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A Survey and Analysis on Various Objective Functions Defined for RPL in 6LoWPAN

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Abstract: Internet of things (IoT) and Internet of Mobile things (IoMT) are the extension of ubiquitous and pervasive computing which enables various types of devices to communicate to the Internet using TCP/IP protocol stack. Since the devices in IoT are characterized with low power, low memory and buffer, they struggle to communicate using the conventional TCP/IP. The RPL proposed by IETF has become the standard routing protocol for devices which are part of 6LoWPAN (IPV6 for Low power Wireless Personal Area Networks). Due to the constrained resources such as low bandwidth and unreliable link, the network often face problems such as congestion, dropped packets, high power consumption for data transmission, decreased throughput, decreased success rate of packet delivery and increased in overall delay. Several metrics, objective functions, methodologies and enhanced protocols have been proposed in the literature to mitigate the problems encountered by the RPL. The proposed approaches either falls under energy aware or congestion aware routing using RPL. Some of the approaches fall under hybrid which attempts to minimize the energy consumption as well as congestion. In this paper we provide a deep insight into various metrics, objective functions and methodologies proposed in the literature for alleviating congestion and minimizing energy consumption for RPL and present the advantages and overheads associated with each. At the end we provide our inference on the possible scope for extensions/enhancement of routing protocol efficiency under situations like high mobility rate with diverse device characteristics.

Index Terms: 6LoWPAN, RPL, Energy Aware, congestion Aware, Internet of Things, Internet of Mobile Things, routing Metrics.

I. INTRODUCTION

Evolution of 6LoWPAN has led to development of several applications and services that runs on devices which are part of IoT that often communicates to Internet. The devices are basically characterized with constrained resources such as less computing power, memory, buffer, bandwidth and battery power. RPL has become a standard routing protocol for 6LoWPAN that replaces TCP/IP due to the additional resources required for it to establish and terminate connection in between source and destination. Though RPL performs well, the increased data rate of nodes often causes packet loss that occurs due to the small buffer size. Alternate path for routing helps to transfer packets to the destination without congestion. But the power required to transmit the packets in the route may consume more power which will decrease the lifetime of the device and network. In order to make RPL efficient in terms of energy consumption and congestion mitigation, several metrics, objective functions, methodologies and enhanced protocols has been proposed in the literature. In this paper we study the various approaches available for energy aware and congestion aware routing.

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II. RPL NETWORK TOPOLOGY

RPL falls into Distance Vector routing protocol category. It is designed considering the IEEE 802.15.4 MAC and Physical layer. The nodes are categorized into Root, Intermediate and Leaf. Root nodes enable external communication for the internal nodes. The packets are being forwarded between Leaf node and Root node through Intermediate node [2][3][4]. The topology formed by RPL is a Directed Acyclic Graph. The nodes that participate in the construction of RPL topology exchanges several messages such as DODAG, DIO and DAO. to find its parent with higher ranks.

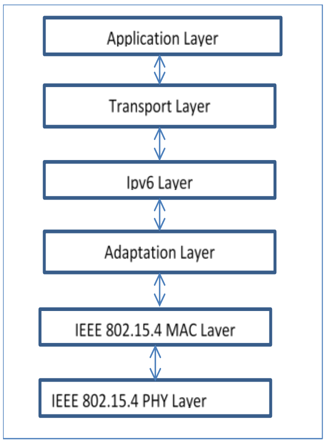

Figure 1: A sample of 6LoWPAN protocol stack

These set of messages are exchanged between the nodes to find their parent and construct DAG. A sample topology is illustrated in the Fig.1. The protocol stack of 6LoWPAN is given in Fig.2. There are several metrics and objective functions proposed for RPL in the literature. The metrics and objective functions are used by RPL while finding path between the leaf nodes and the root.

A. Objective Function Zero proposed for RPL (OF0)

OF0 acts as a default objective function for RPL. It is designed to calculate the closest path to the parent using the gap between the node and its corresponding parent.

Hop count is a parameter which is used to measure the distance between the node and its parent.
A node prefers its predecessor (parent) based on the calculated rank for it using a scalar value called Rank_Increase. But OF0 does not consider the metrics defined for the nodes and links such as lost packets in wireless networks [6].

