LOAD-ADAPTIVE ROUTING ALGORITHM FOR PERFORMANCE IMPROVEMENT

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İZMİR YÜKSEK TEKNOLOJİ ENSTİTÜSÜ İYTE

Abstract

On the way to the Internet of Things (IoT) world, the size and density of wireless end networks are anticipated to grow. Moreover, the carried multimedia traffic is expected to increase. The performance of these large and dense wireless networks, which carry a huge amount of data, is a challenge to be optimized. Previous studies have shown that, the network goodput is affected by the traffic load [1]. This project proposes a load-adaptive routing algorithm that aims to increase the overall network performance. An adaptive, load-aware distributed routing algorithm, which changes the routing decision based on the moving average of the short retry count in a IEEE 802.11g based wireless network is proposed.

Introduction & Background

Multi-hop systems are vastly used and expected to be wide-spread in our daily lives in the future. Wireless networks are used over a vast amount of different areas ranging from home automation networks to urban communication systems.

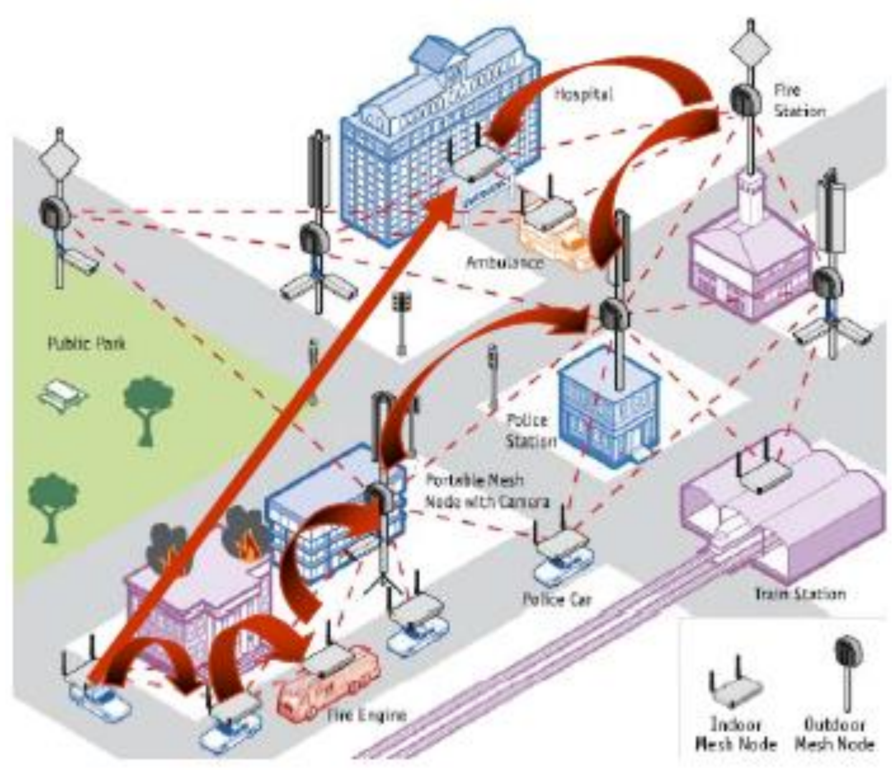

Figure 1. Wireless mesh network for public safety

Two performance metrics are investigated in this study:

1. **Goodput,** is the number of useful bits that is transmitted from source to destination per unit time.
2. **Energy per bit,** is the energy consumed by the whole network for successfully delivering one useful bit to the destination. It is a critical pivot, since it is directly proportional to budget of the system.

Both metrics are a measure of network efficiency in multi-hop systems. We will use both measures for evaluating performance of wireless networks. through simulations results.

