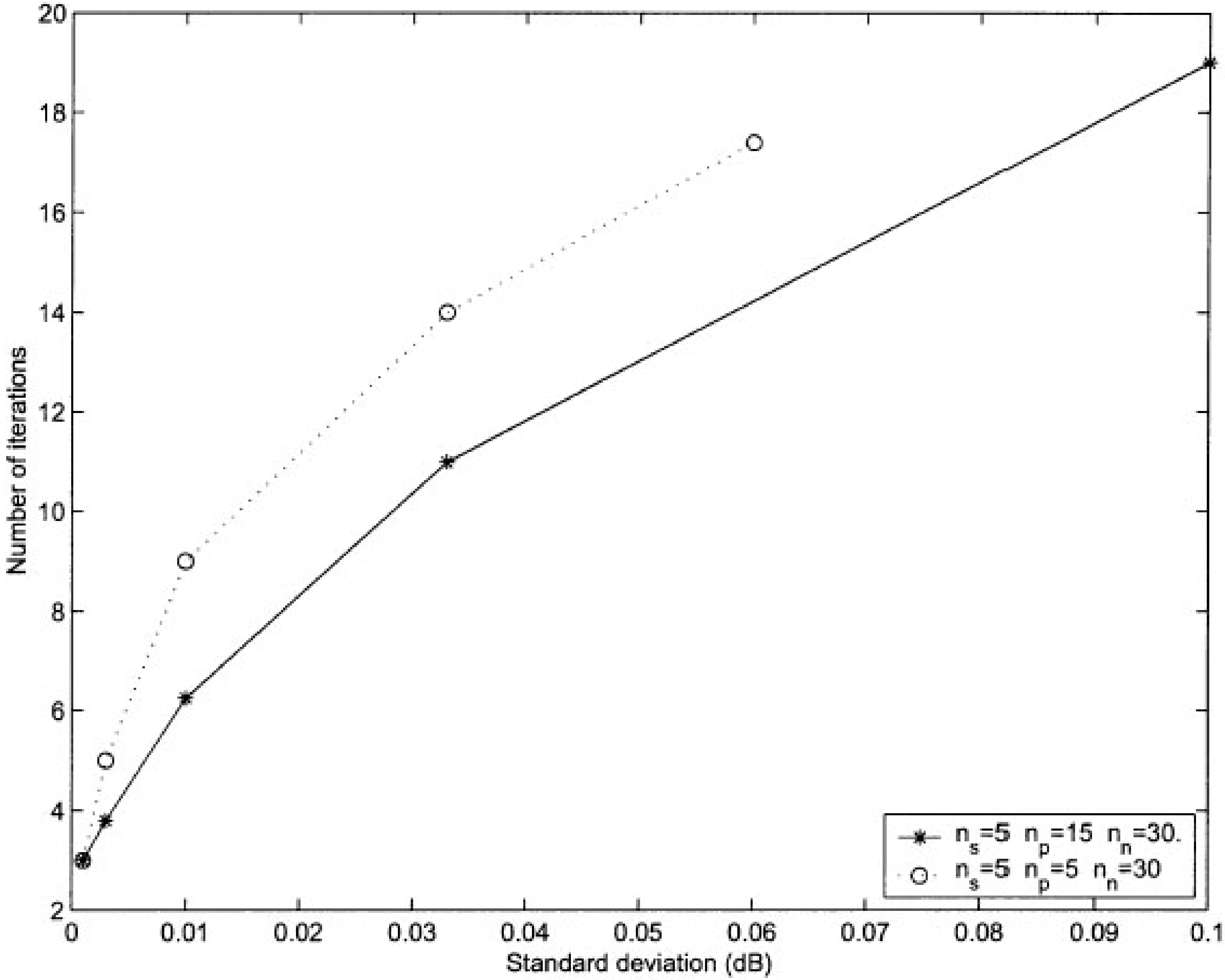
Simulation and Results

- 1-master
- Condition:50 sensors,300X300 unit area

  30 bit frame data

  1) P=15 N=30 and S=5;