B. Objective Function ETX Proposed for RPL (OF-ETX)

Expected transmission count is a metric that is used to calculate the number of transmissions required to carry a message packet through a particular link. The ETX objective function determines the path to carry a packet from the sender node to the receiver node that takes less number of transportations. The approach based on ETX objective function considers the congestion on the wireless communication media. It is not considering the congestion that take place in the node. [7]

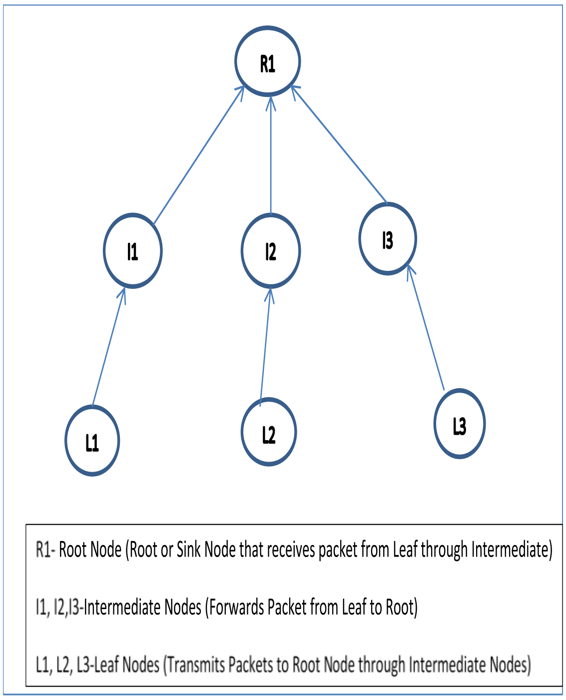

Fig 2 : Organization of Nodes in RPL Topology

The ETX metric can be defined as the total number of transportations required for a node to carry a message packet from the sender node to destination. It can be represented using the below formula

Expected Transmission = 1/ (Prob_Pkt_Del_Neigh× Prob_Ack_Rec)

Where Prob_Pkt_Del_Neigh is a measurement of the probability of delivering a packet to the neighbour and Prob_Ack_Rec is a measurement of receiving an acknowledgement for a packet. The author in [32] has evaluated the performance of OF0 and MRHOF (Minimum Rank Hysteresis Objective Function) under light node densities. The simulation settings and the results obtained are given as below in the Table I to III [32]. Packet delivery ratio (PDR) and power consumption are the metrics which is used to benchmark the performance of OF0 and MRHOF. The MRHOF outperforms the behavior of OF0 in saving the power of nodes thereby improving the life time of the network. Node densities are varied from 20 to 45. Random and grid topologies are used for simulation.

Table I : Simulation parameters for testing OF0 and MRHOF in Grid and Random topology

Parameters	**Value**
Key parameter/approach being used in experiment	Objective function Zero and Minimum Rank Hysteresis Objective function
Transportation Ratio	100%
Communicable Range	100m
Reception capacity	(varied between 20 to 100)
Boot TIme	1.000
Network Structure	Random and Grid
Experimental period	900 Sec.

Table II: Performance evaluation of OF0 and MRHOF in Random Network topology

Metrics	Objective function Zero	MRHOF
Success rate of packet transport	98 %	97%
Energy used	1.22%	1.14%

Table III: Performance evaluation of OF0 and MRHOF in Grid Network topology

Metrics	Objective function Zero	MRHOF
Success rate of packet transport	98%	97%
Energy used	1.19%	1.15%

C. Average delay based metric for RPL

The delay between node and its grand predecessor is minimized by this approach. The average delay is calculated by the sum of link to link delay from the node to its root node. [8]. A scenario showing the calculation of path to the root with less number of hop count and delay is illustrated in Figure 3. The authors in [8] have tested the AVG_DEL based metric for RPL by implementing it in contiki OS and tested with COOJA simulator. The simulation setup and the results are shown in the table IV& V [8].

Table IV: Simulation configuration

Node attribute	19 Tmote nodes
Roots duty cycle	100%
Cycle of back bone node	0.125s
Cycle of outer nodes	0.2s
Packet transmission count from leaf to Root	1000
Structure	DODAG

Table V: Comparison of delay in RPL using AVG_DEL and ETX based objective functions

Number of Nodes / Delay	Delay in AVG_DEL based RPL (in milli seconds)	Delay in ETX based RPL (in milli seconds)
2	15	15
6	160	220
12	150	180
19	450	725

The simulation results show reductions in delay significantly while using AVG_DEL metric compared to ETX metric, as ETX includes more node sleep time.

