On Mass-Spring System Implementation in Cluster-Based MANETs for Natural Disaster Applications

Francisco Balart-Sanchez, Luis F. Gutiérrez and Francisco Cervantes

Western Institute of Technology and Higher Education
Department of Electronics, Systems, and Informatics

October 2020

- **Presenter**: M.Sc. Francisco E. Balart-Sanchez.
- **email:** franciscobalart@iteso.mx
- **About**: Ph.D. Student at the Western Institute of Technology and Higher Education (ITESO). Received the B.S. in Electronics and Communications and M.S. in Electronic Systems at Monterrey Institute of Technology and Higher Education. Recipient of the Academic Excellence Scholarship from the Western Institute of Technology and Higher Education. Published 1 conference article [1]. Author have worked at Motorola, Intel, Oracle and currently working as Quality Assurance Engineer at Amazon and research assistant at ITESO.

Content I

Motivation

- Survivors have a large chance of survival if they are rescued within the initial 72 hours [2].

Motivation

- Survivors have a large chance of survival if they are rescued within the initial 72 hours [2].
- Communication systems are usually down after a catastrophe.
  - Mobile Communications, Wi-Fi access points.

Motivation

- Survivors have a large chance of survival if they are rescued within the initial 72 hours [2].
- Communication systems are usually down after a catastrophe.
  - Mobile Communications, Wi-Fi access points.
- The advantage of wireless Mobile Ad-hoc Networks (MANETs) have yielded a new range of applications [3,4,5,6,7,8,9], including rescue operations.

Mobile Ad-hoc Networks (MANETs)

What to think when talking about MANETs?

- **Network type**: Structureless, non-centralized.
- **Communication**: Wireless links.
- **Devices**: Laptops, drones, smartphones, etc.

Figure: 1. MANETs applications.

Mobile Ad-hoc Networks (MANETs)

Main Characteristics

- Energy constrained.
- Can be Mobile.
- Self-organized.
- Dynamic Topology.

Figure: 2. MANETs.

Mobile Ad-hoc Networks (MANETs)

Main Characteristics

- Energy constrained.
- Can be Mobile.
- Self-organized.
- Dynamic Topology.

Backbone on MANETs

- Efficient communication.
- Topology management.

Figure: 2. MANETs.

Energy-Efficient Self-Organized Algorithm

Energy-Efficient Self Organized Algorithm (EESOA) [1].

- Cluster-based algorithm.
- Constructs and maintain a virtual backbone.

