EEDCR: Energy Efficient Delay Compensation Routing in Distributed Networking System

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***Abstract*—** Delay minimization plays a crucial role in ensuring Quality of Service (QoS) and Quality of Experience (QoE) in future internet architecture, which is still in infancy stage of development. In the distributed networking system with heterogeneous communication protocols, it is difficult to reduce delay. As the nodes executing applications on future internet architecture are wireless with mobility features, an adverse effect of delay leads to high energy consumption. In this paper an Energy Efficient Delay Compensation Routing technique, (EEDCR) is presented which is specially designed to sustain the peak traffic condition of the distributed networking system. Supported by simple and cost effective analytical model with a three level frame work viz, domain, gateway node and operator node, EEDCR has proved to be quite efficient in controlling the delay, minimizing energy consumption and improving the throughput. It is also capable of processing more traffic load compared to the existing conventional techniques.

Index Terms-: Distributed Networking System, Delay Minimization, Energy Efficiency, Future Internet Architecture.

I. Introduction

The existing architecture of internet renders services of different types and also provides the platform for executing number of applications from various domains. The objective of the future internet architecture is to develop a distributed platform for the purpose of enabling wide range of services without any significant impact on the ongoing services [1]. The future internet architecture is actually meant for developing a highly sophisticated and collaborative platform that can develop a well-integrated framework for harnessing different forms of technologies together. A slow pace of development of such architecture is the evolution of Internet-of-Things that connects cloud with sensors [2][3]. The characteristics of future internet architecture are i) provide seamless connectivity between nodes in the distributed networking system, ii) offer faster and reliable accessibility to complex services, iii) leverage parallel processing and task scheduling iv) offer robust security [4][5][6]. In this paper we discuss the problem of delay and energy consumption which are considered as the main components of the heterogeneous devices. The upcoming applications that utilizes the services of future internet architecture are highly distributed in nature, hence these devices require an effective communication protocol [7][8]. This leads to the problem of compute time, which is the time required to process routing message from one network device (e.g. switch/gateways) to other network device. The computation of processing time is highly detrimental for real-time applications and it results in delayed services. Hence, delay is one of the critical factor that play a significant role in both QoS (Quality-of-Service) and QoE (Quality-of-Experience) in upcoming distributed applications [9]. It is observed that, there is only a limited focus on the analysis on delay and the energy consumption in a situation like highly Distributed networking system. Hence, future internet architecture (FIA) is quite a complex structure that calls for a closer investigation on different networking factors and routing mechanisms.

Here, we consider the energy associated with every node involved in communication at that instant. The energy optimization depends on routing and data processing policy of a particular communication technique. Hence, it is noted that if a node suffers undue delay, the node energy will be reduced.

In this paper, we present a novel technique that emphasizes on delay minimization followed by energy optimization exclusively for distributed network system. We discuss some of the research works related to delay minimization and energy optimization in Section II followed by brief discussion of problem identification in Section III. The proposed system and its significant contribution are presented in Section IV. Section V discusses the research methodology followed by Algorithm implementation in Section VI. The accomplished simulated outcomes are discussed in Section VII and finally the summary of the paper is presented in Section VIII as the conclusion.

II. Related Work

The techniques introduced by various researchers for addressing the problems caused due to delay in a distributed network system are discussed in this section.

Bie et al. [10] have presented a technique for modeling the delay in vehicular traffic system. The author have discussed about the queuing model for minimizing the delay in the communication process. The outcome of the work was assessed using prediction error percentage with respect to time interval. A study towards vehicular communication system is being carried out by Tiwari and Kumar [11] recently. Using the simulation-based approach, the authors have discussed a scheme for authenticating the cache at the gateways that significantly reduces the broadcasting operations; by this the delay is minimized. The outcome of the study was tested with response time of a query.

Gancet et al. [12] presented a technique that attempts to minimize the communication latencies for underwater communication. They have designed and developed a remotely operated vehicle with an aid of satellite and communication interfaces to link onshore and offshore communication modules. Study on reducing the delay in planetary networks was carried out by Zhang et al. [13]. The authors have presented an algorithm that can significantly control topology and hence minimize the delay.

Byun et al. [14] have presented a technique to address the problems of delay and energy efficiency in a communication system. The author has used slotted ALOHA protocol [15] for the purpose of minimizing the delay and enhance the rate of transmission. Similar studies on delay and energy minimization was also carried out by Park et al. [16]. However, the authors use controlling mechanism to control voltage and frequency in microprocessor. The authors considered case study of DC-DC converter of PID controller.

Raza et al. [17] have introduced a system that can compute the cumulative delay of the links over multiple networks. Here the study emphasized more on extracting the correlation among the delay with other associated network metrics. Saleh et al. [18] have discussed about minimizing energy dissipation by scheduling the transmission rate for a cognitive network with multiple accesses. The outcome of the work was tested with respect to throughput and delay.

Li et al. [19] have used Markovian chain for analyzing the tradeoff among delay, data quality, and energy for sensor networks using distributed algorithm. Motoyoshi et al. [20] have designed a system that enhances the quality of communication for future mobile networks considering OpenFlow clusters. The outcome of their work was found to minimize the cost significantly.

Hence, it can be seen that there are adequate studies that focus on delay minimization. The next section describes the problems in the existing system.

