Advances in Mobile Medium Ad Hoc Network Research

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Presented by: P. Pochec on July 21, 2021

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Dr. Przemyslaw Pochec is an Associate Professor in the Faculty of Computer Science at the University of New Brunswick in Fredericton, Canada, and is interested in data communications. His early research was on image processing and on 3D computer vision systems. His work on parallel computing involved developing parallel image processing algorithms for transputer based systems, VLSI implementations of neural network classifiers and the introduction of a new type of a queue for modelling mirroring systems. His association with IARIA started in 2010 with the publication of the results his investigation on spontaneous formation of the wireless channel in MANETS.

https://www.iaria.org/fellows/PrzemyslawPochec.pdf

Outline

- The new model: history
- Mobile Medium
- MANET vs M2ANET
- The Medium:
  - Density of nodes
  - Node movement
- Modelling tools:
  - Border effect mitigation
  - Transforming movement paths
  - Simulation in 3D
- Future directions

Mobile Medium

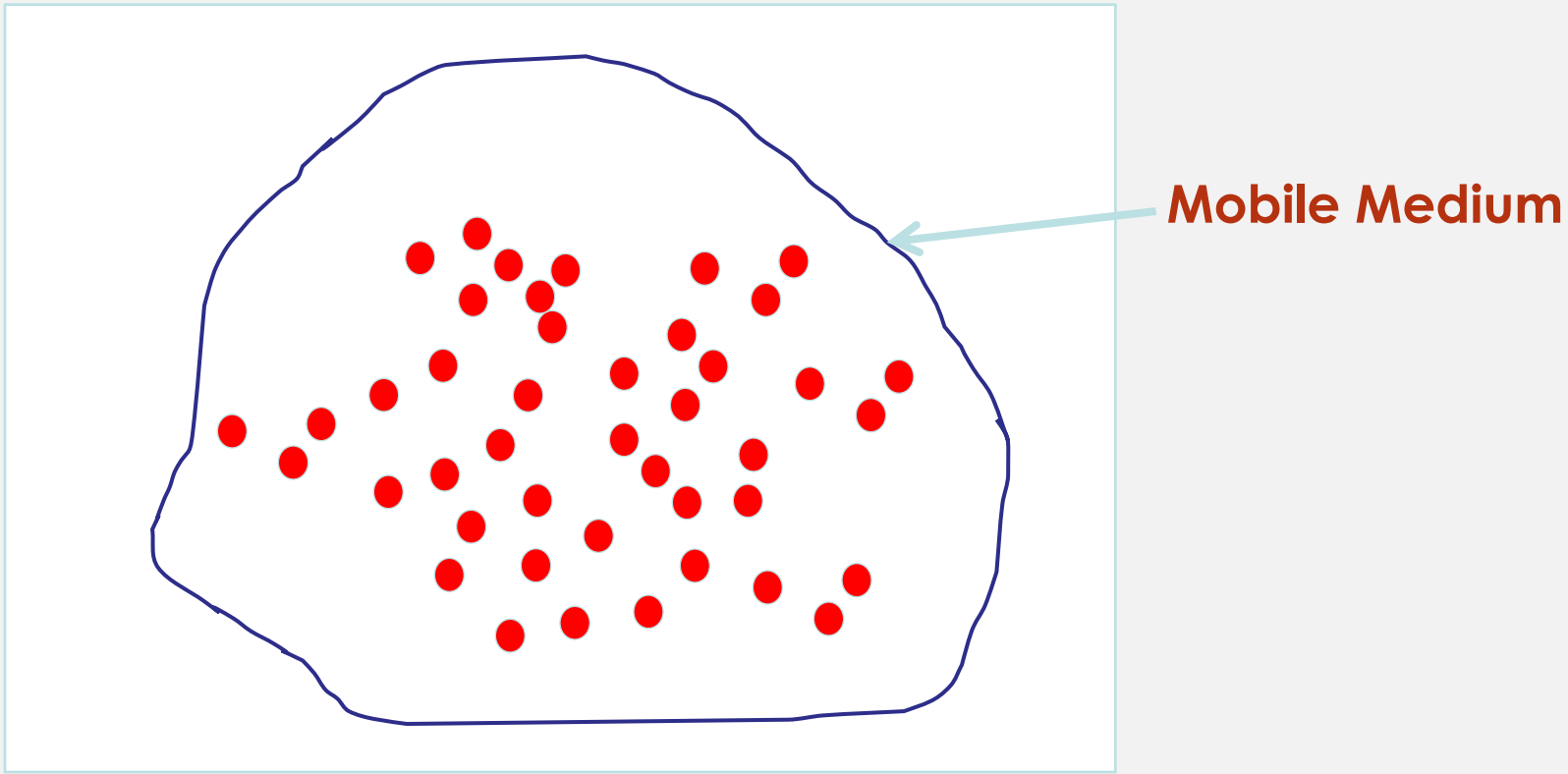
- New model
- New simulation tools
- 10 years effort
- Dozen of graduate students
- Dozen publications

M2ANET:
Mobile Medium Ad Hoc Network

- Similar to MANET
- Two categories of nodes:
  - Forwarding nodes
  - Communicating nodes (users)