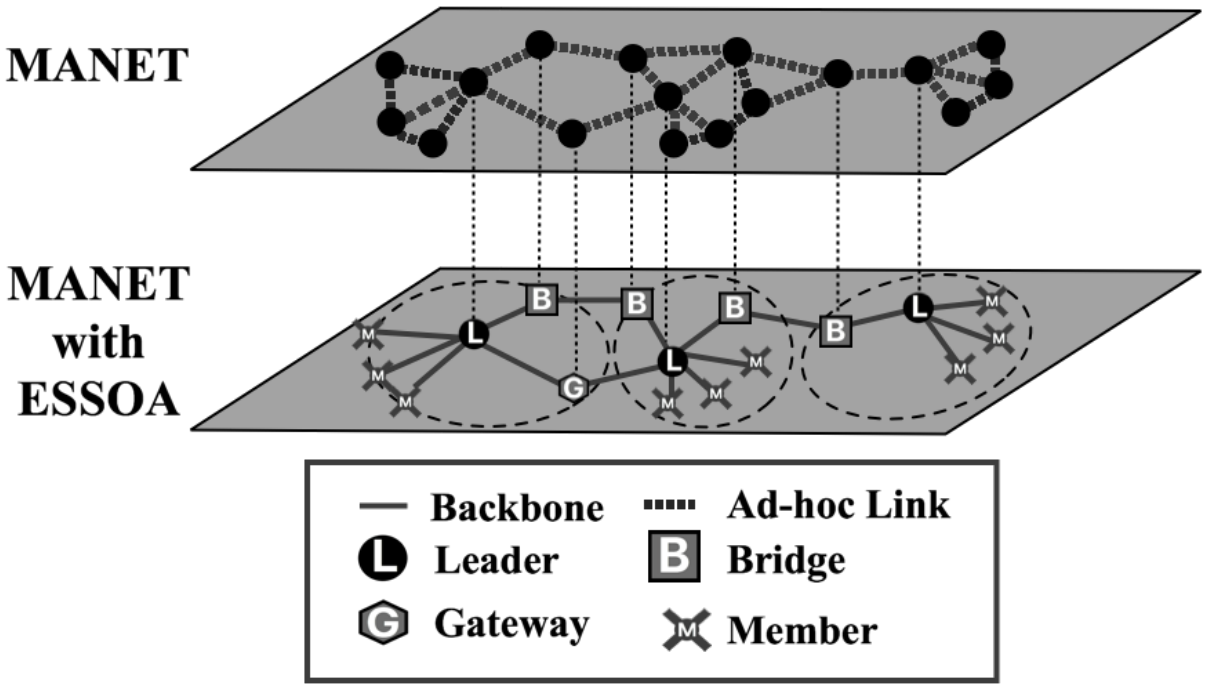


Figure: 3. MANET EESOA backbone

Energy-Efficient Self Organized Algorithm (EESOA)

- Nodes gather information from neighbors within one-hop.
- 4-Hierarchies: Leader, Gateway, Bridge and Member.
- Node with more neighbors and residual energy: Leader role.
  - Inhibit neighbors with broadcast messages.
- Node inhibited by a single Leader: Member role.
- Node inhibited by more than one Leader: Gateway role.

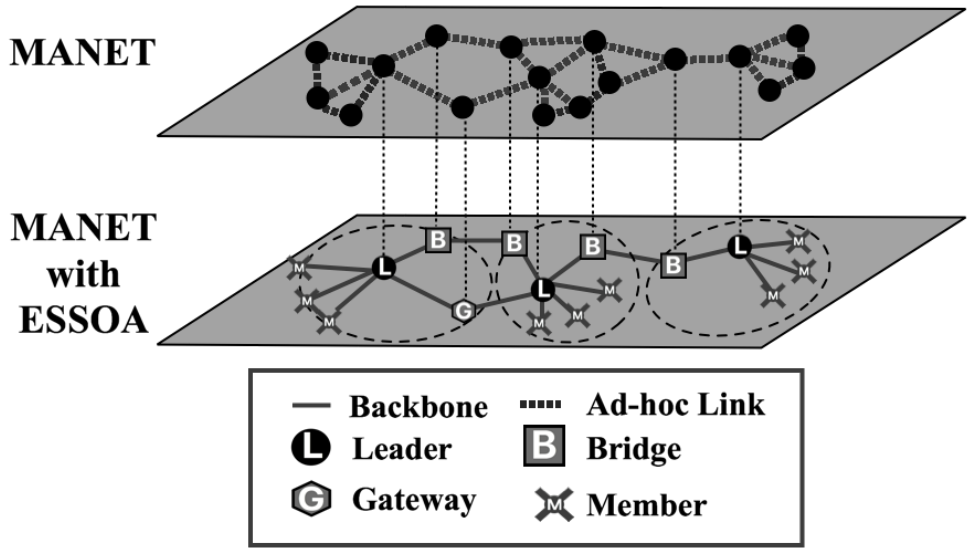
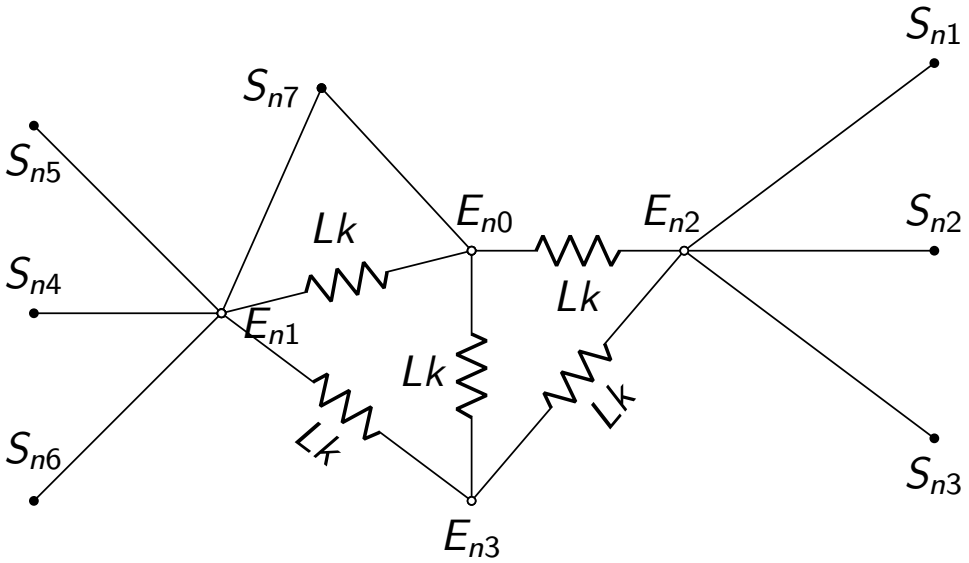