D. Remaining Energy based Metric for RPL

A metric based on remaining energy for the RPL is proposed in [9]. The path to the grand predecessor is selected taking the least value of path cost of the parent and the nodes remaining energy. The authors in [9] have proposed routing based on remaining energy. The available energy for a node is measured and represented as 255 (Full) and 0 (Empty). The simulation settings and the results obtained are provided in the following table VI & VII [9]. The remaining energy based RPL shows a significant increase in the lifetime of the network compared to ETX based RPL with a significant decrease in packet delivery ratio.

Table VI: Simulation settings for remaining energy based RPL in 6LoWPAN

Network size	300*300 mt. Sq
Structure	2D Grid
Sensor count	20
Transportation Range	120m
Interference/BlockingRange	140m

Table VII: Energy Level of Nodes at various time in Remaining energy based RPL and ETX based RPL

Time (Day)	Node Power (Energy Based)	Node Power (ETX Based)
0	100%	100%
5	87%	88%
10	70%	74%
15	58%	64%

20	41%	51%
25	26%	38%

E. Combined Metric proposed for RPL

The proposed work uses several metrics that can be used in a selective manner according to the system and user requirement. Expected transmission count, distance between nodes, remaining energy of nodes and link quality are the metrics used in this approach. [10]

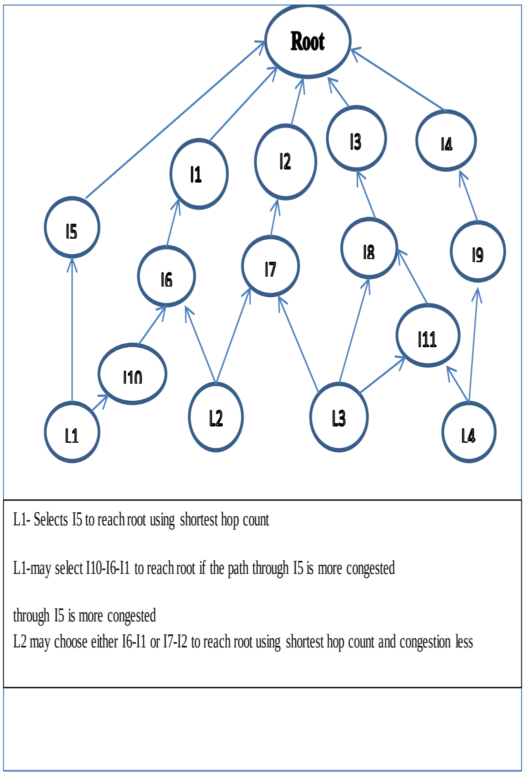

Figure 3: Selection of path to root by leaf nodes based on delay and hop count

The author in [33] proposed a combined metric based routing for RPL. The proposed routing considers the minimum hop distance as in OF0 and the standard deviation of ETX between nodes to calculate the best path from the source to sink, as opposed to average of ETX along the path to destination as in ETXOF. The proposed routing procedure is tested using a simulation in Cooja simulator in contiki 3.0 [33] . The simulation settings and the benefits obtained by the proposed approach in [33] through latency, packet transportation ratio, energy used and lifetime are provided in the table VIII & IX.

Table VIII : Simulation Configuration in COOJA Contiki 3.0

Node Count	20 -100
Transportation Range	150m
Area	500*500M
Count pf packets	200
Protocol	RPL
Topology	Random

Table IX: Performance comparisons of Objective Functions 0F0, MRH0F, Per hop-ETX and SIGMA-ETX

	OF0	MRHOF	PH-ETX	SIGMA-ETX
Latency in seconds	150	63	42	38
Packet transportation Ratio in %	39	46	68	79
Energy used in %	45	32	28	23
Lifetime in Sec.	3200	3400	4100	4800

F. PH-ETX, Link and Node level criteria for RPL

Per hop ETX approach works as follows. The ETX value is distributed among all nodes in the path between the source and its root unlike the ETX-OF. This approach works better when the size of the network grows larger. [11] The work in [4] proposes a group of link and node level parameters that can be used along with RPL. The metrics proposed comes under either node or link. . Throughput, latency and link reliability are few metrics that falls under link.