III. PROBLEM IDENTIFICATION

Future Internet Architecture uses complex distributed networking system where the nodes of different domains communicate with each other through a gateway node. The existing border gateway protocol is applicable for communication in the existing internet architecture but not for future internet architecture because of its dynamic nature. The similar problem exists with energy issues too. The following are the various issues, to be answered for the future internet architecture growth and development:

- How to calculate delay in heterogeneous network domain?
- Even if we calculate delay in heterogeneous network domain, how it is going to be helpful in designing delay compensation technique? (as it may lead to lot of stale routing information)
- Does delay affect energy utilization in distributed network?
- How to develop a simulation model considering heterogeneous distributed network and then address delay problem?
- Should we go for delay calculation at the end (i.e. delay efficient approach) or should be keep on estimating delay in progress of transmission (i.e. delay aware approach)

The distributed network possesses many network domains where the nodes in each domain may be mobile. Mobility introduces dynamicity in the network domain, where there is a higher probability of delay (due to data packet conversion, searching for definite route, existing job processing etc). We have also illustrated in our prior work that futuristic internet-based architecture will use more heterogeneous network as compared to homogeneous network. Developing such type of network topology will obviously invite various challenging scenarios in distributed networking system. Even if our prior framework uses stochastic rate control, cross layer control, Markov modeling (for congestion control), it doesn't address delay compensation. If delay compensation is not carried out in distributed network, it could lead to serious violation of SLA (as future architecture needs cloud environment potentially). Hence, the problem statement of the proposed study can be stated as "*It is computationally challenging to formulate a unified algorithm for delay minimization and energy efficiency for distributed networking system*" The following section presents the proposed system in order to address this issue.

IV. PROPOSED SYSTEM

The proposed system aims at minimizing the communication delay and optimizing the energy consumption in distributed networking system. Our prior study has already laid an emphasis on the need for addressing the complexities in distributed network system [21][22]. Our recent works have also introduced a Rate Control

Metric (RCM) that is responsible for directly controlling the traffic flow rate to minimize the traffic congestion in future internet architecture [23]. This paper is a continuation of the prior work, where we lay emphasis on the delay factor which was not addressed in our earlier studies. We name the proposed technique as Energy Efficient Delay Compensation Routing that is meant for smoothening and normalizing the traffic situation in peak hours especially built for distributed networking system. Fig.1 shows the architecture of the proposed system EEDCR. The proposed work develops a simulation study with distributed nodes, different network domains (to implement heterogeneous distributed network) with one test-destination point for assessing the time duration of receiving the data. A tree-based approach is used as it can ensure that data dissemination time will not be increased beyond the controlled level. Finally, the proposed study develops a model that can calculate the energy consumed by the transceiver in a distributed network. In the entire process of modeling, the prime focus is on computing the time required for performing communication on different scenarios of distributed computing. The significant novelty of the presented work is that it is simple and a potential technique for energy saving. It can jointly conserve energy (apart from calculating it) along with selection of the communication channel with less amount of delay prior to formulate decision of routing in highly challenging dynamic architecture. The objectives are as under:

- To develop a framework which can provide a balanced routing process between two major parameters Viz. energy efficiency and delay factor in the distributed networking system.
- To develop an analytical model that can conceptualize the routing mechanism for future internet architecture by incorporating new modules like domain, gateway node and operator node. Here, domain represents a group of nodes.
- Finally, framing a novel energy efficient routing architecture with delay compensation for heterogeneous environment (EEDCR).

The next section discusses about the research methodology followed by the implementation of the algorithms.

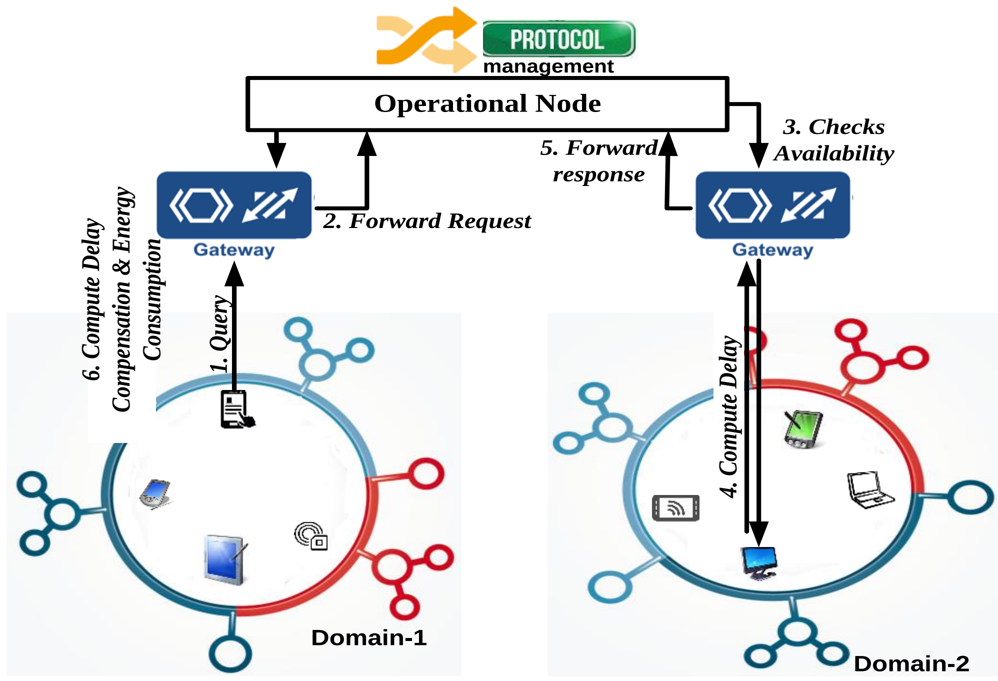

Figure:1 Proposed Architecture of EEDCR

V. Research Methodology

The EEDCR is analyzed using empirical and mathematical models. Through these methods the communication delay is minimized. The formulation of EEDCR is discussed below.

