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DISCOVERING THOUGHTS AND INVENTING FUTURE

Highlights

- Routing for Traffic Allocation
- Ethernet Technology in Computer
- Mobility Based Self Selection
- Analyzing the Query Performance

Computer Server Farm

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Portfolio Selection in Multipath Routing for Traffic Allocation

By M. Karunakar Reddy & S. Nageswara Rao
JNTU-Anantapur

Abstract - Multiple-path source routing protocols allow a data source node to distribute the total traffic among available paths. In this article, we consider the problem of jamming-aware source routing in which the source node performs traffic allocation based on empirical jamming statistics at individual network nodes. We formulate this traffic allocation as a lossy network flow optimization problem using portfolio selection theory from financial statistics. We show that in multi-source networks, this centralized optimization problem can be solved using a distributed algorithm based on decomposition in network utility maximization (NUM). We demonstrate the network's ability to estimate the impact of jamming and incorporate these estimates into the traffic allocation problem. Finally, we simulate the achievable throughput using our proposed traffic allocation method in several scenarios.

Keywords : Jamming, Multiple path routing, Portfolio selection theory, Routing, Wireless Network, Network utility maximization.

GJCST-E Classification : C.2.2

PORTFOLIO SELECTION IN MULTIPATH ROUTING FOR TRAFFIC ALLOCATION

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Portfolio Selection in Multipath Routing for Traffic Allocation

M. Karunakar Reddy [α] & S. Nageswara Rao [σ]

Abstract - Multiple-path source routing protocols allow a data source node to distribute the total traffic among available paths. In this article, we consider the problem of jamming-aware source routing in which the source node performs traffic allocation based on empirical jamming statistics at individual network nodes. We formulate this traffic allocation as a lossy network flow optimization problem using portfolio selection theory from financial statistics. We show that in multi-source networks, this centralized optimization problem can be solved using a distributed algorithm based on decomposition in network utility maximization (NUM). We demonstrate the network's ability to estimate the impact of jamming and incorporate these estimates into the traffic allocation problem. Finally, we simulate the achievable throughput using our proposed traffic allocation method in several scenarios.

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I. Introduction

Jamming point-to-point transmissions in a wireless mesh network [1] or underwater acoustic network [2] can have debilitating effects on data transport through the network. The effects of jamming at the physical layer resonate through the protocol stack, providing an effective denial-of-service (DoS) attack [3] on end-to-end data communication. The simplest methods to defend a network against jamming attacks comprise physical layer solutions such as spread-spectrum or beam forming, forcing the jammers to expend a greater resource to reach the same goal. However, recent work has demonstrated that intelligent jammers can incorporate cross layer protocol information into jamming attacks, reducing resource expenditure by several orders of magnitude by targeting certain link layer and MAC implementations [4]–[6] as well as link layer error detection and correction protocols. The majority of ant jamming techniques make use of diversity. For example, ant jamming protocols may employ multiple frequency bands, different MAC channels, or multiple routing paths. Such diversity techniques help to curb the effects of the jamming attack by requiring the jammer to act on multiple resources simultaneously. In this paper, we consider the ant jamming diversity based on the use of multiple routing paths. Using multiple-path variants of source routing protocols such as Dynamic Source Routing (DSR) or Ad Hoc On-Demand Distance Vector (AODV), or example the MP-DSR protocol, each source node can request several routing paths to the destination node for concurrent use. To make effective use of this routing diversity, however, each source node must be able to make an intelligent allocation of traffic across the available paths while considering the potential effect of jamming on the resulting data throughput. In order to characterize the effect of jamming on throughput, each source must collect information on the impact of the jamming attack in various parts of the network.

However, the extent of jamming at each network node depends on a number of unknown parameters, including the strategy used by the individual jammers and the relative location of the jammers with respect to each transmitter–receiver pair. Hence, the impact of jamming is probabilistic from the perspective of the network, and the characterization of the jamming impact is further complicated by the fact that the jammers' strategies may be dynamic and the jammers themselves may be mobile.2 In order to capture the nondeterministic and dynamic effects of the jamming attack, we model the packet error rate at each network node as a random process. At a given time, the randomness in the packet error rate is due to the uncertainty in the jamming parameters, while the time variability in the packet error rate is due to the jamming dynamics and mobility. Hence, more sophisticated anti-jamming methods and defensive measures must be incorporated into higher-layer protocols, for example channel surfing [8] or routing around jammed regions of the network [6].

a) My Contributions

- We formulate the problem of allocating traffic across multiple routing paths in the presence of jamming as a lossy network flow optimization problem.
- We map the optimization problem to that of asset allocation using portfolio selection theory. We formulate the centralized traffic allocation problem for multiple source nodes as a convex optimization problem.
- We show that the multi-source multiple-path optimal traffic allocation can be computed at the source nodes using a distributed algorithm based on decomposition in network utility maximization (NUM).