G. Fuzzy logic based objective function for RPL

A quality of service aware fuzzy based objective function has been proposed by [3]. It uses a collection of metrics such as point to point delay, hop distance and remaining battery power and applies fuzzy procedures such as fuzzification and defuzzification and arrives on a single metric that can be used to determine the neighbour quality.

H. Congestion Aware RPL for 6LoWPAN networks

The use of 6LoWPAN has been increased significantly in several IoT applications. Several protocols are being developed for applications that make use of 6LoWPAN. RPL being a routing protocol developed by ROLL has become a standard one for applications using 6LoWPAN [2][3]. Applications that often interact to the Internet, faces problems such as congestion. The authors in [1] have proposed a metric called Buffer Occupancy, which is used along with routing protocol to minimize the number of lost packets during high data transmission rate. The authors in [1] have also proposed an objective function named CA-OF (Congestion Aware Objective Function) that can be used to select alternate path when congestion occurs. The proposed approach works efficiently in presence of congestion thereby leading to the reduced lost packets count , increased throughput, increased packet transportation ratio and reduced energy-use in a high traffic environment. The authors in [1] have proposed a metric by combining congestion aware in node level and congestion aware in channel level. The congestion in the channel level is identified by a metric called ETX (Expected Transmission count). The congestion at node level is identified by metric called buffer occupancy. The objective function is built by combing both of this metrics to achieve reduced packet loss, increased network throughput and packet transportation ratio. The authors in [1] have proposed a mathematical model for the metric as given below.

United_metric= w1*Expected_Transmission_count + w2*Buffer_Occupancy_level ..[1]

The components w1 and w2 are used proportionately to the data transmission rate. During low data transmission late w1 is set to maximum value. During the high data transmission rate w2 is set to its full value. The proposed metric by the authors in [1] which is called Buffer_Occupancy, reduces the number of dropped packets during high transmission rate. The proposed metric for RPL is tested against the other metrics such OF0, ETX-OF, Average_Delay-OF and Energy-OF. The simulation results obtained through simulation of smaller and larger networks using COOJA simulator for 6LoWPAN shows a significant improvement compared to the existing metrics for RPL in most of the perspectives. The simulation setup and the results obtained are provided in the table X & XI.

Table X: Simulation settings for CA-OF based RPL

parameter	Value
Platform	Contiki
Simulator	Cooja
Period	30 Minutes
Node class	Tmote
Communicable Range	50m
Non communicable/Interference Range	100m

Table XI: Benefits of CA-OF for RPL compared to other Objective functions

Name of the Objective function	ETX-0F	ENERGY-0F	0F0
Packet loss occurred during transmission	33.5%	36.7%	39.1%
Network overall performance	34%	45.6%	52.8%
Success rate of packet transportation	34.1%	45.4%	52.9%

Used level of energy	17.9%	31.8%	24.4%

III VARIOUS ENERGY AWARE AND CONGESTION AWARE APPROACHES FOR RPL

A. An Approach to Reduce Congestion for 6LoWPAN Based on Duty Cycle

The proposed approach observes the prevalence of radio cycle in the network and tunes the network correspondingly. Buffer Overflow is used as a metric to find the congestion that occurs in the network. In addition AIMD (Increasing in addition based and decreasing in multiplication based) is used to minimize congestion in the network [16].

B. QU-RPL: Usage of Queue Based RPL

Every node measures the usage of queue and uses the same to choose its parent. A node that faces frequent buffer overflow conveys that to other nodes through a DODAG information object message. A node which receives notification of congestion changes its parent eventually with less number of hop distance and buffer overflow to the root node [19][20].

C. Hybrid Approach to Alleviate Congestion in 6LoWPAN Networks

Wireless Sensor Network (WSN) plays a vital role being a part of IoT. The nodes in WSN run variety of application such as time sensitive and non-time sensitive. It is important for protocols designed for 6LowPAN to consider the priorities of node and the collection of applications running on the nodes as well. IPV6 low power wireless personal area networks plays a crucial role in integrating WSN and the Internet. Though the nodes in WSN can speak TCP/IP protocol to interact with the Internet, they are prone to scarce resources such as energy, bandwidth and buffer. This leads to occurrence of congestion in 6LoWPAN which causes packet loss and decreased throughput in the network.

