Location Sensitivity of Deployment and Re-configuration Algorithms in WSAN

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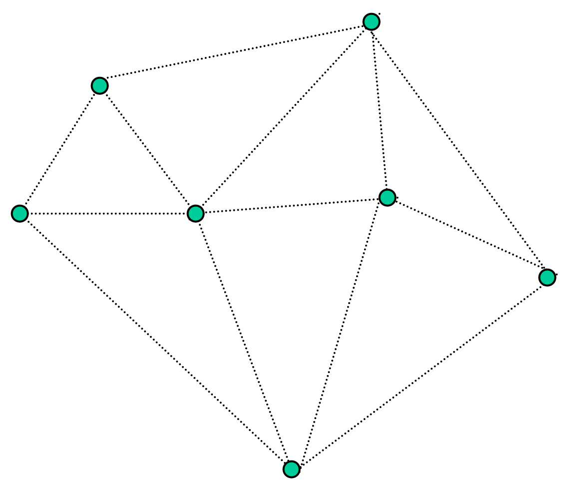
Overview

- Research questions
- What are WSANs?
- The dependency on location
- Formation of coverage holes
- Proposed simulator
- VOR / VEC algorithms
- Conclusion

Research Questions

- **How do the algorithms behave in a real-world environment?**
- **What are the effects of location inaccuracies on the algorithms?**

❑ What is a WSAN?