Author α : Computer Science and Engineering, MITS/ JNTU A, India.
Author σ : Computer science and Engineering, MITS/ JNTU A, India.

- We propose methods which allow individual network nodes to locally characterize the jamming impact and aggregate this information for the source nodes.
- We demonstrate that the use of portfolio selection theory allows the data sources to balance the expected data throughput with the uncertainty in achievable traffic rates.

II. Background

a) Characterizing the Impact of Jamming

In this Module, the network nodes to estimate and characterize the impact of jamming and for a source node to incorporate these estimates into its traffic allocation. In order for a source node s to incorporate the jamming impact in the traffic allocation problem, the effect of jamming on transmissions over each link must be estimated. However, to capture the jammer mobility and the dynamic effects of the jamming attack, the local estimates need to be continually updated.

b) Effect of Jammer Mobility on Network

The capacity indicating the link maximum number of packets per second (pkt/s) eg: 200 pkts/s which can be transported over the wireless link. Whenever the source is generating data at a rate of 300 pkts/s to be transmitted at the time jamming to be occurring. Then the throughput rate to be less. If the source node becomes aware of this effect the allocation of traffic can be changed to 150 pkts/s on each of paths thus recovers the jamming path.

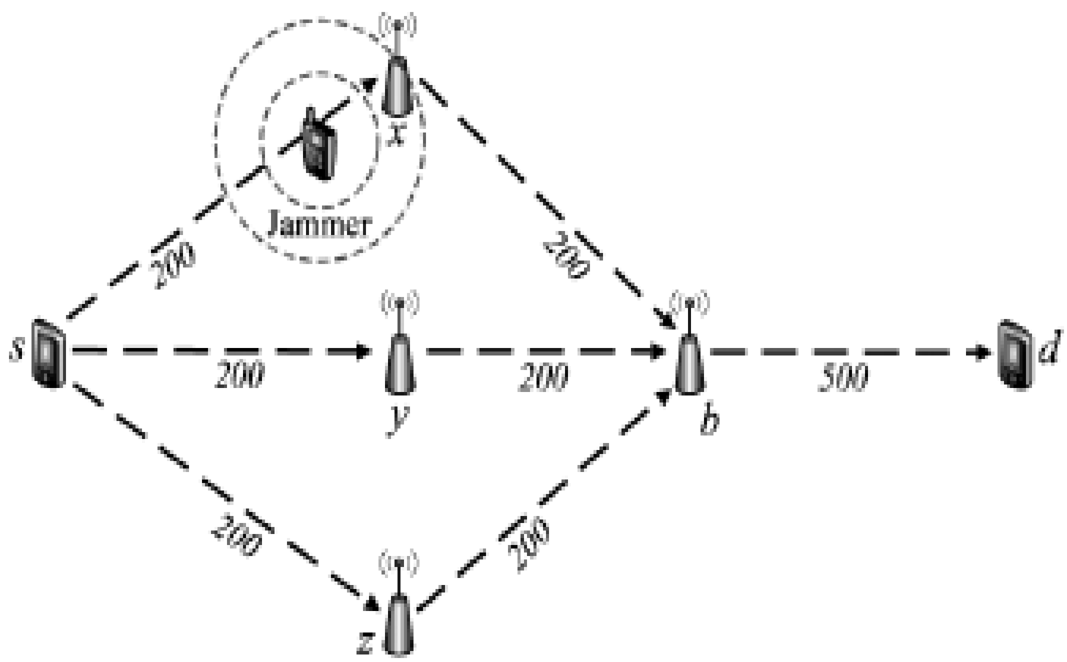


Fig.1 : An example network that illustrates a single-source network with three routing paths.