A. *Core Modules Involved:*

Usually, the future internet architecture will consist of number of nodes, which are obviously quite heterogeneous in nature. We introduced two types of nodes namely *gateway node* and *operator node* along with conventional concept of *domain*. A *domain* is formulated by a group wise communication of homogeneous networks of similar applications or with different applications if they follow similar routing protocols in distributed networking system. The member nodes present inside the domain can communicate with each other but not with members of different domains. This is because of the incompatible compliance of routing protocol on different domains. This problem is addressed by considering a *gateway node* as shown in fig 2 that can process messages from different domains and also assist in routing process. The energy is managed at an optimal level by the use of a third party node called as *operator node*. A gateway node is responsible for gathering the data from its domain and forwards it to *operator node*

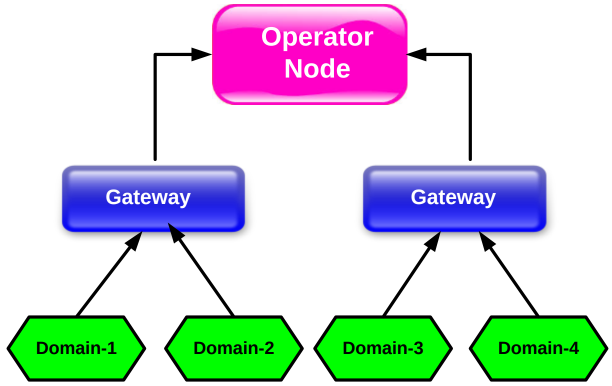

Figure 2 Relationships among Domain, Gateway and Operator Node

The gateway nodes maintain the details of other gateway nodes in-order to process the request generated by the member nodes of one domain to member nodes of other domains. The information gathered by the gateway nodes is forwarded to the operator node which is an intermediated node in the communication network that identifies the gateway node closer to the destination node.

Routing Technique Applied

The routing technique for communication among nodes in heterogeneous network is shown in (Fig.3). The routing process is initiated by forwarding a query generated by a node located in a particular domain (say D_1). The density of nodes in a domain is uneven, just to assume real time situation. The query forwarded by the node is received by its respective gateway node. Normally, a gateway has the list of the entire registered operator nodes, which must get connected in order to deliver the message to another domain. In our proposed system, we do not establish a direct contact among the domains in order to minimize the energy dissipated due to the data processed by the gateway. As the spatial distance and traffic intensity of the operator nodes may differ from each other, the requesting gateway node has to select an appropriate operator node that can ensure less delay and high energy efficiency.

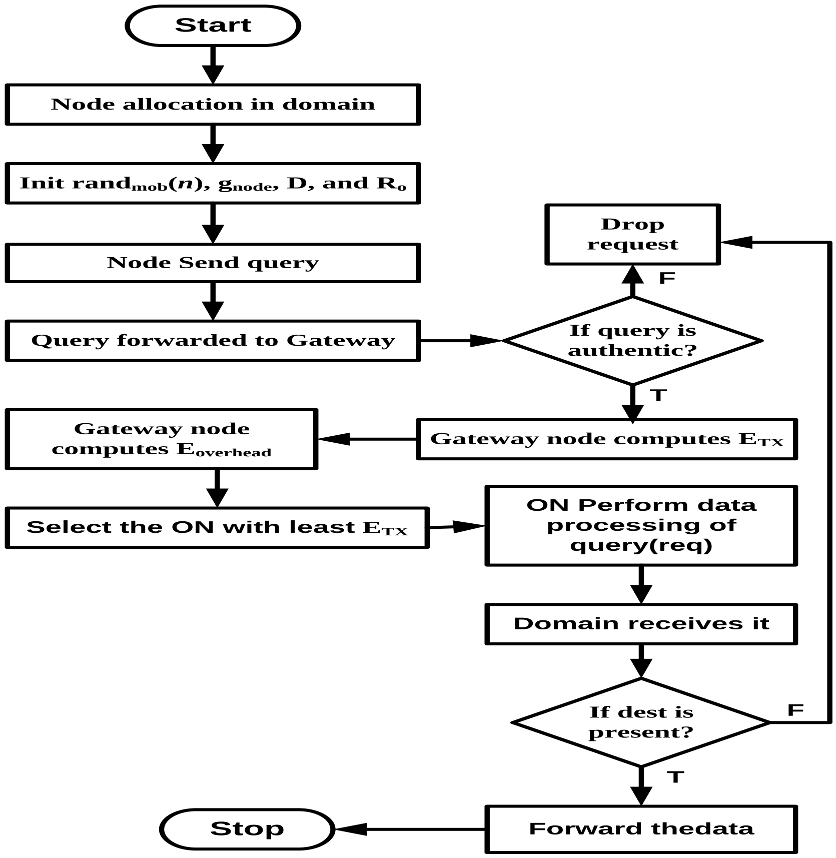

Figure 3 Routing Technique of EEDCR

Upon receiving a request from the gateway (say Gateway-1), the Operator Node (ON) searches for an appropriate gateway and instantly responds to the requesting gateway with total time required to process and transmit the data to the end node. The requesting gateway node broadcasts the request to all the available ON and in turn receives the responses that have time duration details in terms of latency. The requesting gateway node then computes delay and also calculates how much delay will be required to compensate for all the response along the different routes. Based on the route with lowest energy depletion and least delay, the requesting gateway node selects the final ON forwards the same and processes the data to its destination gateway node (say gateway-2) reaching the final destination node.

Delay Compensation

In order to compute the delay, the proposed EEDCR determines the time duration required for performing specific task with respect to given number of modules involved. The process flow of delay compensation technique is highlighted in Fig.4, which shows that initially, the system starts allocating different number of nodes in all the domains that computes time slots for all the essential routing operation during peak traffic condition in the distributed network. The computation of timeslots potentially depends on size of network and number of domains involved in the process.

