Ad Hoc Positioning System (APS) Using AOA

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Outline

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Introduction

- Position information of individual nodes is useful for routing in ad-hoc networks.
  - Location-aided routing
  - geocast
- Finding location without the aid of GPS in each node of an ad hoc network is important.
  - Cost
  - Accessible
  - Limited power
  - Light of sight

Introduction

- Location would also enable routing in sufficiently isotropic networks without the use of large routing tables.
- How to determine orientation and position of all nodes in an ad hoc network where only a fraction of the nodes have positioning capabilities.

Introduction

- We can derive position information by measuring
  - Time difference of arrival (TDOA)
    - Cricket[2], AhLOS[3]
  - Signal strength
    - RADAR[4], APS[5]
  - Angle of arrival (AOA)

Ad hoc Positioning System (APS)

- APS is used in sensor networks
  - Low power nodes
  - Low mobility
  - Large size
- The design goal of APS
  - Routing without the use of large conventional routing tables.
- APS algorithm is a distributed, hop by hop positioning algorithm.

Ad hoc Positioning System (APS)

- APS works as extension of both distance vector and GPS positioning.
- APS is appropriate for indoor location aware applications.

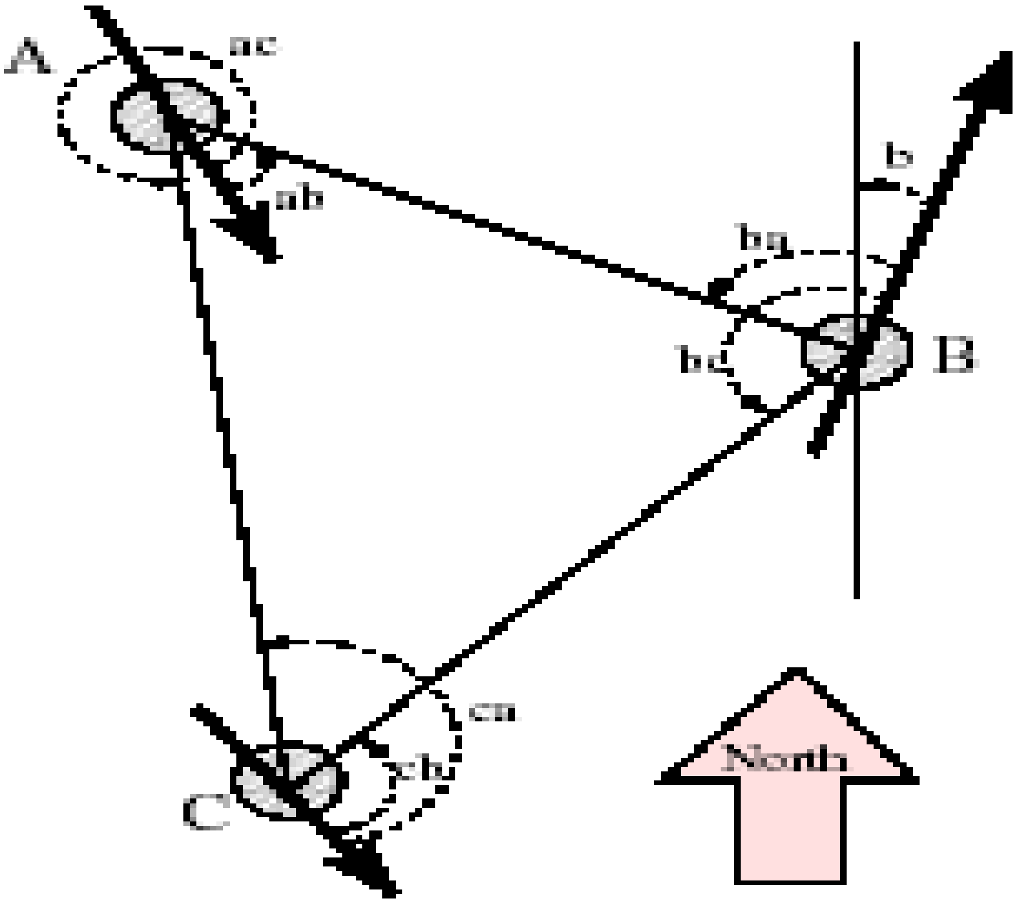
Angle of Arrival (AOA) theory

- AOA sensing requires either an antenna array or several ultrasound receivers.
  - The angle of arrival is as shown in fig. 2[6]
- Any node can only communicate directly with its immediate neighboring nodes within radio range.
- Nodes
  - Landmarks
  - Regular nodes

