Mobile-Assisted Localization in Wireless Sensor Networks

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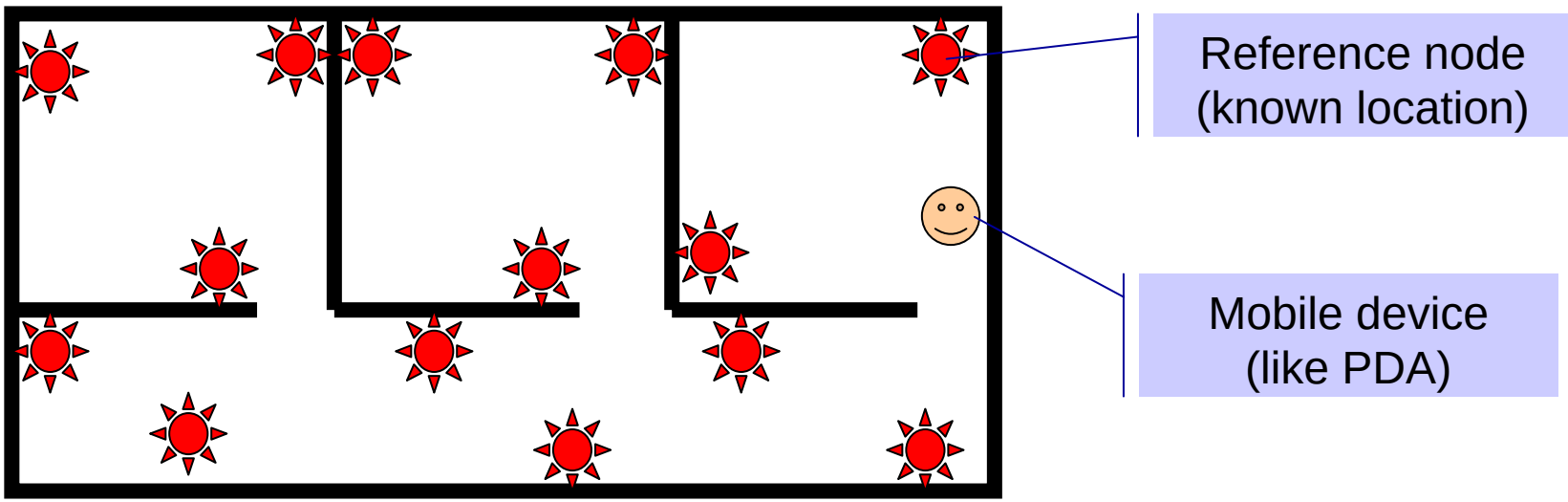
Outline

- Introduction
- MAL: Mobile-Assisted Localization
  - Distance Measurement
  - Movement strategy
- AFL: Anchor-free Localization
  - Proposed in 2003 April
- Simulation
- Conclusion

Introduction

- Knowledge of sensor location enable
  1. Sensed data useful to application
  2. Efficient routing protocol
- Node location information is also useful in indoor environment

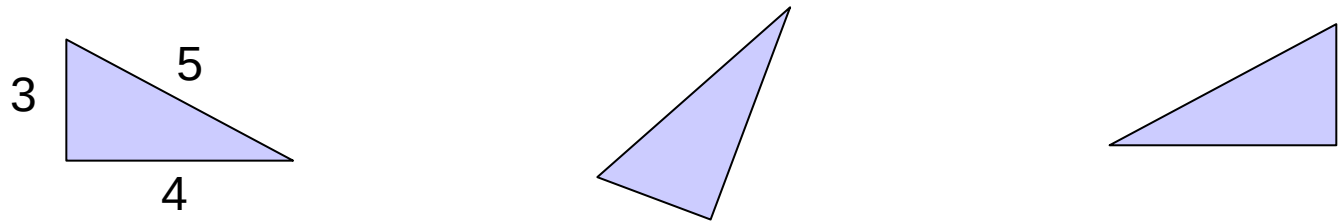


Introduction

- How reference node know location
  - Manually configuring
    - Cumbersome and error-prone
  - Automatically localize
    - Each node obtain distance to neighbor
    - Computes a coordinate assignment for all node

Introduction

- The localization problem is to determine an assignment of *coordinates* to nodes in a wireless ad-hoc or sensor network that is consistent with measured pairwise node distances.
- In the absence of an external coordinate reference, this assignment can be unique only up to an arbitrary rotation, translation, and possible reflection, but its scale is determined by the measured ranges.

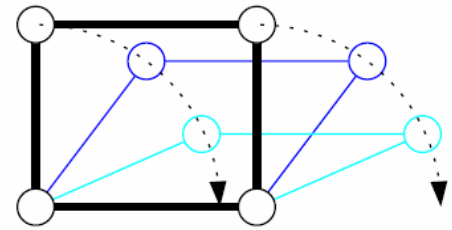


Introduction

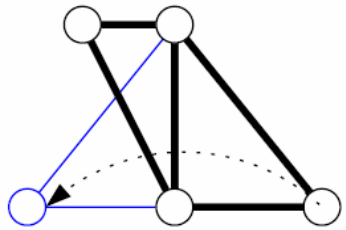
- This paper shows that use the mobile device to measure pairwise node distance
  - Then fed the distance information into AFL
- Why do we use the mobile device ?

Indoor Localization Problems

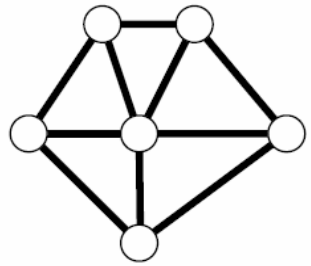
- Obs
  - EX
    ins



not locally rigid



locally rigid
not globally rigid



globally rigid

placed

- The dware

A framework that can be continuously deformed while still satisfying all the constraints is said to be *flexible* ; otherwise it is *rigid.*

A graph is globally rigid if it has a unique embedding

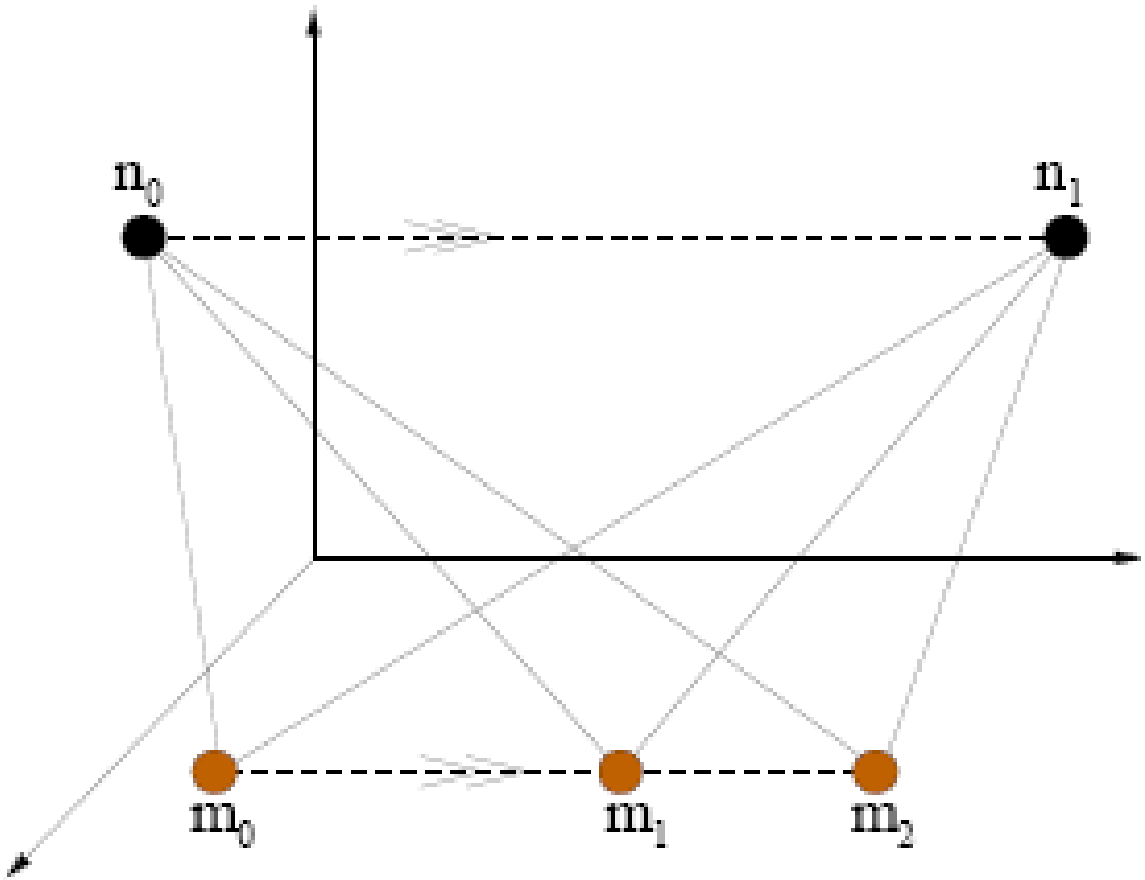
MAL:
three distance measurement approach

1. Measure distance between **two** node at a time

2. Measure distance between **three** nodes at a time

3. Measure distance between **four** or more nodes at a time

Measure distances among two nodes

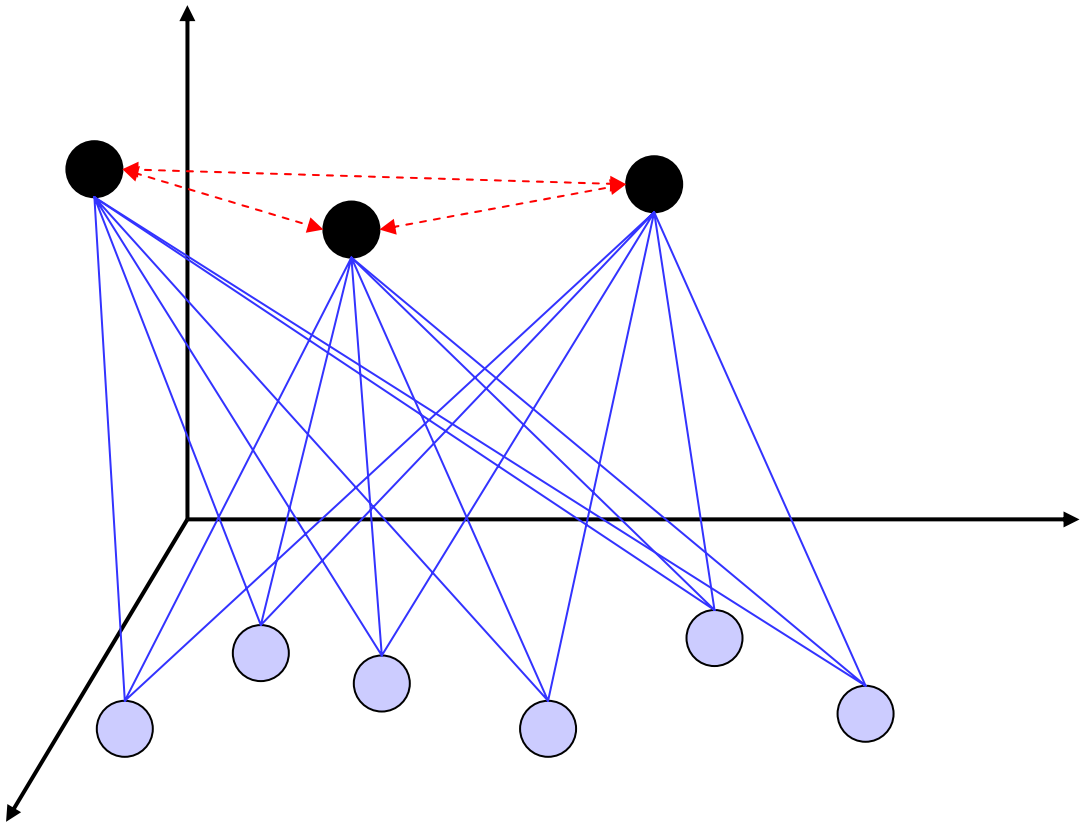


Assumption:
At least need **3** mobile position

n_o,n_1,m_0,m_1,m_2 are coplanar

m_0,m_1,m_2 are collinear
Use a larger number of points would reduce GDOP

Measure distances among three nodes



Assumption:

At least need **6** mobile position

n_o,n_1,n_2 are non-collinear

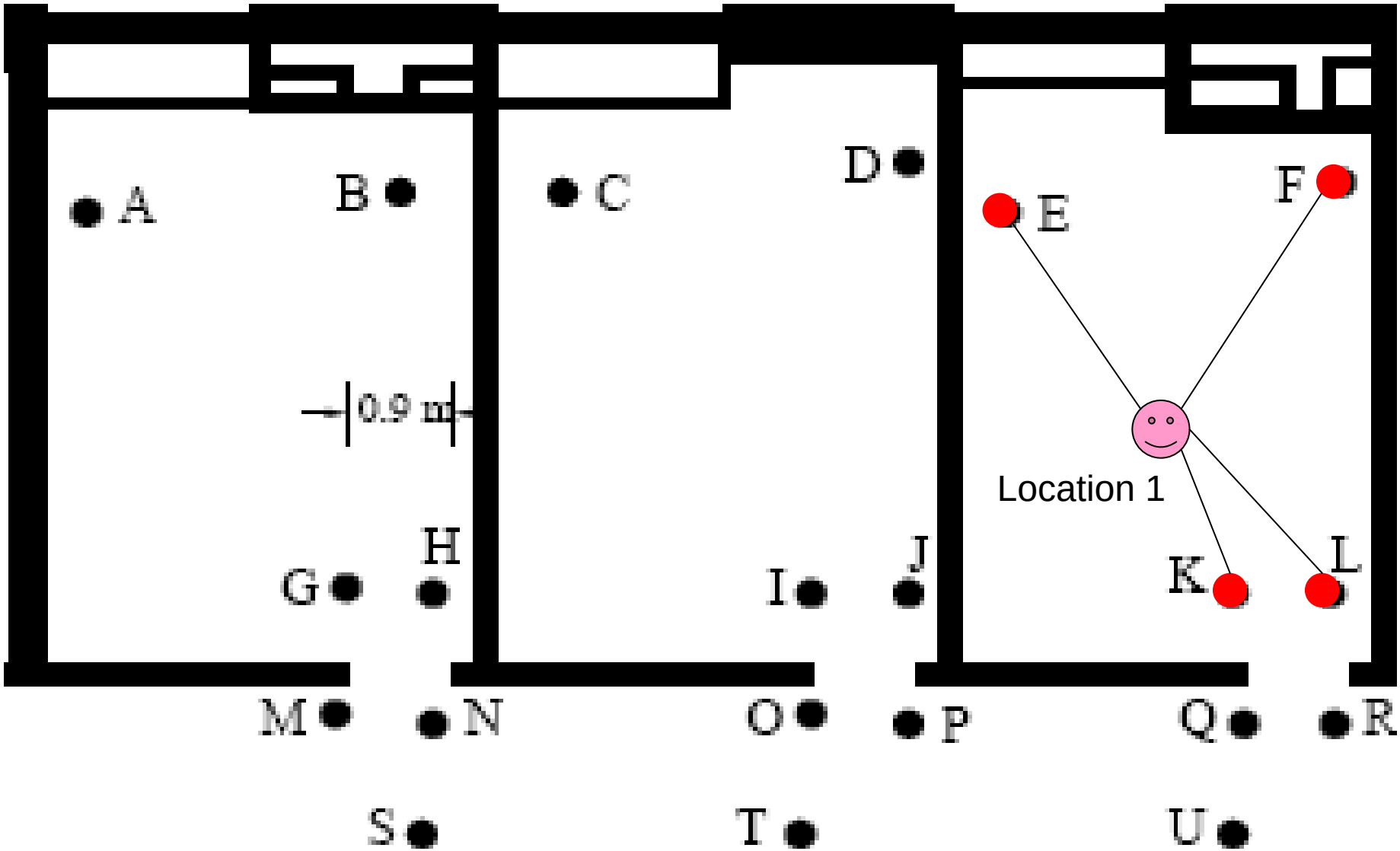
m_0~m_5 are coplanar no three of which are collinear