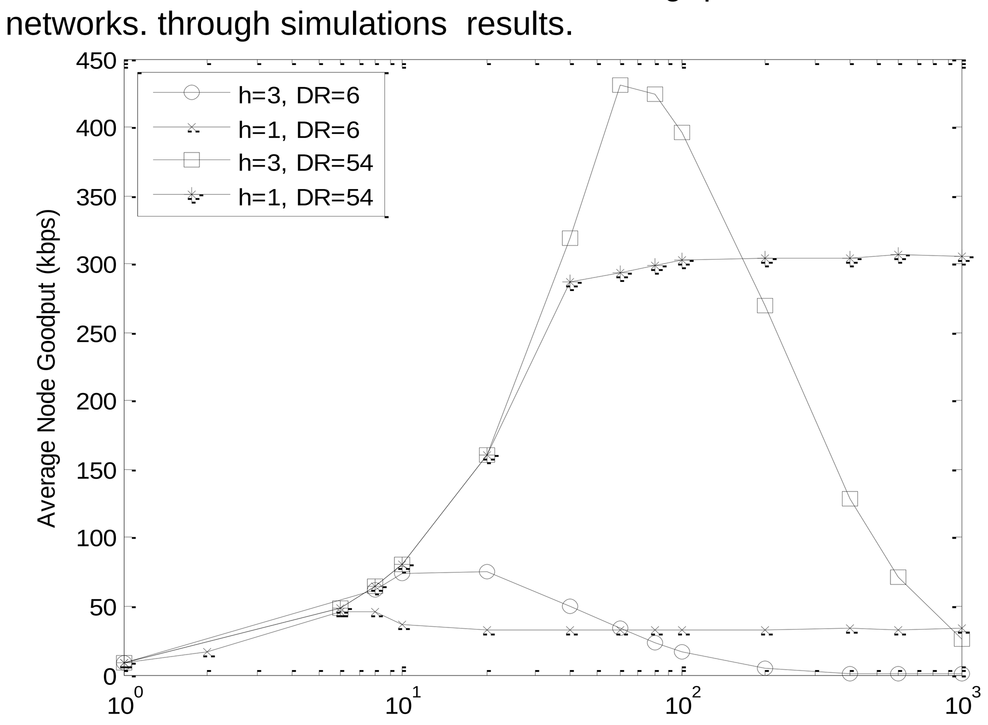

Figure 2. Goodput for Direct and Multi-hop Transmission

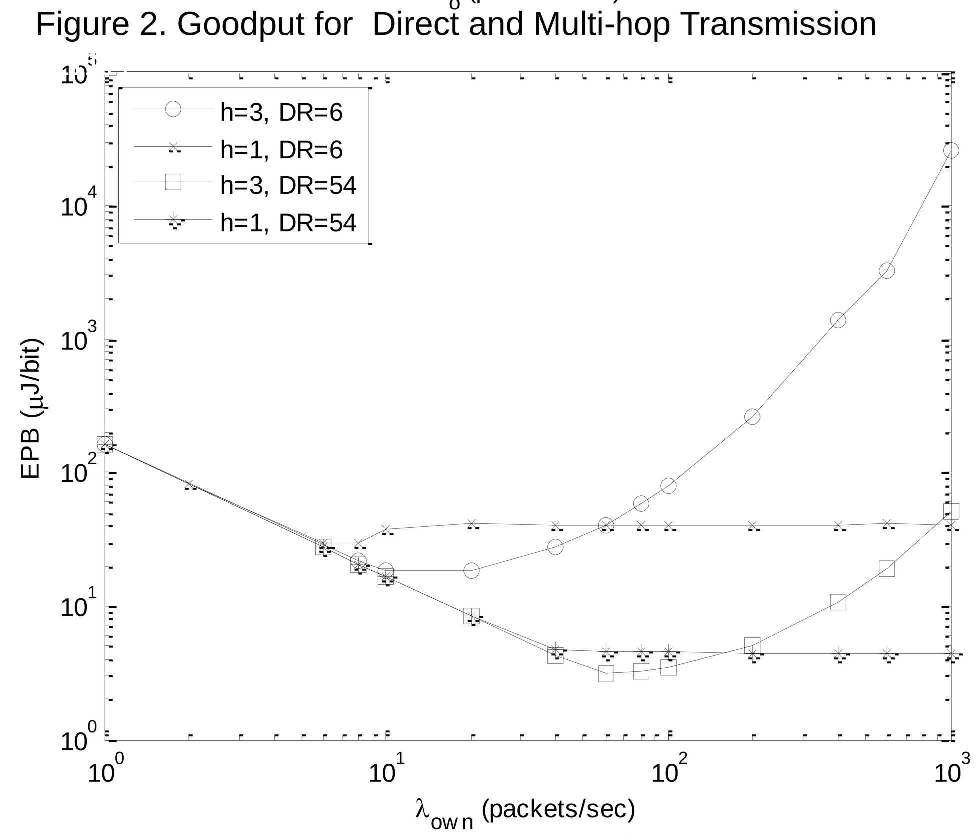

Figure 3. Energy per Bit For Direct and Multi-hop Transmissions

Proposed Routing Algorithm

Pseudo-code for the load-adaptive routing algorithm
1 Start with multi-hop routing
2 for each node i, initialize SRC vector= {0,0,0}
3 if maximum retry limit is reached
4 insert 7 to the SRC vector
5 if RTS transmitted successfully over a link
6 insert the instantaneous SRC
7 Using the SRC vector calculate the 3-point moving average, avgSRC
8 if avgSRC > limit (limit is selected 1 for DR 6Mbps, 0.5 for 54Mbps)
9 switch routing strategy to direct transmission
10 else
11 switch to multi-hop routing strategy

Simulation Settings

- Simulation tool used in the project is ns-2.35 discrete event network simulator.