Angle of Arrival (AOA) theory

- Bearing
  - An angle measurement with respect to another object.
- Radial
  - A reverse bearing
  - Radial = pi - bearing
- Heading
  - Bearing to north

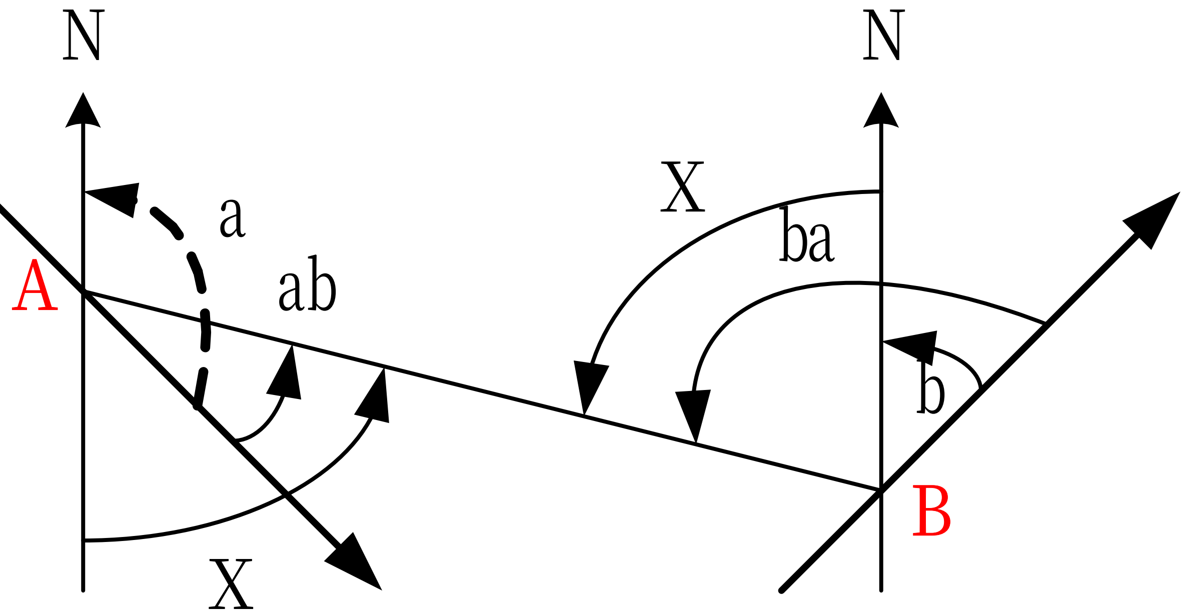
Angle of Arrival (AOA) theory



Angle of Arrival (AOA) theory

- Problem
  - Given imprecise bearing measurements to neighbors
  - Find headings and positions for all nodes in the networks.

Angle of Arrival (AOA) theory



X=pi – (a-ab)

X+b=ba

->pi-(a-ab)+b=ba

->pi-a+ab+b=ba

->a=pi-ba-ab+b

Ad hoc positioning system algorithm

- The propagation method is similar with the distance vector routing.
  - Each node only communicates with its immediate neighbors
  - In each message exchange it communicates its available estimates to landmarks acquired.
- The algorithm is to use hop by hop propagation capability of the network to forward
  - distances (original APS)
  - orientation=bearing, radial or both.

  to landmarks.

Ad hoc positioning system algorithm

- Distance vector Bearing
  - which allows each node to get a bearing to a landmark.

- Distance vector Radial
  - which allows a node to get a bearing and radial to a landmark.
  - We assume that compasses are available in nodes.