Measure distances among four or more nodes

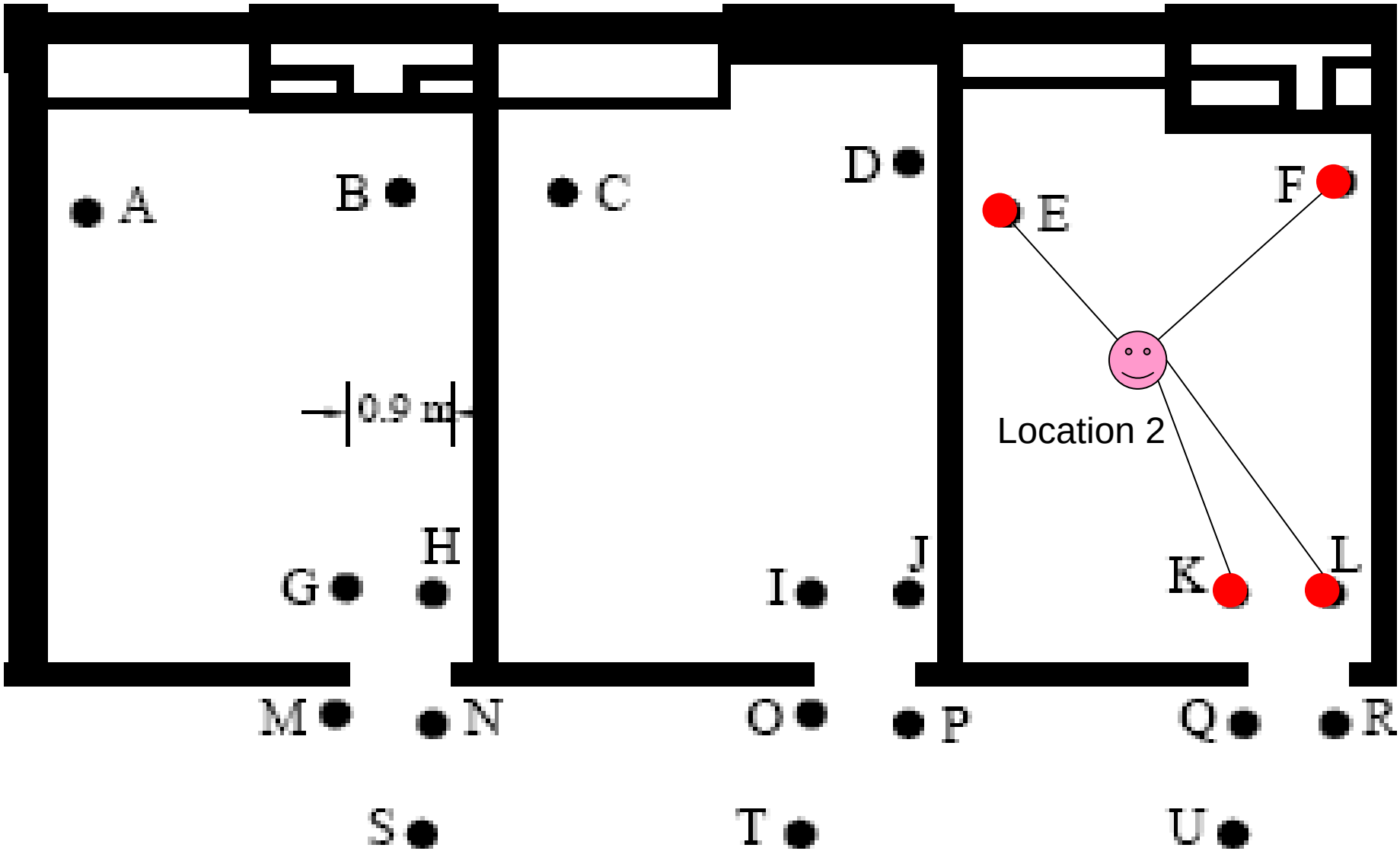
- Require at least [(3j-5)/(j-3)] mobile position
- Ex. J=4 then [(3j-5)/(j-3)] = 7
  - At least need 7 mobile position

- Assumption
  - n1,n2,n3,n4,m1,m2,m3,m4,m5,m6,m7
  - No four of which are coplanar

Movement Strategy: Initialize



Movement Strategy: Initialize



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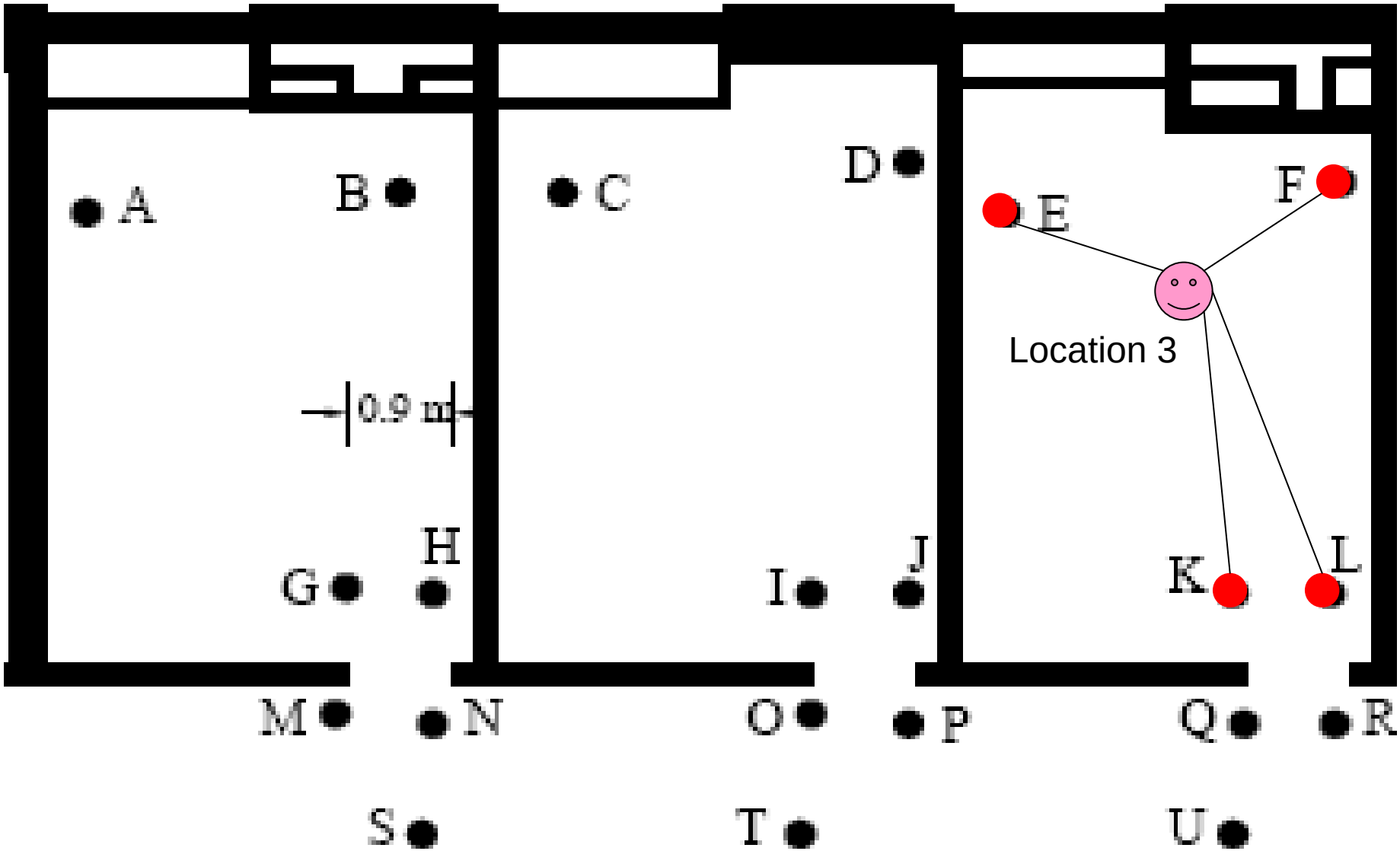
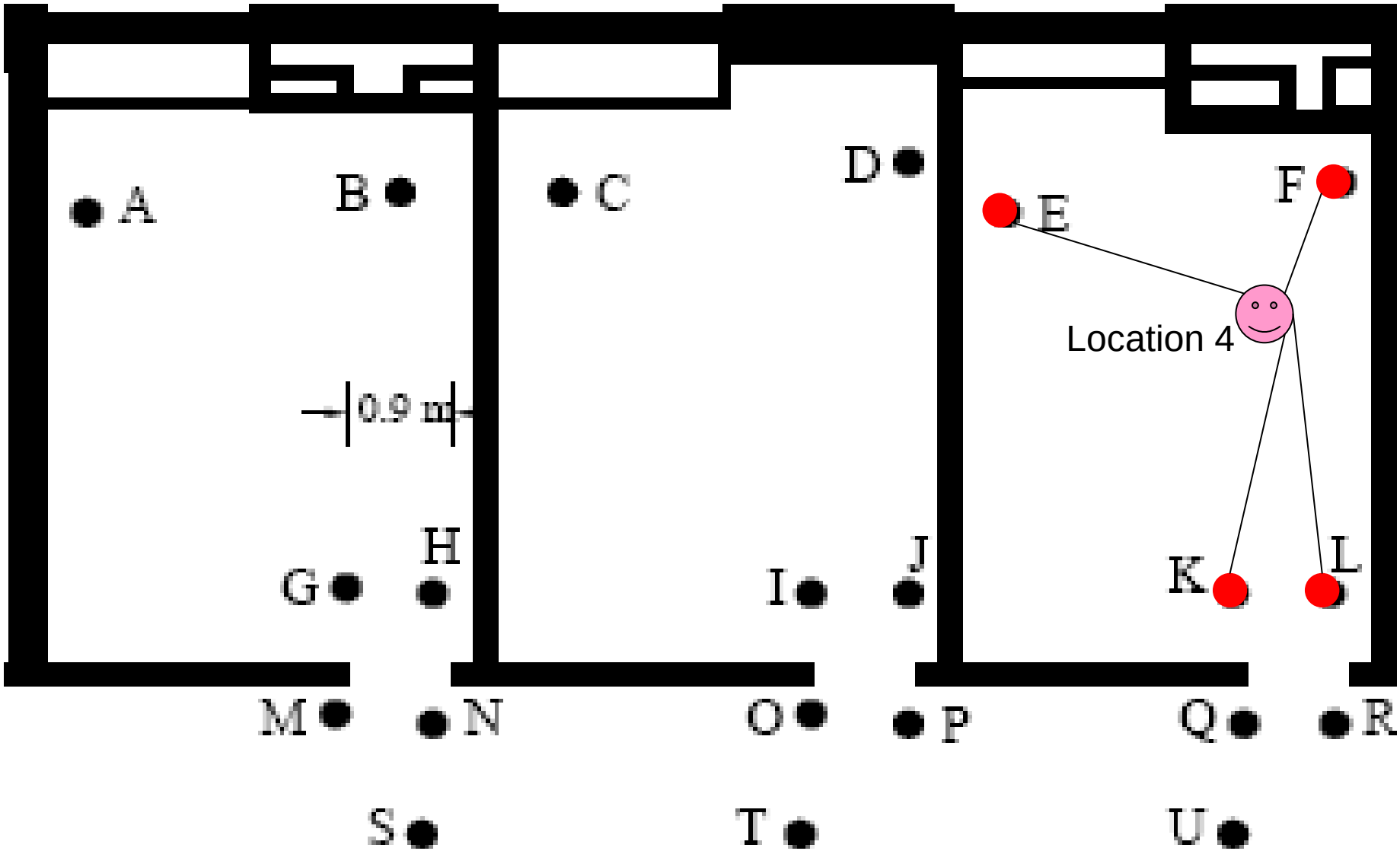
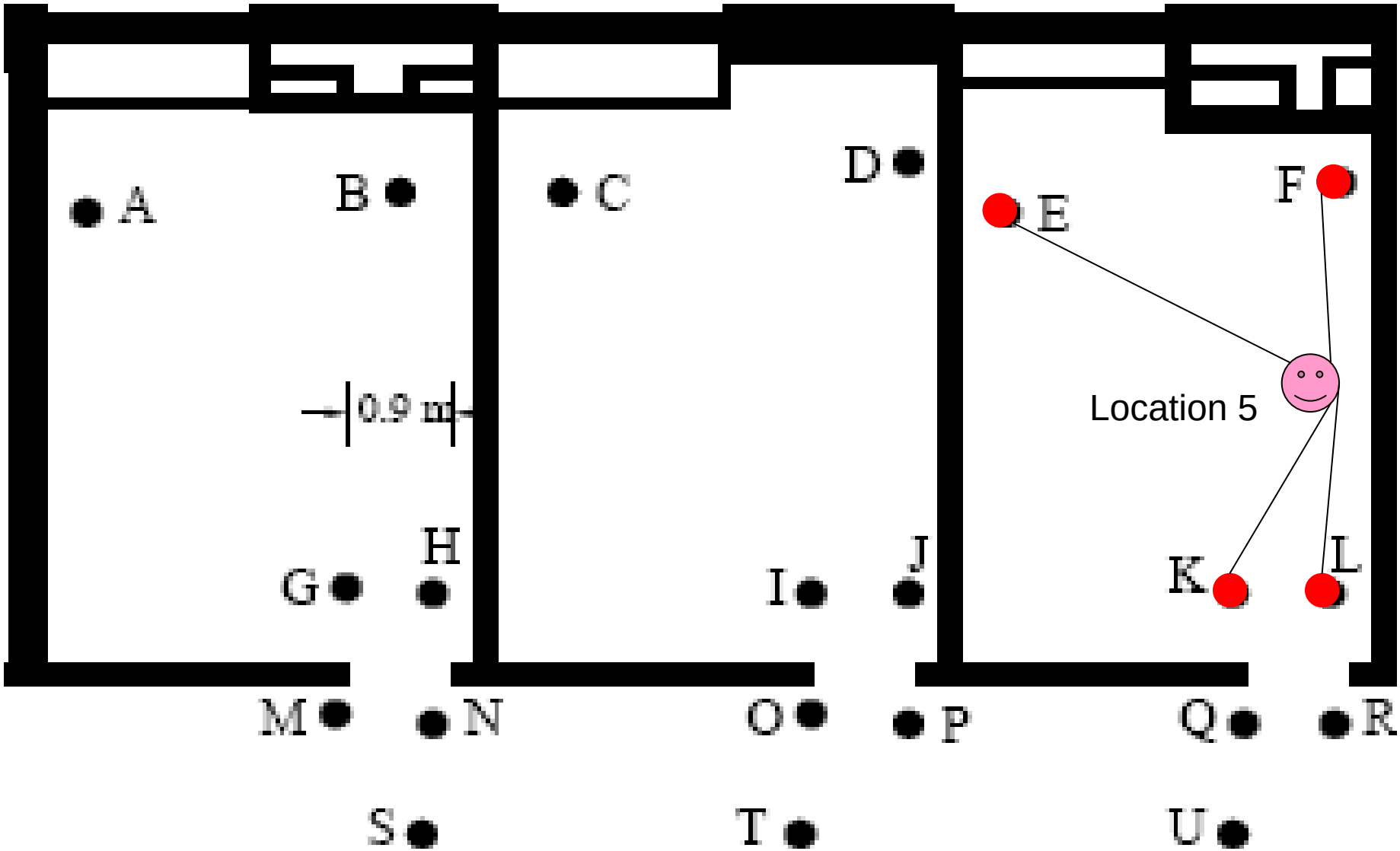