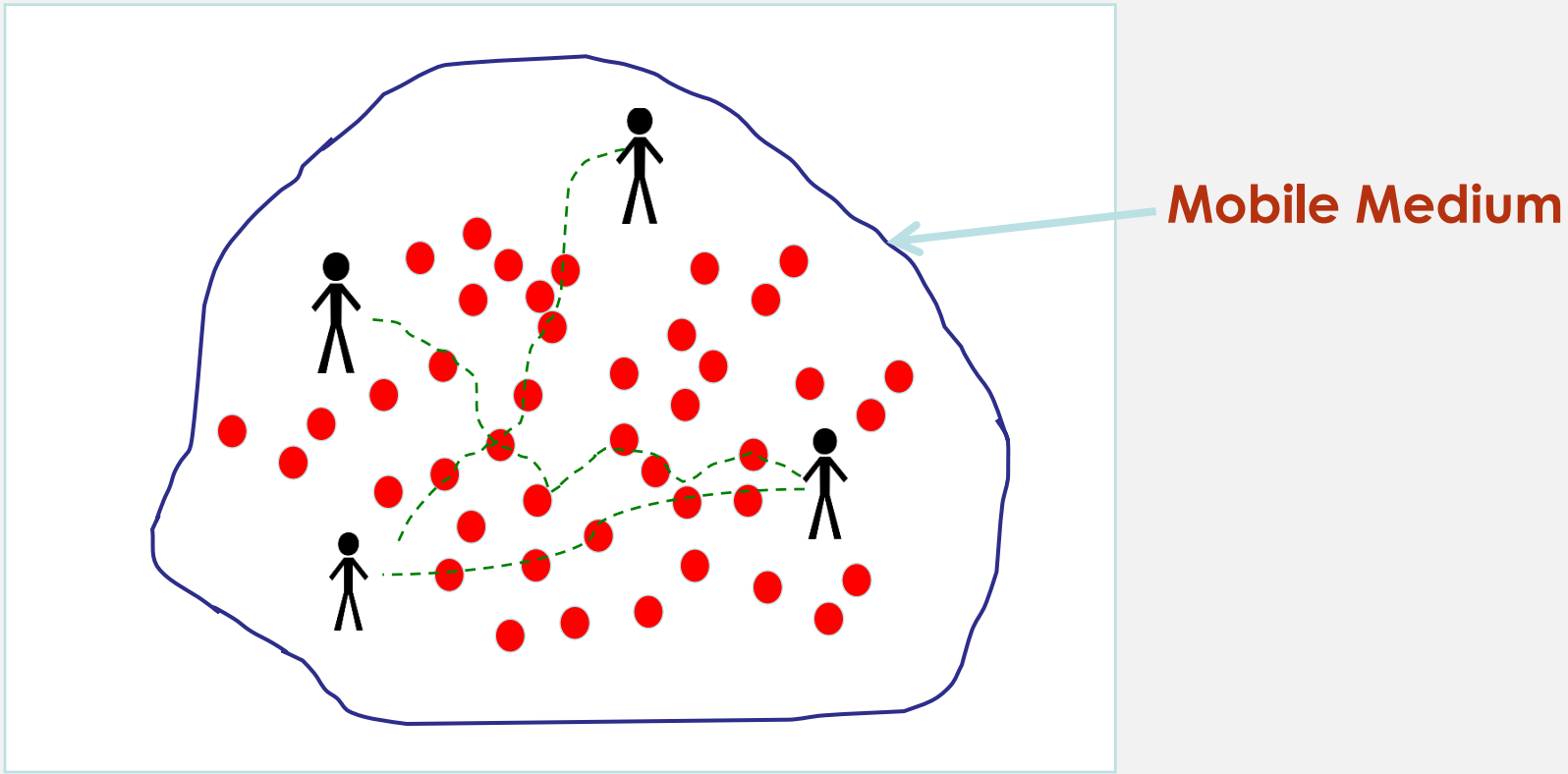
Creating Mobile Medium

- Deploy a large number (a cloud) of forwarding nodes over the area of interest

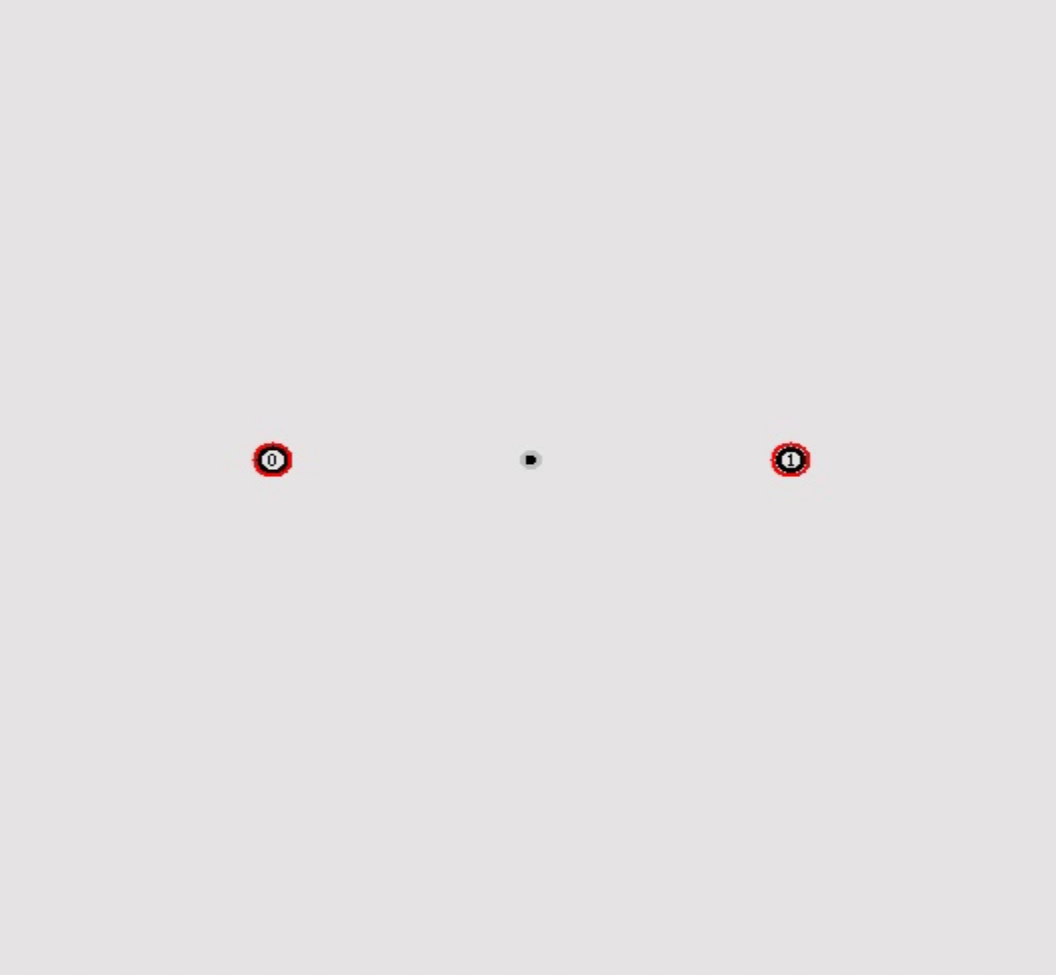


Using Mobile Medium

- Users connect to the Mobile Medium and the Mobile Medium forwards the data



Sample deployment scenario



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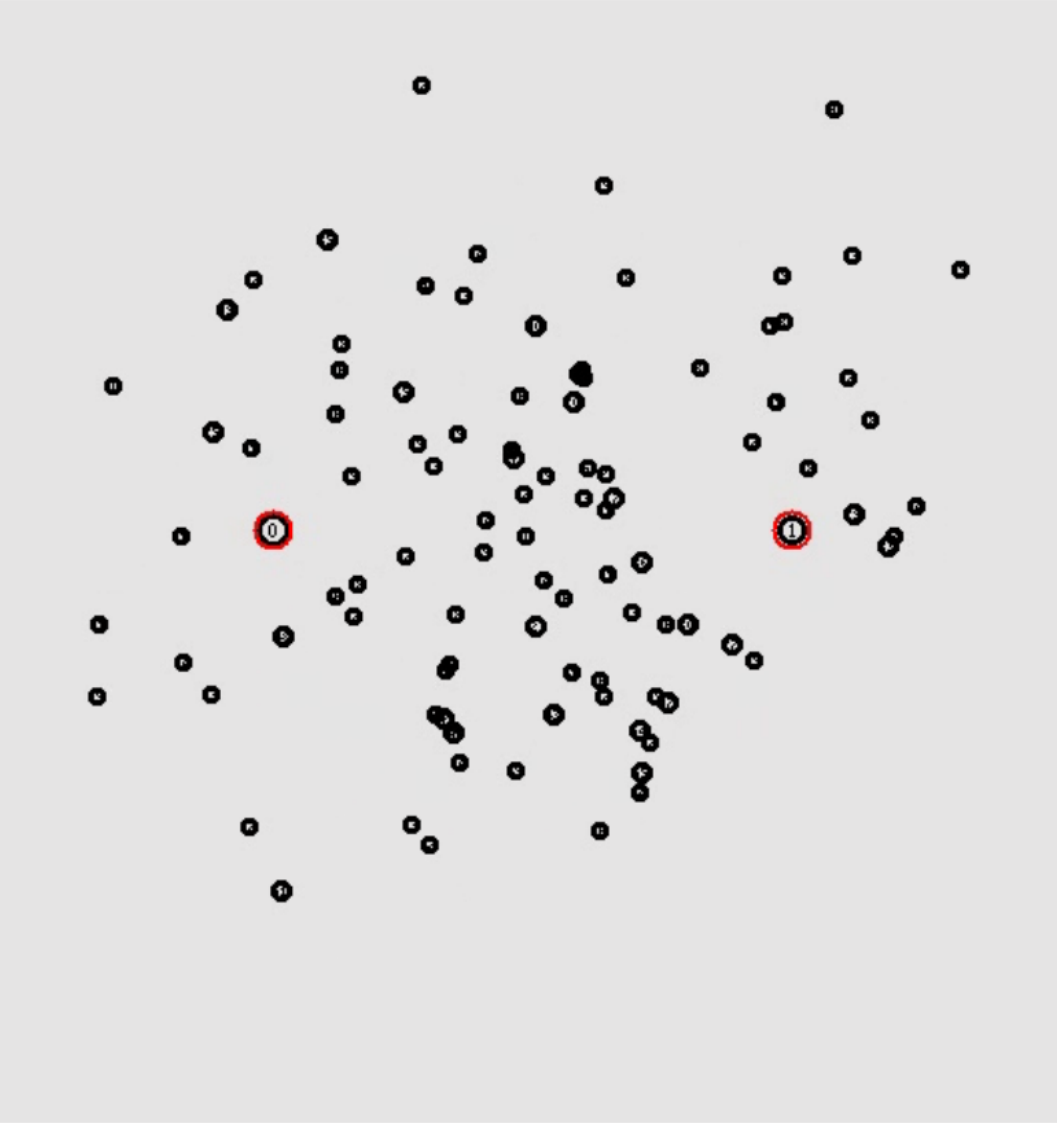
Sample deployment scenario