- The topology of the network for this study has 127 hexagonal placed nodes.
- IEEE 802.11g protocol is used where carrier frequency is 2.472 GHz.
- The topology is simulated under two data rates which are 54Mbps and 6Mbps.

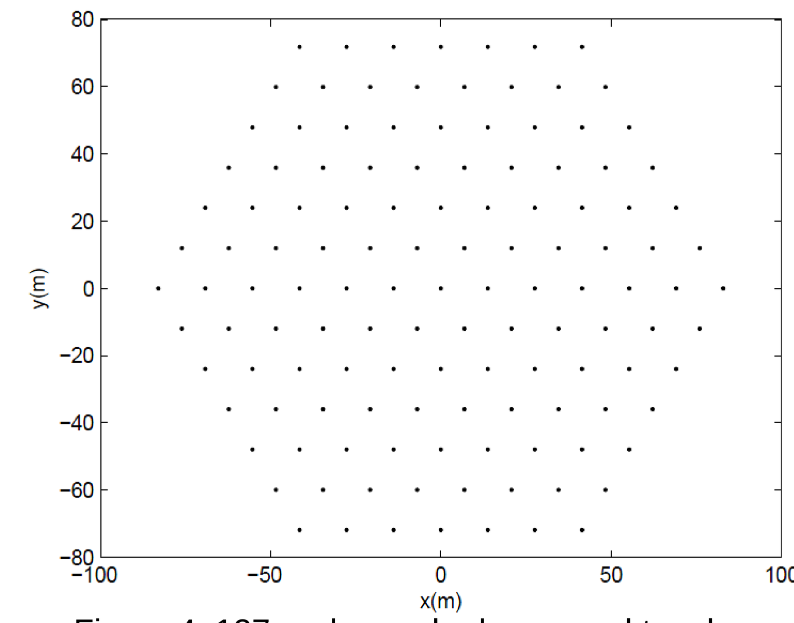

Figure 4. 127-node regular hexagonal topology

Data rate	6 Mbps	54 Mbps
Basic rate	6 Mbps	24 Mbps
RxSensitivity	−112.0 dB	−95.0 dB

Table 1.Receiver sensitivities and basic rates for each investigated data rate

$P_{transmit}$	$1.425 + 0.25h^{-\eta}$ W
$P_{receive}$	1.425 W
P_{idle}	1.319 W

Table 2. Power consumption values

Data rate (DR)	6/54 Mbps
PLCP rate	6 Mbps
W_0	16
B	3
Short Retry Count (SRC)	7
Long Retry Count (LRC)	4
SlotTime	20 μs
DATA	1000 bytes
RTS	20 bytes
CTS	14 bytes
ACK	14 bytes
SIFS	10 μs
DIFS	50 μs
EIFS	412 μs
IFQ buffer size	5
path loss exponent η	3

Table 3. Parameters used for simulation runs.