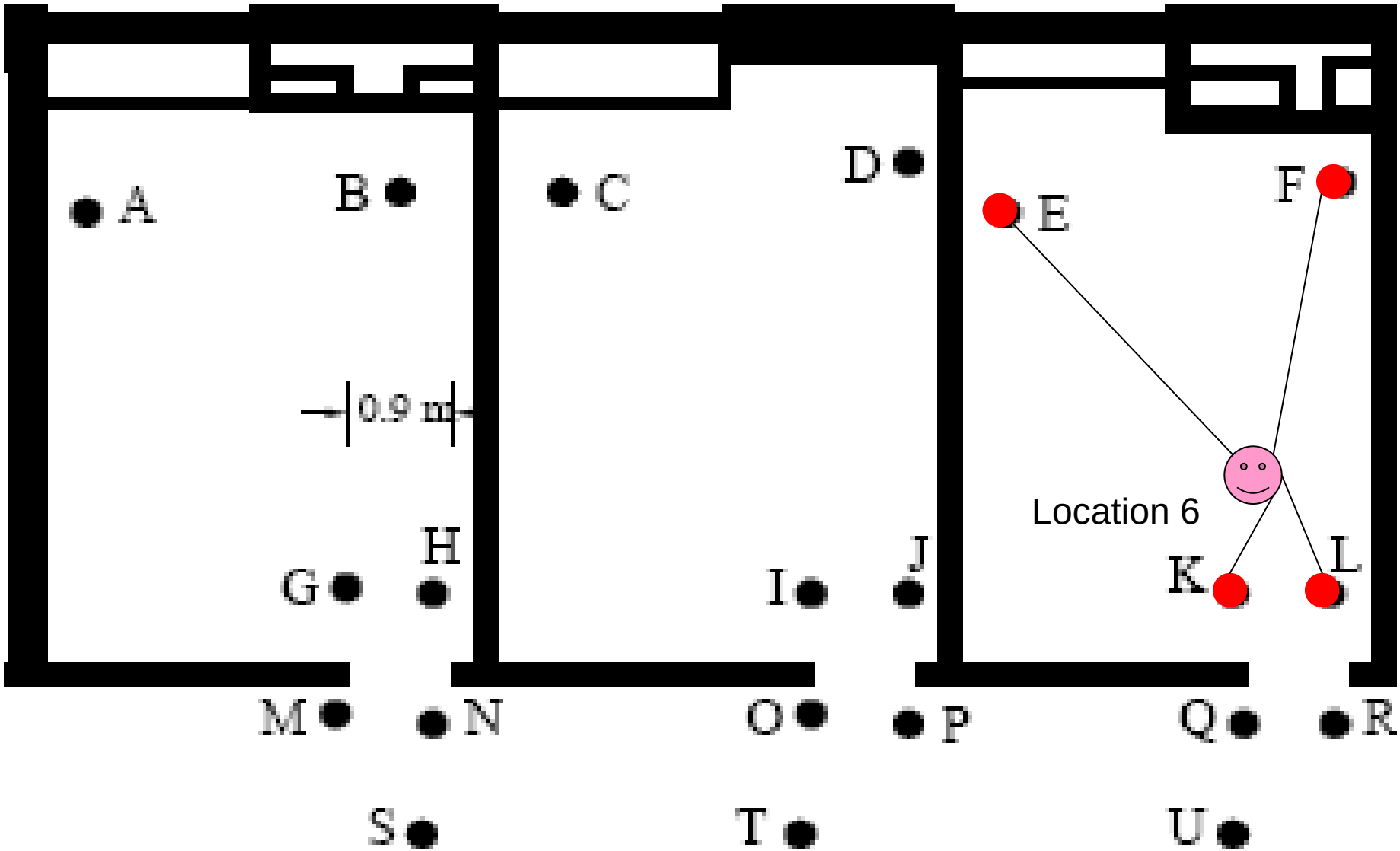
Movement Strategy: Initialize



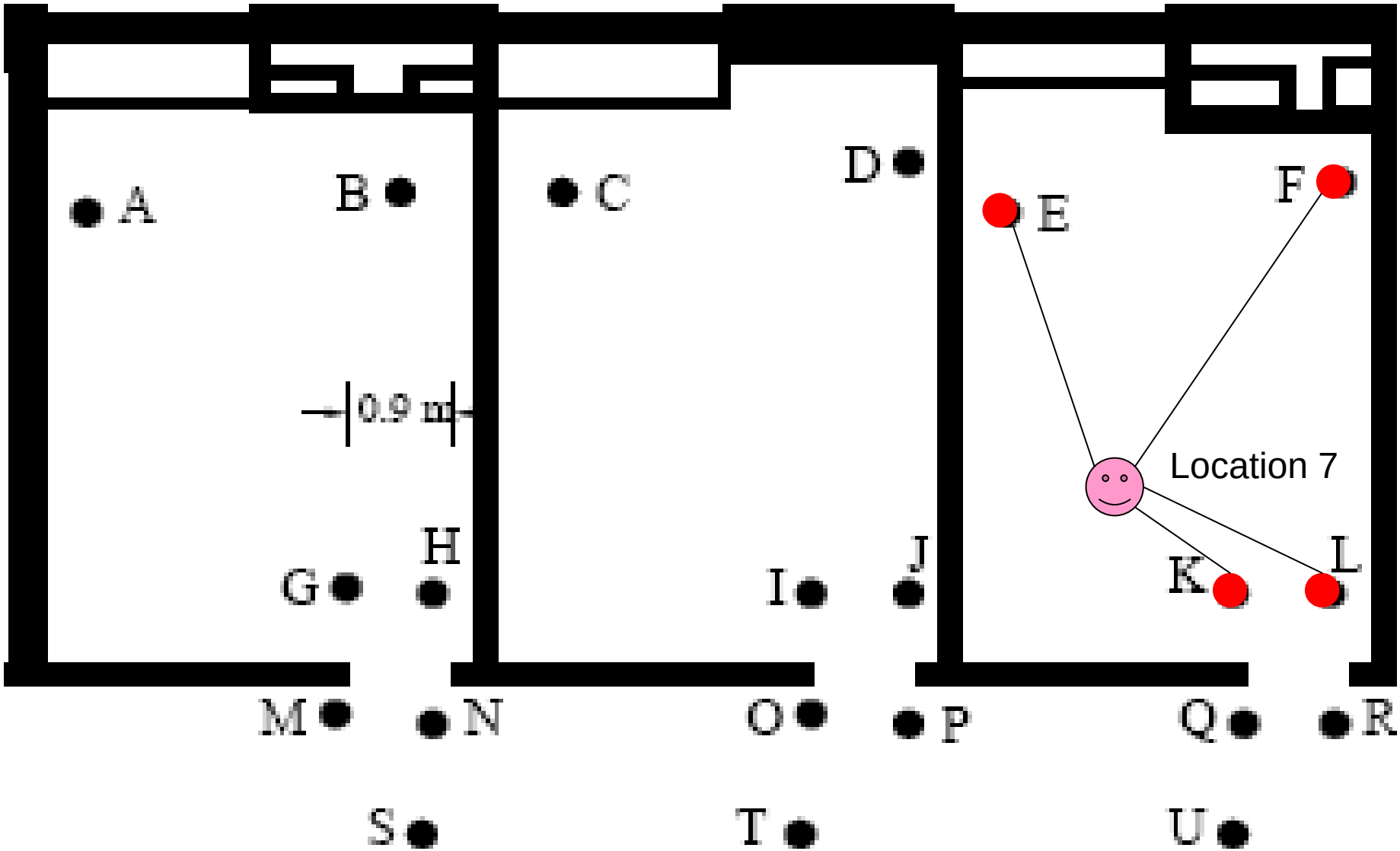
Movement Strategy: Initialize



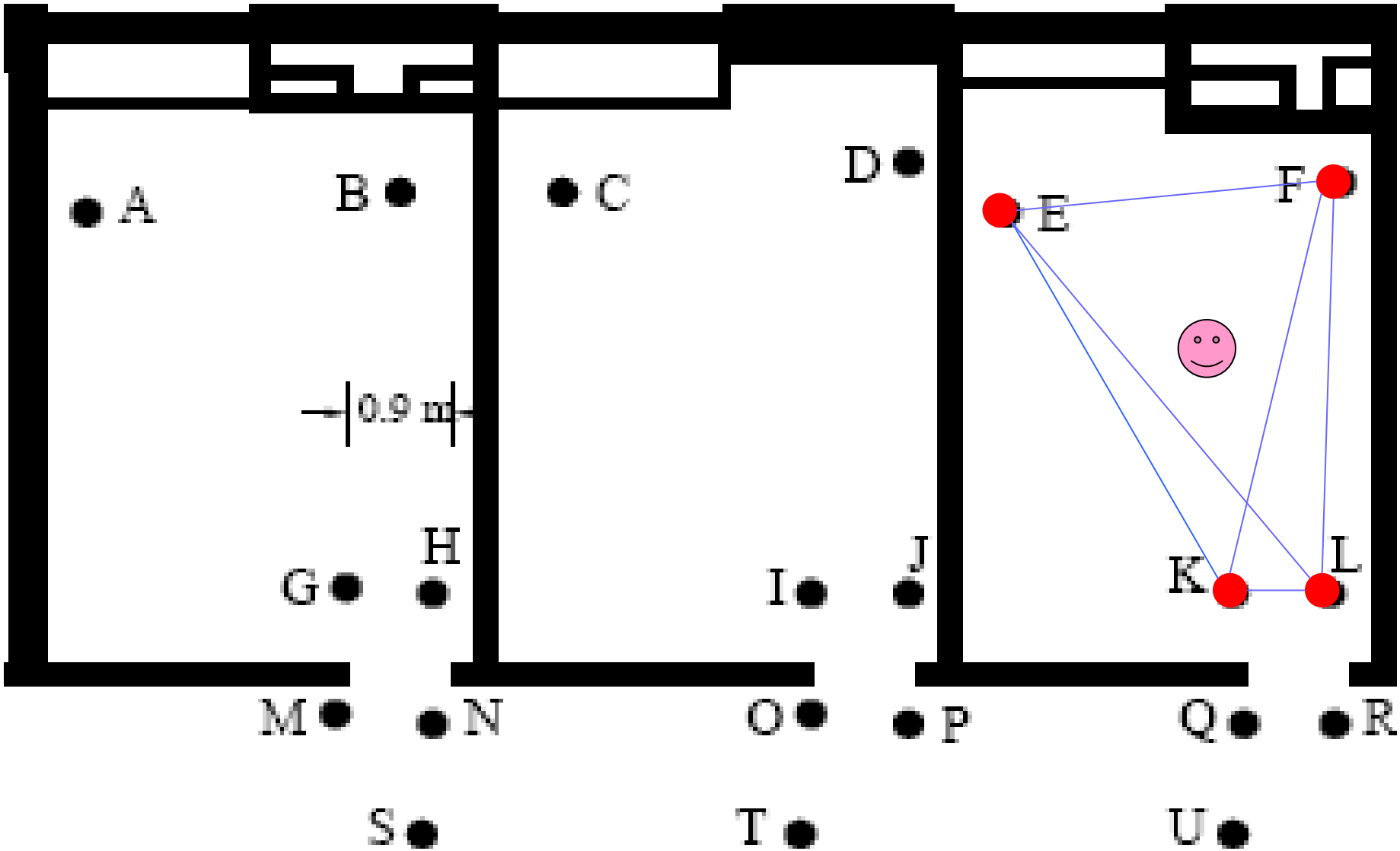
Movement Strategy: Initialize



Movement Strategy: Initialize