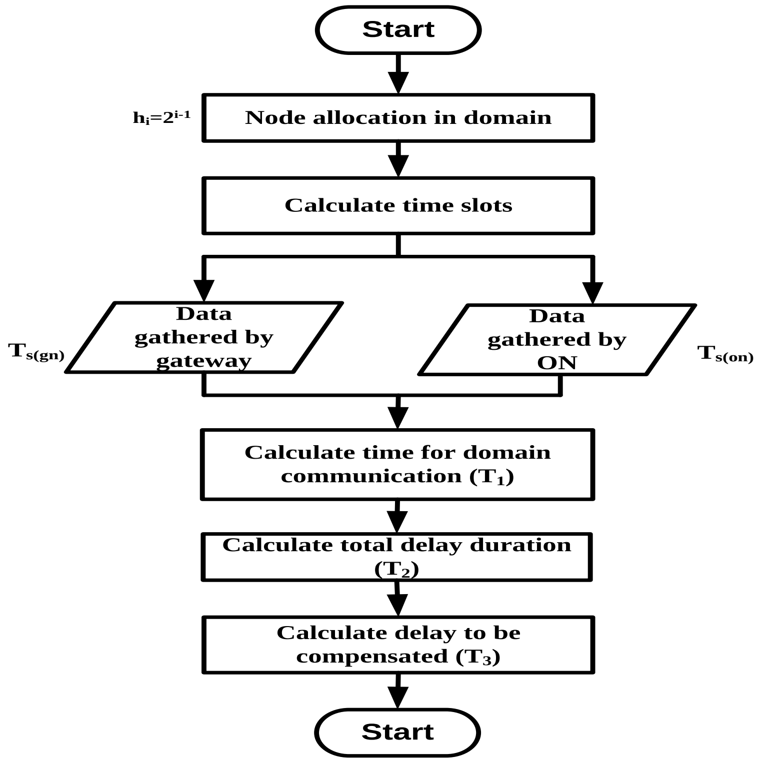

Figure 4 Delay Compensation Technique of EEDCR

The system computes the duration of the time required for data gathering by the gateway node $T_{s(gn)}$ and the operator node $T_{s(on)}$. The system then computes the total time T_1 required for domain-based communication which is then followed by the computation of total delay (T_2) using probability theory. Finally, based upon the response from the ON, the requesting gateway node calculates the exact amount of delay to be compensated. This technique is similar to routing as it complements the routing during the situation of congestion in future internet architecture.

Energy Optimization

The energy efficiency of the EECDR is based on observing the amount of energy being dissipated during routing process using threshold-based scheme in order to control avoidable energy depletion. The schema of energy efficiency and control is highlighted as in Fig.5.

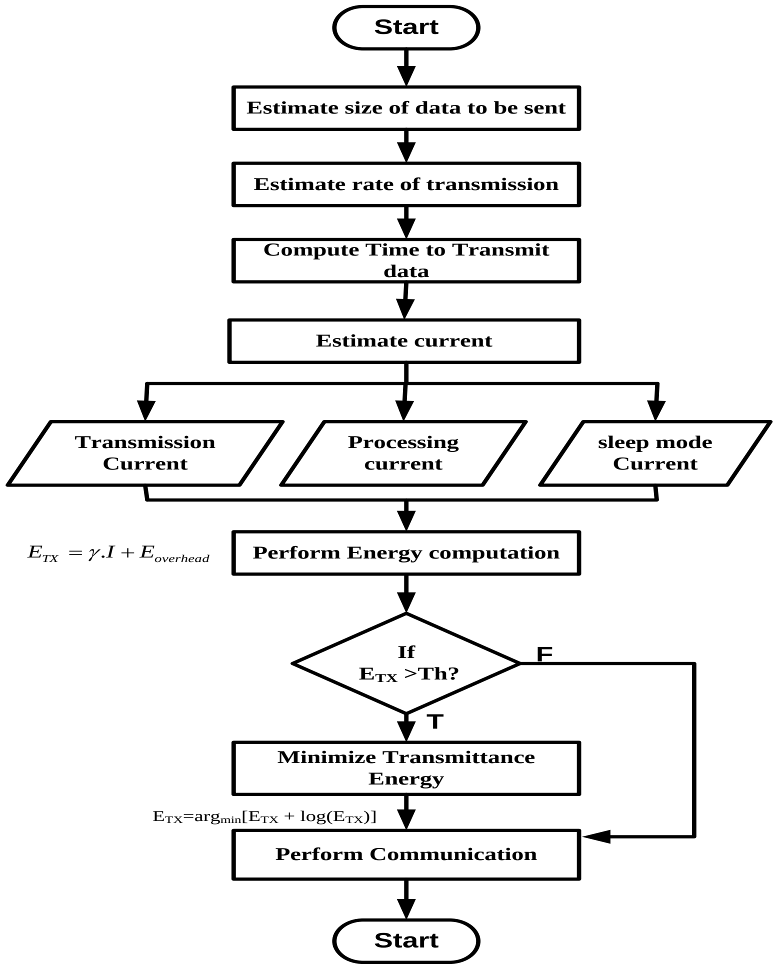

Figure 5 Energy Efficiency Technique of EEDCR

VI. ALGORITHM IMPLEMENTATION

The development of EEDCR is carried out using mathematical modeling and implemented through MATLAB. The complete design of the proposed algorithm is focused on developing and incorporating delay calculation and compensation techniques during the peak traffic condition in distributed networking scenario. The important simulation attributes used for the proposed study is as shown in Table1.