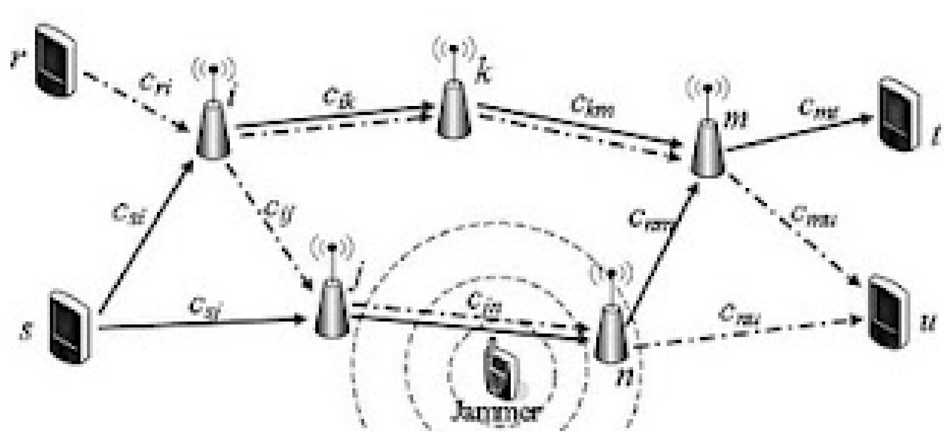


Fig. 2 : An example network with sources S = {r, s} is illustrated. Each unicast link (i, j) ! E is labeled with the corresponding link capacity

c) Estimating End-to-End Packet Success Rates

The packet success rate estimates for the links in a routing path, the source needs to estimate the effective end-to-end packet success rate to determine the optimal traffic allocation. Assuming the total time required to transport packets from each source s to the corresponding destination is negligible compared to the update relay period

d) Computational Complexity

We note that both the centralized optimization problem in and the local optimization step in the distributed algorithm are quadratic programming optimization problems with linear constraints . The computational time required for solving these problems using numerical methods for quadratic programming is a polynomial function of the number of optimization variables and the number of constraints.

e) Optimal Jamming-Aware Traffic Allocation

An optimization framework for jamming-aware traffic allocation to multiple routing paths for each source node. We develop a set of constraints imposed on traffic allocation solutions and then formulate a utility function for optimal traffic allocation by mapping the problem to that of portfolio selection in finance. In order to define a set of constraints for the multiple-path traffic allocation problem, we must consider the source data rate constraints, the link capacity constraints, and the reduction of traffic flow due to jamming at intermediate nodes. Due to jamming at nodes along the path, the traffic rate is potentially reduced at each receiving node as packets are lost.

In Markowitz's portfolio selection theory an investor is interested in allocating funds to a set of financial assets that have uncertain future performance. The expected performance of each investment at the time of the initial allocation is expressed in terms of return and risk. The return on the asset corresponds to the value of the asset and measures the growth of the investment. The risk of the asset corresponds to the variance in the value of the asset and measures the degree of variation or uncertainty in the investment's growth. We describe the desired analogy by mapping this allocation of funds to financial assets to the allocation of traffic to routing paths. We relate the expected investment return on the financial portfolio to the estimated end-to-end success rates and the investment risk of the portfolio to the estimated success rate covariance matrix .We note that the correlation between related assets in the financial portfolio corresponds to the correlation.

Packet delivery ratio: The packet delivery ratio in this simulation is defined as the ratio between the number of packets sent by constant bit rate sources (CBR,"application layer") and the number of received packets by the CBR sink at destination.

Routing Overhead: It is the number of packet generated by routing protocol during the simulation.

Average end-to-end delay of data packets: There are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

Distributed Jamming-Aware Traffic Allocation

Initialize $n = 1$ with initial link prices λ_1.

1. Each source s independently computes
$$\phi^*_{s,n} = \arg\max_{\phi_s \in \Phi_s} \left(\gamma_s^T - \lambda_n^T W_s\right) \phi_s - k_s \phi_s^T \Omega_s \phi_s .$$
2. Sources exchange the link usage vectors $u_{s,n} = W_s \phi^*_{s,n}$.
3. Each source locally updates link prices as
$$\lambda_{n+1} = \left(\lambda_n - a\left(c - \sum_{s \in S} u_{s,n}\right)\right)^+ .$$
4. If $\|\phi^*_{s,n} - \phi^*_{s,n-1}\| > \epsilon$ for any s, increment n and go to step 1.

f) Traffic Allocation Constraints

In order to define a set of constraints for the multiple-path traffic allocation problem, we must consider the source data rate constraints, the link capacity constraints, and the reduction of traffic flow due to jamming at intermediate nodes. The traffic rate allocation vector "s is trivially constrained to the nonnegative orthant, i.e. "s * 0, as traffic rates are non-negative.