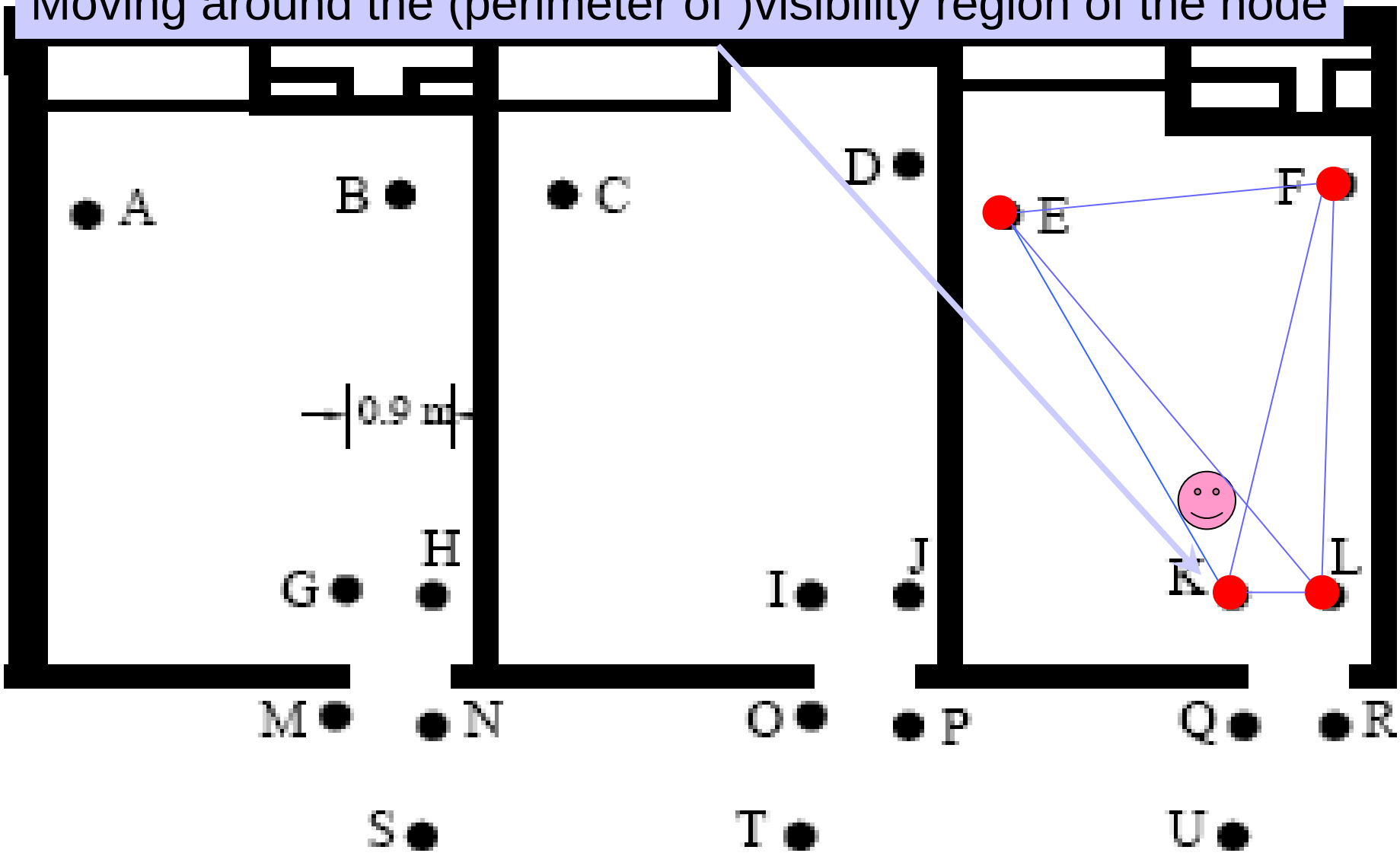


Movement Strategy: Initialize

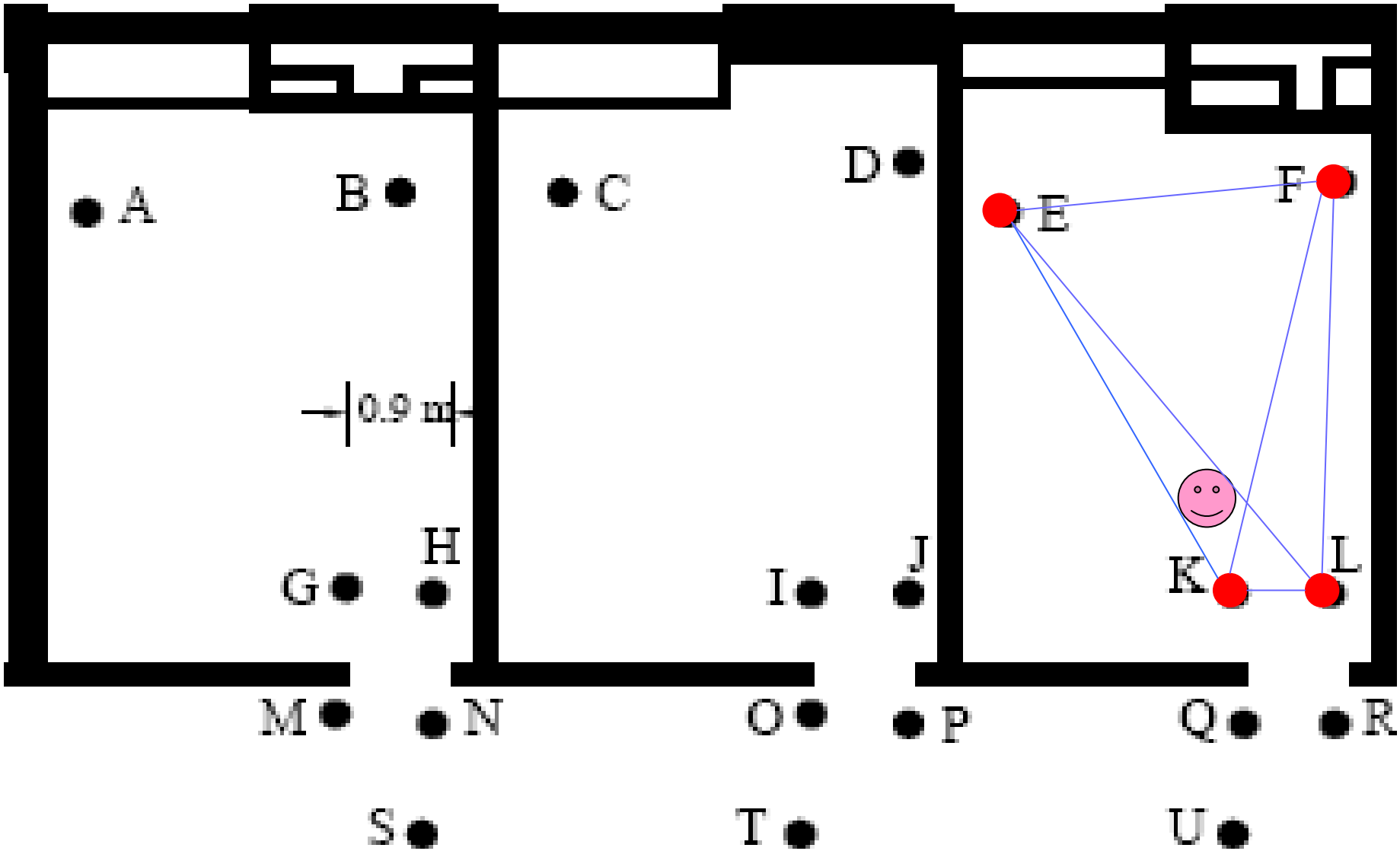


Movement Strategy: Loop

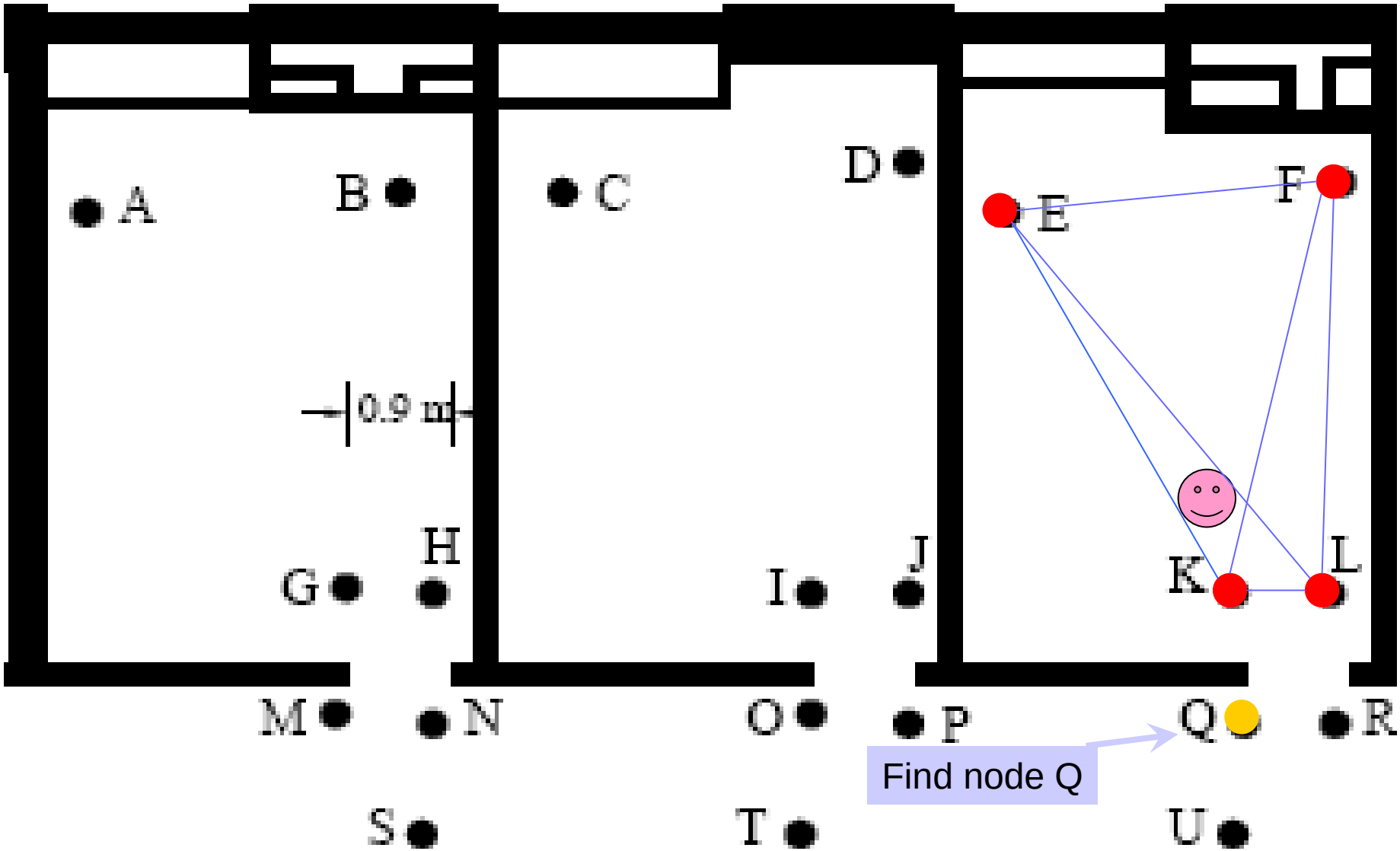
Moving around the (perimeter of)visibility region of the node



