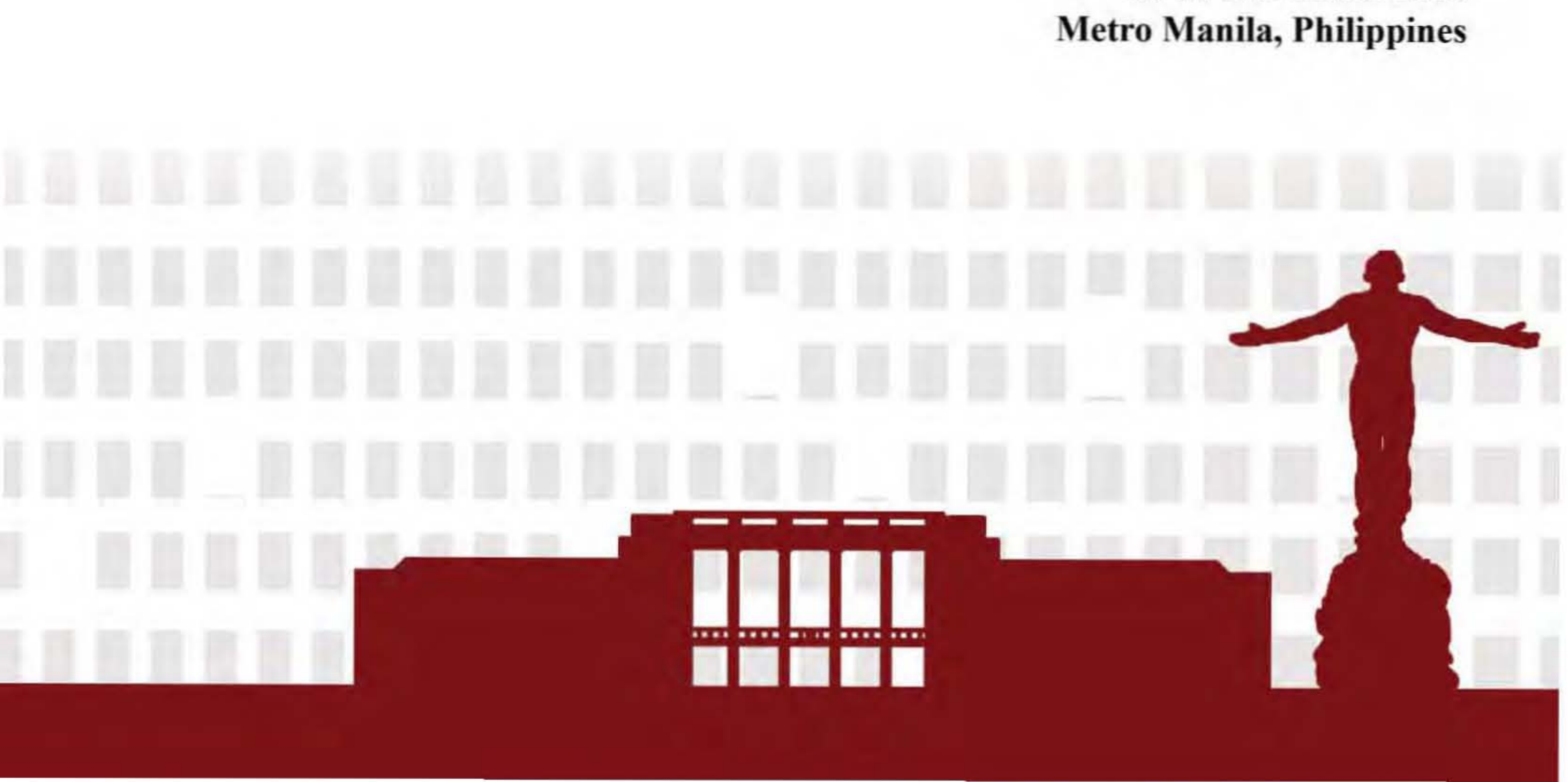
AUN/SEED-Net

8th AUN/SEED-Net
REGIONAL CONFERENCE ON ELECTRICAL AND ELECTRONICS ENGINEERING
Envision, Enable, and Empower
Smarter and Resilient Societies

co-located with

11th ERDT Conference
on Semiconductor and Electronics, Information and Communications Technology and Energy