III. Case Study

a) Routing

Routing is the process of selecting paths in a network along which to send network traffic. Routing is performed for many kinds of networks, including the telephone network (Circuit switching), electronic data networks (such as the Internet), and transportation networks. This article is concerned primarily with routing in electronic data networks using packet switching technology.

b) Routing protocol

A routing protocol is a protocol that specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network, the choice of the route being done by routing algorithms. Each router has *a priori* knowledge only of networks attached to it directly. A routing protocol shares this information first among immediate neighbours, and then throughout the network. This way, routers gain knowledge of the topology of the network.

c) Multiple path Routing

Multipath routing is the routing technique of using multiple alternative paths through a network, which can yield a variety of benefits such as fault tolerance, increased bandwidth, or improved security. The multiple paths computed might be overlapped, edge-disjointed or node-disjointed with each other.

IV. Performance Evaluation

In this section, we simulate various aspects of the proposed techniques for estimation of jamming impact and jamming aware traffic allocation. We first describe the simulation setup, including descriptions of the assumed models for routing path construction, jammer mobility, packet success rates, and estimate updates. We then simulate the process of computing the estimation statistics µij (t) and !2 ij (t) for a single link (i, j). Next, we illustrate the effects of the estimation process on the throughput optimization, both in terms of optimization objective functions and the resulting simulated throughput.

Distributed Formulation Algorithm:
Input: Load
Output: Allocates the load in different number of paths

Step1: starts the packets allocation

Step2: select multiple source and multiple destination

Step3: forward the feedback from first route to next route

Sep4: packets allocation in different number of routes till gets the optimal solution

Step5: All the routes are distributes successfully using parallel paths communication

V. Simulation setup

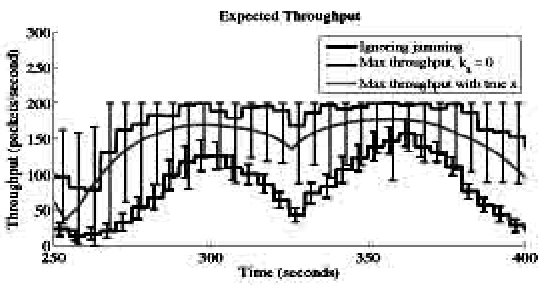
The simulation results presented herein are obtained using the following simulation setup. A network of nodes is deployed randomly over an area, and links are formed between pairs of nodes within a fixed communication range. The set S of source nodes is chosen randomly, and the destination node ds corresponding to each source s! S is randomly chosen from within the connected component containing s.

a) Simulation of Estimation Process

We first simulate the process of computing the estimate µij(t) and the variance !2 ij (t) over a single link (i, j). Figure 4 shows the true packet success rate xij (t) with the estimate µij(t) and the estimation variance !2 ij (t) for various parameter values. By inspection of below Figure , we see that a shorter update relay period Ts and a longer update period T yield a more consistent estimate µij (t) with less variation around the true value of xij (t).

b) Simulation of Parameter Dependence

We next evaluate the effect of varying network and protocol parameters in order to observe the performance trends using the jamming-aware traffic allocation formulation. In particular, we are interested in the effect of the update relay period Ts and the maximum number of routing paths |Ps| on the performance of the flow allocation algorithm.