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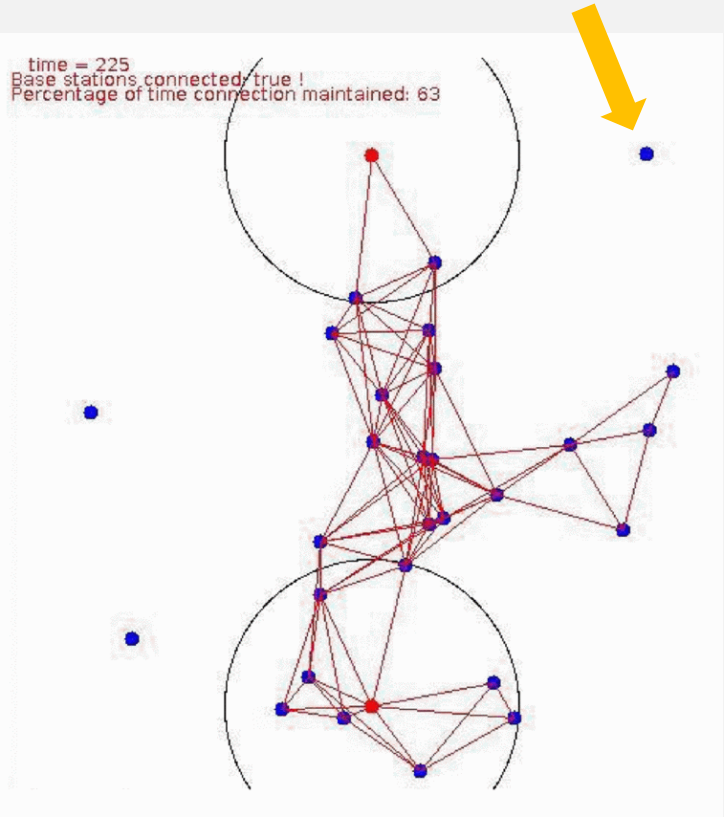
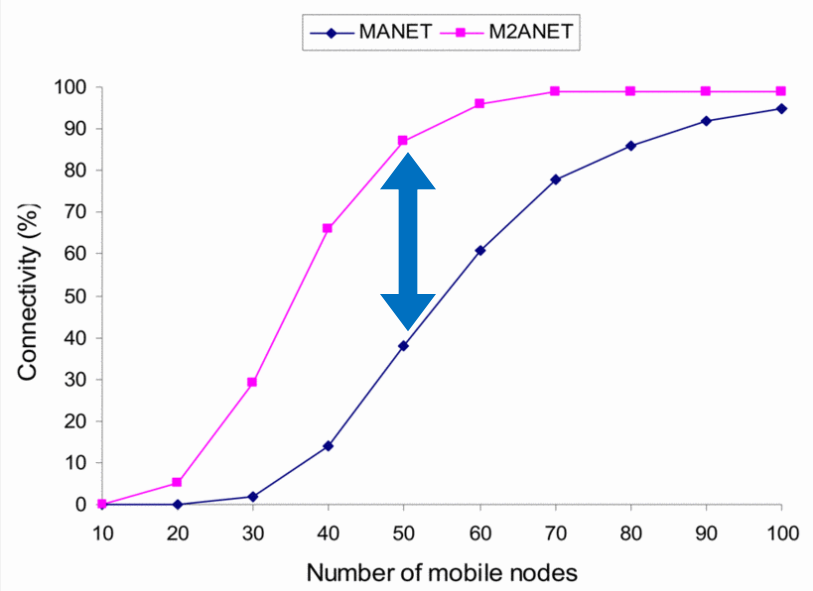
Similar configurations

- any MANET
- LEO satellite systems
  - Iridium
  - Starlink
  - Telesat Lightspeed

M2ANET: Mobile Medium Ad Hoc Network

- Similar to MANET
- Two categories of nodes:
  - Forwarding nodes
  - User nodes
- Performance metric
  - Throughput between communicating (user) nodes
  - Connecting ALL nodes not a factor