Figure: 4. MANET EESOA backbone.

Mass Spring Model

- Mass-Spring Force for node u with minimum distance L:

$$F_u = \sum_i \left[k_i(|x_i - x_u| - L_i) \frac{x_i - x_u}{|x_i - x_u|} \right], \quad i \neq u \tag{1}$$



k: Mass-spring constants
o: EESOA nodes (E_{ni}) •: Survivor Nodes (S_{ni})

Figure: 5. Mass-spring model between nodes.

Results

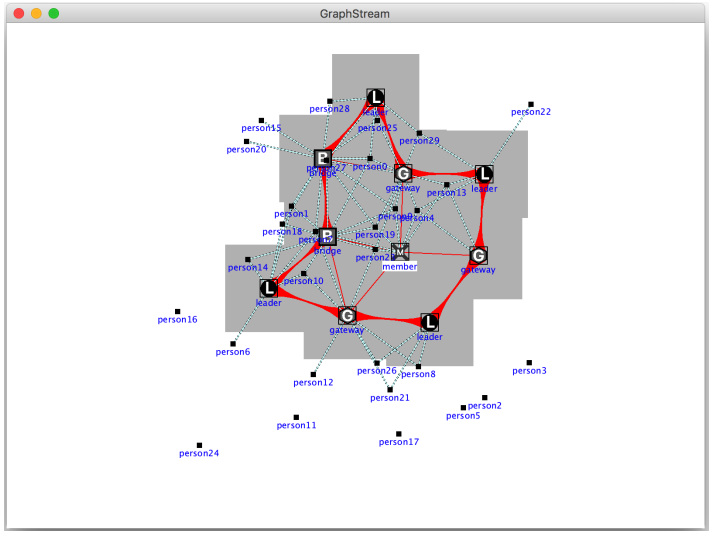


Figure: 6. Dense MANET with Spread survivors deployment.

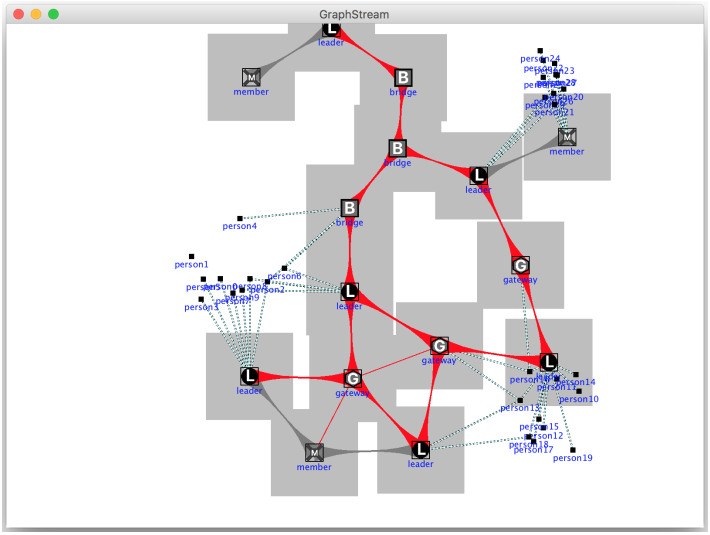


Figure: 7. Dense MANET with Dense survivors deployments.

