ISOTROPIC MULTI-HOP MODEL FOR WIRELESS SENSOR NETWORKS

Zlatan Ganev

Department of Electrical Engineering, Technical University of Varna, 9010 Varna, Bulgaria,
E-mail: zganev@gmail.com

Sava Savov

Department of Electrical Engineering, Technical University of Varna, 9010 Varna, Bulgaria,
E-mail: sava.savov12@gmail.com

Abstract

This article deals with idealized isotropic model of data transmission. This is a model by which data to base station does not arrive directly, but by the means of multi-hop method. Thus data transmission energy is considerably reduced and network life is prolonged, which is a main task of any designer.

In this article a particular example of multi-hop data transmission is pointed out, as energy model is simulated with Matlab and results visualized with appropriate graphics.

1. INTRODUCTION

Wireless sensor networks (WSN) are networks with a decentralized structure in which information is wirelessly transmitted, mostly through radio or optical connection and there are high expectations for size and lifetime of the nodes. This network types are preferred when building infrastructure is difficult or uneconomic or network is of temporary purpose.

Devices compactness and possibility of rapid deployment of WSN makes them extremely suitable for emergency situations: fires, floods and other natural disasters [1].

The so far given characteristics lead to certain requirements: low power consumption (as it works with limited autonomous power supply); small size of sensor nodes; security and protection of data transmitted.

It is typical for WSN nodes to have a limited scope for data transmission. In most cases, packets of information are transmitted from source to receiver, passing through many intermediate nodes. This method allows for the level of energy used to be reduced, but on the other hand imposes the condition of dynamic routing of transmission [2]

2. ENERGY MODEL

A main challenge in the design of an energy coefficient wireless network is that sending a bit of information through free space directly from node A to node B in curs an energy cost Et, which is a strong function of the distance*d b*etween then odes and can be represented in the follow in g form:

$$Et = \beta \times d^n \qquad (1)$$

with n > 1 as the path-loss exponent (a factor that depends on the RF environment, and is generally between 2 and 5). β is a proportionality constant describing the over head per bit. Given this greater than linear relationship between energy and distance, using several short intermediate hops (Fig. 1) to send a bit is more energy-efficient than us in gone longer hop [3,4,5,6].

This model does not take into account the energy for calculations and for operation of the receiver at each node.

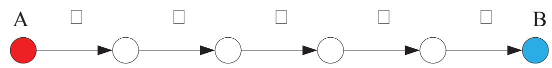

Fig. 1. Multihop networks, using several intermediate nodes to send information

3. RESULTS FROM SIMULATIONS

3.1. Example one

Weas sume that n = 4, which is a common case in indoor environments, and β = 0.2 femtojoules/meter *n*. Than one hop over 50 meters requires 1.25 nanojoules per bit (Fig. 2), where as five hops of 10 meters (Fig. 3), according (1), require only 5 × 2 picojoules per bit [1]. This is graphically shown in Figure 4.

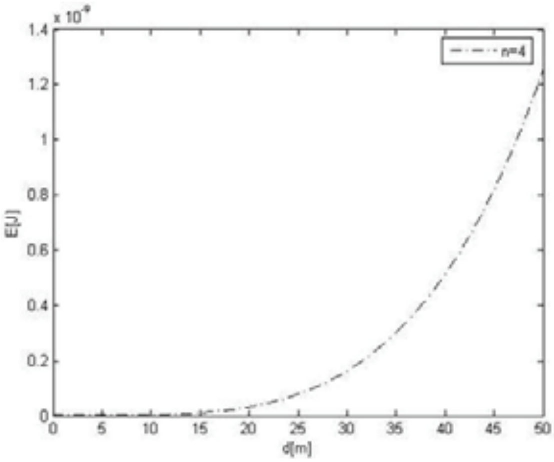

Fig. 2. One hope transmission (n=4,d=50m)

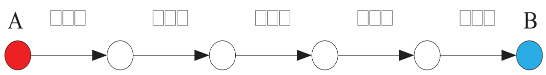

Fig. 3. Multi hop networks, using five intermediate hopes to send information

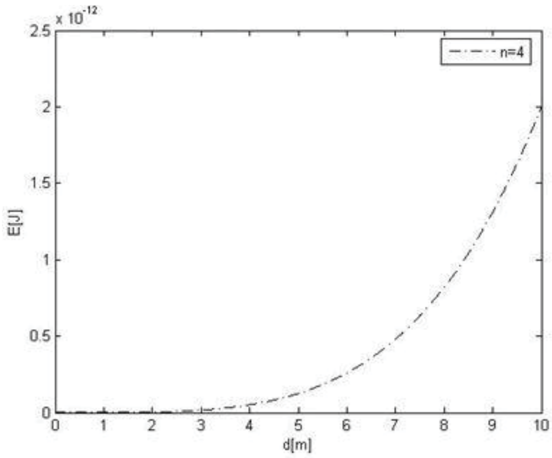

Fig. 4.Multi-hop transmission (n=4,d=10m)

The multi hop approach in this example reduces transmission energy by a factorof125.