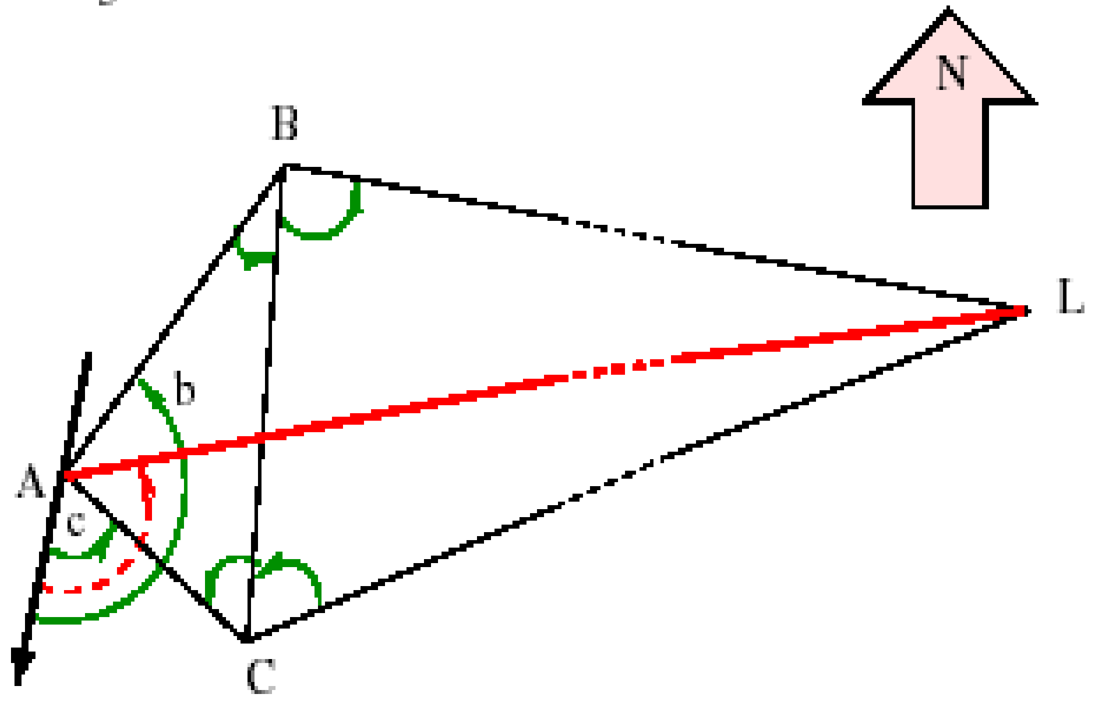
Ad hoc positioning system algorithm

Find deg(a)?

deg(a)

=deg(c)+deg(LAC)

Fig. 5. Node A infers its bearing to L by corroborating $B's$ and $C's$ bearings to L