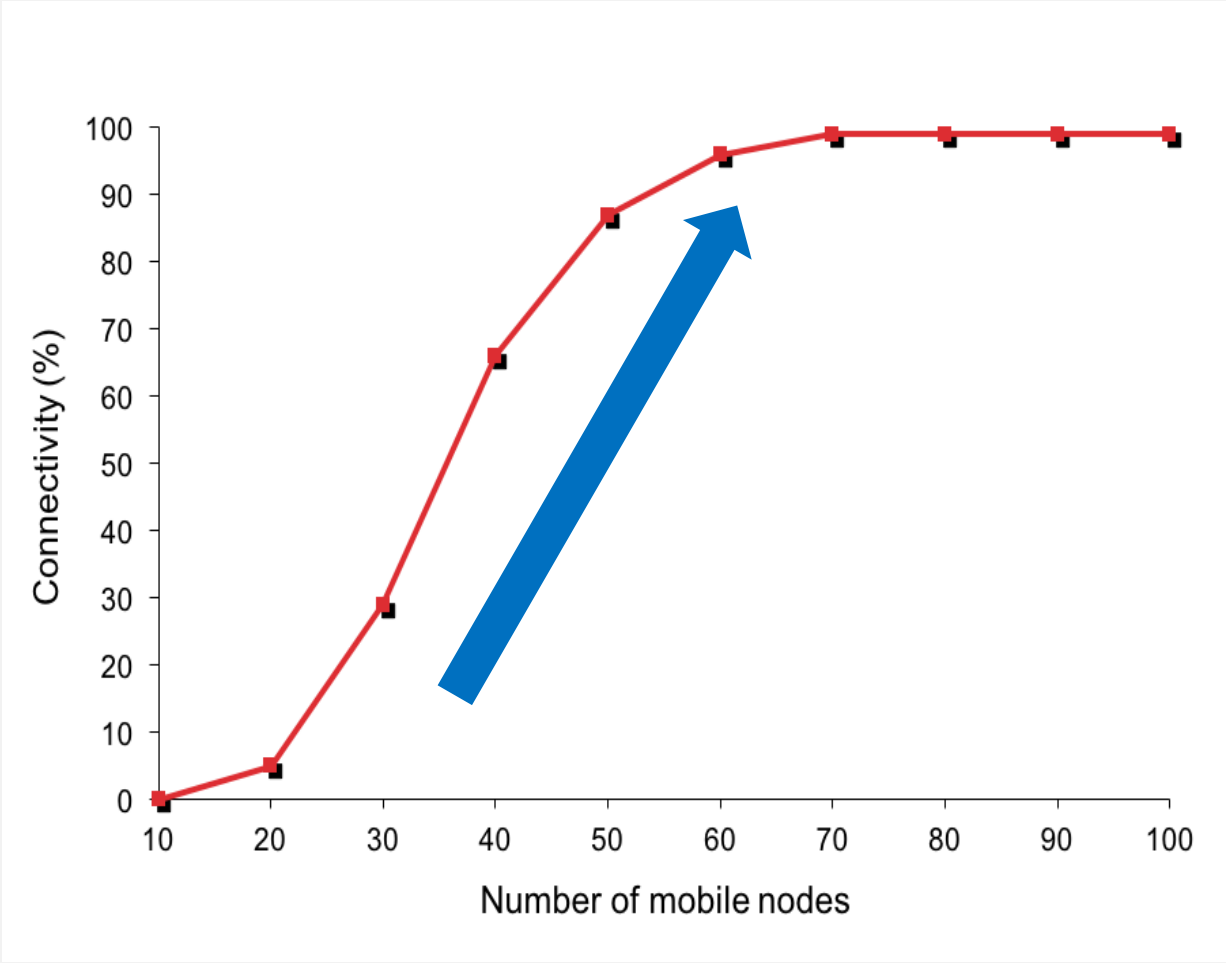
- MANET: full connectivity
- M2ANET: connectivity measured between communicating nodes only

M2ANET advantage

J. DeDourek and P. Pochec, "M²ANET: a Mobile Medium Ad Hoc Network", Wireless Sensor Networks: Theory and Practice, The Fourth IFTP International Conference on New Technologies, Mobility and Security NTMS 2011/WSN 2011, Paris, France, pp. 1 - 4, Feb. **2011**.

Mobile Medium deployment considerations

- Maintaining adequate node density for successful communication
  - > use a large number of forwarding nodes
  - > place the nodes where they would be most useful
    - Node movement strategies



Using more nodes

J. DeDourek and P. Pochec, "M²ANET: a Mobile Medium Ad Hoc Network", Wireless Sensor Networks: Theory and Practice, The Fourth IFTP International Conference on New Technologies, Mobility and Security NTMS 2011/WSN 2011, Paris, France, pp. 1 - 4, Feb. **2011**.

Mobile Medium deployment considerations

- Maintaining adequate node density for successful communication
  - > move nodes along predefined paths

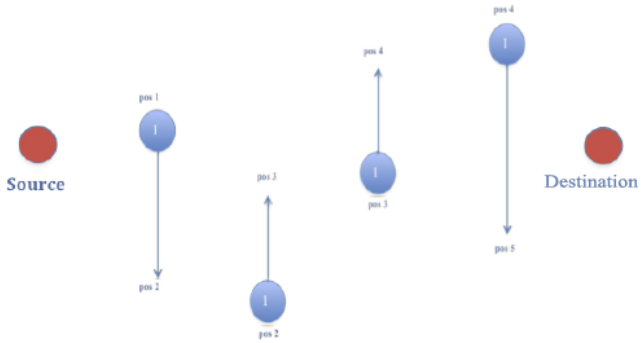


Figure 2. Vertical motion.

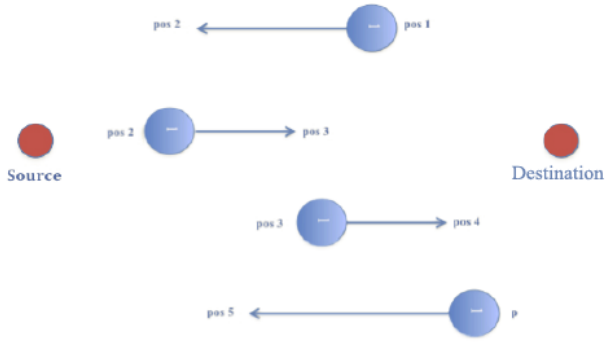
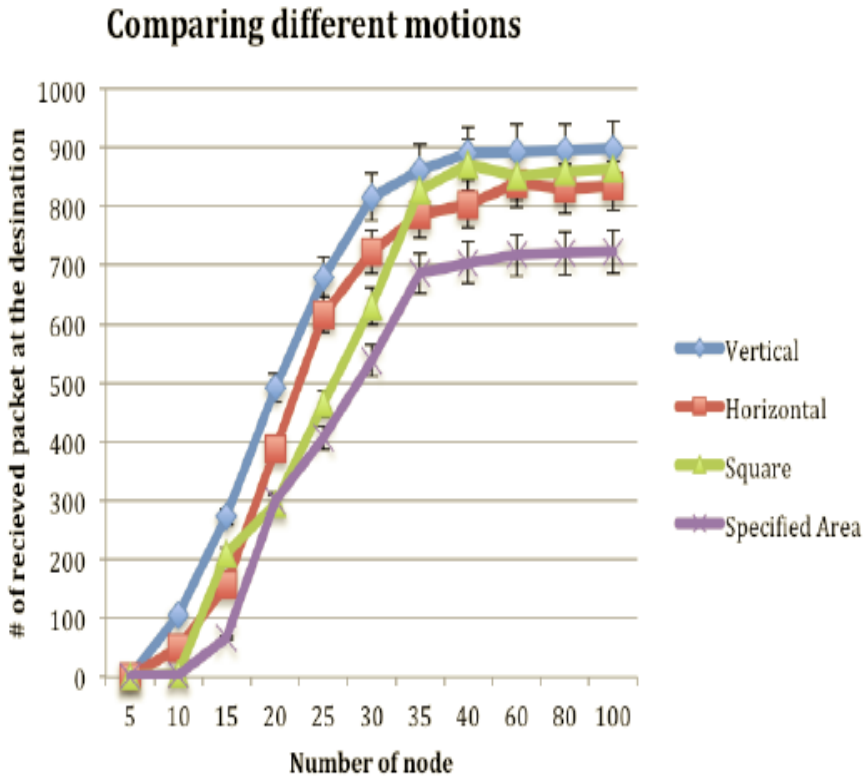


Figure 3. Horizontal motion.