3.2. Example two

Now weas sume that n = 4, and β = 0.2 femto-joules/meter *n*. Than one hop over 50 meters requires 1.25 nanojoules per bit (Fig. 2), where as ten hops of 5 meters (Fig. 5) require only 10 × 0.125 picojoules per bit. This is graphically shown in Figure 6.

Fig. 5. Multihop networks, using ten intermediate hopes to send information

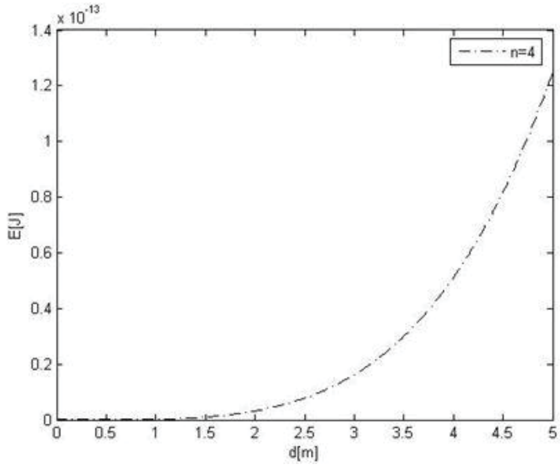

Fig. 6.Multi-hop transmission (n=4,d=5m)

The multi-hop approach in this example reduces transmission energy by a factor of 1000.

3.3. Example three

Now weas sume that n = 4, and β = 0.2 femto-joules/meter *n*. Than one hop over 50 meters requires 1.25 nanojoules per bit (Fig. 2), where as ten hops of 2 meters (Fig. 7) require only 25 × 0.0032 picojoules per bit. This is graphically shown in Figure 8.

Fig. 7. Multihop networks, using ten intermediate hopes to send information

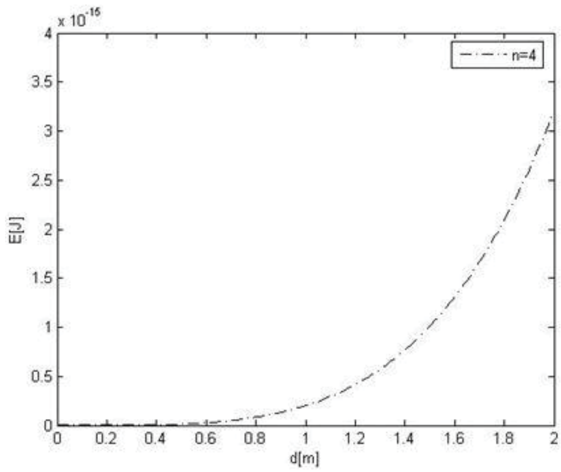

Fig. 8.Multi-hop transmission (n=4,d=2m)

The multihop approach in this example reduces transmission energy by a factor of 15625.

3.3. Example four

Now weas sume that n = 4, and β = 0.2 femtojoules/meter *n*. Than one hop over 50 meters requires 1.25 nanojoules per bit, where as ten hops of 1 meter (Fig. 9), require only 50 × 0.0002 picojoules per bit. This is graphically shown in Figure 10.

Fig. 9. Multihop networks, using ten intermediate hopes to send information

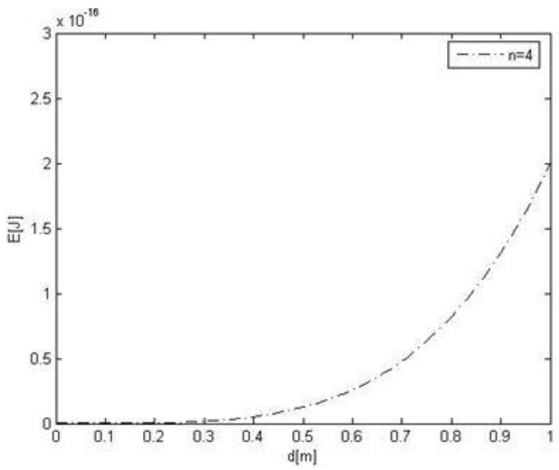

Fig. 10. Multi-hop transmission (n=4,d=1m)

The multihop approach in this example reduces transmission energy by a factor of 125000.

4. CONCLUSION

In this article we present idealized isotropic multi-hop model for wireless sensor networks. This model does not take into account transmission irregularity, shadowing effects and the energy for calculations. It also does not take into consideration the energy for signal amplification in the different nodes, which are used as active repeaters.

The main purpose was to demonstrate that the energy for transmission of information between two nodes (A and B) can be reduced significantly by using a multi-hop route. It is found through simulations in Matlab environment that the energy transmission is highest in the direct transmission (one-hop) and lowest in the multi-hop approach in example four, where we use 50 hopes. The transmission energy there reduces by a factor of 125000.

5. Appendix and acknowledgments

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