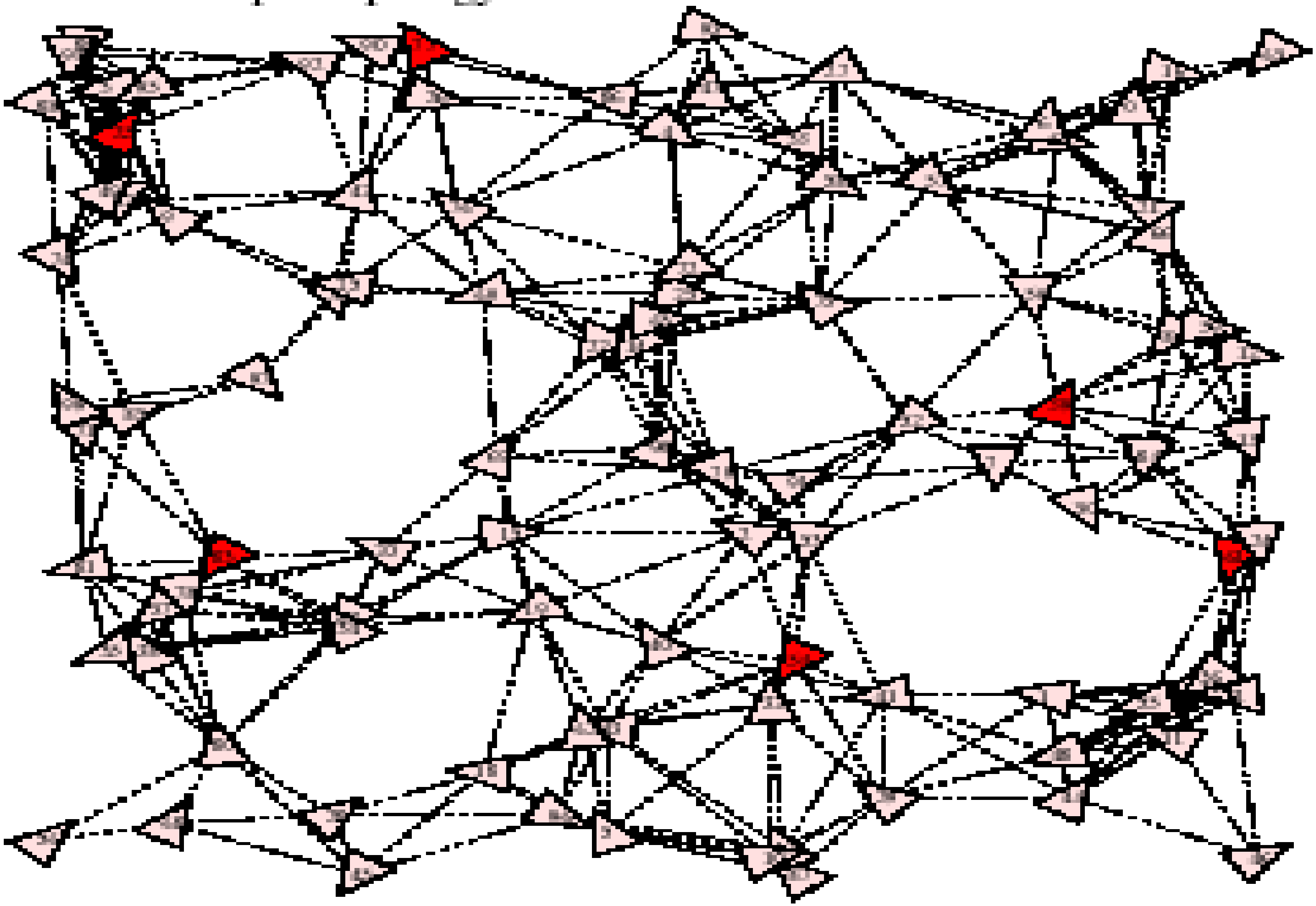


Simulation result

- Simulation model
  - 1000 nodes
  - Degree=10.5
  - Diameter=32
  - A fraction of nodes are landmarks
  - DV bearing: TTL=5
  - DV radial: TTL=4
- Performance will be evaluated based on
  - The accuracy of positioning for non-landmark nodes
  - Accuracy of heading
  - Percentage of the regular nodes which succeed the solving for a position