Results

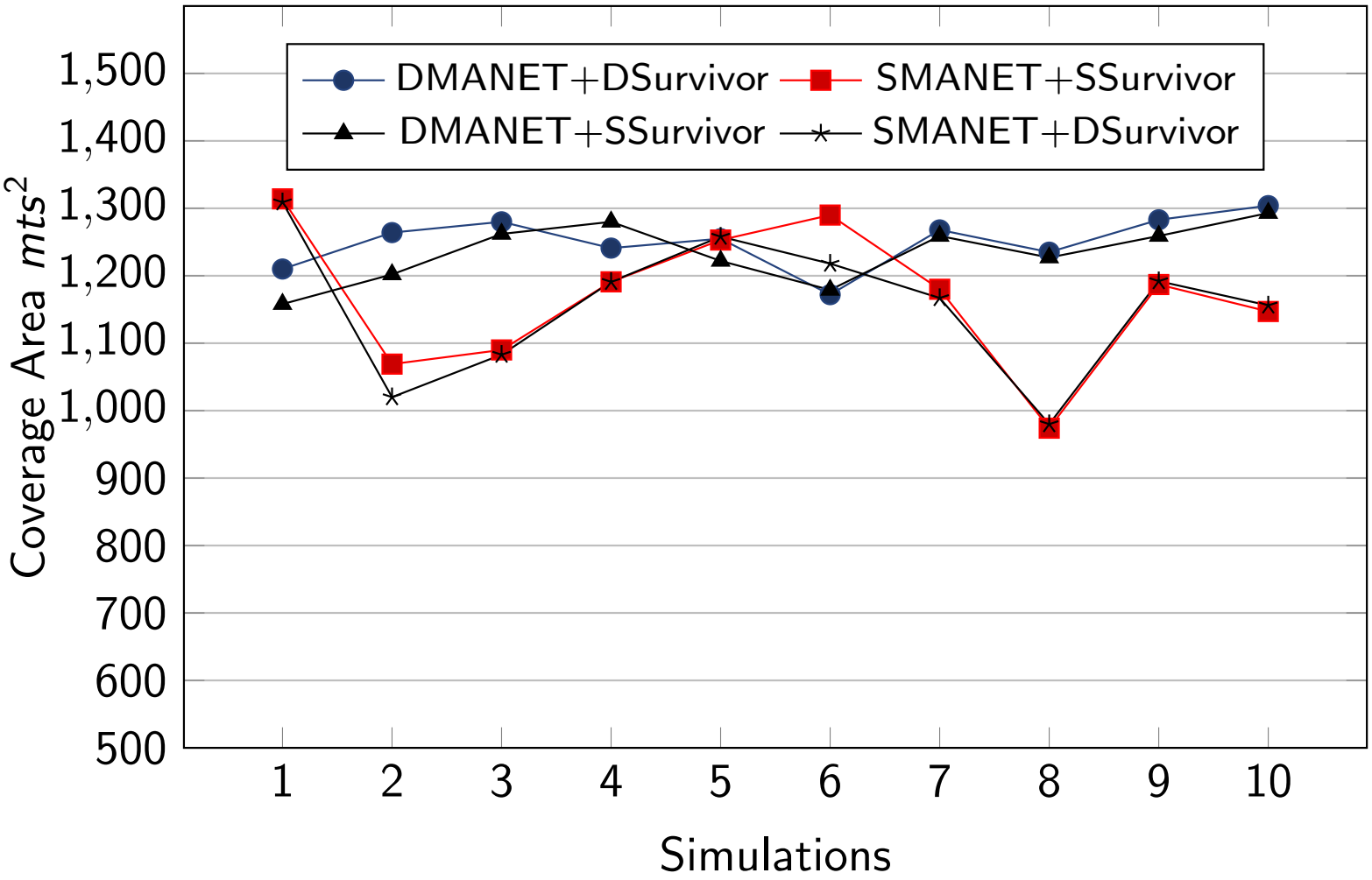


Figure: 8. MANET & Survivors scenarios Area comparison.