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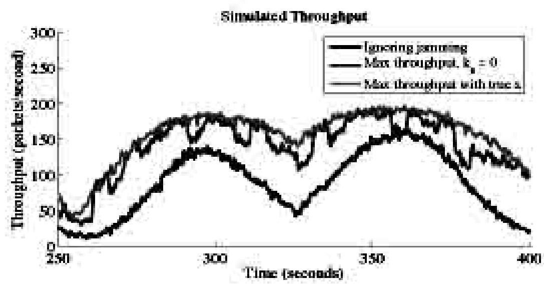

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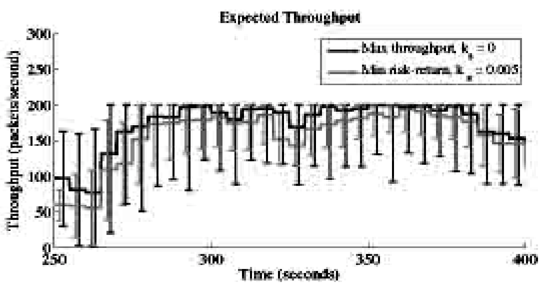
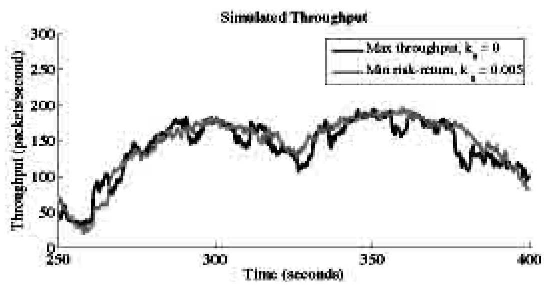


(c)



(d)

VI. Conclusion and Future work

We studied the problem of traffic allocation in multiple-path routing algorithms in the presence of jammers whose effect can only be characterized statistically. We have presented methods for each network node to probabilistically characterize the local impact of a dynamic jamming attack and for data sources to incorporate this information into the routing algorithm. We formulated multiple-path traffic allocation in multi-source networks as a lossy network flow optimization problem using an objective function based on portfolio selection theory from finance. We showed that this centralized optimization problem can be solved using a distributed algorithm based on decomposition in network utility maximization (NUM). We presented simulation results to illustrate the impact of jamming dynamics and mobility on network throughput and to demonstrate the efficacy of our traffic allocation algorithm. We have thus shown that multiple path source routing algorithms can optimize the throughput performance by effectively incorporating the empirical jamming impact into the allocation of traffic to the set of paths. We propose a scheme based on multiple routing paths. The wireless network of interest can be represented by a directed graph. The solution is when a source node S want to send data to a target node T, it finds all the paths to route the packet from S to T. The traffic to be sent from S to T is split and sent across multiple paths. Say there is 100 packets to be sent, how many packets to sent in each routing path is to be decided. The logic of how to split the traffic across multiple paths takes into consideration the expected jamming in each path. The algorithm to solve is called as Optimal Jamming aware traffic allocation.

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Analyzing the Query Performance Over a Distributed Network of Data Aggregators

By P. Prabhakar & S. Nageswara Rao
Madanapalle Institute of Technology and Science, AP, India

Abstract - Typically a user desires to obtain the value of some aggregation function over distributed data items. We present a low-cost, scalable technique to answer continuous aggregation queries using a network of aggregators of dynamic data items. In such a network of data aggregators, each data aggregator serves a set of data items at specific coherencies. Our technique involves decomposing a client query into sub-queries and executing sub-queries on judiciously chosen data aggregators with their individual sub-query incoherency bounds. We provide a technique for getting the optimal set of sub-queries with their incoherency bounds, which satisfies client query's coherency requirement with least number of refresh messages sent from aggregators to the client. For estimating the number of refresh messages, we build a query cost model which can be used to estimate the number of messages required to satisfy the client specified incoherency bound. Performance results using real-world traces show that our cost based query planning leads to queries being executed using less than one third the number of messages required by existing schemes.

Keywords : Content distribution network, continuous query, online decision making, data dissemination, coherency, performance.

GJCST-E Classification : C.2.1

ANALYZING THE QUERY PERFORMANCE OVER A DISTRIBUTED NETWORK OF DATA AGGREGATORS

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Analyzing the Query Performance Over a Distributed Network of Data Aggregators

P. Prabhakar $^{\alpha}$ & S. Nageswara Rao $^{\sigma}$

Abstract - Typically a user desires to obtain the value of some aggregation function over distributed data items. We present a low-cost, scalable technique to answer continuous aggregation queries using a network of aggregators of dynamic data items. In such a network of data aggregators, each data aggregator serves a set of data items at specific coherencies. Our technique involves decomposing a client query into sub-queries and executing sub-queries on judiciously chosen data aggregators with their individual sub-query incoherency bounds. We provide a technique for getting the optimal set of sub-queries with their incoherency bounds, which satisfies client query's coherency requirement with least number of refresh messages sent from aggregators to the client. For estimating the number of refresh messages, we build a query cost model which can be used to estimate the number of messages required to satisfy the client specified incoherency bound. Performance results using real-world traces show that our cost based query planning leads to queries being executed using less than one third the number of messages required by existing schemes.