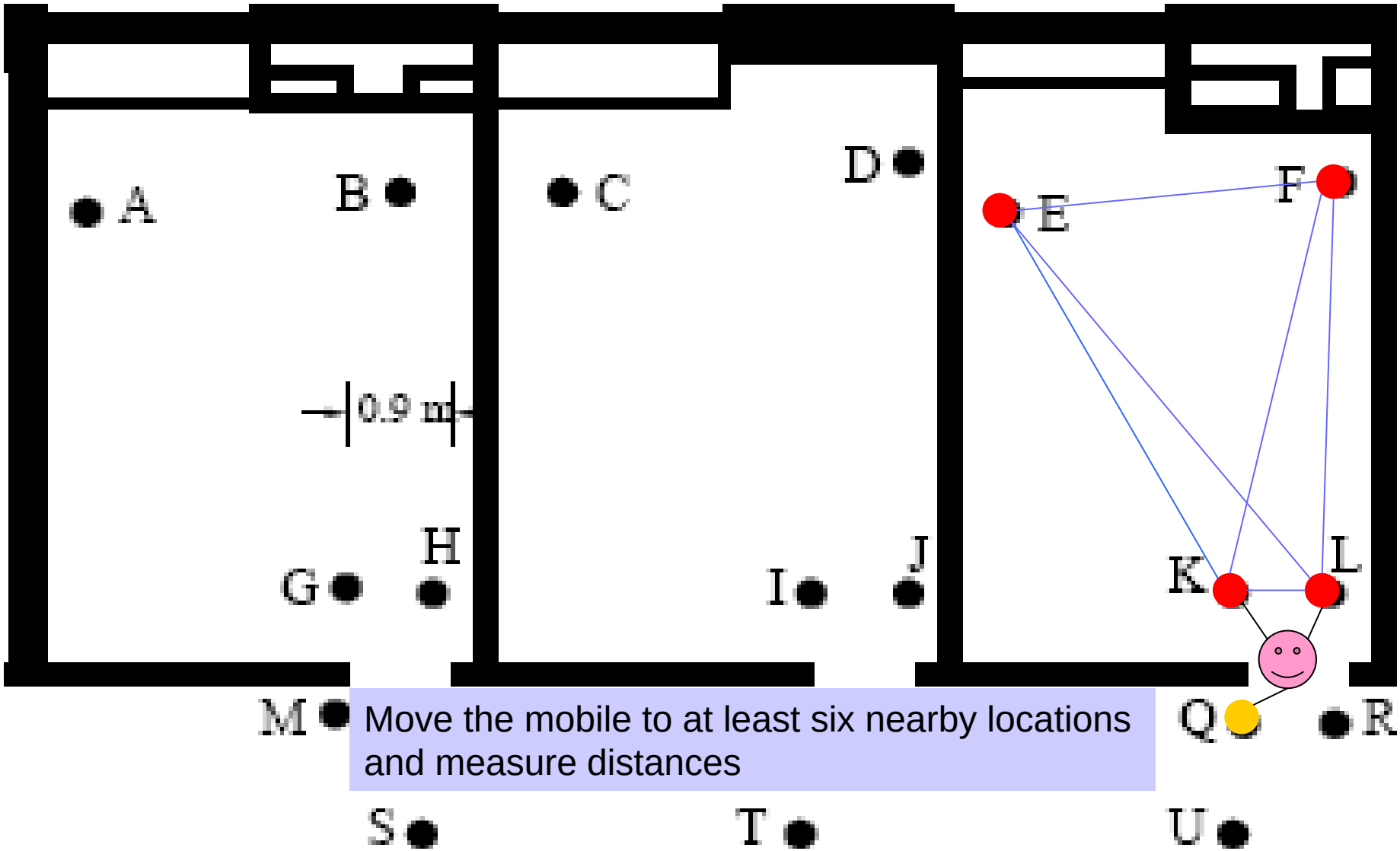
Movement Strategy: Loop



Movement Strategy: Loop

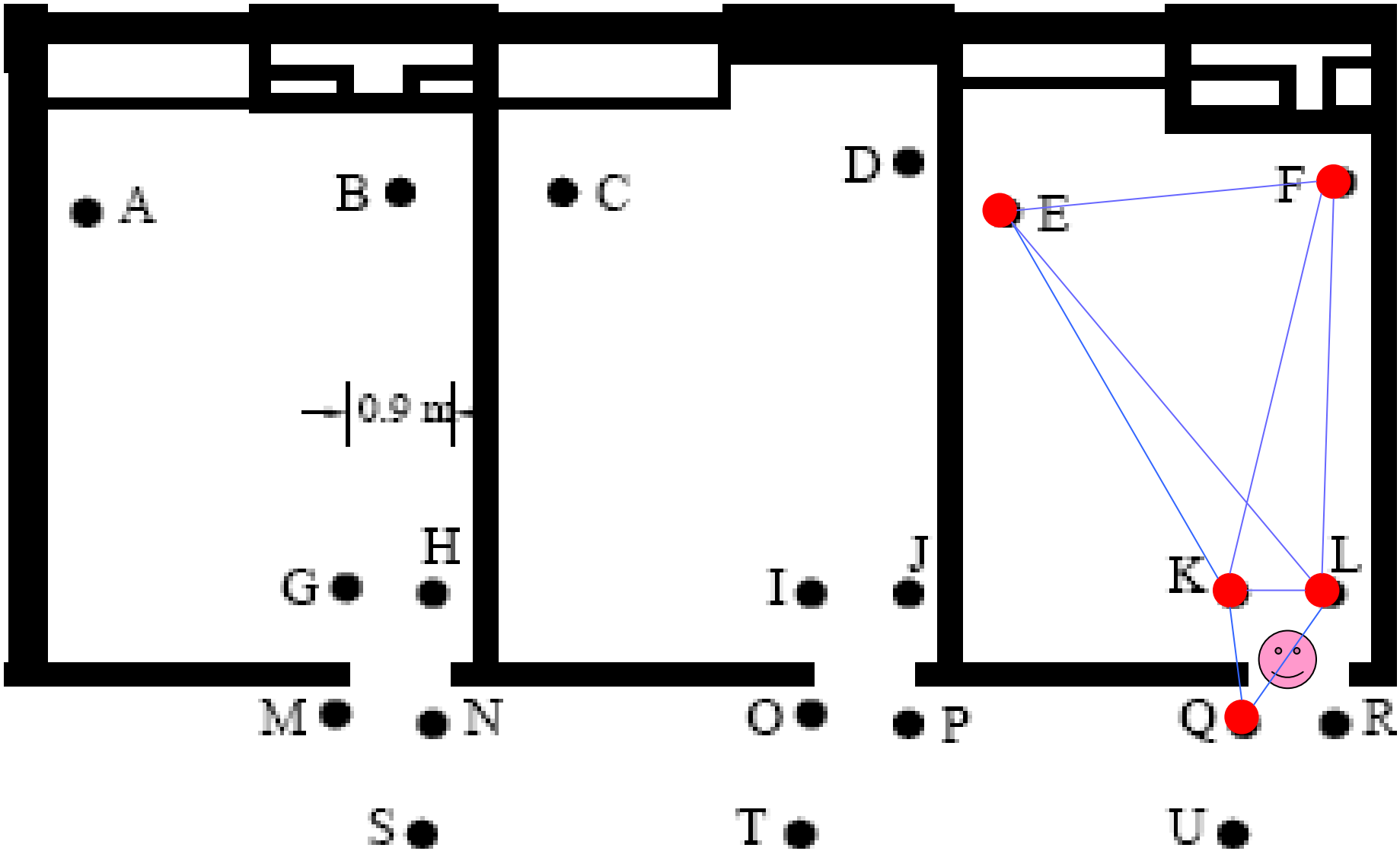


Movement Strategy: Loop

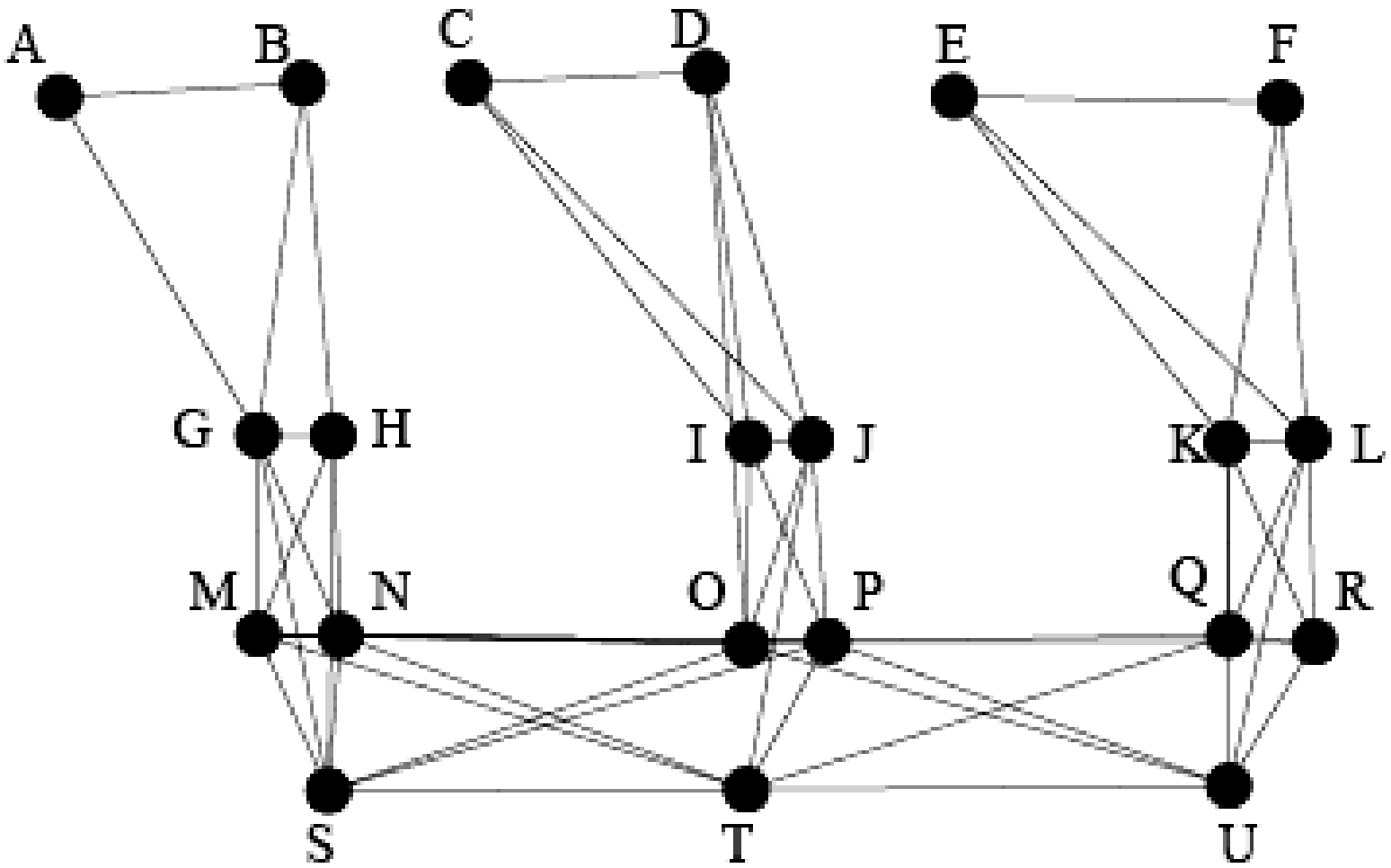


Move the mobile to at least six nearby locations and measure distances

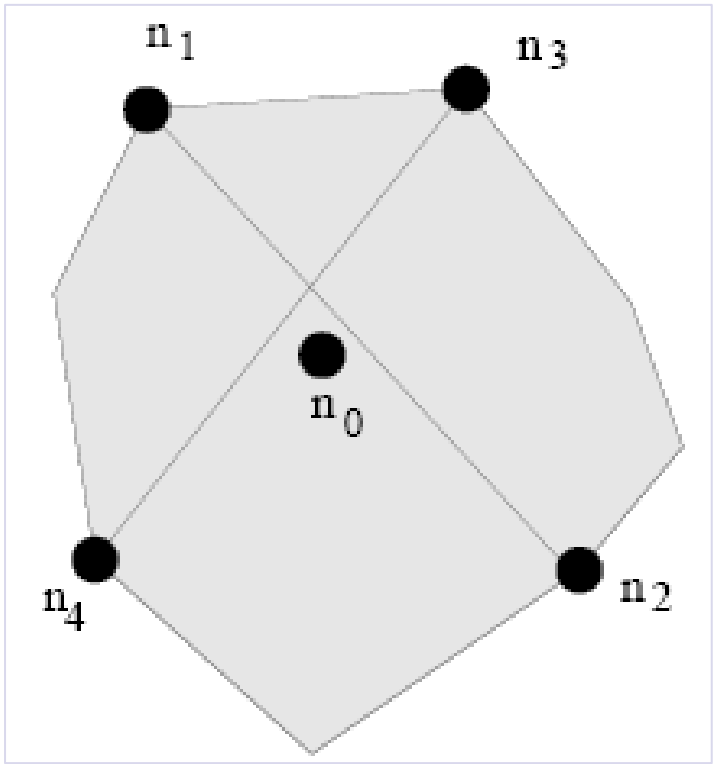
Movement Strategy: Loop



Distance information graph



AFL: Anchor-Free Localization
2003 April



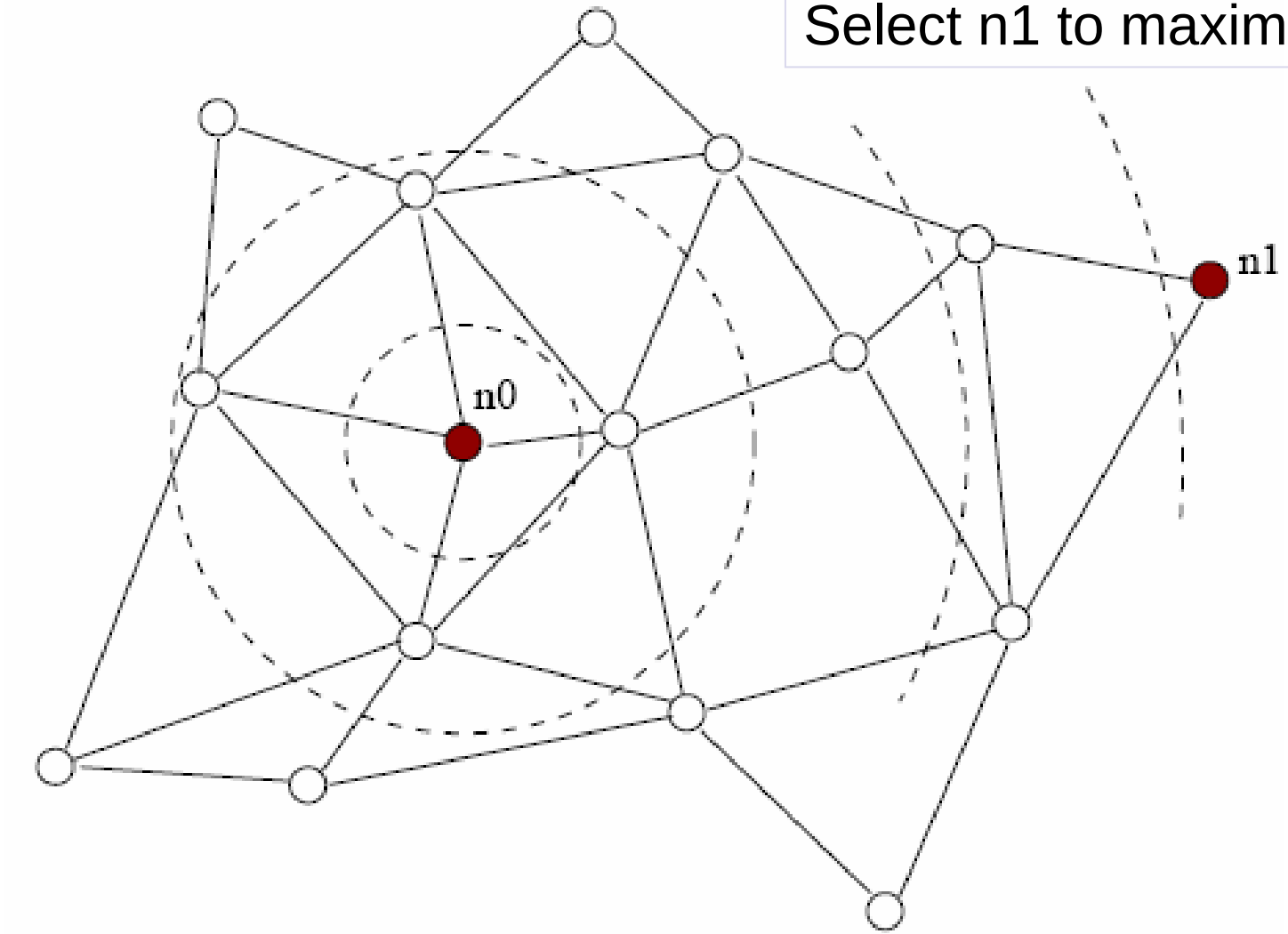
Coordinate of node$_i$

$$x(i) = Rh_{0,i}\frac{h_{3,i}-h_{4,i}}{\sqrt{(h_{3,i}-h_{4,i})^2+(h_{1,i}-h_{2,i})^2}}$$

$$y(i) = Rh_{0,i}\frac{h_{1,i}-h_{2,i}}{\sqrt{(h_{3,i}-h_{4,i})^2+(h_{1,i}-h_{2,i})^2}}$$