Results

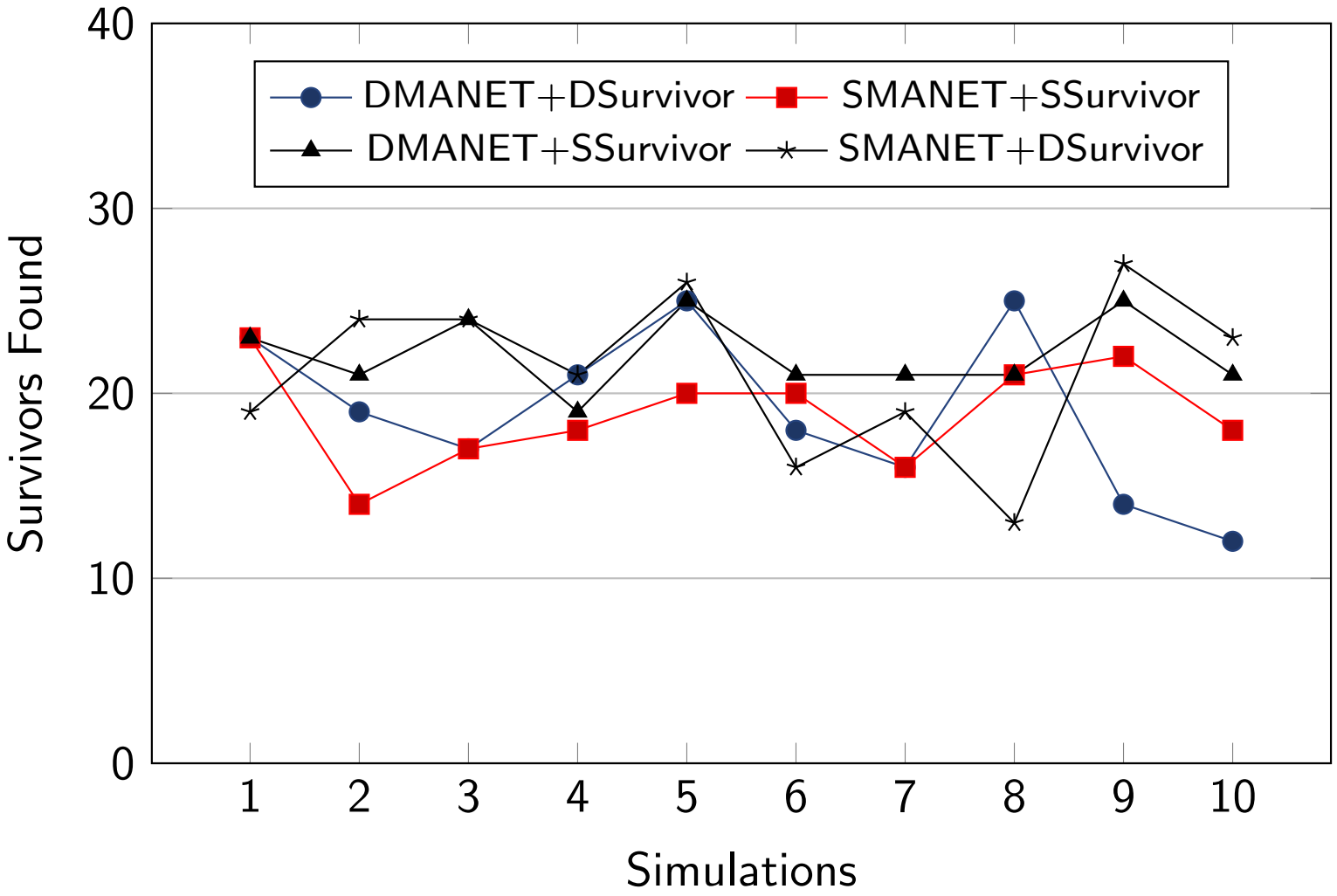


Figure: 9. MANET & Survivors scenarios: Survivors comparison.