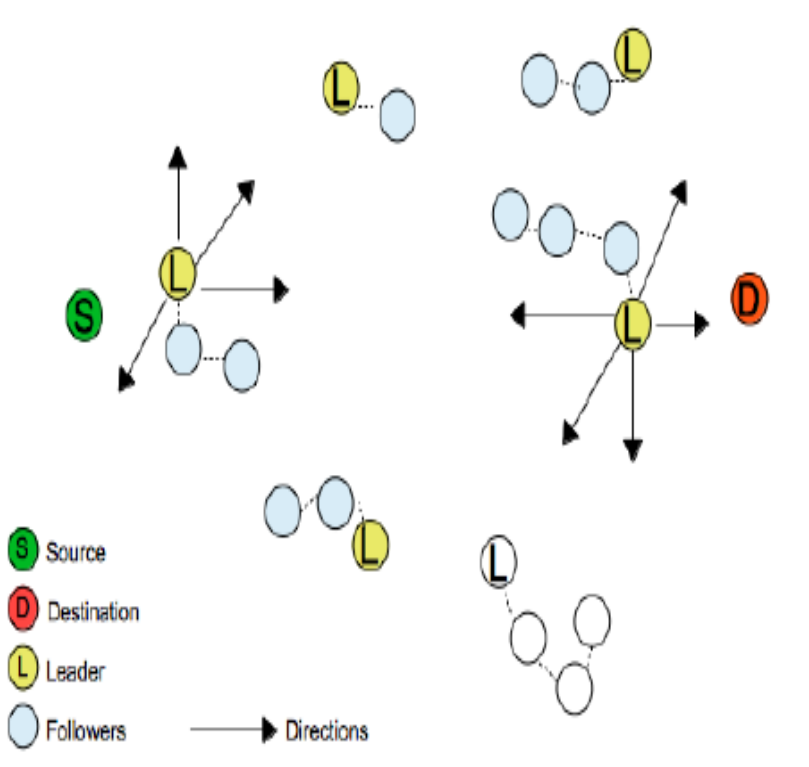


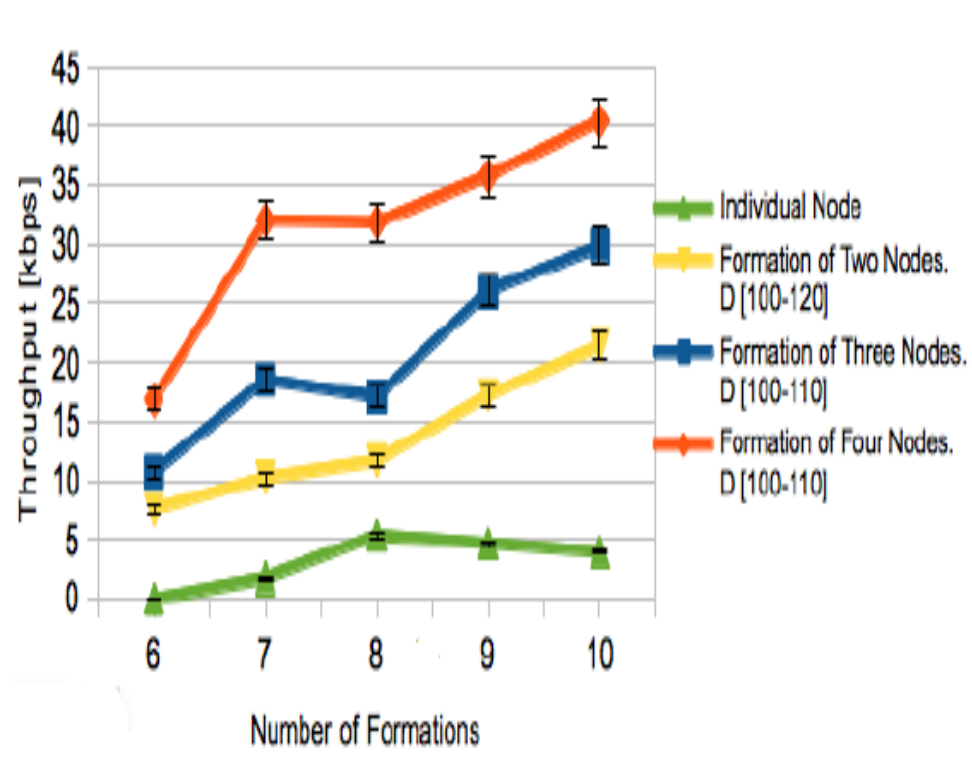
Nodes move along predefined paths

Mohammed Alzaylaee, J. DeDourek and P. Pochec, " Linear Node Movement Patterns in MANETS", The Ninth International Conference on Wireless and Mobile Communications ICWMC 2013, Nice, France, pp. 162-166, July 21-26, 2013.

Mobile Medium deployment considerations

- Maintaining adequate node density for successful communication
  - > move nodes in groups (formations)