Coverage holes…

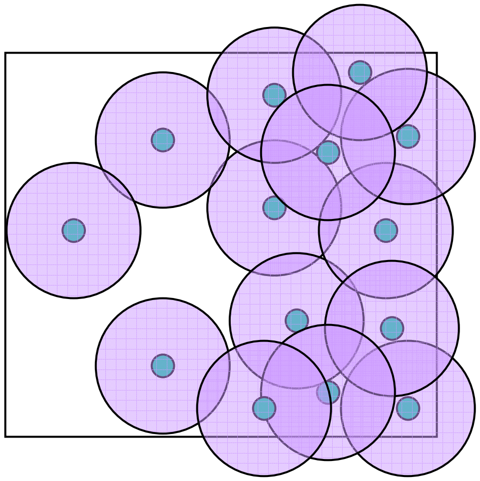


Figure 1 Deployment with coverage holes

Reconfiguration

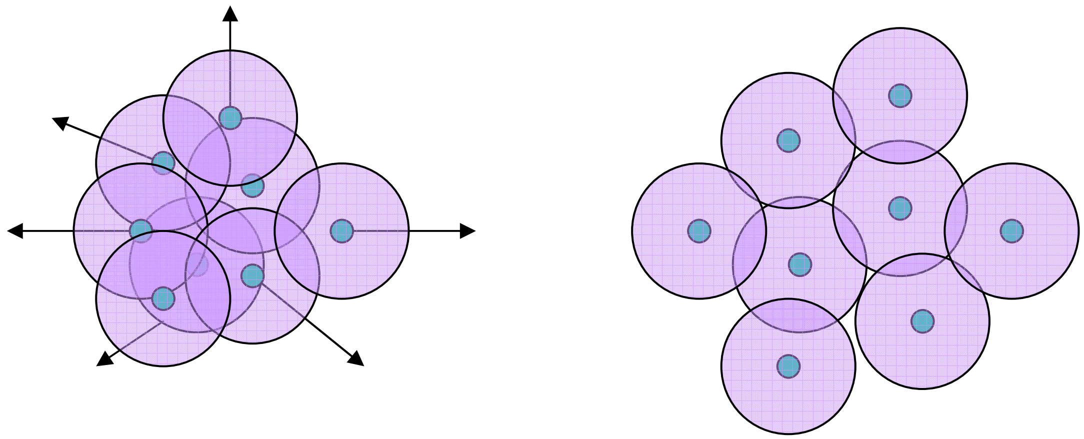


Figure 2 Reconfiguration of a mobile network

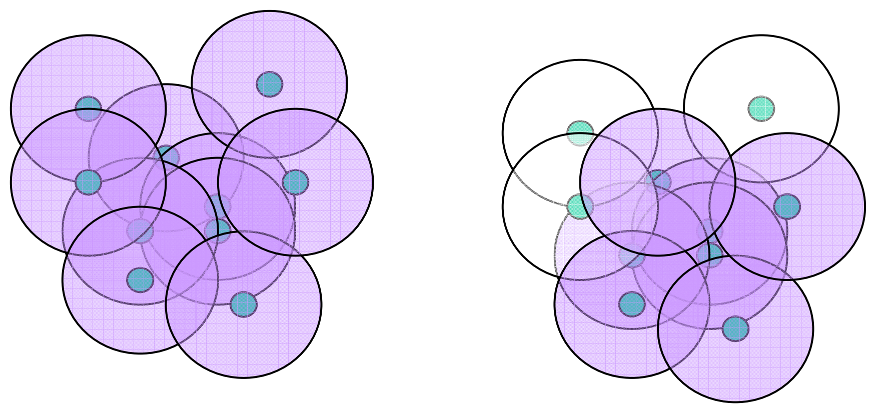


Figure 3 Reconfiguration of a static network

❑ Voronoi-polygons…

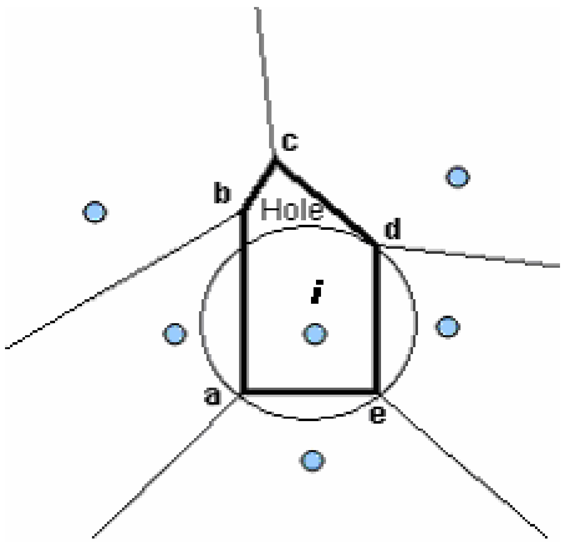


Figure 4 Determining the existence of a coverage hole

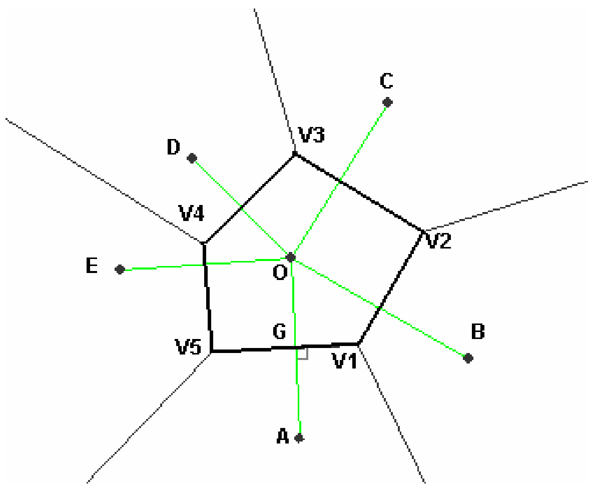


Figure 5 Voronoi polygon Gp(O) of point (O) represented as Vp (O), Ep(O)