Keywords : Content distribution network, continuous query, online decision making, data dissemination, coherency, performance.

I. Introduction

Application such as auctions, personal portfolio for financial decisions, sensors based monitoring, route planning based on traffic information, etc., make extensive use of dynamic data. For such applications, data from one or more independent data sources may be aggregated to determine if some action is warranted. Given the increasing number of such applications that make use of highly dynamic data, there is significant interest in systems that can efficiently deliver the relevant updates automatically. Many data intensive applications delivered over the Web suffer from performance and scalability issues. Content distribution networks (CDNs) solved the problem for static content using caches at the edge nodes of the networks. CDNs continue to evolve to serve more and more dynamic applications [1, 2]. A dynamically generated web page is usually assembled using a number of static or dynamically generated fragments. The static fragments are served from the local caches whereas dynamic fragments are created either by using the cached data or by fetching the data items from the origin data sources. One important question for satisfying client requests through a network of nodes is how to select the best node(s) to satisfy the request. For static pages content requested, proximity to the client and load on the nodes are the parameters generally used to select the appropriate node [3]. In dynamic CDNs, while selecting the nodes node(s) to satisfy the client request, the central site (top-level CDN node) has to ensure that page/data served meets client's coherency requirements also. Techniques to efficiently serve fast changing data items with guaranteed incoherency bounds have been proposed in the literature [4, 5]. Such dynamic data dissemination networks can be used to disseminate data such as stock quotes, temperature data from sensors, traffic information, and network monitoring data. In this paper we propose a method to efficiently answer aggregation queries involving such data items. In data dissemination schemes proposed in literature [4, 11], a hierarchical network of data aggregators is employed such that each data aggregator serves the data item at some guaranteed incoherency bound. Incoherency of a data item at a given node is defined as the difference in value of the data item at the data source and the value at that node. Although CDNs use page-purge [8] based coherency management, we assume that in dynamic data dissemination networks, these messages carry the new data values thereby an invalidation message becomes a refresh message. For maintaining a certain incoherency bound, a data aggregator gets data updates from the data source or some higher level data aggregator so that the data incoherency is not more than the data incoherency bound. In a hierarchical data dissemination network a higher level aggregator guarantees a tighter incoherency bound compared to a lower level aggregator. Thus, data refreshes are pushed from the data sources to the clients through the network of aggregators.

Data incoherency: data accuracy can be specified in terms of incoherency of a data item, defined as the absolute difference in value of the data item at the data source and the value known to a client of the data. Let $v_i(t)$ denote the value of i^{th} data item at the data source at time t; and let the value the data item known to the client be $u_i(t)$. Then the data incoherency at the client is given by $|u_i(t)-v_i(t)|$. For a data item which needs to be refreshed at an incoherency bound C a

Author α : M.Tech Student, Dept of CSE, Madanapalle Institute of Technology and Science, AP, India.
E-mail : prabhakar.mth@gmail.com
Author σ : Assistant Professor, Dept of CSE, Madanapalle Institute of Technology and Science, AP, India. E-mail : nag_sirisala@yahoo.com

data refresh message is sent to the client as soon as data exceeds C, i.e., $|u_i(t)-v_i(t)|>C$.

Network of data aggregators: Data aggregators are one kind of secondary server it serves as data sources (data items). The data refreshes can be done using two mechanisms. *(a)Push* based mechanism data source send update messages to client on their own. *(b)Pull* based mechanism data sources send messages to the client only when client makes a request. For scalable handling of push based data dissemination, network of DA's are proposed in the literature [12,15,16].