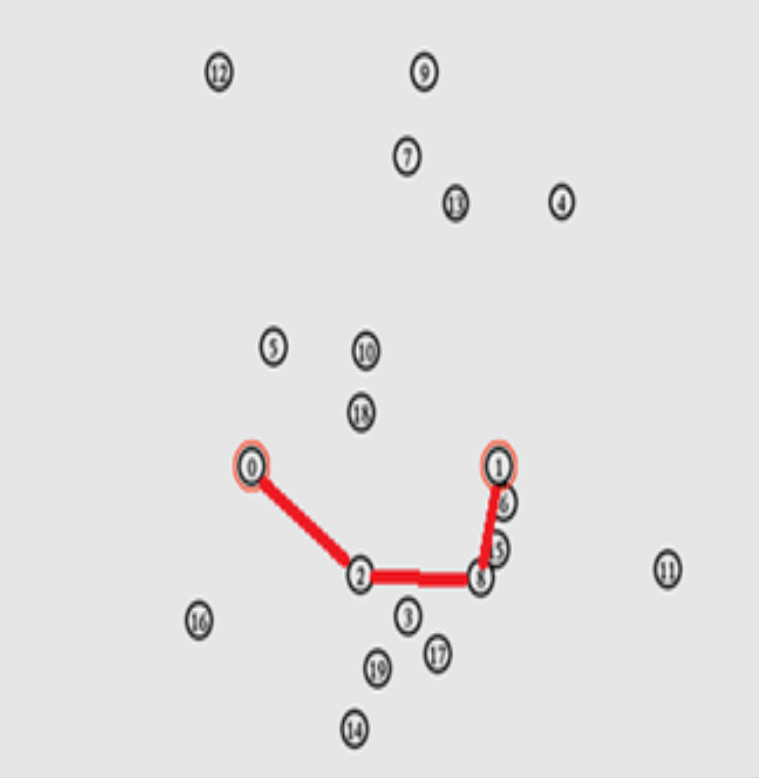


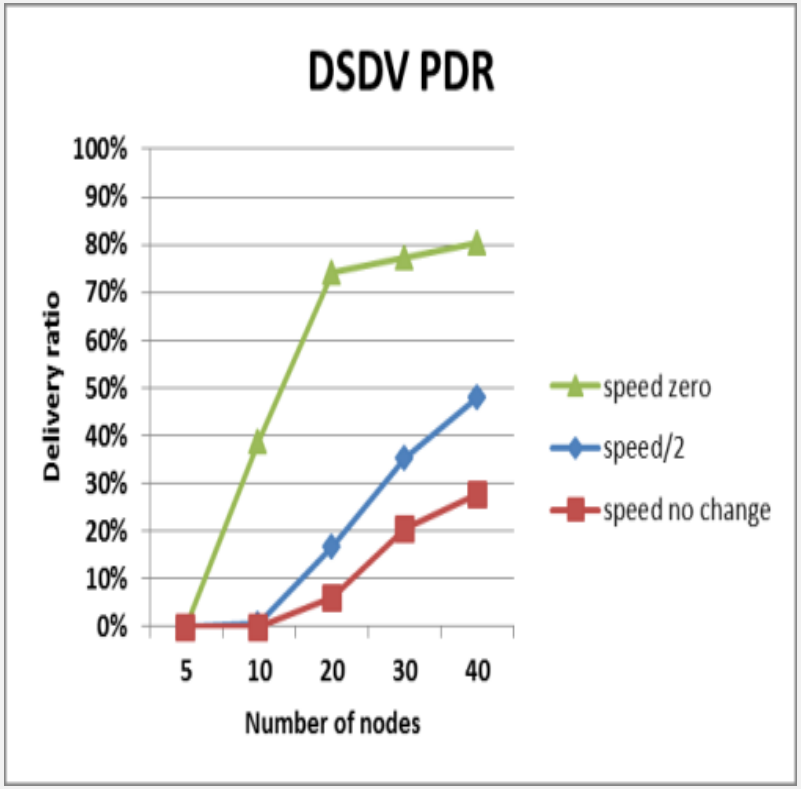
Nodes move in formations

Abdullah Alshehri, J. DeDourek and P. Pochec, " The Advantage of Moving Nodes in Formations in MANETs and M2ANETs", The Ninth International Conference on Wireless and Mobile Communications ICWMC 2013, Nice, France, pp. 228-232, July 21-26, 2013.

Mobile Medium deployment considerations

- Maintaining adequate node density for successful communication
  - > slow down the nodes when they are actively forwarding data (i.e. are on the routing path)



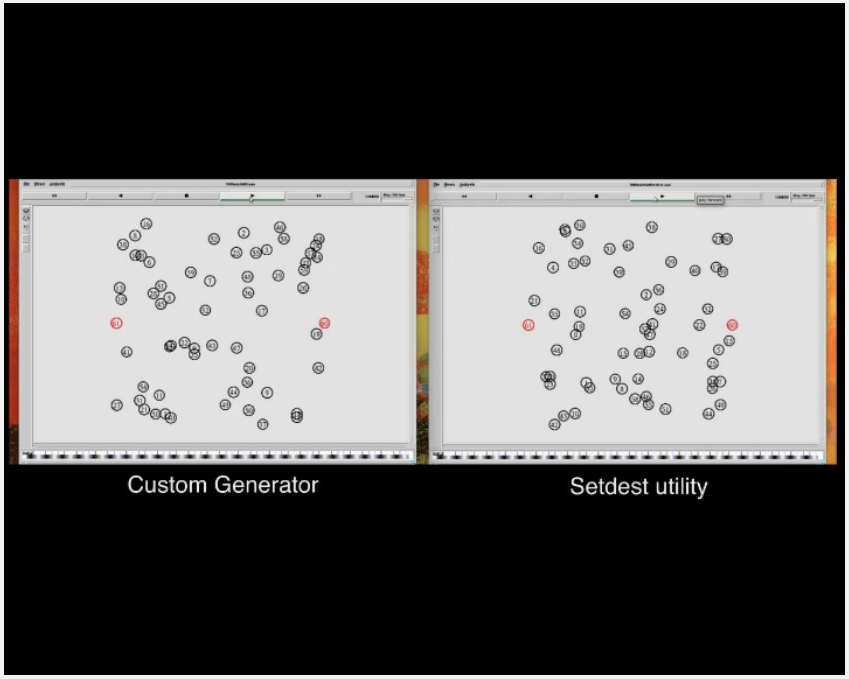


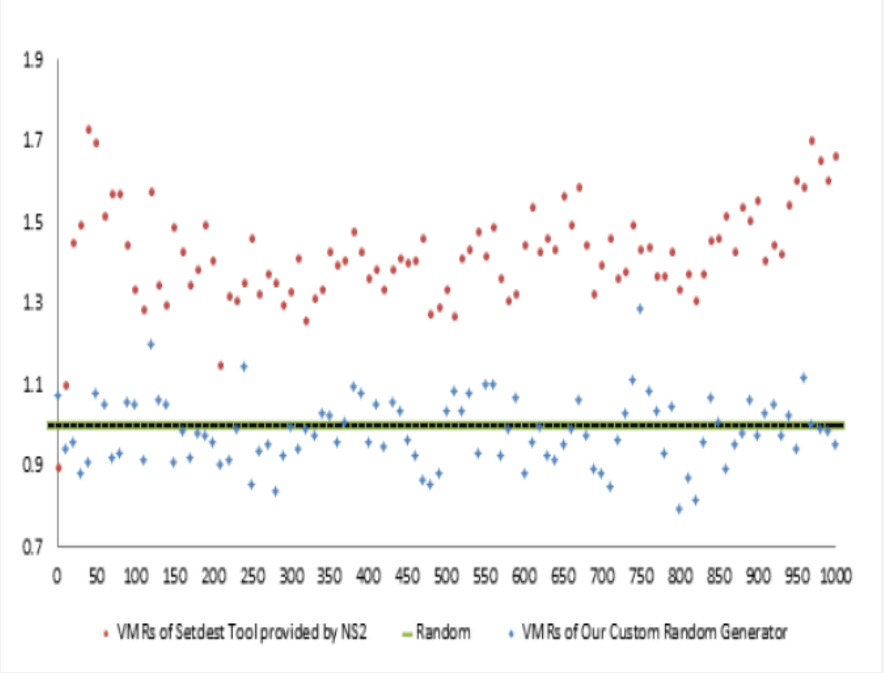
Nodes slow down when in range

Hanin Almutairi, J. DeDourek and P. Pochec, "Dynamic Node Movement Control in a Mobile Medium Ad hoc Network", The Seventh International Conference on Emerging Networks and Systems Intelligence, EMERGING 2015, July 19 - 24, 2015 - Nice, France