Location In-accuracy

❑ Location inaccuracy…

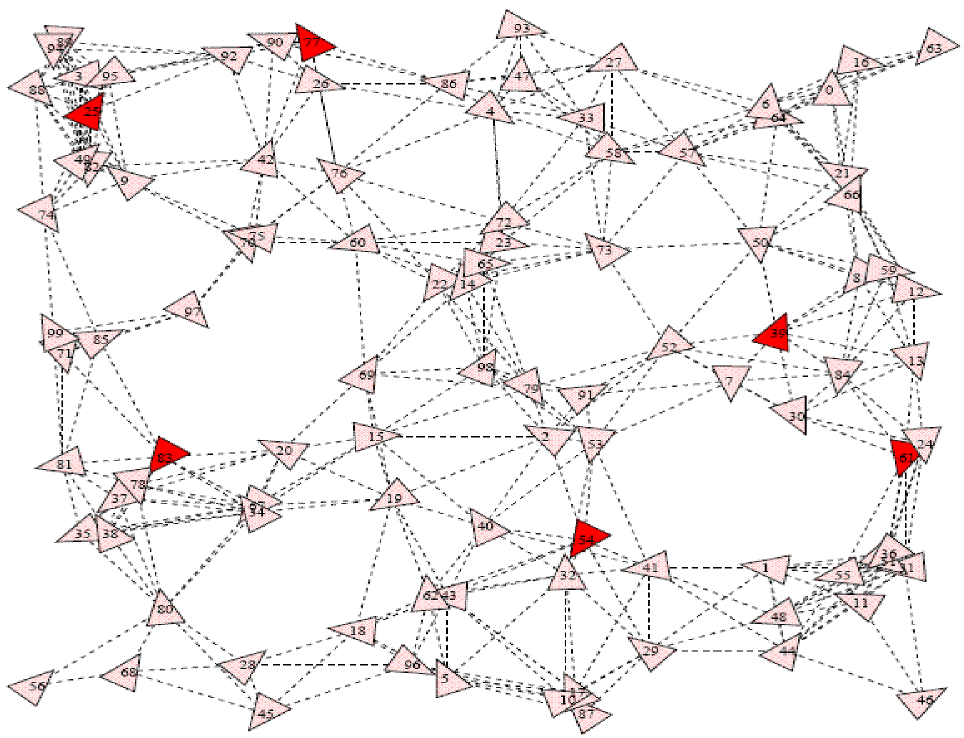


Figure 6 Calculation of location by radiolocation / triangulation

Location Within Coverage Algorithms

Category	*Approach*	*Proposed Solution*	*Main Assumptions*	*Characteristics*
Mobile Sensors	Computational Geometry	VEC, VOR, Minmax [13]	Location information	Localized, scalable, distributed.
		Co-Fi [18]	Location information. Nodes can predict their death	Single coverage based. Residual energy considerations.
	Virtual Forces	Potential Fields [14]	Range and bearing	Scalable, distributed. No local communication required for localization or movement.
		DSS,IDCA [16]	Location information	Scalable,distributed,residual energy based.
	Sequential	Incremental [15]	Line of sight for localization	Centralized. Bidirectional communication with base station.
Hybrid Sensors	Single Mobile Sensor	UAV [19]	Predetermined topology information	Flying robot for deployment and network repair. Inaccuracies using aerial deployment
		Single Robot [20]	Location information	Distributed, no multi-hop communication for network deployment and repair.
	Multiple Mobile Sensors	Bidding Protocol [21]	Location information	Uses Voronoi diagram for single coverage requirement.
Static Sensors	Multiple Coverage	CCP [10]	Location information, uniform sensing disk	Configurable degree of coverage, calculated by intersection points of sensing circles.
		k-UC, *k*-NC [6]	Location information	Perimeter coverage, non-disk sensing model supported.
		Differentiated [22]	Location information, time synchronization	Grid based differentiated degree of coverage.
	Single Coverage	OGDC [23]	Location information, uniform sensing disk	Residual energy consideration.
		Sponsored Area [24]	Location information	Sector based coverage calculations, non-disk sensing model supported.
		Extended-Sponsored Area [25]	Location information, time synchronization	Uniform disk sensing model.