Simulation result

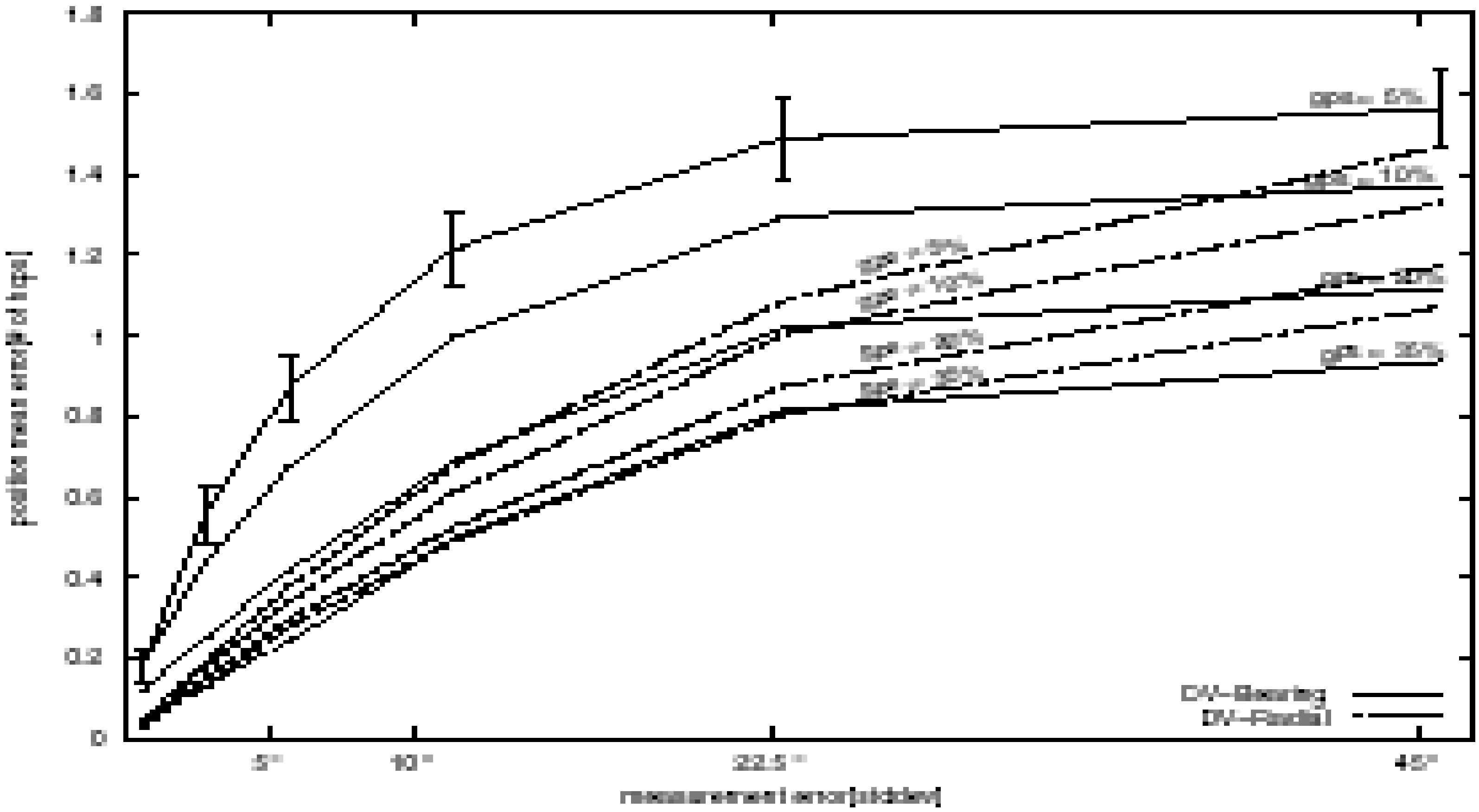
Fig. 10. Isotropic topology



Simulation result

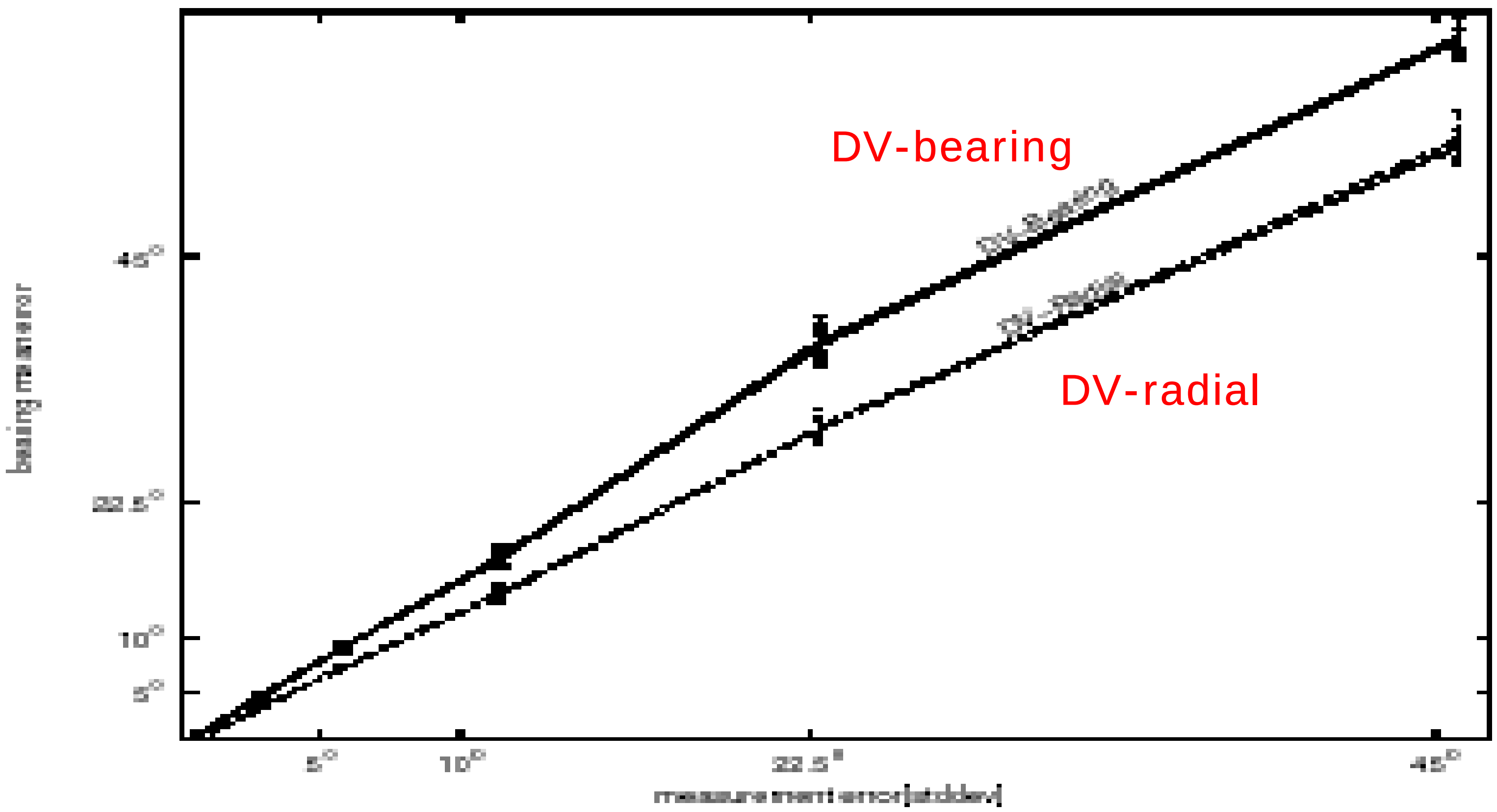
- Position error

Fig. 11. Positioning error