	λ(packets/s)		
6 Mbps Data Rate	1	20	1000
54 Mbps Data Rate	1	200	1000

Table 4. Selected λ's for Adaptive Simulations

Simulation Results

Pifq, is the probability of packet loss at the interface queue, which lies in between the network and medium access control layer. Tail drop is a queue management system often used by network routers. Until the maximum capacity is reached, incoming packets are put in a queue. When the queue buffer is full, newly arriving packets are dropped. PIFQ had been considered as the decisive parameter for the algorithm, but it had been realized that the decisions made by this parameter was late in response, since congestion has already set in by the time that packets are lost and the algorithm needs an immediate decision for an immediate response.

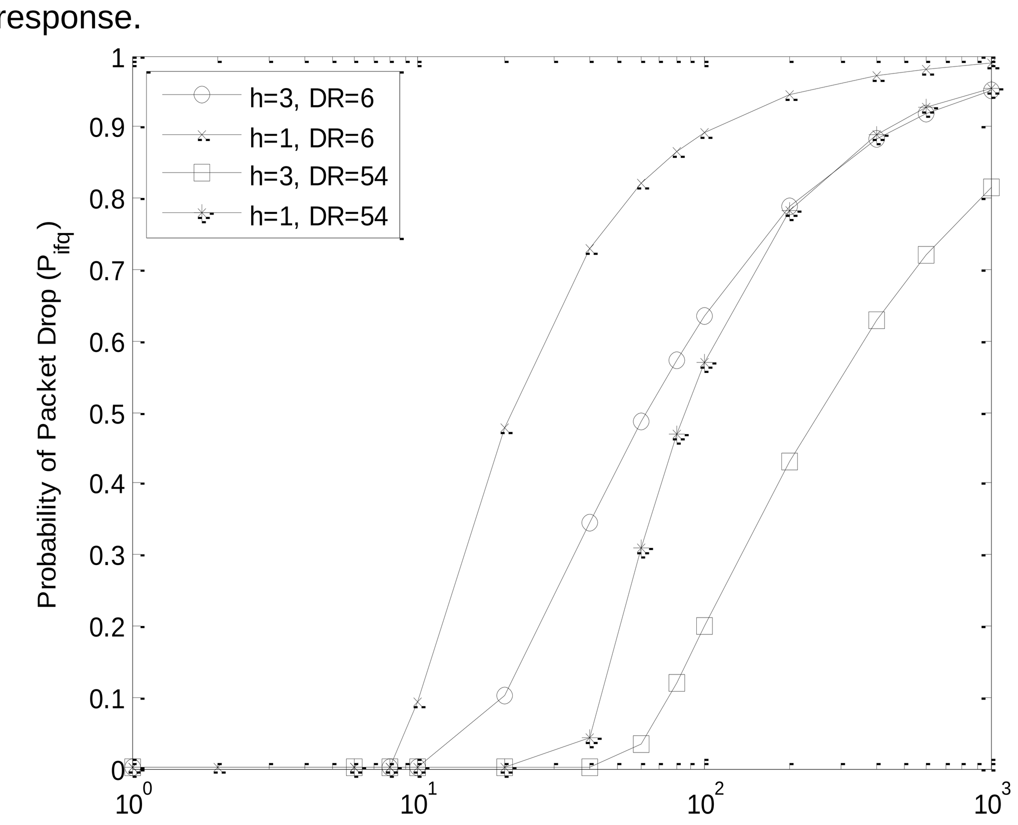

Figure 5. Packet loss probability at the interface queue

Short Retry Count(SRC), is the number of trials for a transmitter to transmit an RTS packet. Here, random shadowing and multipath effects are disregarded. Under heavy traffic load, packet collisions increase and SRC increases. When a collision occurs repeatedly, an RTS packet is sent repeatedly until the maximum retry count is reached. If the transmission is still unsuccessful, the RTS packet is dropped. The proposed algorithm relies on the moving average of the short retry count. The window size is 3 SRC samples. This gives the necessary quick response, since it is calculated every time that a packet collides or drops.