Table 1 Ahmed comparison of algorithms

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GIS Aided Simulation

❑ Proposed simulator

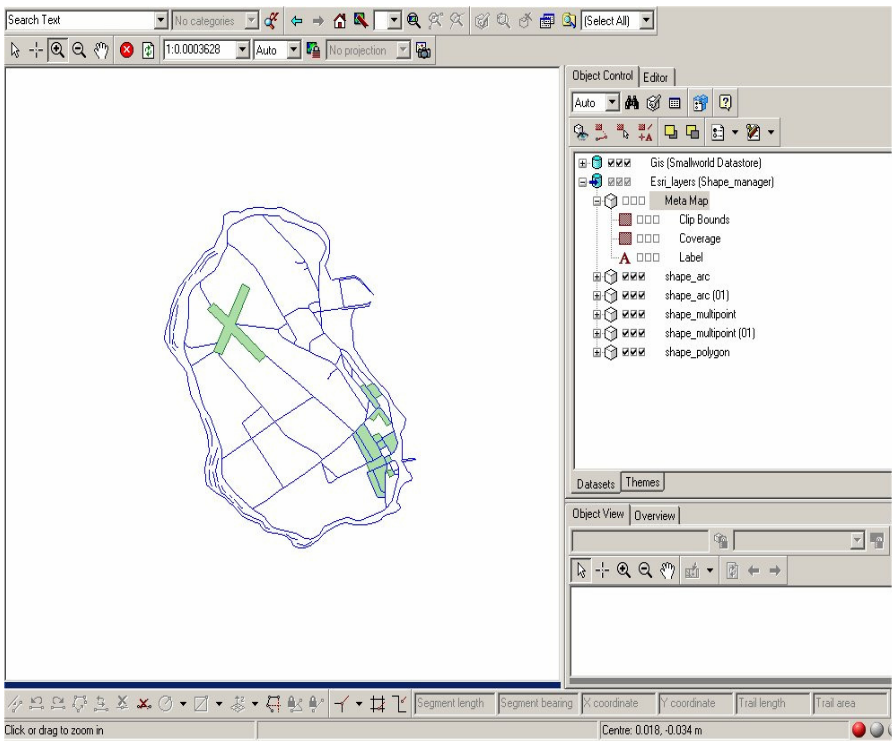

Figure 7 GE Smallworld Core GIS

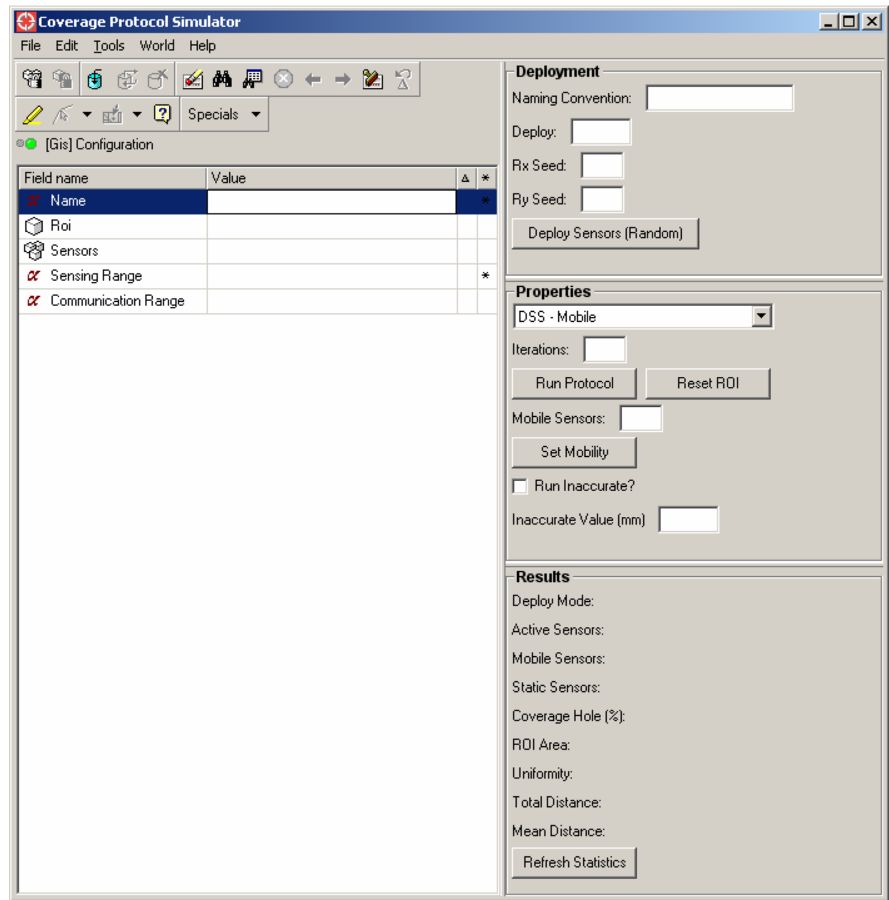

Figure 8 Coverage simulator

❑ Inaccuracy

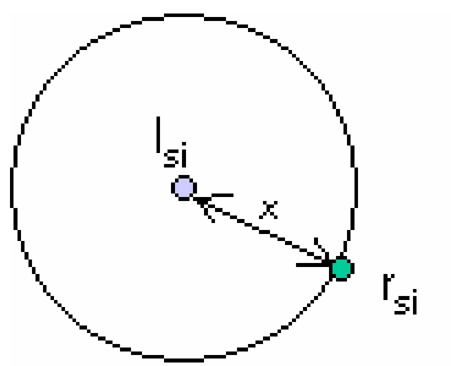

Figure 9 Simulating inaccuracy calculation

VORonoi algorithm

- $V_{far} = d(S_i, A) - R_i$

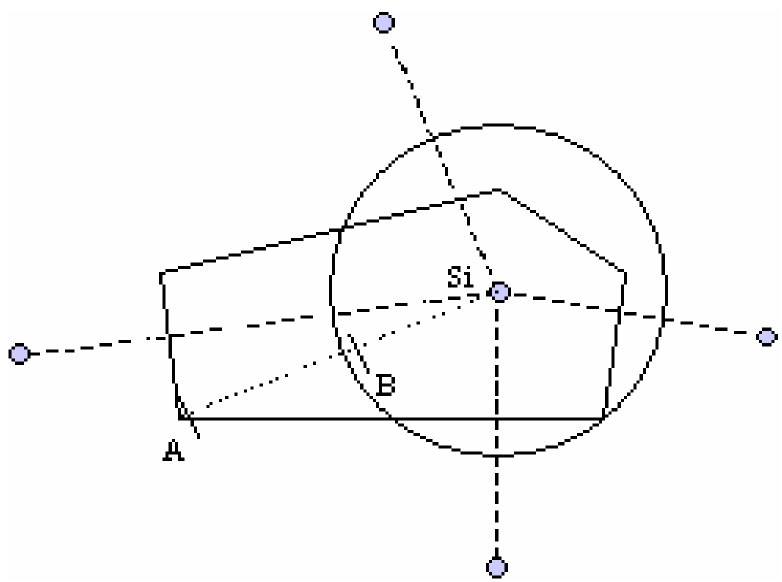

Figure 10 Movement of a node using VOR