Table 1 Simulation Attributes used

Simulation Attributes	Values Used	Simulation Attributes	Values Used
Size of network	500-1000	Sensing time of Channel	0.5 sec
Simulation area	1000 x 1000 m^2	Size of Control Packet	30 bits
Simulation Time	500 seconds	Size of Data	3000 bytes

Path loss exponent	0.5	Highest velocity of node	100 ms^{-1}
MAC Type	802.11	Lowest velocity of node	1 ms^{-1}
Traffic Model	CBR / VBR	Range of Transmission	10 meter
Capacity of Channel	300 mbps	Initialized energy of node	10 Joule

The uncertain traffic condition will always lead to delay in the network. Owing to the distributed nature of the traffic, it is quite difficult to compute the delay factor which also leads to massive energy consumption among the nodes. The description of the algorithms used in design of EEDCR techniques is given below:

i) Algorithm for Delay Compensation

The initial operation of this algorithm begins by exploring size of the network and its relationship with the domain. We assume that the size of the network *S* is limited between *D* to (*D*-1) domains in each of the iteration, where *D* will represent last domain and (*D*-1) will represents its previous domain. The algorithm than finds the highest number of the nodes in i^{th} domain that can be represented as $h_i = 2h_{i-1}$. Therefore, line-2 of the algorithm will represent the maximum number of domains in progression. The size of the network is controlled by lower limit of 2^{D-1}-1 and highest limit of 2^D-1. During the transmission, it is quite natural that data packets will be compressed by the forwarding nodes. The proposed work doesn't focus on compression much, but still it considers a hypothetical rate of compression in order to justify the utilization of generic compression technique. The EEDCR structures and arranges its nodes in the form of a tree in *D* domain. The proposed algorithm focuses on the allocation of the nodes particularly in order to minimize the delay by allocating the initial (*D*-1) domains with certain number of nodes. Hence, the time interval scheduled for a gateway node is represented as

$$T_{s(gn)}=S-2^{D-1}.$$

Whereas the second line of step-3 shows the time interval for a specific schedule. This will also mean that $T_{s(gn)}$ is the time interval spent for gathering the data by the gateway node and $T_{s(on)}$ is the time interval for transmitting the data to the operator node.

In this section we calculate the time required for domain-based communication (T_1). A closer look into the time calculation T_1 is the addition of (2^{D-1}-1) and (S-2^{D-1}+1). Therefore, we use a function *f*(x) in equation(1) to compute the time T_1, which is cumulative period of time for the initial (D-1) domain to gather data and then forward the same to the operator node considering the rate of compression.

$$T_1 = f(x) + |\delta^{T_{s(gn)}} + \int_{x=1}^{T_s(gn)} \delta^x dx| \qquad (1)$$

The second component of the equation (1) is cumulative rate of compression starting from gateway node to operator node considering the maximum time duration to be equivalent to $T_{s(gn)}$ expressed in setp-3 of algorithm. The delay calculation is carried out using equation (2) considering another function *g*(*x*) that considers number of selected operator nodes.

$$T_2 = h_{i(D-1)} - 1 + g(x) \qquad (2)$$

It means that EEDCR can control the overhead in the selection of operator node by the gateway node. We performed majority of the testing using 3-7% of selection criteria in order to compute T_2. Finally, delay to be compensated is computed using equation (3) which uses further two functions i.e. α(x) and β(x).

$$T_3 = \alpha(x) + \beta(x) \qquad (3)$$

The function α(x) is computed using maximum time consumed on respective domain and β(x) is computed by summing up all the rate of compression being considered for each gateway nodes. The computation will lead to generation of T_3, which is the delay associated in the network during the peak traffic condition. The computation of the delay is carried out within the gateway node *gn* considering its associated connectivity with its nodes in one domain and other operator nodes.

Algorithm for Delay Compensation

Input: S (Size of Network), D (Domain), δ (rate of compression).

Output: Delay duration (T_2) and delay to be compensated (T_3).

Start:

1. Init S

2. Allocate nodes in domain

$$h_i=2^{i-1}$$

3. Perform Domain Allocation

$$T_{s(gn)}=S-2^{D-1}$$

$$T_{s(on)}=S-2^{D-1}+1$$

4. Calculate time for Domain Communication

$$T_1 = f(x) + |\delta^{T_{s(gn)}} + \int_{x=1}^{T_s(gn)} \delta^x dx|$$

5. Calculate total delay duration

$$T_2 = h_{i(D-1)} - 1 + g(x)$$

6. Calculate delay to be compensated

$$T_3 = \alpha(x) + \beta(x)$$

End

ii) Algorithm for Energy Efficiency

The computation of energy is strongly associated with the selection procedure of the operator node. As there are various operator nodes and heterogeneous domains, the complexity could be further increased resulting in unwanted energy exhaustion. Hence, we formulate an algorithm where a novel technique is applied to compute the amount of energy drained and a simple threshold-based technique to control energy dissipation of the nodes.

Algorithm for Energy Efficiency

Input: θ_1 (size of data to be sent), θ_2 (rate of transmission) , I_1 (current required to perform transmission), I_2 (current require to perform algorithm processing), I_3 (current required in sleep mode of node), Th (Threshold)

Output: Minimized Transmittance Energy

Start

1. init θ_1 and θ_2.