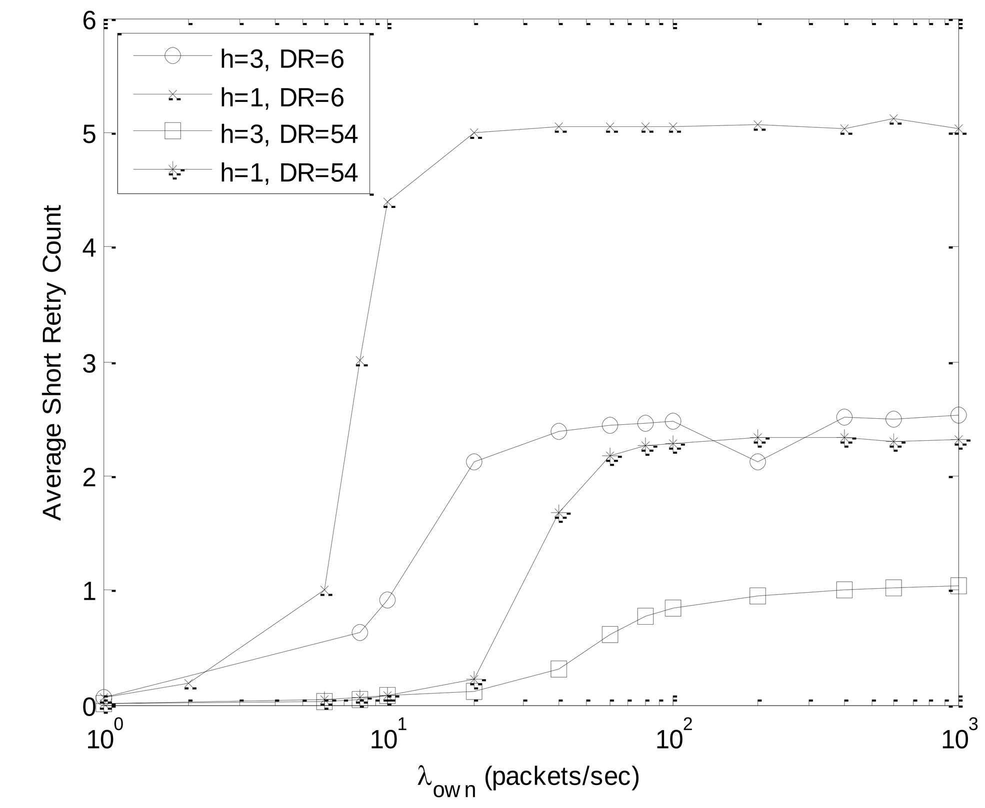

Figure 6.Average Short Retry Count

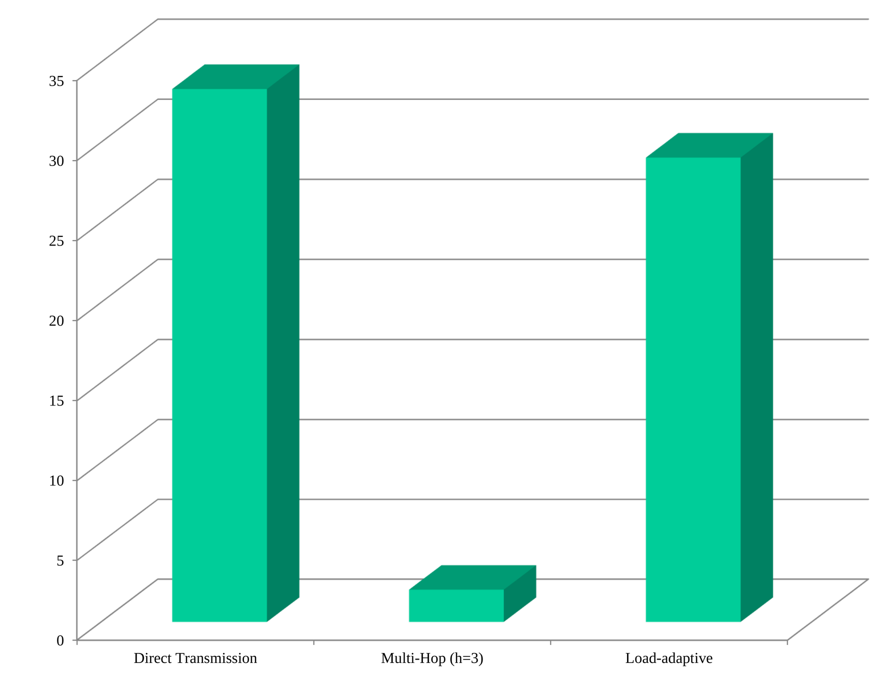

Figure 7. Adaptive Algorithm Goodput for Data Rate 6Mbps

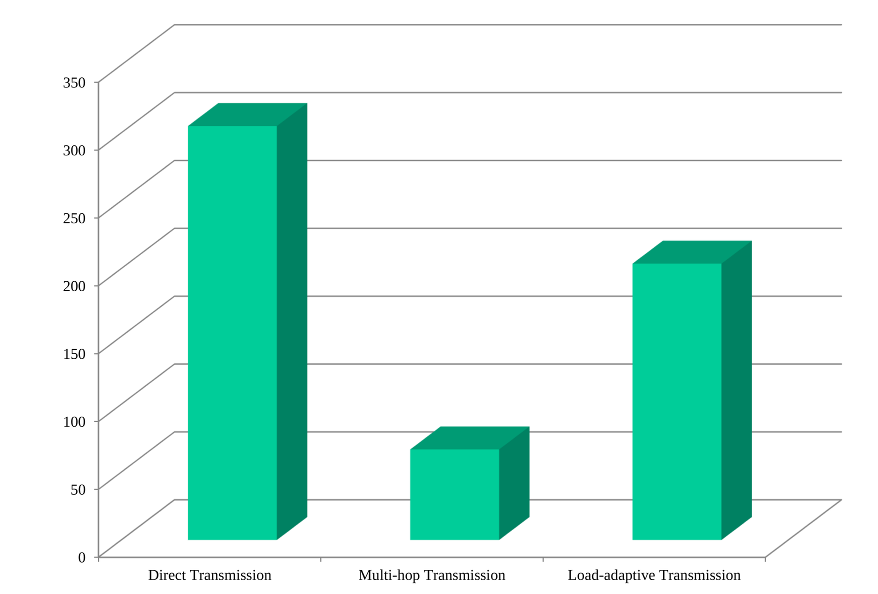

Figure 8. Adaptive Algorithm Goodput for Data Rate 54Mbps

	6 Mbps Data Rate	54 Mbps Data Rate
Direct Transmission	40.57 μJ	4.58 μJ
Multi-hop Transmission	25534 μJ	44.27 μJ
Adaptive Transmission	45.94 μJ	7.125 μJ

Table 5. Energy per bit for different type of tranmissions

Conclusion

- The proposed algorithm switches between the direct and multi-hop transmission efficiently by changing the routing strategy on certain traffic regions with respect to avgSRC to acquire higher goodput.
- Adaptive transmission achieves higher goodput than the multi-hop transmission simulated under the defined ranges, but lower than direct transmission. This suggests that a room for improvement still exists with an algorithm that uses direct transmission for a certain amount of period after a switch has been made. A more stable approach which keeps the direct transmission for some fixed time after the change can be utilized.

Future Work

1. Different topologies must be simulated in order to get broader limits for avgSRC.