There are several congestion handling algorithms exists for 6LoWPAN networks in the literature [13],[14],[15]-[21]. They follow any of these two approaches, named resource control and traffic control to alleviate congestion in the network. The first approach attempts to find a non-congested path to the destination to forward the packets. The second approach attempts to reduce the high data sending rate of nodes to an optimal value. The authors in [12] have proposed a solution to avoid congestion which is based on the combination of Resource handling and Traffic handling. It is named as **"Optimization based Hybrid Congestion alleviation"**.

Table XII : Simulation Settings

Layers	values
Application	30 bytes of Data packets
Transport	Protocol: UDP
Network	Protocols: IPV6 and RPL
Adaptation	SICSLowPAN
Data link	Buffer size= 8
Physical	CC2420 RF

Table XIII : Performance of DCCC6, OCHA and QU-RPL in perspective of packet transportation efficiency

Time in Seconds	OHCA performance(packets/s)	DCCC6 performance(packets/s)	QU-RPL performance(packets/s)
120	1.8	1.3	1.6
240	2.1	1.9	1.4
480	2.2	1.7	1.3
600	2.1	1.8	1.4

Table XIV: Performance of DCCC6, OCHA and QU-RPL in perspective of WFI

Time in Seconds	OHCA	DCCC6	QU-RPL
120	0.89	0.81	0.62
240	0.91	0.83	0.65
480	0.99	0.82	0.64
600	1	0.9	0.61

Table XV: Performance of DCCC6, OCHA and QU-RPL in the perspective of Delay

Time in Seconds	OHCA Average Delay/Packet (seconds)	DCCC6 Average Delay/Packet (seconds)	QU-RPL Average Delay/Packet (seconds)
120	10	13	14
240	9.8	19	17
480	8	18.8	18
600	7.5	18	17

The authors in [12] have taken the benefits of resource control and traffic control approaches to form a hybrid solution to reduce congestion. Firstly the nodes attempt to find a non-congested path available to the sink node to forward packets. In case of non-availability of paths, the second approach is followed. It tries to reduce the higher data sending rate of nodes to an optimal value so that the amount of packets floated in the networks is minimized significantly thereby leading to a reduction in congestion to a large extent.
The proposed approach by [12] is evaluated and simulated in Contiki OS using COOJA Simulator. The results show a significant benefit on the parameters such as delay, weighted Fairness Index, Energy used, Throughput, and lost buffer packets. A sample of the simulation results and the simulation parameters are provided in the table XII to XV.

D. Griping, fuse and Deaf for CoA/6LoWPAN

The proposed approach aims to control the data flow in constrained application protocol for 6LoWPAN. A new feature named Back Pressure is used to control congestion. In griping techniques the amount of buffer overflow is used to control congestion. The non-arrival of acknowledgement is considered as sign of congestion in Fuse and Deaf approach [17].

E. Congestion control for Constrained application protocol in 6LoWPAN (CoA/6LoWPAN)

The proposed approach is based on bird flocking concept which diverts the network traffic through non-congested path and avoiding the congested one. It uses the measure of buffer overflow to handle congestion and reduces the congestion in the network by transporting data in a less congested path [18].

F. Congestion alleviation for 6LoWPAN based on Game theory approach

The packet transmission rate of the network is calculated by subtracting the rate at which the packets are being serviced from the rate at which the packets are being generated. The congestion is detected by the packet transmission rate of the network. When a node senses congestion, it conveys the same to the other nodes through DIO message. Upon receiving congestion notification, a node changes its parent using game theory approach [21]-[22].

G. Congestion avoidance multipath routing for 6LoWPAN (CA-RPL)

The proposed approach uses the metric DELAY_ROOT to minimize the average delay to the root node. The traffic is being distributed across several paths to reduce congestion in the network [23].