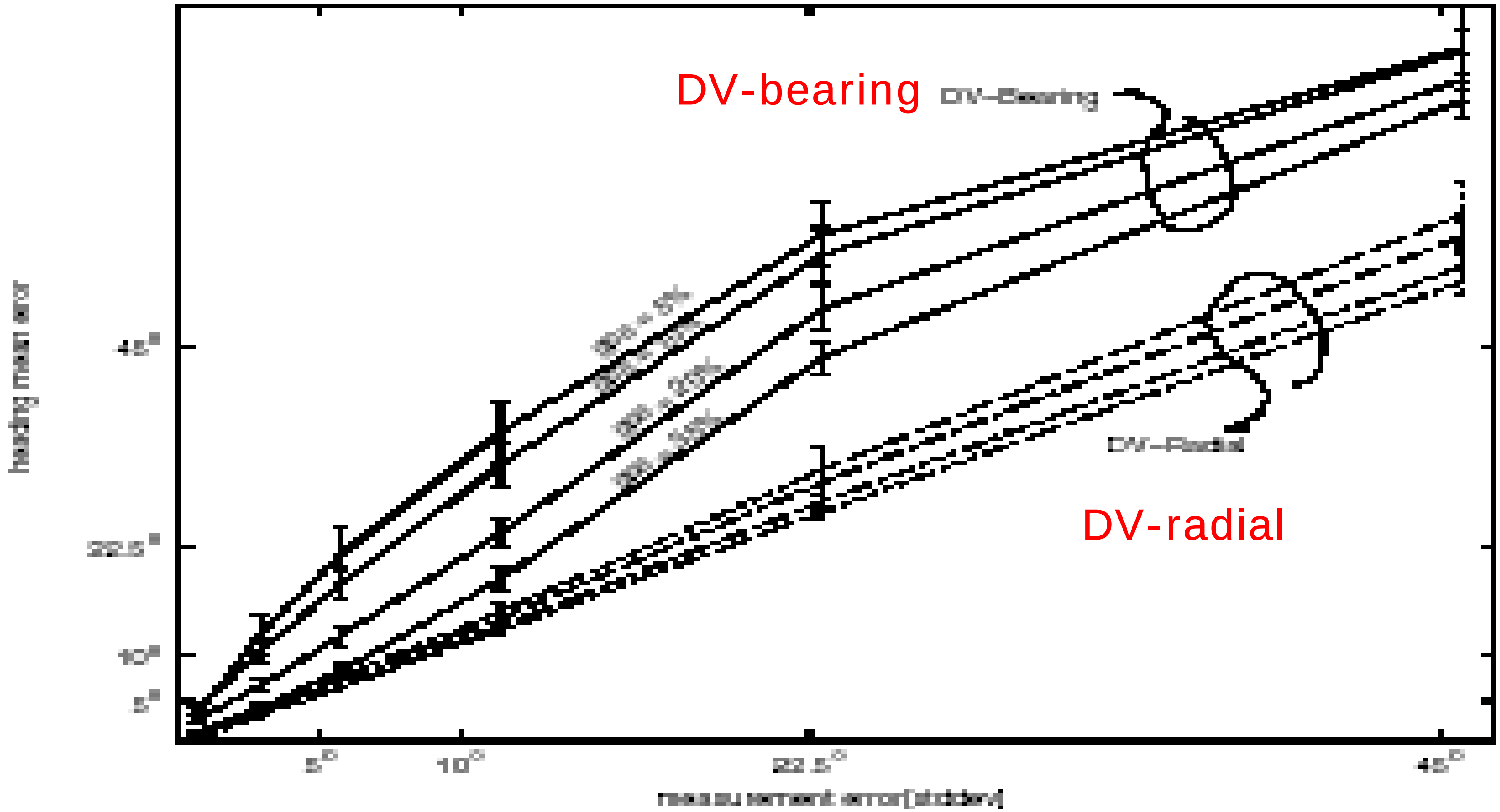
Simulation result

- Bearing error
  - The average error of the bearing to landmarks



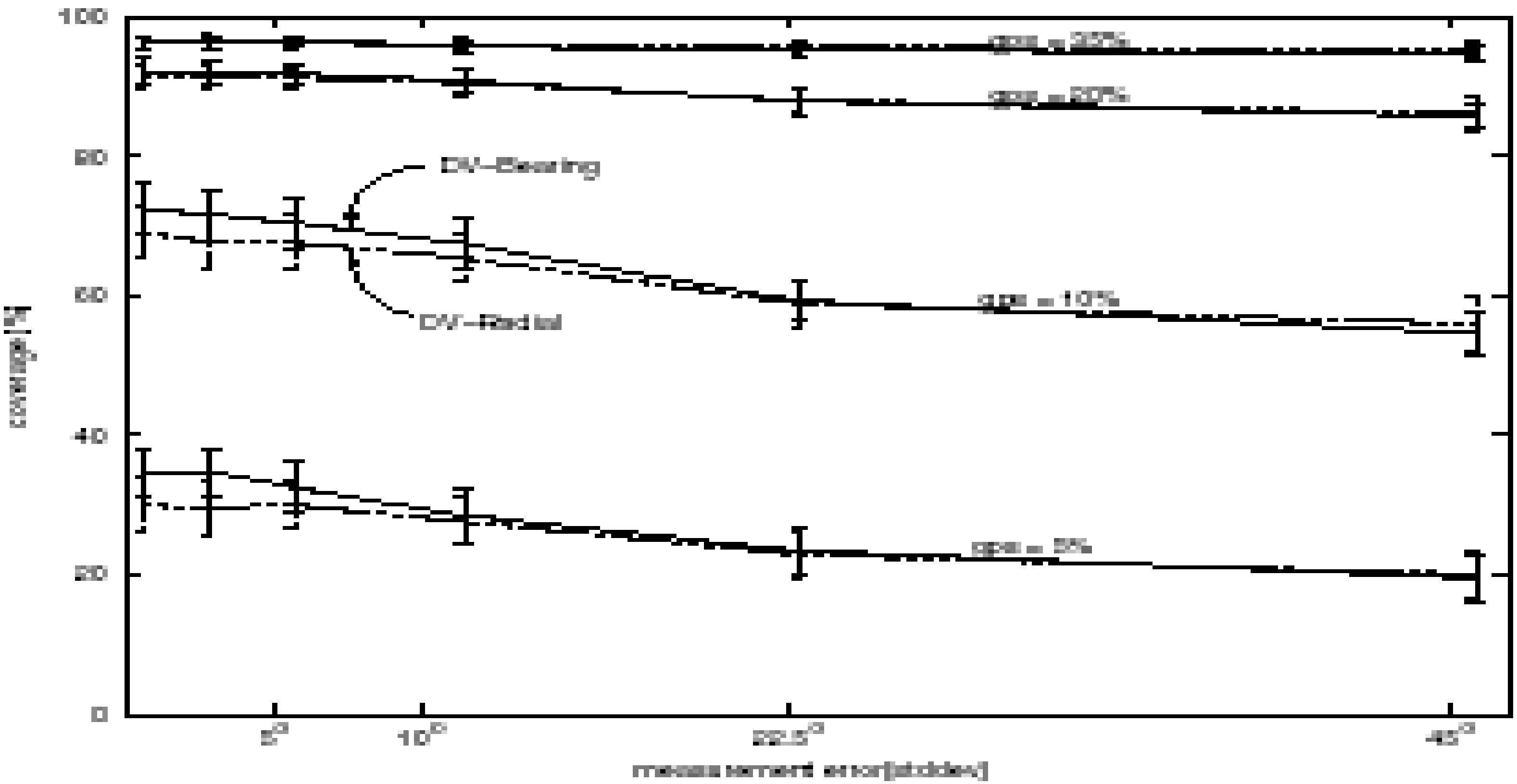
Simulation result

- Heading error
  - The angle between nodes axis and the north



Simulation result

- Coverage
  - The percentage of non landmark nodes which are able to resolve for a position