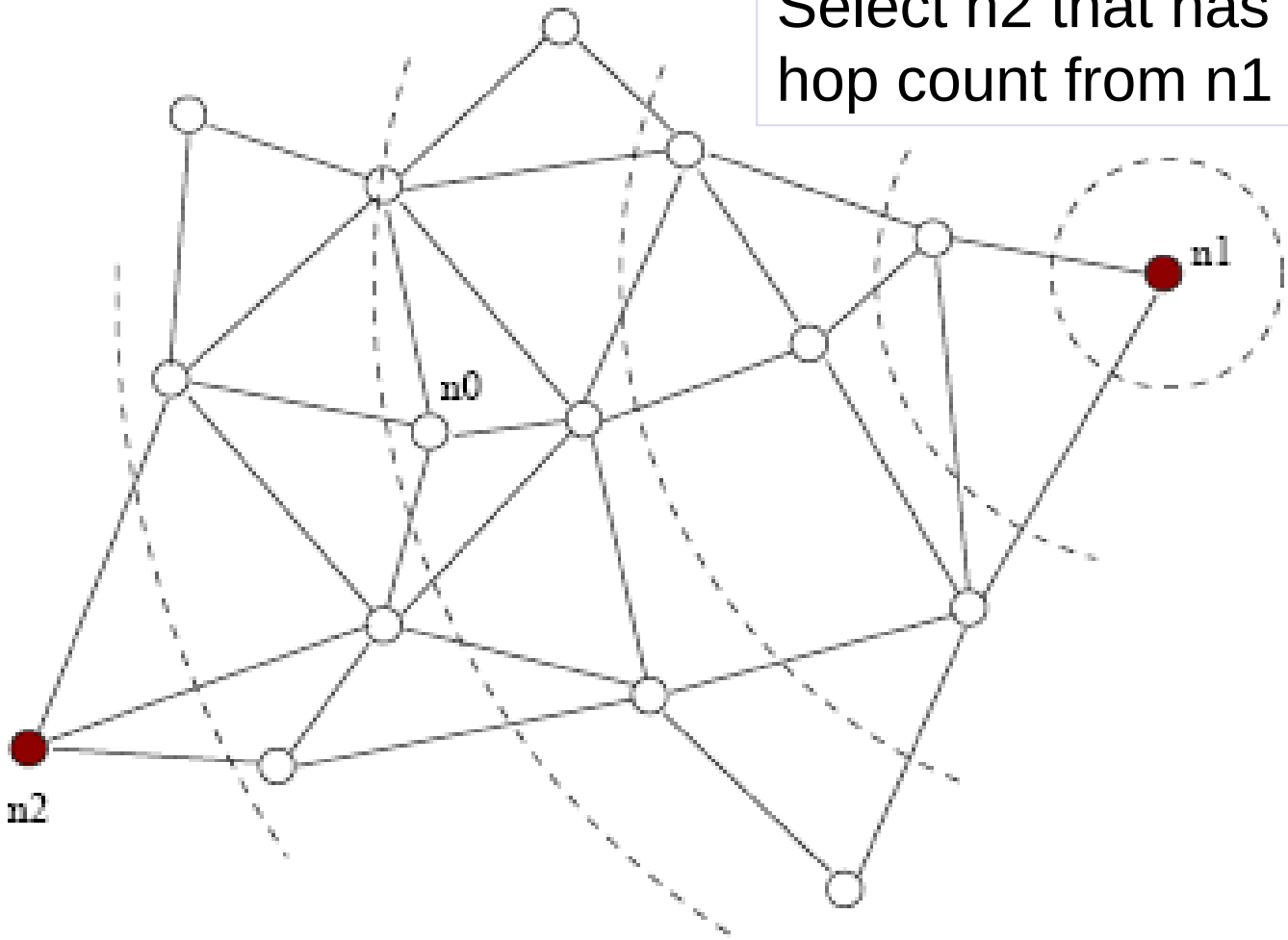
AFL: Phase 1

Select n1 to maximize h0,1

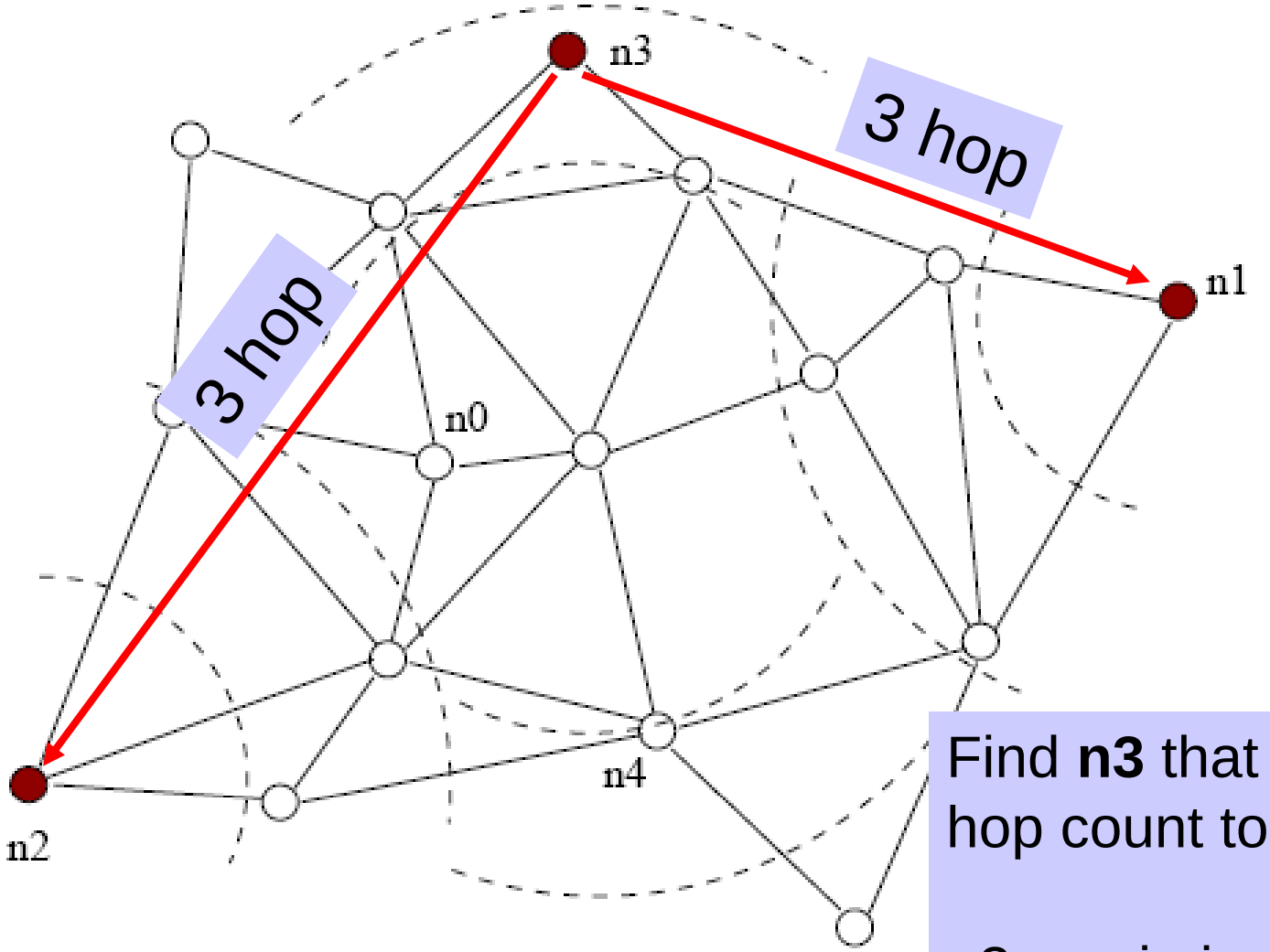


AFL: Phase 1

Select n2 that has the maximize hop count from n1



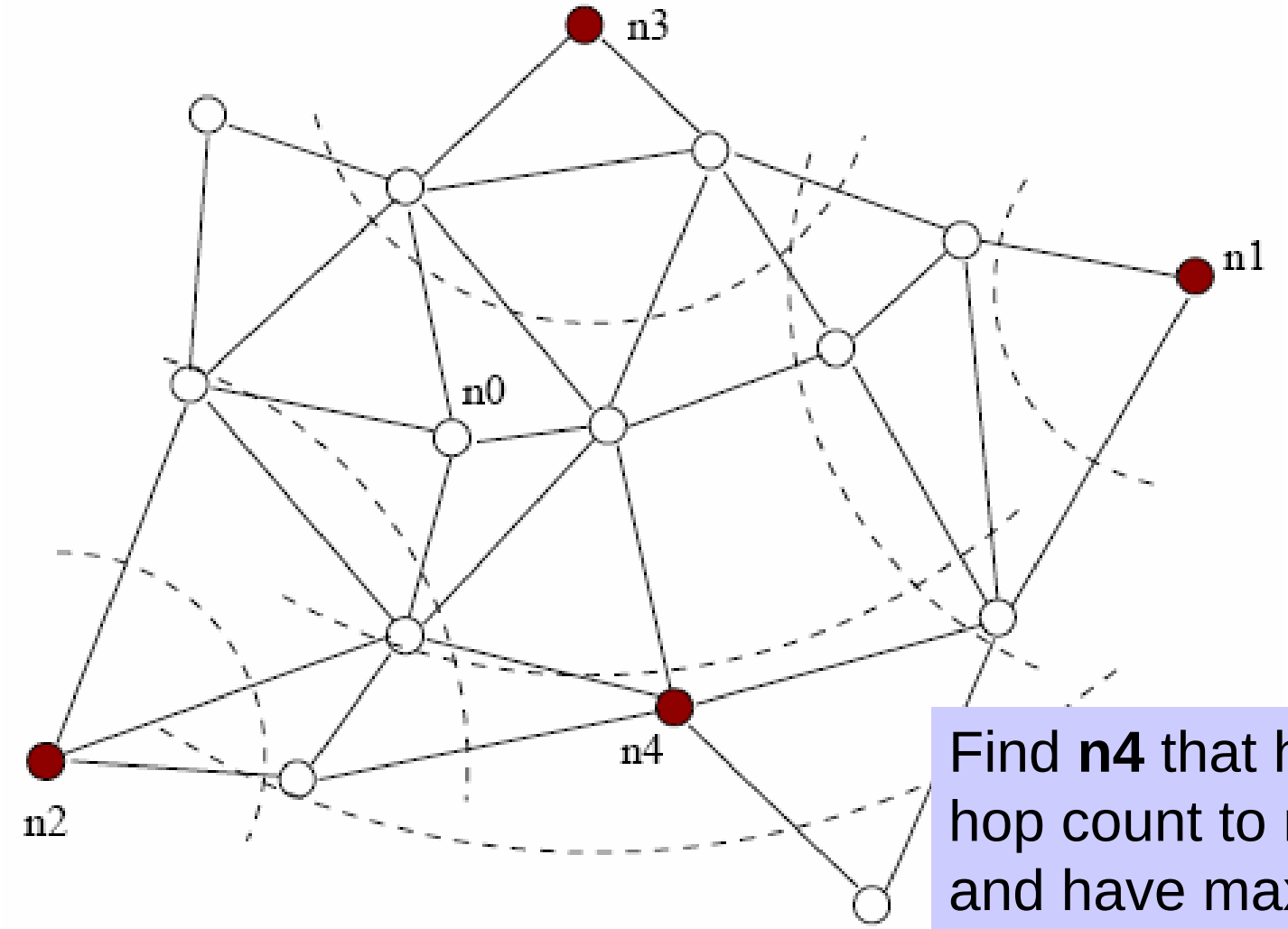
AFL: Phase 1



Find **n3** that has the equal hop count to n1 and n2

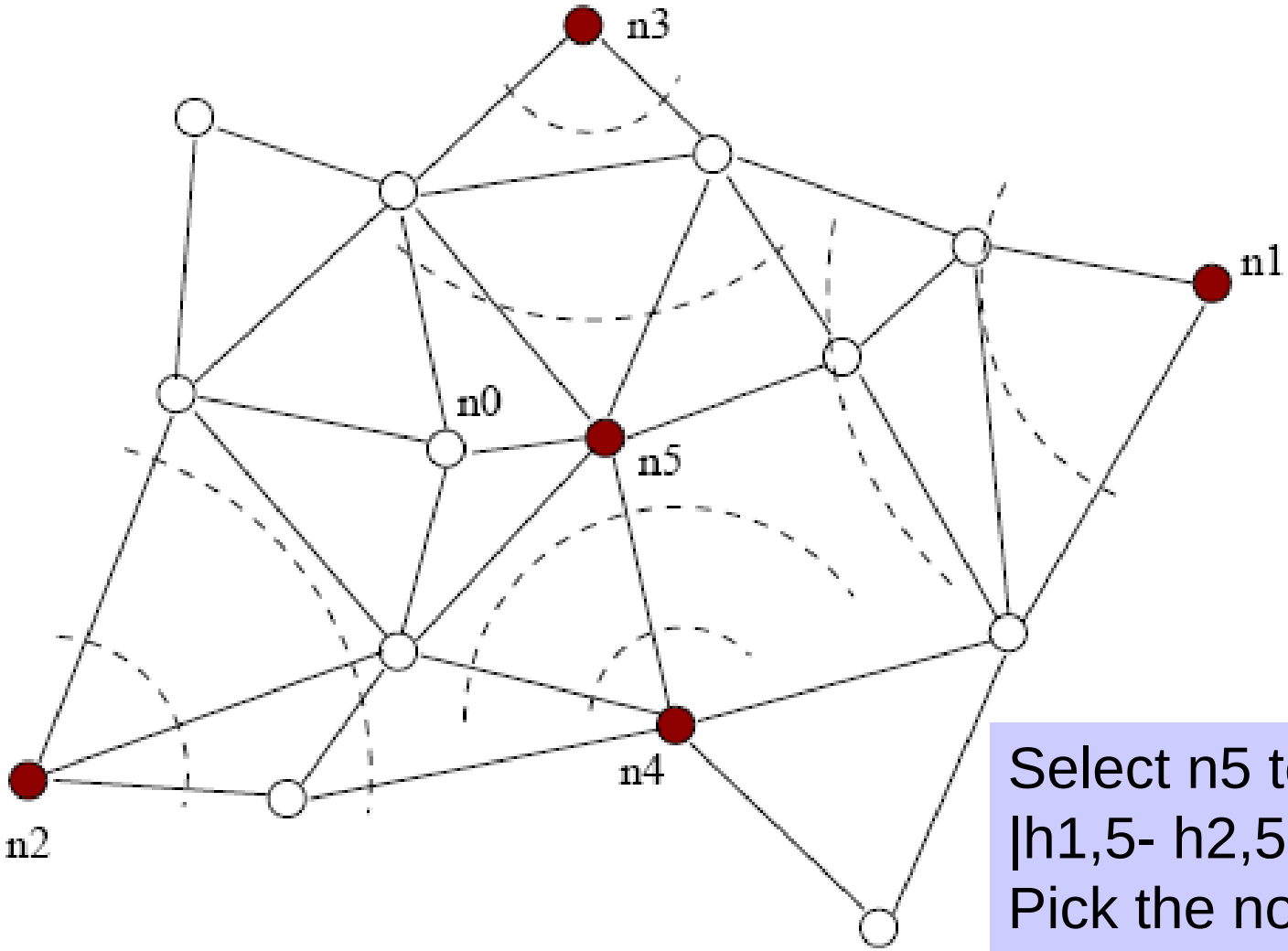
n3 maximize h1,3 + h2,3

AFL: Phase 1



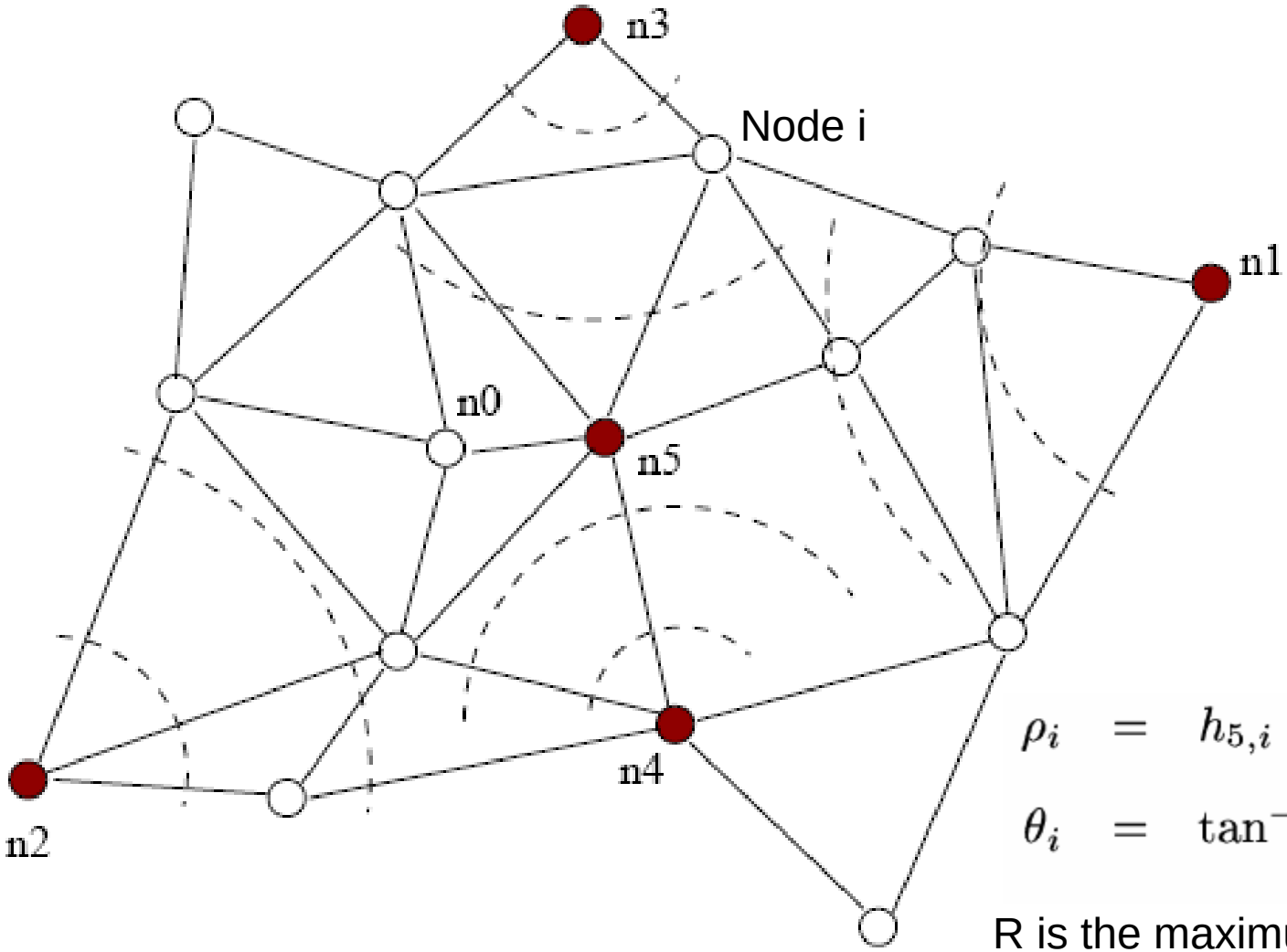
Find **n4** that has the equal hop count to n1 and n2 and have max hop count to n3

AFL: Phase 1