2. Estimate time to transmit data

$t_s = \theta_1 / \theta_2$

3. Compute power drawn

$I = I_1 + I_2 + I_3$

4. Perform Energy computation

$E_{TX} = \gamma . I + E_{overhead}$

5. do(

$E_{TX} = \arg_{min}[E_{TX} + \log(E_{TX})]$

6. While $E_{TX} > Th$

7. Perform communication

End

The processing of this algorithm is carried out in the gateway node that has to select the operator node with maximum residual energy based on preliminary evaluation (before performing the routing).The algorithm for energy efficiency considers the time required to transmit selected data from one node to gateway by dividing size of data to be sent with respect to rate of transmission. Hence, it is quite clear that the value of t_s in step-2 will differ in all iterations of routing. The novelty of this technique the emphasis lied on the power used during the communication process. For analysis purpose, we consider usage of three different sources of power i.e. power required for performing transmission, power required to perform algorithm processing, and power required in sleep mode of the node.

The transmitted energy is calculated using equation (4) that also includes energy that is expended due to overhead ($E_{overhead}$).

$$E_{TX} = \gamma . I + E_{overhead} \quad (4)$$

A simple logic is applied to control the energy dissipation by using threshold energy. As majority of the electronic and communication devices comes with standard specification of energy efficiency [24], hence, it is possible to generalize the cut-off energy of all such devices in order to perform optimal communication operations. The computation explained in step-5-6 is carried out by gateway node during selection of operator node. The probability of selecting an operator node by a gateway is around 3-7%. The gateway chooses the operator node through iteration in-order to find the one which yields lower value of E_{TX}. Hence, the logic written in sep-5 in do statement is about lowering the value of E_{TX} by the log value of it. For an effective computation we use a scale that represents 10 Joules (initialized energy) using 1 unit of probability. This means that the algorithm considers lowest value of E_{TX} as 0 while highest value equivalent to 0.9 units. This consideration is intentionally done so that log of any value within the limit of 0-0.9 will generate negative values that lower the energy consumption during routing.

VII. RESULTS & DISCUSSION

This section discusses the outcomes of the proposed system. As the proposed EEDCR system emphasizes on delay minimization and energy conservation techniques the performance parameters viz. delay estimates, throughput, energy consumption, traffic load are chosen so that they can scale effectively on peak traffic condition with respect to increasing iteration rounds.

Rationale of Comparative Analysis

The proposed system is reviewed by considering the study that has similar concept of delay minimization and very closely associated with it. In order to measure the effectiveness of the proposed EEDCR, we compare the outcomes with the work done by Asadi [25] and Hong [26]. Asadi have developed a technique called as DRONEE (Dual-radio opportunistic networking for energy efficiency), which is essentially meant for achieving energy efficiency for futuristic networking applications e.g. LTE (Long-Term Evolution) with opportunistic scheduling. DRONEE is also characterized by distributed network architecture and is designed for enhancing the quality of signal focusing on energy saving features. The design of this technique also allows a node residing in one cluster to communicate with node located in another cluster. However, the study [25] chooses homogeneity in designing nodes, clustering, and routing process with a target to conserve maximum possible energy in uplink transmission. The study carried out by Hong [26] has focused on using distributed computing for retaining maximum throughput, delay, and energy efficiency. The author have used Slepian-Wolf bound [27], Markov chain, and adaptive MAC for controlling delay, energy in the communication process. The next section discusses about the outcomes accomplished from the simulation study.

A. *Analysis of Delay Estimates*

The delay is estimated by considering the time duration for a data to travel from sender node in one domain to destination node in another domain via gateway and operator node. The outcome highlighted in Fig.6 showcase the comparative analysis of the delay estimates which shows that EEDCR has a superior delay performance as compared to Asadi [25] and Hong [26]. The method presented by [26] is based on the Slepian-Wolf technique that performs source coding in a distributed nature and ALOHA protocol for enhancing the throughput. The problem with this method is the adopted sequential encoding mechanism which consumes more time for processing the algorithm especially on heterogeneous distributed networking system. Another problem of this approach is the usage of linear recursive operation which consumes more processing time in order to identify the skew in the delay vector and then perform minimization of it. Hence, it has maximum delay.

The DRONEE algorithm has mainly focused on performing clustering mechanism on LTE-based network considering the effect of stationary fading. DRONEE doesn't have any form of recursive-based operation during clustering and hence it can assists in reducing the time duration of the data transfer as compared to Hong [26] approach. Alternatively, his method uses modulation and coding techniques in order to maintain better fairness in its throughput. The modeling also includes computation of various power-related factors resulting in increased delay when compared to proposed EEDCR. Therefore, EEDCR reduces its computational process through multiple threading processes that results in simultaneous balance between data delivery and energy efficiency. Moreover, channel errors are less in EEDCR as the delay incurred in routing is estimated before the original routes are established. As a result it is evident from the graph depicted below that after 300ith iteration the delay is almost linear in case of EEDCR whereas the other approaches experiences maximum delay. Therefore, proposed EEDCR provides an efficient routing mechanism with a better delay performance as compared to existing techniques.

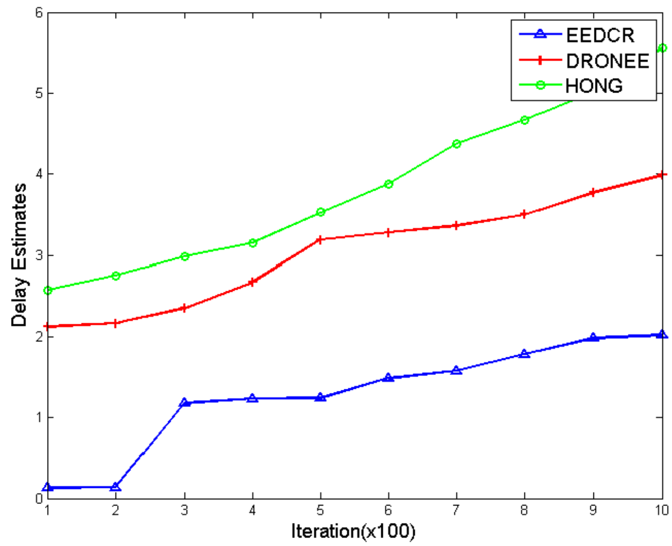

Figure 6 Analysis of Delay Estimates

B. *Analysis of Average Throughput*

The QoS parameter throughput is considered for measuring the effectiveness in communication in the scenario of an additional operator node in EEDCR. It is computed as the cumulative amount of the data relayed from the gateway and the same being processed by the operator node per unit time (second). The result depicted in Fig.7 reveals that the average throughput of EEDCR has comparatively better performance in contrast to existing approaches.