Greedy algorithm

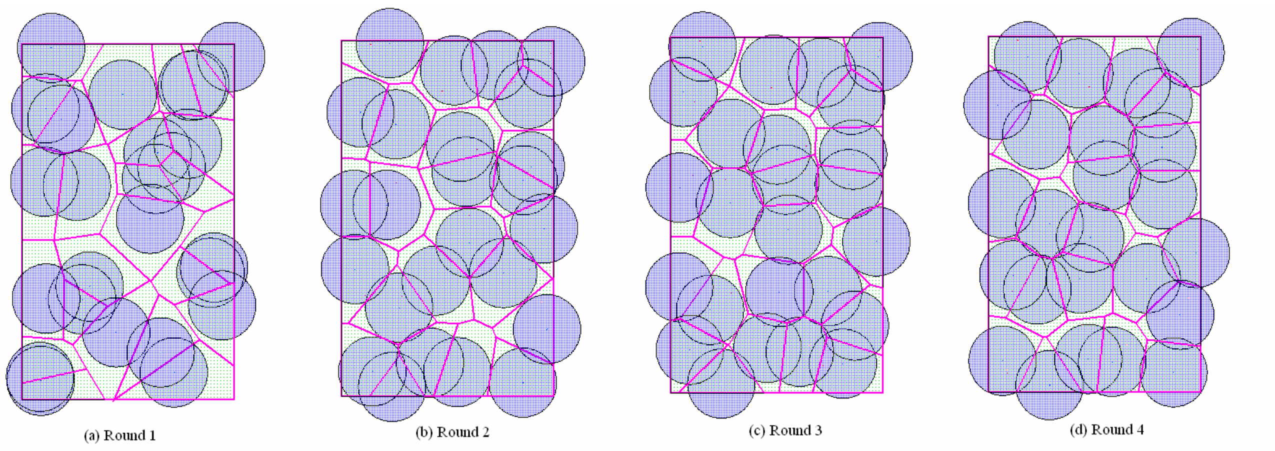

Figure 11 Execution of the VOR Algorithm over four iterations.

VOR Algorithm (cont)

Results

- Reasonably robust when inaccuracies are some what lower then the sensing distance
- When the inaccuracies are high, but in a small proportion of the nodes

VECtor algorithm

- F = (davg - d(Si, Sj)) / 2

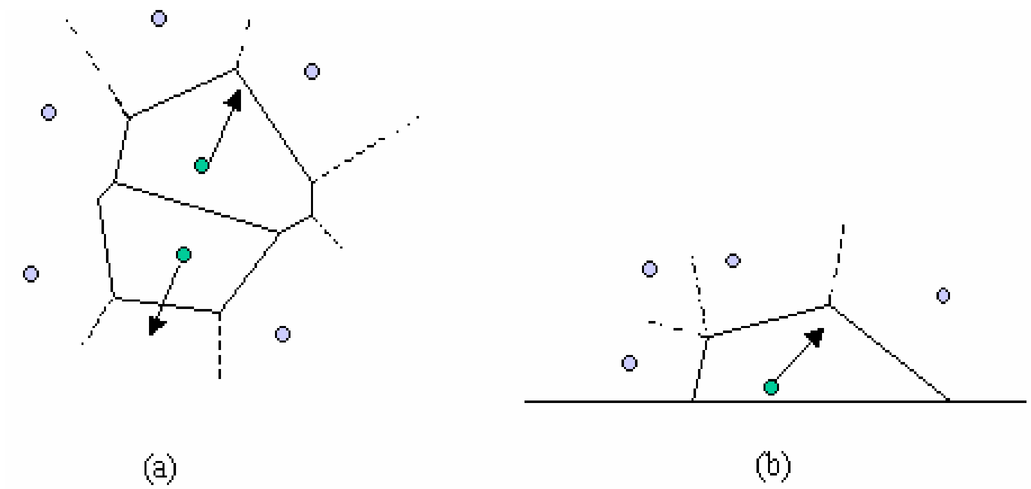

Figure 12 (a) Virtual Forces between two sensors, (b) Virtual Force exerted by a boundary.