Select n5 to minimize |h1,5- h2,5|
Pick the node that minimizes |h3,5 - h4,5|

AFL: Phase 1



$$\rho_i = h_{5,i} \times R$$

$$\theta_i = \tan^{-1}\left(\frac{h_{1,i} - h_{2,i}}{h_{3,i} - h_{4,i}}\right)$$

R is the maximum radio range

AFL: Phase 1

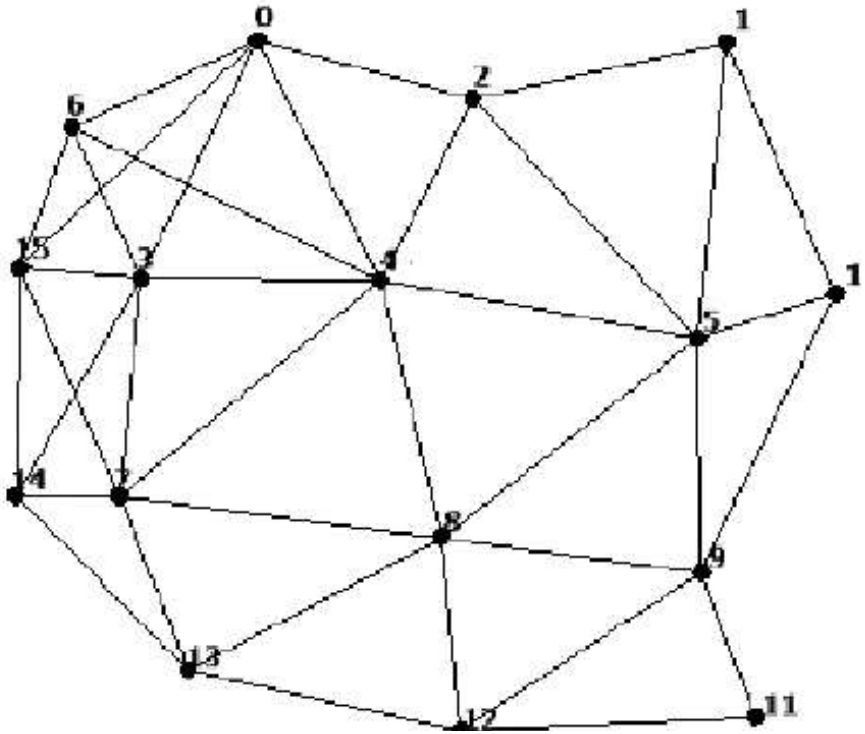
- Coordinate of node$_i$

$$x(i) = Rh_{0,i}\frac{h_{3,i}-h_{4,i}}{\sqrt{(h_{3,i}-h_{4,i})^2+(h_{1,i}-h_{2,i})^2}}$$

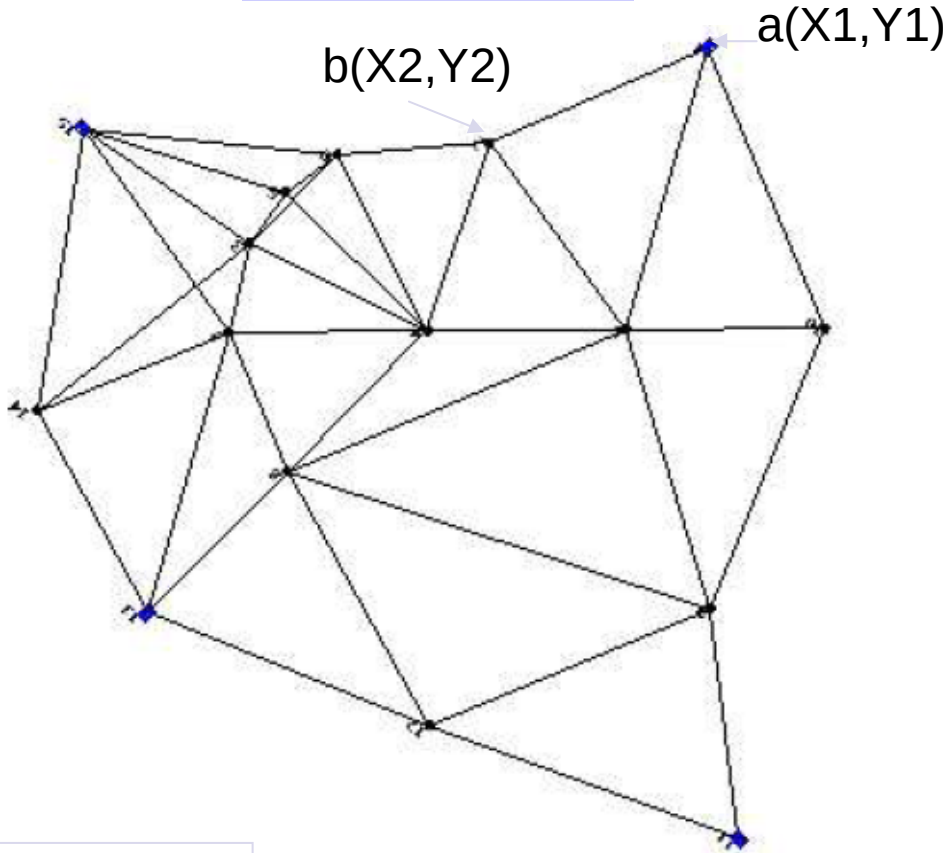
$$y(i) = Rh_{0,i}\frac{h_{1,i}-h_{2,i}}{\sqrt{(h_{3,i}-h_{4,i})^2+(h_{1,i}-h_{2,i})^2}}$$