Discussion

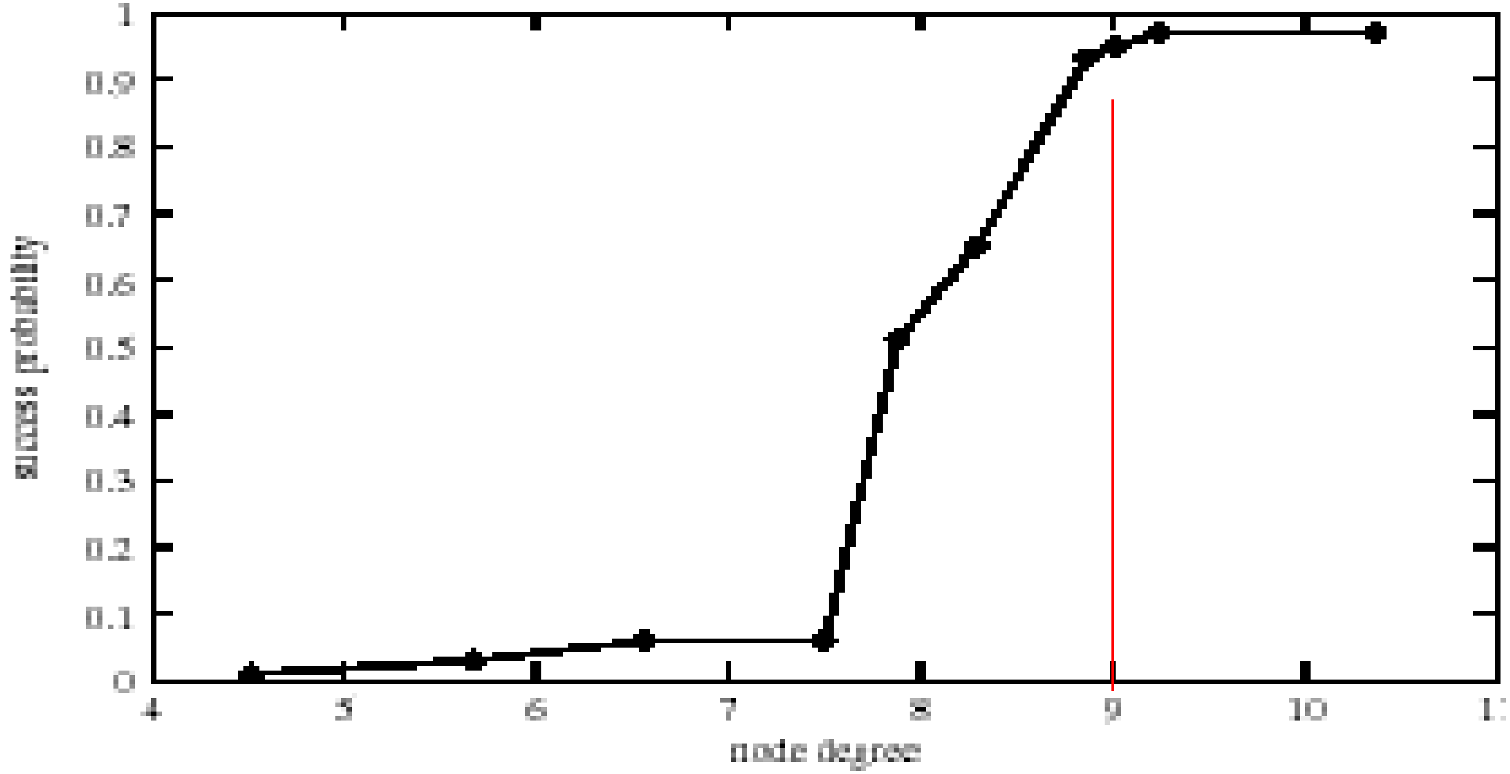
- Hardware requirement
- Signaling overhead
  - TTL / per landmark
  - Signaling-accuracy tradeoffs

compass	method	signaling	accuracy
nowhere	*DV-Bearing*	less	less
only at landmarks	*DV-Bearing* *DV-Radial*	less more	less more
all nodes	*DV-Radial*	less	more

Discussion

- Network density

Fig. 6. Probability for a node to satisfy conditions necessary for orientation forwarding



Discussion

- Error control
  - Bearing propagation
- The author think that the error control is lightweight due to the environment is
  - Low power
  - Low communication capacities nodes
  - …
- Solutions
  - Limited TTL
  - To avoid to deal with small angle (angle threshold)

Discussion

- Node mobility
  - In this paper, the network topology is static.
- When a moves,
  - it will get DV updates form its new neighbors.
- When a landmark moves,
  - It will cause a communication surge in this approach.
  - The only things that identify a landmark are its coordinates.

Conclusion

- The author extends the original APS with distance measurement to angle measurement (APS with AOA).
- Two algorithms are proposed
  - DV-bearing
  - DV-radial
- The performance of DV-radial is better than DV-bearing
- But the signaling overhead of DV-radial is higher than DV-bearing.