VEC Algorithm (cont)

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Results

- High dependency on location accuracy
- Boundary knowledge does allow for large inaccuracies

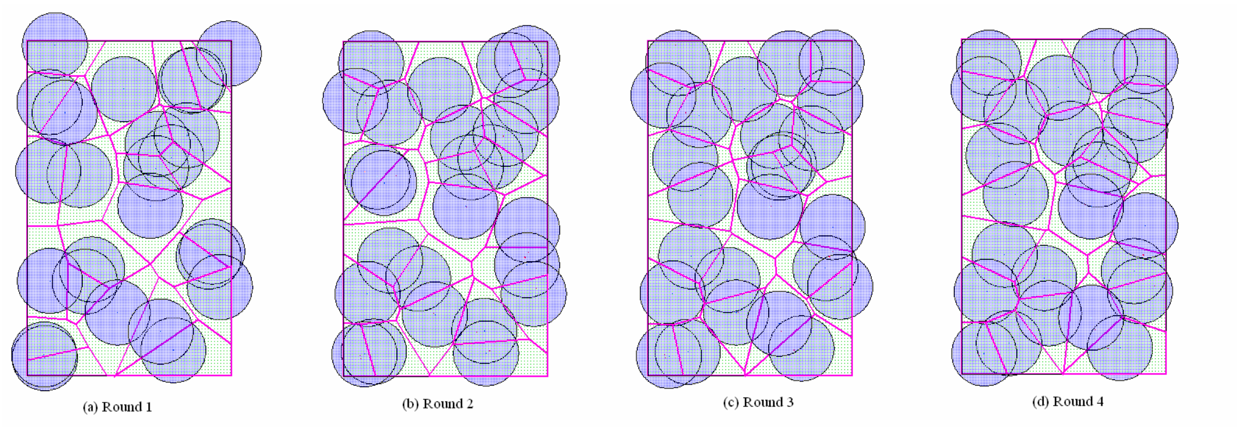

Figure 13 Execution of the VEC Algorithm over four iterations.

Experiments

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- **Baseline experiment**
  - Uniform deployment with no failure
  - Used to verify the simulation environment
  - Baseline for the algorithms performance
- **Random initial deployment**
  - Terminating threshold set to 100
  - Various starting deployment scenarios

Experiments (cont)

- **Inaccuracy**
  - Insert degrees of inaccuracy across all nodes
- **Sensitivity to inaccuracy**
  - Simulate different percentage of nodes within the ROI to be accurate
- **Iteration sensitivity to inaccuracy**
  - Terminating threshold of 100
  - Variable degree of inaccuracy

Conclusion

- **Assessment**

- **Related and future work…**

References

- **N. Ahmed and S.S. Kanhere, S. Jha, "The Holes Problem in Wireless Sensor Networks: A Survey", Mobile Computing and Communications Review, Volume 1 Number 2.**
- **I.F. Akyildiz and I.H. Kasimoglu, "Wireless sensor and actor networks: research challenges", Georgia institute of technology, 2004.**
- **F. Aurenhammer. Voronoi Diagram – A Survey of a Fundamental Geometric Data Structure. *ACM Computing Surveys*. Volume 23, Number 3, September 1991**
- **D. Nicules and B. Nath. Ad-hoc position system (APS) using AoA. In *proceedings of the IEEE INFOCOM,* 2003**
- **G.Wang, G Cao and T La Porta. Movement-assisted sensor deployment. *In IEEE INFOCOM 2004*, June 2004**
- **GE SmallWorld Core Documentation Version 4, GE Power Systems, 2003**
- **N. Neo and P.K. Varshney. Energy-Efficient Deployment of Intelligent Mobile Sensor Networks. *IEEE Transactions on Systems, Man and Cybernetics – Part A: Systems and Humans,* Volume 35, Number 1, January 2005**

Questions...