AFL: Phase 1

True position



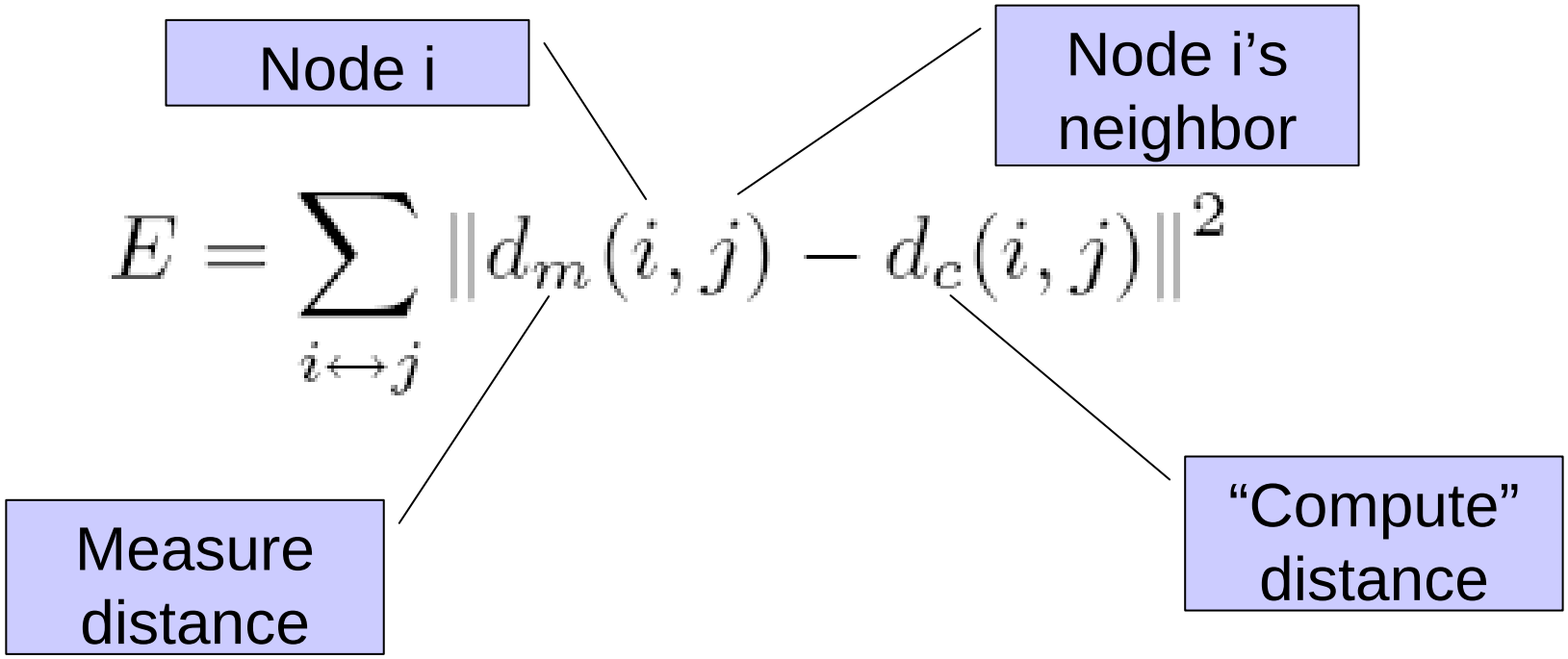
AFL Phase1



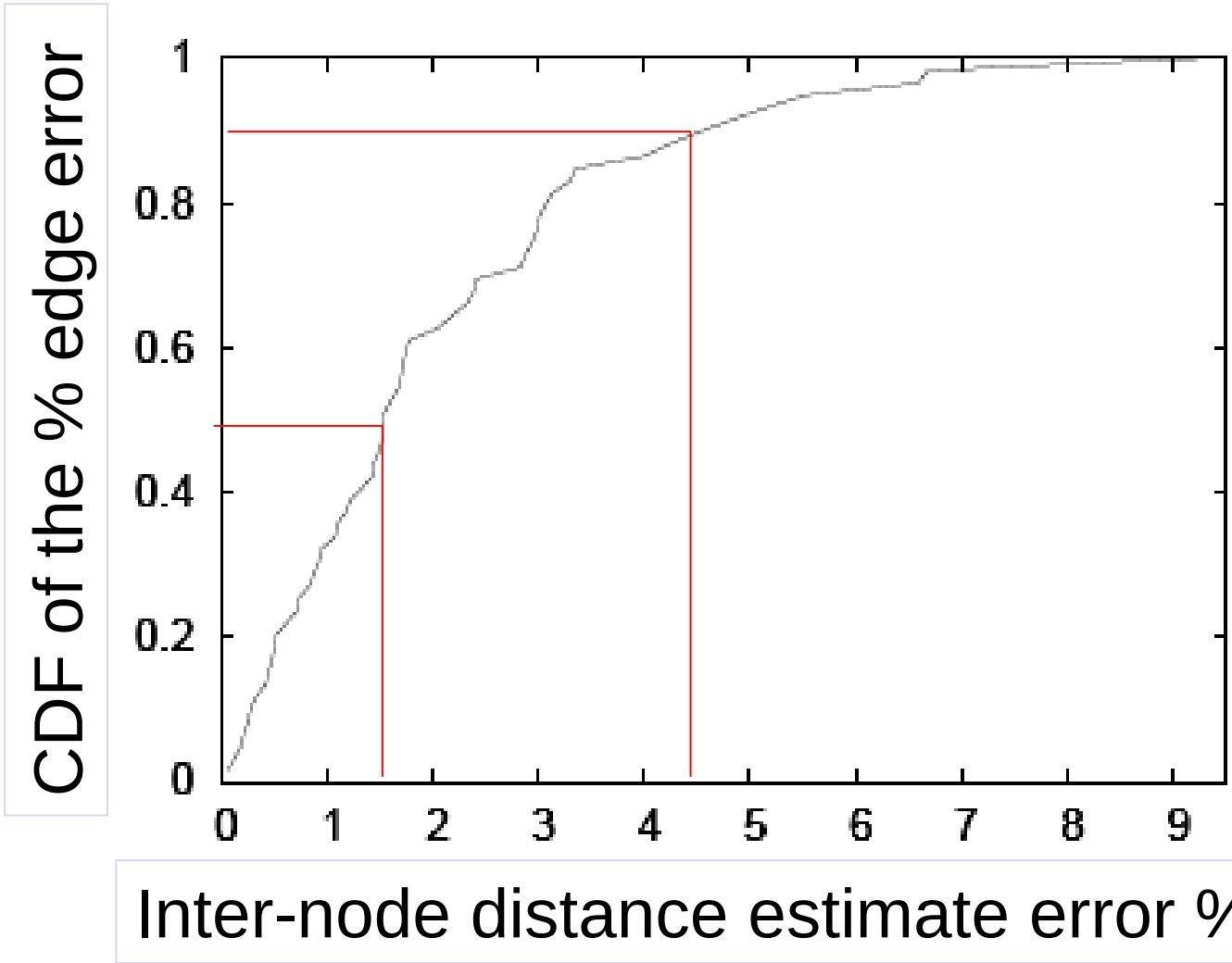
$$E_{ab} = \| d_m(a,b) - \sqrt{(X1-X1)^2+(Y2-Y2)^2} \|^2$$

AFL: Phase 2

- AFL use a optimization algorithm to minimize the Graph ***E****rror*

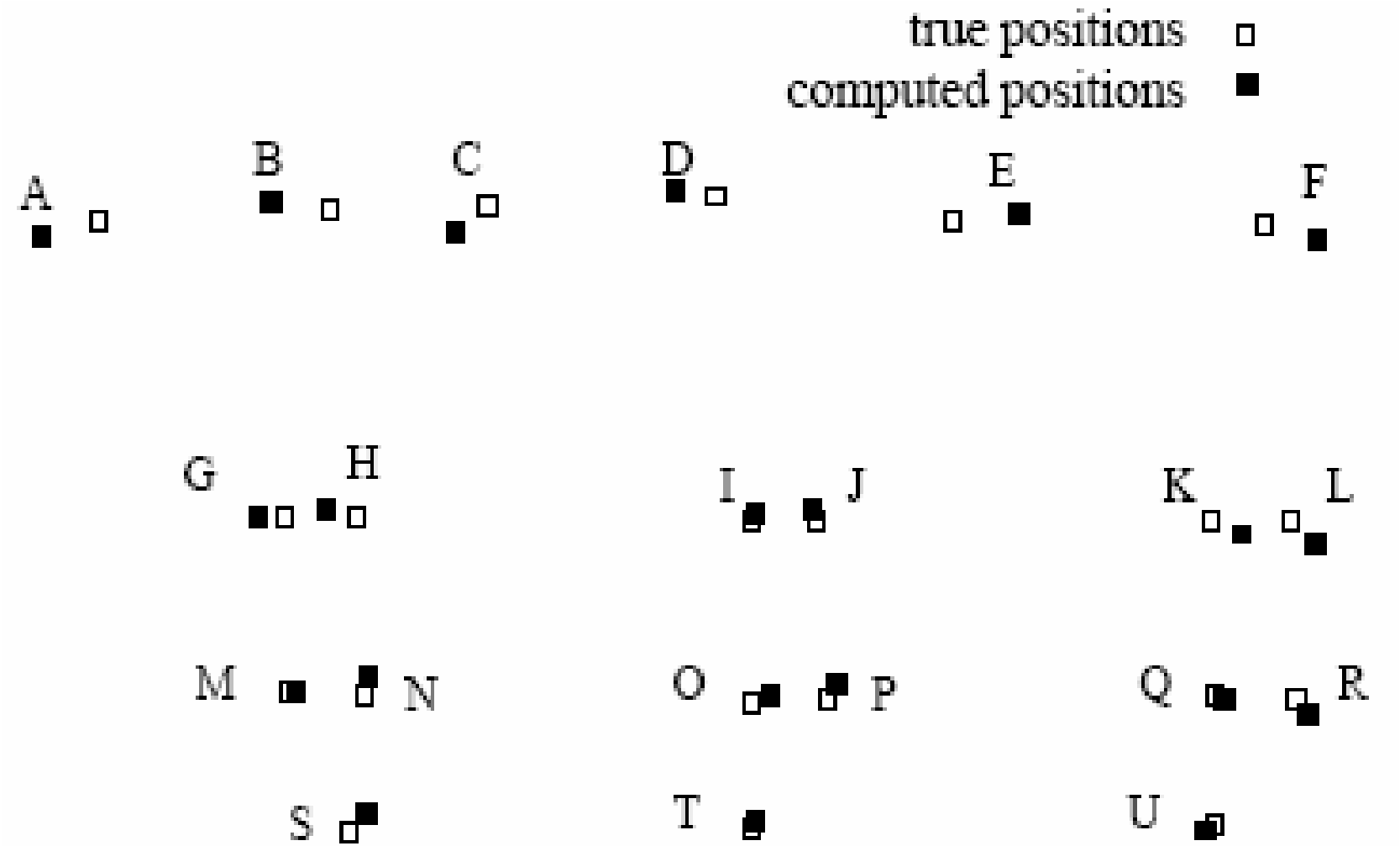


Performance Evaluation

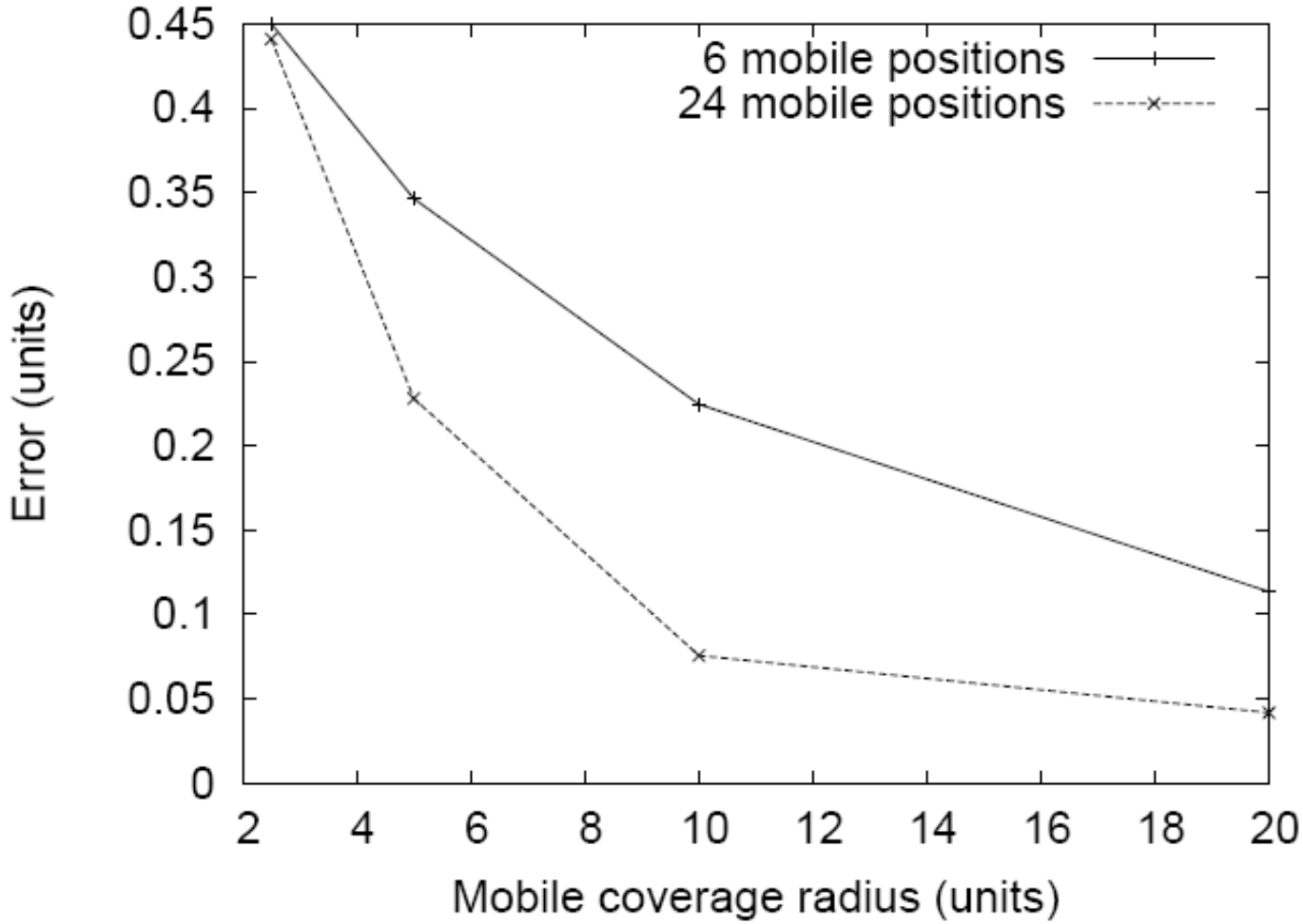


Cause by physical obstacle such as furniture

Coordinates obtained after running AFL

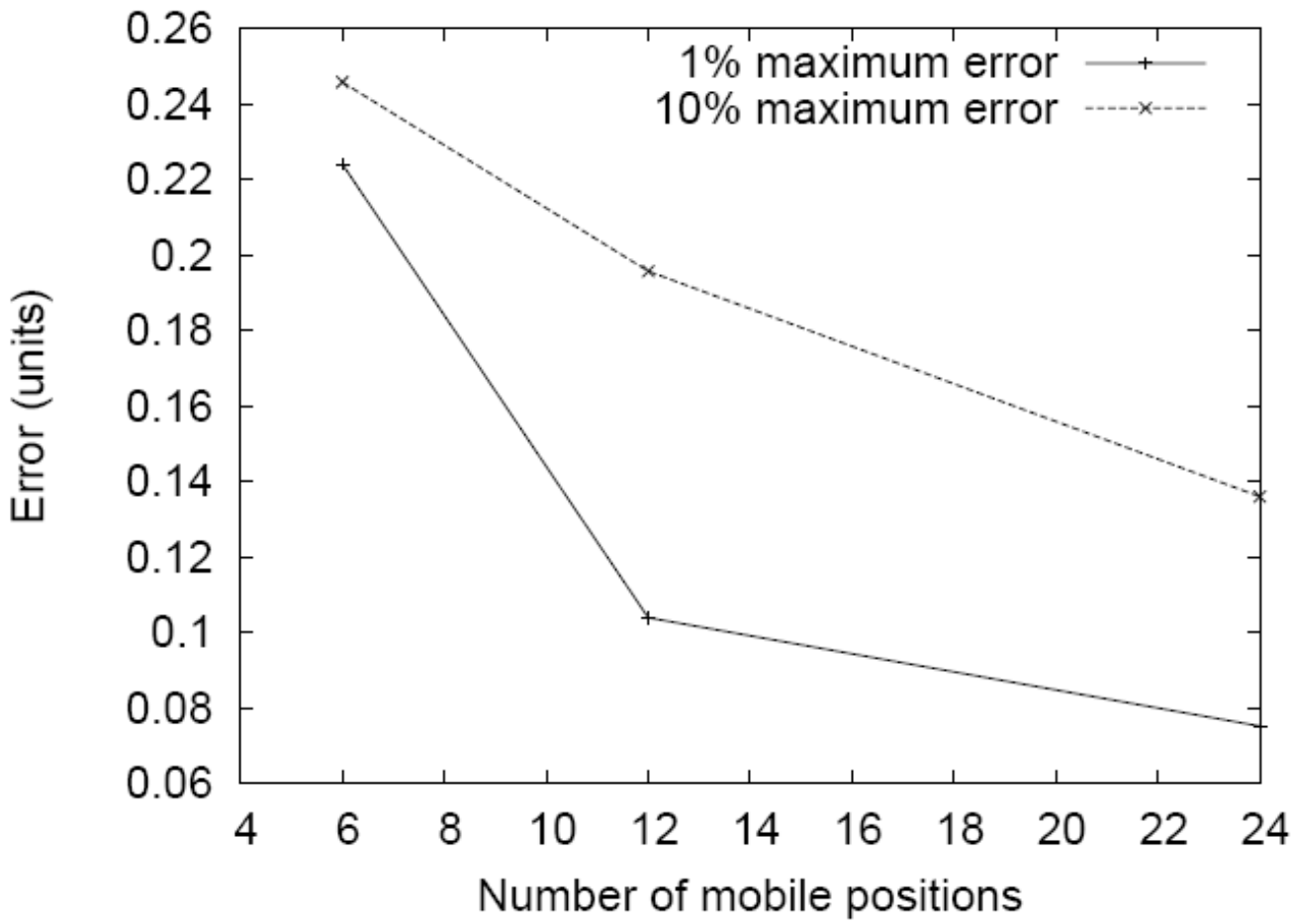


MAL Performance



Radius larger reduce more GDOP error

MAL Performance



Edge length error

We can obtain a large number of mobile distance estimates to reduce the distance error

Conclusion

- We evaluate the algorithm using real-world experiment
- The average distance error is less than 1.5%
- With sufficient distance samples, AFL can produces coordinate assignment

THANK YOU