Conclusions

- Configurations with a Dense MANET deployment shown better performance for coverage area and survivors found.
  - With an average of 82% of ideal coverage area.
  - With an 28% increase from initial state.

Conclusions

- Configurations with a Dense MANET deployment shown better performance for coverage area and survivors found.
  - With an average of 82% of ideal coverage area.
  - With an 28% increase from initial state.
- Mass-spring implementation trade-offs

Conclusions

- Configurations with a Dense MANET deployment shown better performance for coverage area and survivors found.
  - With an average of 82% of ideal coverage area.
  - With an 28% increase from initial state.
- Mass-spring implementation trade-offs
  - Ensures a connected network.

Conclusions

- Configurations with a Dense MANET deployment shown better performance for coverage area and survivors found.
  - With an average of 82% of ideal coverage area.
  - With an 28% increase from initial state.
- Mass-spring implementation trade-offs
  - Ensures a connected network.
  - Limits the coverage area.

Conclusions

- Configurations with a Dense MANET deployment shown better performance for coverage area and survivors found.
  - With an average of 82% of ideal coverage area.
  - With an 28% increase from initial state.
- Mass-spring implementation trade-offs
  - Ensures a connected network.
  - Limits the coverage area.

ITESO

Thank You !

ITESO

References I

F. E. Balart-Sanchez, L. F. Gutierrez-Preciado, and J. G. Olascuaga-Cabrera, "Minimizing routing broadcast and packet loss in wireless ad-hoc networks with a cluster-based self-organized algorithm as mac protocol," in *2019 IEEE 9th Annual Computing and Communication Workshop and Conference (CCWC)*, Las Vegas, NV, USA, Jan 2019, pp. 0499–0505.

N. Islam and G. S. Shaikh, "Towards a disaster response system based on cognitive radio ad hoc networks," in *Proceedings of Second International, Conference on Next Generation Computing and Communication Technologies (ICNGCCT 2015)*, UAE, 2015.

N. Kumar, A. Agrawal, and R. Ahmad Khan, "Emergency alert networks for disaster management: Applications perspective," in *2018 International Conference on Research in Intelligent and Computing in Engineering (RICE)*, El Salvador, Aug 2018, pp. 1–5.

References II

B. Ojetunde, N. Shibata, and J. Gao, "Secure payment system utilizing manet for disaster areas," *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, vol. 49, no. 12, pp. 2651–2663, Dec 2019.

J. A. L. Calvo, G. Alirezaei, and R. Mathar, "Wireless powering of drone-based manets for disaster zones," in *2017 IEEE International Conference on Wireless for Space and Extreme Environments (WiSEE)*, Montreal, QC, Canada, Oct 2017, pp. 98–103.

H. Verma and N. Chauhan, "Manet based emergency communication system for natural disasters," in *International Conference on Computing, Communication Automation*, Noida, India, May 2015, pp. 480–485.

References III

N. Aschenbruck, M. Frank, P. Martini, and J. Tolle, "Human mobility in manet disaster area simulation - a realistic approach," in *29th Annual IEEE International Conference on Local Computer Networks*, Nov 2004, pp. 668–675.

H.-C. Jang, Y.-N. Lien, and T.-C. Tsai, "Rescue information system for earthquake disasters based on manet emergency communication platform," in *Proceedings of the 2009 International Conference on Wireless Communications and Mobile Computing (IWCMC 2009)*. New York, NY, USA: ACM, Jun 2009, pp. 623–627.

M. Deruyck, J. Wyckmans, W. Joseph, and L. Martens, "Designing UAV-aided emergency networks for large-scale disaster scenarios," *EURASIP Journal on Wireless Communications and Networking*, vol. 2018, no. 1, p. 79, Apr. 2018.

References IV: Images

- **Cellphones Manet**
  - Link
- **Bridgefy Mobile picture**
  - Link
- **Bridgefy logo**
  - Link
- **Firechat:**
  - Link