Although the Hong [26] approach was developed for improving the throughput, but its design principle was found to take the decision of enhancing the throughput only based on probability analysis. In order to perform probability analysis, the approach is highly dependent on continuous arbitrary data and lacks capturing of events that occur at preliminary routing stage. Another significant impediment is the dependency on static sink for data processing, which reduces the throughput in a heterogeneous environment. On the other hand, the DRONEE algorithm makes use of the cooperative communication that assists in faster delivery of data packets in shortest interval of time for LTE networks. However, it also performs this task considering the probability of scheduling using enhanced round robin mechanism by selecting the channel that can assure QoS. Hence, both these approaches do not have significant change in their throughput. EEDCR addresses this problem by introducing operator node that is designed for performing data conversion from one domain to another domain during the routing process. Here, because of the pre computation technique associated with the EEDCR system in identifying the best route at the gateway and operator node which does not have any resource constraint, there will be significant enhancement in throughput quality of the network. From the average throughput analysis graph it is noticed that at after 500th iteration the EEDCR ensures improvement it the throughput where as the other two approaches do not show specific changes. Hence, EEDCR has maximum throughput performance.

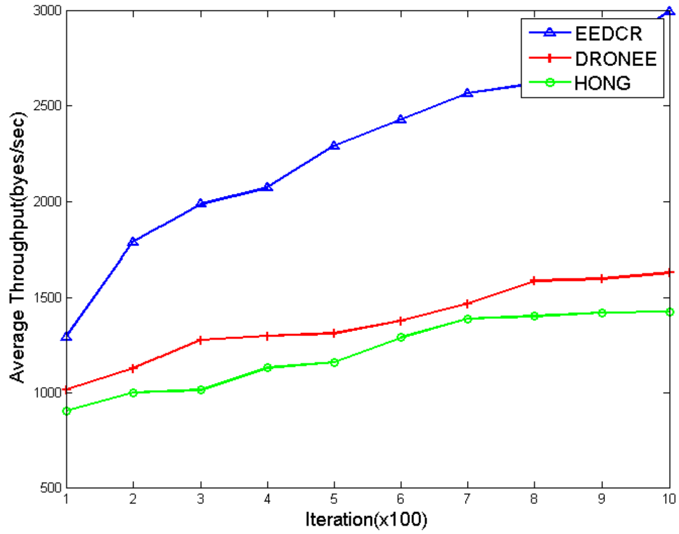

Figure 7 Analysis of Average Throughput

C. ***Analysis of Energy Consumption***

The Future Internet Architecture may operate with low power devices. The nodes are operated at maximum energy level for routing process. It is to extend the life time of the network and enhance the quality of service. The comparative analysis of energy optimization in EEDCR and existing approaches is presented in the fig 8.

The approach presented by HONG [26] has emphasized on clustering process in wireless sensor networks to reduce the energy consumption, it does not implement any optimization technique. It is due to the demand of the algorithm (recursive operation and probability theory) for recursive operation. When this approach was implemented on our scenario considering a scale 0 (lower battery state] and 1(higher batter state), we found that it is incompatible with the heterogeneous devices in perspective to energy conservation. The Slepian-Wolf method has proved efficient for small sensor operations, but fails to retain energy. This is because of the utilization of energy towards data processing. The results depicted in the graph shows that the performance of the prior approach with respect to energy consumption was better till 500th level of iterations owing to usage of Markov chain process. As the iteration process was increased, the energy dissipation also increased, because, in this system maximum number of operations are used for counting the state of the messages. On the other side, DRONEE [25] used clustering mechanism for energy optimization but when it was applied in our environment it spends most of its energy in performing opportunistic scheduling. Hence, we conclude that there is no significant difference in the outcomes of both these approaches. The proposed EEDCR adopts a simple threshold-based technique to compute the delay on the routes. It involves less overhead and results in accurate delay calculation that leads to significant conservation of energy. The behavior of EEDCR (Fig.8) with respect to energy is quite predictive in nature after 600th round of simulation in heterogeneous distributed networking system where as the other two approaches exhibits irregularities in their performances.

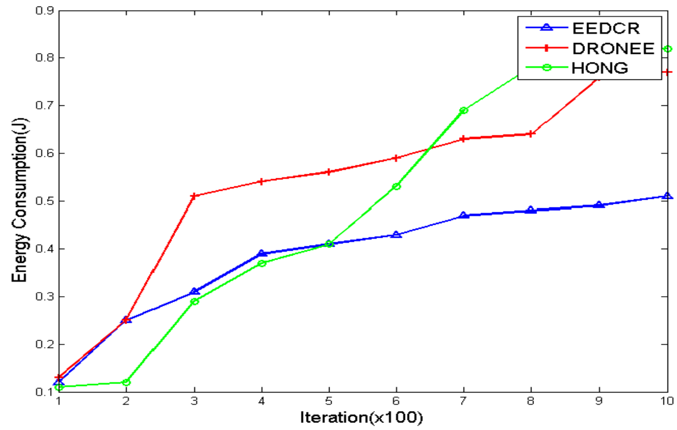

Figure 8 Analysis of Energy Consumption

D. *Analysis of Average Traffic Load*

The traffic load is estimated by considering the number of request being generated over a period of time and the mean time required to process the same. It measures the sustainability of the system with increasing traffic load. It is assumed that if a system has the property of normalizing the traffic, then it exhibits a curve with gradient decent to prove its effectiveness in managing the traffic load under peak traffic condition.