16-17 November 2015
Metro Manila, Philippines



Proceedings of the 8th AUN/SEED-Net RCEEE 2015 and 11th ERDT Conference on Semiconductor and Electronics, Information and Communications Technology, and Energy

Editors:
Dr. Joel Joseph S. Marciano Jr.
Dr. Jhoanna Rhodette I. Pedrasa
Dr. Rhandley D. Cajote

ISBN: 978-616-406-075-3

Published by: ASEAN University Network / Southeast Asia Engineering Education Development Network (AUN/SEED-Net) JICA Project
Faculty of Engineering, Bldg. 2
Chulalongkorn University, Bangkok
Thailand 10330

Printed in the Philippines by: ERZALAN PRINTING PRESS
45 Cotabato Street, Luzviminda Village, Batasan Hills, Quezon City, Philippines

8th AUN/SEED-Net Regional Conference
on Electrical and Electronics Engineering 2015

co-located with

11th ERDT Conference
on Semiconductor and Electronics, Information and Communications Technology, and Energy

Envision, Enable and Empower Smarter and Resilient Societies

Published by: ASEAN University Network / Southeast Asia Engineering Education Development Network (AUN/SEED-Net) in partnership with Engineering Research and Development for Technology (ERDT) and University of the Philippines Diliman.

ISBN: 978-616-406-075-3

COST AND EFFECT OF APPLYING REDUNDANCY TO IMPROVE THE RESILIENCY OF A WIRELESS SENSOR NETWORK (WSN)

Joy Alinda Madamba and Louis Alarcon

Electrical and Electronics Engineering Institute, University of the Philippines Diliman, PHILIPPINES.
E-mail: jpreyes1@up.edu.ph, louis.alarcon@up.edu.ph

ABSTRACT

Wireless sensor networks (WSNs) are an emerging technology that uses small computing elements for an increased contact with the environment, providing more opportunities to reshape interactions between people and computers. With an increasing adoption of these WSNs in critical systems, resiliency has become an important factor when designing these networks. For this research, we define resiliency as the ability of a WSN to continue to operate correctly even in the presence of attacks on the system.

After reviewing existing WSNs and the techniques they employed to introduce resiliency, one inherent feature seen is redundancy. Generally, it's been found that with increasing redundancy a WSN becomes more and more fault-tolerant.1 We focused on applying redundancy on the node and network level as its effect can propagate to the highest levels of WSN abstraction. Also, the cost of applying redundancy can be clearly seen in the energy consumption of a WSN and would thus have a large impact on how the design goals of network lifetime, sensing reliability and sensing & communication coverage can be met.2 How then do we incorporate these redundancy techniques into WSN design while taking into consideration its energy cost and effects?

Energy-saving techniques in WSN are normally applied to the network and sensing subsystem as these consume the most energy.3 Thus, for the first part of the research, we looked into the energy cost and effect of redundancy on communications. To determine this, we first created a basic model of a WSN, which is a single node and a sink. After classifying the types of redundancy techniques (physical and temporal), we applied them on the basic model and on different networks (line and tree, see Figure 1) to look at the cost in terms of energy consumption. This was computed based on the number of transmissions needed for all the nodes to send its data to the sink, or one network cycle. For the basic node, the energy cost was the same for all types of redundancy. Then, we applied physical redundancy on the line and tree networks. For the line networks, we found that placing a redundant node with its input farthest from the sink node and its output directly to the sink node will result to the least additional energy cost. For the tree network, placing a redundant node with its input from a leaf node and its output directly to the sink node will result to the least additional energy cost. These results are shown in Table 1.