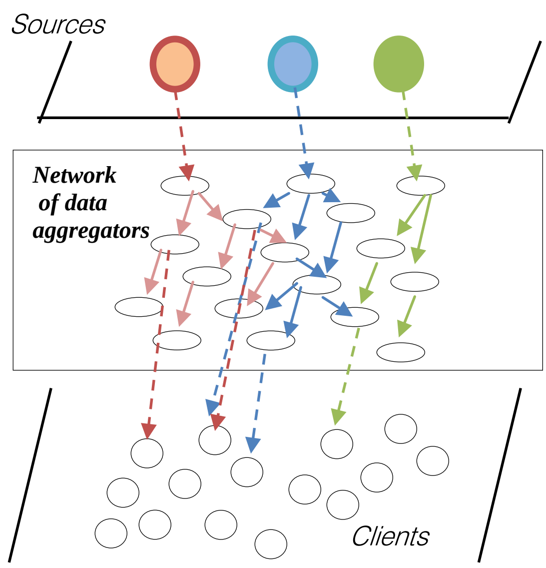

Figure 1 : Data dissemination network for multiple data items

In such network of DA's, data refreshes occur from data sources to the client through one or more DA's. In this paper we assume that each DA maintains its configured incoherency bounds for various data items. Dissemination networks for various data items can be overlaid over a single network of data aggregators as shown in Figure 1. Thus, From a data dissemination capability point of view, each data aggregator (DA) is characterized by a set of (d_i, c_i) pairs, where d_i is a data item which the DA can disseminate at an incoherency bound C_i.The configured incoherency bound of data item at a DA can be maintained using any of following methods: (a) the data source refreshes the data value of the DA whenever DA's incoherency bound is about to get violated. This method is scalability problems. (b) data aggregators with tighter incoherency bound help the DA to maintain its incoherency bound in scalable manner as explained in [4,7].

Example 1: In a network of data aggregators managing data items *D1-D4*, various aggregators can be characterized as-

A1: {(*D1*, 0.5), (*D3*, 0.2)}
A2: {(*D1*, 1.0), (*D2*, 0.1), (*D4*, 0.2)}

Aggregator *A1* can serve values of *D1* with an incoherency bound greater than or equal to 0.5 whereas *A2* can disseminate the same data item at a looser incoherency bound of 1.0 or more. Usually, client is interested in an aggregation of these dynamic data items at a certain incoherency bound. These continuous queries are used to monitor changes in dynamic data and provide results useful for online decision-making. For generating the result of a query, data from multiple sources is required. As a result, the query has to be evaluated either at data aggregators or at the client.

In this work, our aim is to satisfy the client's query requirements while minimizing the query execution cost in terms of number of dissemination messages. Towards that end, we have achieved the following:

1. Developed techniques for estimating the cost of disseminating a data item, at specified incoherency bound.
2. Using the estimated data dissemination cost, we developed query cost model for estimating the cost of executing an incoherency bounded continuous query.
3. Used the query cost model for assigning a client query to one or more data aggregators so that the query can be executed with the least number of messages.

Our work involves dividing the client query into sub-queries and allocating it to different data aggregators for optimal execution. In comparison, all the related work in literature [3,5] propose getting individual data items from the aggregators which, as we show in this report, leads to large number of dissemination messages. In the rest of the Introduction, we present basic concepts underlying incoherency bounded continuous query execution using a distributed network of data aggregators.

a) *Problem Statement and Contributions*

In this paper, we develop query cost model for aggregation query involving multiple data items:
- Additive aggregation with each data item possibly different weights, and - MIN/MAX aggregation queries. The weighted aggregation query can be mathematically written as:

$$v_s^q(t) = \sum_{i=1}^{i=n^q} s_i(t) \times w_i^q \qquad (1)$$

V_s^q is the value of a client query q involving n^q data items with the weight of the i^{th} data item being w_i^q, $1 < i < n^q$. $s_i(t)$ is the value of the i^{th} data item at the data source at time t. Such a query encompasses SQL aggregation operators SUM and AVG besides general weighted aggregation queries such as portfolio queries, involving aggregation of stock prices, weighted with number of shares of stocks in the portfolio. Due to space limitations, we are not presenting execution schemes for other aggregation queries such as MIN/MAX. Interested readers are referred to [13] for the extended version of this paper.