Fig.9 shows the analysis of the average traffic load. The Hong [26] uses arbitrary access mechanism and distributed source coding in a homogeneous network. However, when the simulation environment is changed to a system with heterogeneous nodes, this approach is found to consume more time in encoding the groups. From the average traffic load analysis graph it is proved that the existing mechanism is good for sensor network but not ideal for dynamic networks and hence the system is having lesser capability to sustain increasing traffic load with increasing rounds of iterations.

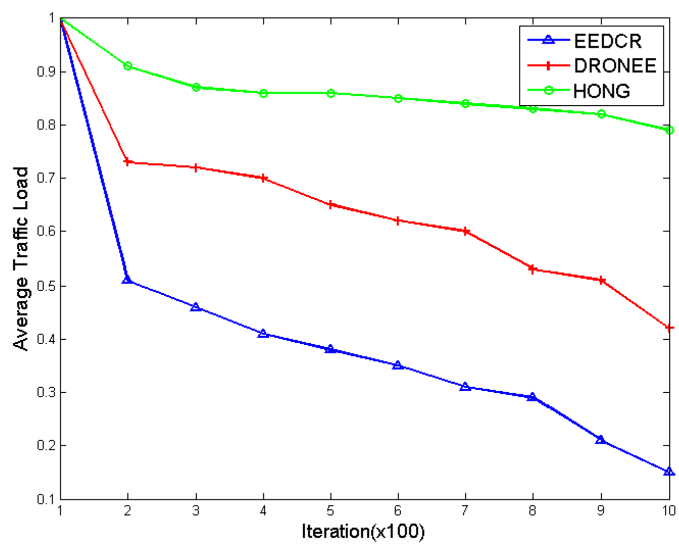

Figure 9 Analysis of Average Traffic Load

The DRONEE algorithm used cooperative communications scheme among wireless relay nodes to achieve high rate of data transmission. This feature was not enabled to compute delay during or before the routing process. The pre computation technique associated with the EEDCR system in identifying the best route for communication at the gateway and operator node assists in leveraging the capability of the node to sustain increasing traffic load. The simulation results depicted in Fig 9 reveals that the performance of EEDCR decreases linearly with increasing rounds of iteration and traffic load. The following section presents the quality analysis of the proposed EEDCR to conclude that it excels better in its performance when compared to existing techniques with respect to multiple performance parameters.

Quality Analysis

The performance parameters considered for quality analysis are delay, average traffic load, average throughput and energy consumption. The following are the observations arrived from results discussed in section VII.

The delay estimates depicted in the fig 6 shows that at the initial iteration rounds EEDCR have the minimum delay of 0.2 milliseconds. This is because the delay compensation algorithm helps in finding routes with less delay before the routing process is initiated. Absence of this technique in the existing approaches increases the delay to 2 milliseconds in DRONEE algorithm and 2.6 milliseconds in Hong. As the number of iteration rounds increases the delay in EEDCR rises to 1 millisecond and later it almost increases linearly by 10%. In case of the existing approaches they exhibits random variations and therefore the behavior of these systems are unpredictable in future. The average throughput of EDDCR presented in the fig 7 revels that as the number of iteration rounds increase the throughput also increases by 15% for every round of iteration. This is because of the additional operator node used in EEDCR to identify the best routes. The approaches adopted by DRONNE and Hong do not show remarkable changes with respect to average throughput. The comparative analysis of energy consumption by EEDCR showed in fig 8 scales linearly by 0.05 joules for every one step increase in iteration. This controlled dissipation on energy improves the lifetime of the network. In case of DRONNE algorithm the energy consumption increases to 0.5 joules at the 300th iteration and later increases linearly by 0.02 joules for every increase in the iteration round. At 800th iteration it rises to 0.88 joules resulting fast drainage of the battery power and leading to low network lifetime. The Hong approach exhibits high energy consumption in every simulation round resulting in degradation in QoS. Hence both these approaches do not show improvements in the life time of the communicating nodes in the network. Finally the average traffic load depicted in the fig 9 infers that the EEDCR system has about 80% capability to withstand the increasing traffic load due to the presence of operator nodes for sharing the load of gateways and domain nodes ,whereas the DRONNE algorithm and Hong approach has 40% and 20% respectively.

VIII CONCLUSION

This paper has laid an emphasis on the fact that the delay minimization is only possible if the persistent problems associated with traffic and communication protocols are addressed efficiently. In existing internet architecture, the gateway node is overburdened with various networking and authentication responsibilities that degrade the data transmission to certain extent. Hence, we share some of the responsibilities of gateway to a third party node called as operator node. In the proposed model, a requesting node may reside within a particular domain (out of many domains) or move to another domain. Each domain is also assumed to follow its own routing techniques. The request messages of the nodes will be passed on to their respective gateways which are directly communicating with the operator nodes. There are many operator nodes, which keeps addresses of other respective gateways in order to access or forward the data to another node in different domains. The gateway node computes the routes based on minimal delay and minimal energy and perform data transmission, which gives guaranteed results of data transmission. Our result shows better outcomes with respect to data transmission and energy conservation in comparison to the existing techniques.

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