Mobile Medium simulation

- Maintaining uniform node density during simulation
  - > reduction of border effect in random node movement generation





Quadrats Count measure (VMR shown) for two random movement generators (100 runs)

Note: Variance to Mean Ratio for Poisson distribution:
VMR = 1

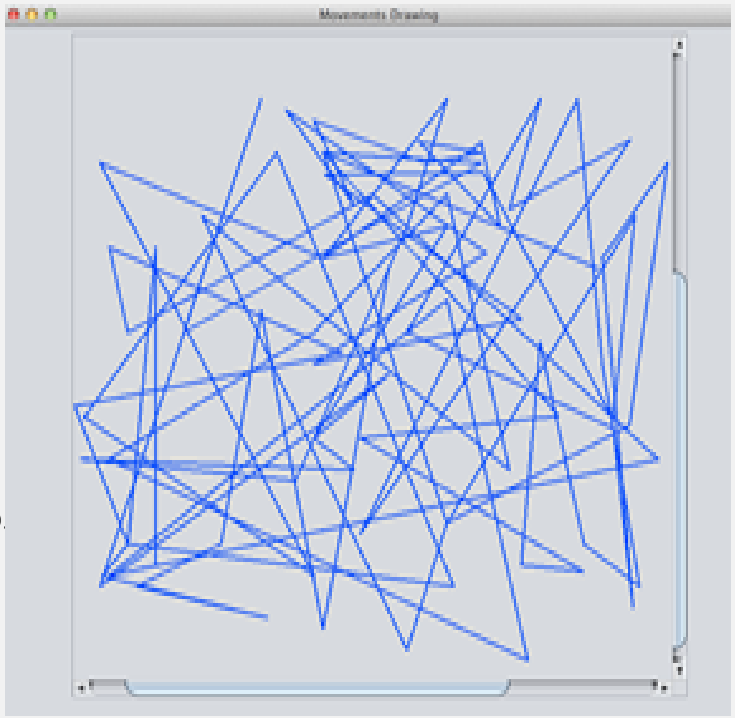
Raid Alghamdi, J. DeDourek and P. Pochec, "Avoiding Border Effect in Mobile Network Simulation", The Twelfth International Conference on Networks ICN 2013, Seville,

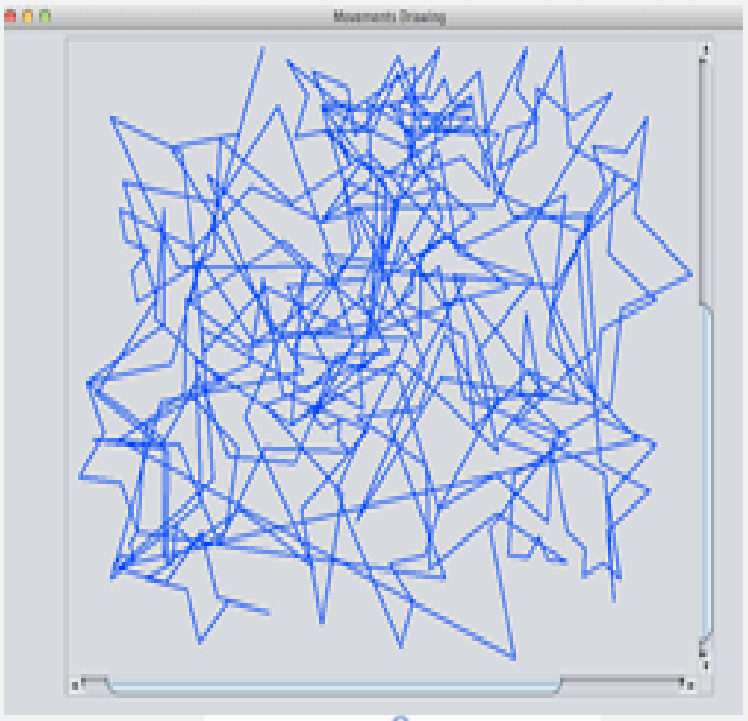
Spain, pp. 184-189, Jan 27 - Feb 1, 2013.

Mobile Medium simulation

- Processing node movement data sets
  - > replacing straight lines with curves (fractal)