2. Exponentially Weighted Moving Average can be used for handling congestion.[2]
3. Topology with gateways such as access-points can be simulated to implement a more realistic approach.
4. Shadowing and Multipath affects can be put into account.

References

1.Canan Aydogdu, Ezhan Karaşan, "Goodput and Throughput Comparison of Single-Hop and Multi-Hop Routing for IEEE 802.11 DCF based Wireless Networks," Wireless Communications and Mobile Computing, vol. 16, no. 9, pp. 1078–1094, 25 June **2016**, Doi: 10.1002/wcm.2588.

2. A Wikipedia article about " ***Moving Average***" https://en.wikipedia.org/wiki/Moving_average#Exponential_moving_average

3.Canan Aydogdu, Sibel Sancaklı, "Joint Effect of Data Rate and Routing Strategy on Energy-Efficiency of IEEE 802.11 DCF based Multi-Hop Wireless Networks under Hidden Terminal Existence", Ad Hoc Networks Journal Elsevier, vol. 30, pp. 1-21, July **2015**, Doi: 10.1016/j.adhoc.2015.02.004.

4.Canan Aydogdu, Ezhan Karasan, "An Analysis of IEEE 802.11 DCF and Its Application to Energy-Efficient Relaying in Multi-Hop Wireless Networks," ***IEEE Transactions on Mobile Computing*** (ISSN: 1536-1233), vol.10, no. 10, pp.1361-1373, Oct. **2011**.