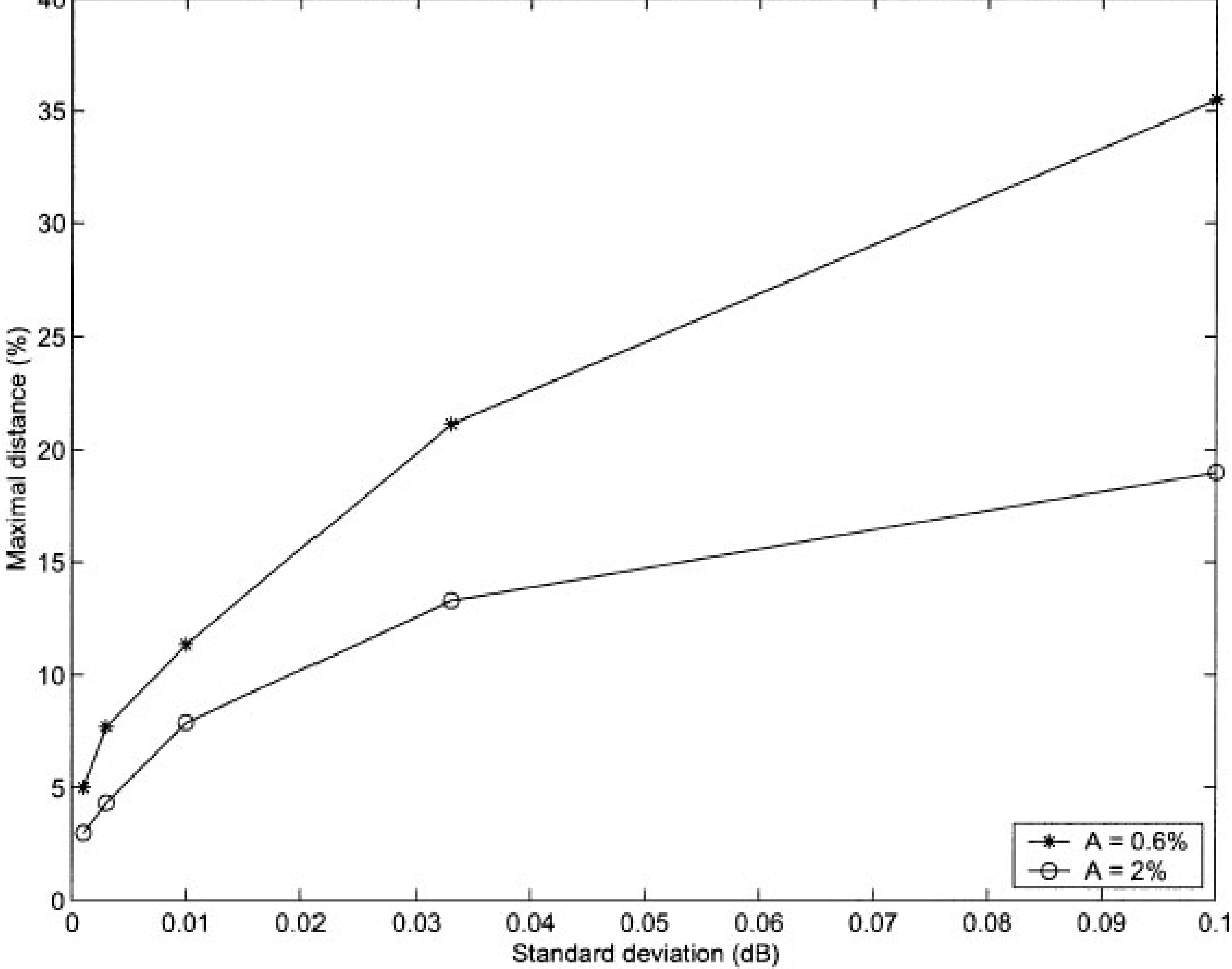
  2) P=5 N=30 and S=5.



5 — Convergence of the refinement map algorithm

Simulation and Results

- 3-master
- The system is simulated when the area of the triangle is the 0.6% and the 2% of the total area considered.



. 6. Uncertainty of the sensors positioning in a three-master architecture.

Simulation and Results

- uncertainty in the 3-master is bigger than in the 1-master architecture and can be reduced increasing the distance between masters.

Conculsion and Discussion

- **configuration** and **communication** in two different sensor network architectures, were presented.
- one master

  1.it's possible to identify every node

  2.to locate all sensor in space

  3.finding lowest energy transmission path to reach the master

Conculsion and Discussion

- three master

  1.to locate by triangulation and when a transmission occurs

  2.can't optimize energy consumption during communication

  3.can localize moving sensor and dynamically changing sensor topologies

Conculsion and Discussion

- 3-master

  →faster,flexible,expensive,energy wasting (about 30 times)

- 1-msater

  →less expensive, less power

Reference

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