Table XVI: Comparison of various approaches /metrics/objective functions for RPL and their benefits

Name of the Author/Approach/RPL Metric/Objective Function for 6LoWPAN	Benefits in Routing
P.Thubert et. al [6]	Calculates the shortest path to the parent using a scalar value **Rank_Increase**. Does not consider the Node and link characteristics
o. Gnawalis et.al [7]	Finds the path between source and destination that takes less **number of transmissions** to forward a packet. Considers link characteristics but not node characteristics
P. Gonizzi, R. Monica et.al [8]	Calculates path based on **link to link delay** from source to its root.
P. O. Kamgueu et.al [9]	Similar to OF-ETX suits well for larger networks
O. Gaddour, A. Koubaa et.al [3]	Takes several metrics into account such as End to end Delay, hop distance etc. and applies fuzzy procedures to arrive on a metric to find neighbour.
Hayder A et.al [1]	Considers the behaviour of the channel and node to form a metric based on buffer occupancy and link congestion. Performs well for small and larger networks compared to all other metrics defined above. Reduces significantly packet loss, energy consumption and increases throughput and packet delivery ratio.
Hayder A et.al [12]	Makes use of a hybrid solution based on resource control and traffic control to reduce congestion to a large extent. Priorities of nodes as well as applications are given importance. Improves End to End Delay, weighted Fairness Index, Energy Consumption, Throughput, and buffer dropped packets
V. Michopoulos et.al [16]	Detects the presence of radio duty cycle. Uses BO and modified AIMD (Additive Increase Multiplicative Decrease) to reduce congestion
A. P. Castellani et.al [17]	Uses back pressure concept, BO and AIMD to reduce congestion in constrained application protocol 6LowPAN.
H. Hellaoui et.al [18]	Reduces Congestion in CoAP/6LoWPAN
H.S Kim et.al [18[19]	Senses the buffer overflow and conveys it to other nodes through DODAG and DIO messages to reduce congestion
Al-Kashoash et.al [28]	A node changes its parent based on game theory whenever congestion occurs.
W. Tang et.al [23]	Congestion avoidance multipath routing is followed using DELAY_ROOT as a routing metric. Minimizes the average delay towards the root.

Al-Kashoash et.al [28]	Models congestion as Game theory to identify non cooperatives nodes in the network.
Ullah, Rehmat et.al [31]	Proposed energy and congestion aware routing for Advanced Metering Infrastructure (AMI) devices. Uses residual energy and queue utilization factor of neighbour nodes as a routing metric.

H. Distributed monitoring: A Proactive approach to increase robustness of IoT

More number of applications and services evolves along with the evolution of Internet of Things. Connectivity and availability are two key essential things for services and applications in IoT. The authors in [24] proposed distributed monitoring of DODAG to foresee and quick recover of failure to ensure the demand of time critical applications in IoT. RPL being a standard routing protocol for 6LoWPAN has an inbuilt repairing mechanism which is of reactive in nature.

But applications which are time sensitive, demands a proactive repairing scheme to increase robustness of IoT and provide applications a quick recovery upon node failures in the network topology. The proposed approach considers power requirements as the nodes in IoT are constrained with battery power. [24]. There are several QoS aware approaches available for mobile nodes and the cloud environment which can be extended to the WSN nodes in IoT too. [25][26][27]

I. Game Theory Based Congestion Control Framework (GTCCF)

To provide connectivity between a set of low power nodes in wireless sensor network to the Internet, IETF designed a group of protocols. Due to the heavy data traffic in wireless sensor networks, applications face quality of services problems such as end-to-end delay, throughput and high energy consumption. The congestion problem is modelled as a game theoretic to identify non cooperative nodes which pushes high data rate traffic in the network. The work have proposed a congestion handling mechanism called "Game theoretic based congestion control framework" (GTCCF) that outperforms duty cycle aware congestion control mechanism. [28] The simulation configuration and the corresponding output are shown in the table 17 & 18. The result shows that GTCCF based approach for congestion control outperforms duty cycle based congestion control approach by an overall average of 39.77%, 30.45%, 91.37%, 26.37%, 13.42% in terms of end-to-end delay, throughput, packets lost count, energy dissipation and weighted fairness index.