The next part of the research is to determine the effects of applying redundancy. We first defined attack resiliency as the ability of the WSN to handle three types of attacks, namely external, internal and energy loss. We then determined which of the redundancy techniques could withstand the most number of attacks using the basic model. The result was having an additional node and a redundant sink would help the model handle most attacks. For the line and tree networks, we needed to determine where the additional node would be placed for the network to send the most number of transmissions if an attack takes place. This is done by determining how many nodes will be able to send their data to the sink when a node is attacked. Both networks show that the critical node that needs redundancy is the node found nearest to the sink or the node with the most number of connections downline. However, based on the results of cost, these would lead to a higher amount of energy consumption.

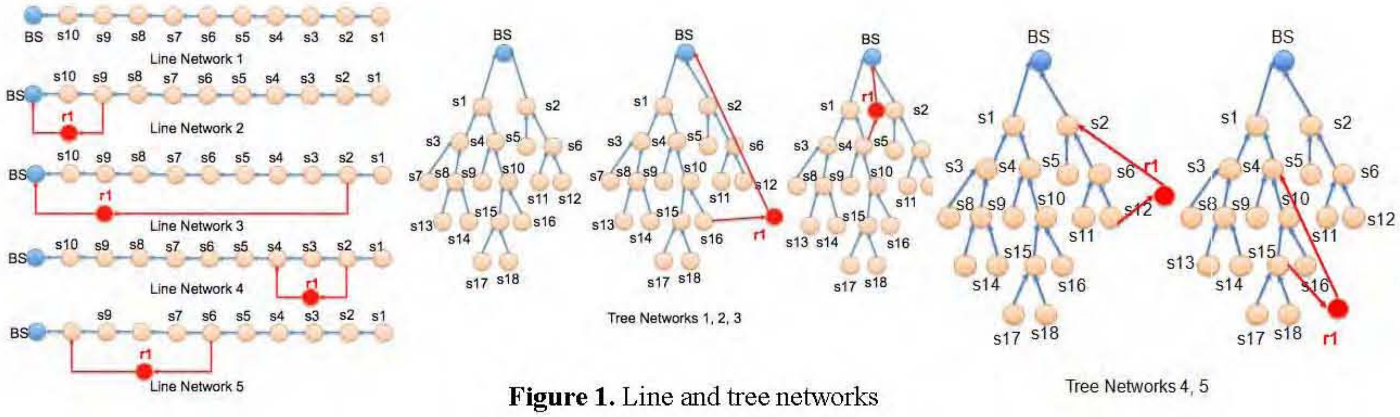


Figure 1. Line and tree networks

	Line Networks					Tree Networks				
	1	2	3	4	5	1	2	3	4	5
Energy Cost	100	119	105	143	127	90	93	105	97	113
Attack Resiliency	45	54	61	47	69	270	271	277	271	273

Table 1. Energy costs and attack resiliency of line and tree networks

In conclusion, using redundancy on a WSN to handle attacks introduces additional energy cost. The placement of redundant nodes near the sink can improve the chances of data from other nodes to be received, as seen in the attack resiliency. However, the network will use more energy even if an attack does not occur. Thus, we need to determine how to balance these two if a WSN is constrained in terms of energy resources. Also, the energy cost and effect of redundancy on the sensing subsystem must be investigated as this could introduce more issues. A methodology that would include the overall cost and effect of redundancy when designing would then help in achieving a resilient WSN.

Keywords: Wireless sensor networks (WSN), resiliency, redundancy.

Acknowledgment
The authors would like to express appreciation for the support of the Engineering Research and Development for Technology (ERDT), the Department of Science and Technology (DOST), UP Diliman and the EEEI.

References
[1] Curiac, et.al., "Redundancy and Its Applications in Wireless Sensor Networks: A Survey", *WSEAS Transactions on Computers*, Vol. 8, Issue 4, pp. 705-714, 2009.

[2] Romer, Mattern, "The Design Space of Wireless Sensor Networks", *IEEE Wireless Communications*, Vol. 11, Issue 6, pp. 54-61, 2004.

[3] Anastasi, et.al., "Energy Conservation in Wireless Sensor Networks: A Survey", *Ad Hoc Networks*, Vol. 7, No. 3, pp. 537-568, 2009.