D



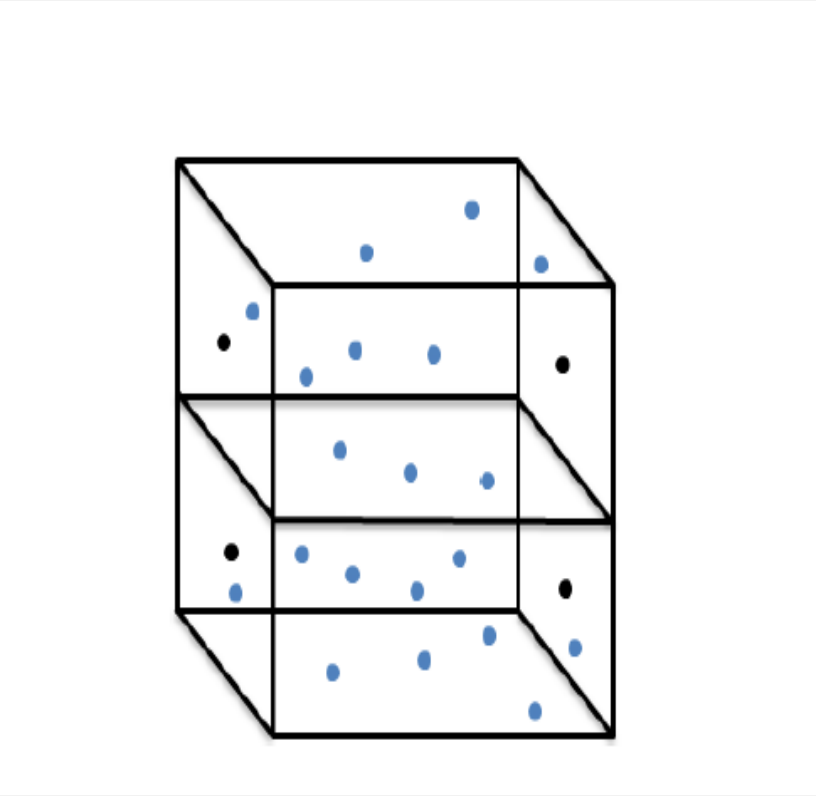


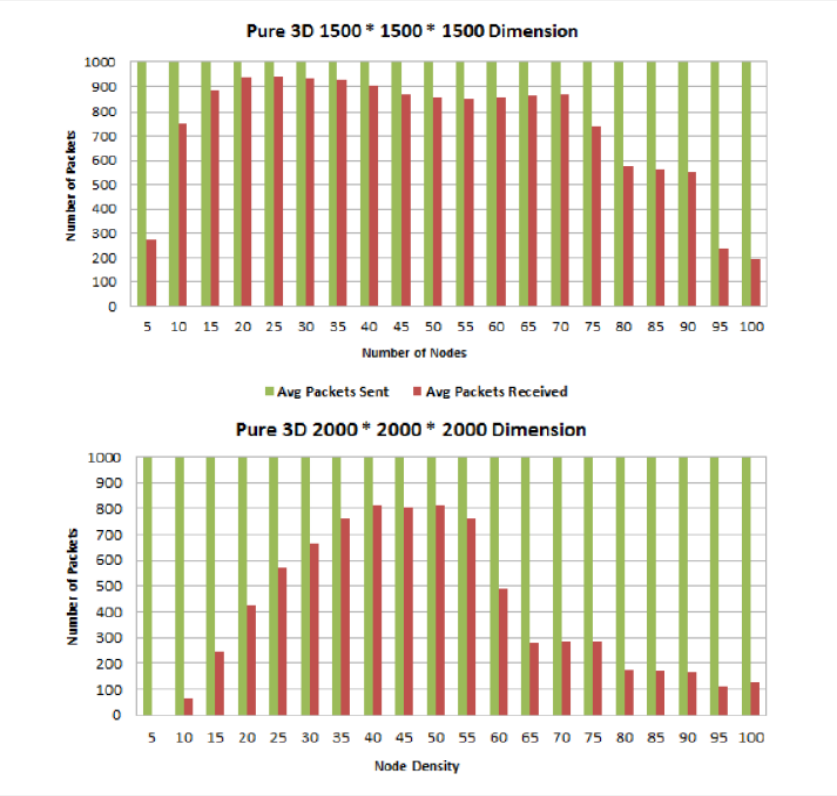
Straight lines (movement) replaced with fractal curves

Hawra Alseef, J. DeDourek and P. Pochec, "A Method for Custom Movement Generation in Wireless Mobile Network Simulation", The Fifth International Conference on Mobile Services, Resources, and Users, MOBILITY 2015, June 21 - 26, 2015 - Brussels, Belgium.

Mobile Medium simulation

- **Modelling M2ANETs in 3D**
  - **> modifications to ns2 simulator (open source)**





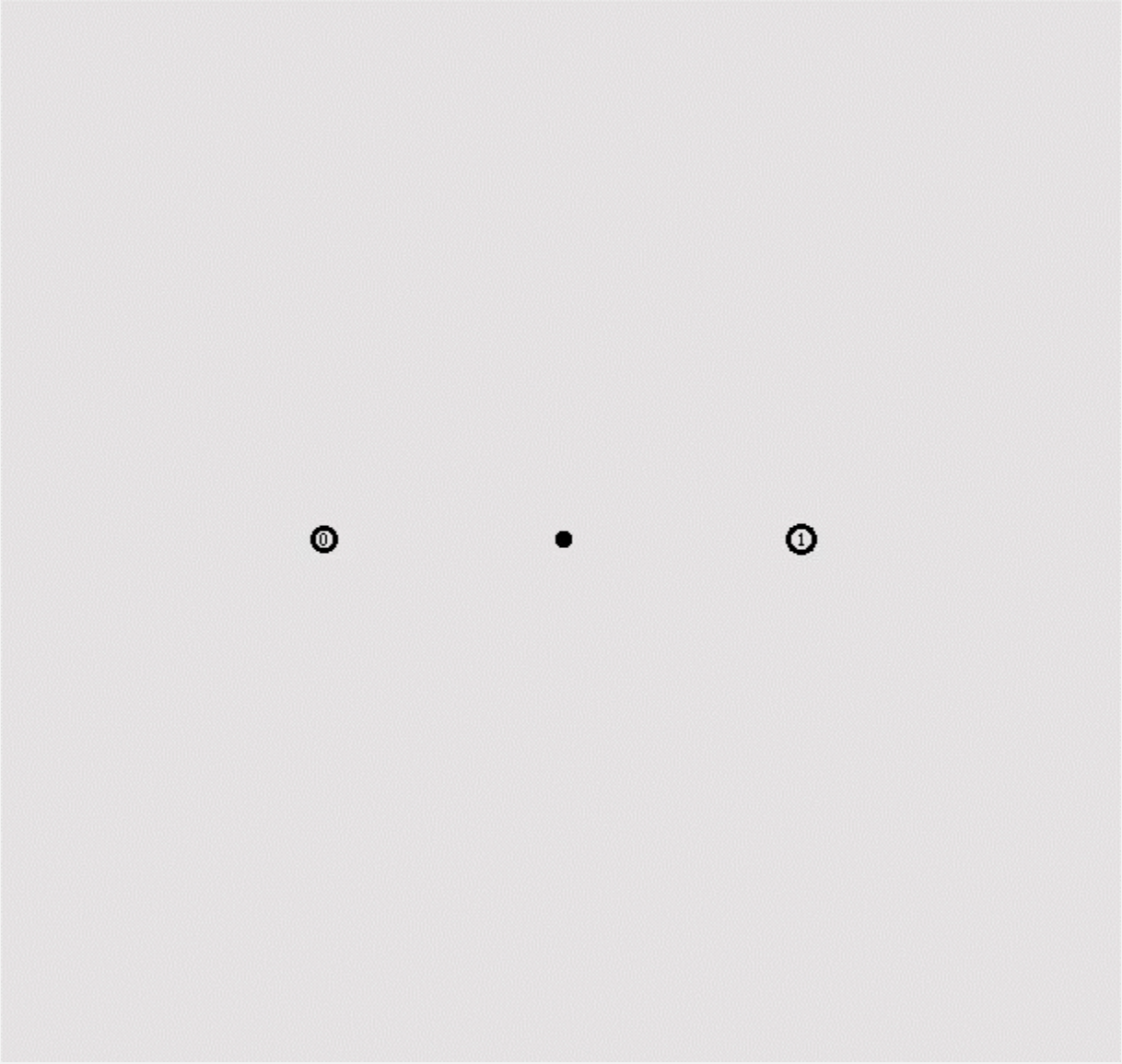
Modelling Mobile Medium in 3D

Nasir Mahmood, J. DeDourek and Przemyslaw Pochec, "M2ANET simulation in 3D in ns2", The Sixth International Conference on Advances in System Simulation SIMUL 2014, October 12 - 16, 2014 - Nice, France.

Conclusion

- New model of a communication system based on Mobile Medium developed
- Improvements to simulation environment made
- Sample Mobile Medium configurations investigated
  - Higher node density and positioning of nodes in areas of high demand improve performance of a communication system based on Mobile Medium.
- Mobile Medium could form the basis of future infrastructureless networks.

Final word ...



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