Table XVII: Simulation Configuration

Layers	Parameter values
Application	30 bytes of Data
Transport	Protocol: UDP and 0F0
Network	Protocols: RPL
Adaptation	SICSLowPAN
Datalink	Size of buffer = 8packets
Physical	CC2420 RF

Table XVIII Benchmarking GTCCF, DCCC and Griping

Parameter	GTCCF	DCCC6	Griping
Overall performance	3.214	2.242	0.203
Delay in sending a packet to destination	0.493	1.104	0.549
Energy consumed while transferring a packet to its destination	5.266	7.135	21.496
Number of packets lost per second	0.025	0.385	0.094
Average Weighted Fairness Index	0.970	0.856	0.847

J. Architecture for 6LoWPAN to Handle Mobility of Devices with Energy and Bandwidth Consciousness

The authors in [29] proposed architecture to handle mobility of devices in 6LoWPAN network with a focus on energy and bandwidth conservation. This helps the node to communicate without a disruption. Due to the scarce resources and less power operated characteristics of devices in 6LoWPAN, implementing protocols such as MIPV6 becomes infeasible. The consumption of energy by a mobile node increases significantly as it goes away from the Gateway which obviously decreases the life time of the node. This is because of high energy needed for transmission by the mobile node when the distance between the mobile node and Gateway increases. The proposed architecture deploys special nodes which are static and randomly deployed to support the multi-hop communication of the mobile node. The IP connectivity of the mobile node is maintained with less power signaling [29].

K. M-Health: Role of 6LoWPAN in Mobile Health

The mobile nature of devices in 6LoWPAN leads to several applications and services in mobile health.

The devices worn by the patients shall be able to communicate with Internet. The authors in [30] have suggested usage of technologies such as Bluetooth and ZigBee network which are similar to the 6LoWPAN which operates on low power and resources.

L. Power and Congestion Aware Routing in 6LoWPAN for AMI (Advanced metering Infrastructure)

AMI plays an important role in offering utility services for smart cities. AMI includes devices such as smart electricity, gas and water meters which operate with low power and constrained resources and memory. The low power devices which are part of AMI infrastructure need a routing protocol which is aware of low power consumption so that the life of network and devices stands for long. The authors in [31] proposed power and congestion aware routing metric that reduces the average power consumption of the network and improved packet delivery ratio. The proposed work is tested under COOJA simulator 3.0 using random and grid structure. The settings in simulation and the results obtained are given in the Table XIX –XXI.

Table XIX: Settings for AMI Simulation in smart network infrastructure

Simulator	Cooja contiki OS
Structure	Random and Grid
Node count	20 to 100 in steps of 20
Device	Tmote sky sensors
Communicable Range	50m
Disturbance Range	60M
Network perimeter	300*300 m
Queue capacity	10 packets

Table XX : Benchmarking of ECRM and ELPS based on power consumption vs send interval

Send Interval (in seconds)	ECRM (Power consumed in mw)	ELPS (power consumed in mw)
2	7.5	8.8
4	5	6.8
6	3.5	4.1
8	2	2.7
12	1.6	1.8
16	0.2	0.1

Table XXI: Comparison of ECRM and ELPS based on packet delivery ratio vs send interval

Send Interval (in seconds)	ECRM Packet delivery ratio %	ELPS Packet delivery ratio %
2	48	38
4	64	55
6	75	60
8	88	70
12	93	82
16	98	93

The proposed approach ECRM overtakes ELPS by power consumption and packet transportation as shown in table XIX –XXI.

IV. INFERENCE

Based on the survey made on the existing works in the literature we find that there are some scopes to improve the efficiency of RPL/MRPL routing protocol in high mobility scenarios. There are two types of devices in IoT: Static and dynamic (Mobile). Devices having high mobility rate often cause changes in the network topology which triggers the routing protocol. The routing overhead increases significantly in this situation. We plan to analyse the effect of mobility with diverse device characteristics (High or Low in resources) and look for the possibilities on arriving an effective solution that reduces the routing overhead in presence of high mobility rate.

V. CONCLUSION

Evolution of 6LoWPAN has increased the variety of applications and services in IoT which often communicate to the Internet. RPL, a standard routing protocol for 6LoWPAN developed by IETF facilitates devices to communicate with the Internet. Various metrics, objective functions, methodologies and enhanced protocols have been proposed for RPL to thwart problems such as dropped packets, delay and high energy consumption for packet transmission. We studied various energy aware routing schemes and congestion aware routing schemes that exists for 6LoWPAN and presented the same with its advantages and overheads. We also presented the scope for possible extensions or enhancements for routing in 6LoWPAN that considers diverse device characteristics under high mobility rate

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