Let the value of i^{th} data item, in Equation (1), known to the client/DA be $d_i(t)$. Then the data incoherency is given by $|s_i(t)-d_i(t)|$. For a data item which needs to be disseminated at an incoherency bound C the data refresh is sent to the client or lower level DA, if the $|s_i(t)-d_i(t)|$ is more than C. If user specified incoherency bound for the query q is C^q, then the dissemination network has to ensure that:

$$\sum_{i=1}^{n^q}\left(s_i(t)-d_i\right)\times w_i^q \le c^q \qquad (2)$$

Whenever data values at sources change such that query incoherency bound is violated, the updated value(s) is disseminated to the client. If the network of aggregators can ensure that the i^{th} data item has incoherency bound C_i then the following condition ensure that the query incoherency bound C^q is satisfied:

$$\sum_{i=1}^{n^q} c_i \times w_i^q \le c^q \qquad (3)$$

For additive aggregation queries, a client specified query incoherency bound needs to be translated into incoherency bounds for individual data items or sub-queries such that these satisfy Equation (3).

MIN/MAX queries involve set of data items, whose extremes are the required result, and its incoherency bound. In a MIN (MAX) query, even if one data value changes it is possible that that value is minimum (maximum) thus individual data incoherency bound cannot be more than query incoherency bound. Thus in case of MIN/MAX queries the dissemination network has to ensure that $Ci \le Cq$ for all the data items appearing in the query.

b) Summary of Distributed Execution approach

Consider a client query Q=50 $D1$ + 200 $D2$ + 150 $D3$ with a required incoherency bound of 80 (in a stock portfolio $D1$, $D2$, $D3$ can be different stocks and incoherency bound can be \$80).We want to execute this query over data aggregators given in Example1, minimizing number of refreshes. There are various options for the client to get the data items.

The client may get the data items $D1$, $D2$ and $D3$ separately. The query incoherency bounds can be divided among data items in various ways while satisfying Equation 3. In this report, we show that getting data items independently is a costly option. This strategy ignores facts that the client is interested only in the aggregated value of the data items and various aggregators can disseminate more than one data item.

If a single DA can disseminate all three data items required to answer the client query, the DA can construct a composite data item corresponding to the client query (Sq=50 $D1$ + 200 $D2$+ 150 $D3$) and disseminate the result to the client so that the query incoherency bound is not violated. It is obvious that if we get the query result from a single DA, the number of refreshes will be minimum (as in this case data item updates may cancel out each other, thereby keeping the query result within the incoherency bound). As different data aggregators disseminate different subsets of data items, no data aggregator may have all the data items required to execute the client query, which is indeed the case in Example1. Further, even if an aggregator can disseminate all the data items, it may not be able to satisfy the query coherency requirements. In such cases, the query has to be executed with data from multiple aggregators.

Another option is to divide the query into a number of sub-queries and get their values from individual DAs. In that case, the client query result is obtained by combining the results of more than one sub-query. For the DAs given in Example1, the query Q can be divided in two alternative ways:

Plan1: $A1$ {50 $D1$ + 150 $D3$}; $D2$ {$D2$}

Plan2: $A1$ {$D3$}; $D2$ {50 $D1$, + 200 $D2$}

i.e., in plan1 result of sub-query 50 $D1$ + 150 $D3$ is served by $A1$ whereas value of (or 200 $D2$) by $D2$ is served by $A2$. In plan2, value of $D3$ is served by $A1$ whereas result of sub-query 50 $D1$ + 200 $D2$ is served by $A2$. Combining them at the client gives the query result.

Selecting the optimal plan among various options is not-trivial. As a thumb-rule, we should be selecting the plan with lesser number of sub-queries. But that is not guaranteed to be the plan with the least number of messages. Further, we should select the sub-queries such that updates to various data items appearing in a sub-query have more chances of cancelling each other as that will reduce the need for refresh to the client (Equation 2). In the above example, if updates to $D1$ and $D3$ are such that when $D1$ increases, $D3$ decreases, and vice-versa, then selecting *plan1* may be beneficial. We give an algorithm to select the query plan based on these observations.

While solving the above problem of selecting the optimal plan we ensure that each data item for a client query is disseminated by one and only one data aggregator. Although a query can be divided in such a way that a single data item is served by multiple DAs (e.g., 50 $D1$ + 200 $D2$ + 150 $D3$ is divided into two sub-queries 50 $D1$ + 130 $D2$ and 70 $D2$ + 150 $D3$); but in doing so the same data item needs to be processed at multiple aggregators, increasing the unnecessary processing load. By dividing the client query into disjoint sub-queries we ensure that a data item update is processed only once for each query (For example, in case of paid data subscriptions it is not prudent to get the same data item from the multiple sources).

The query incoherency bound needs to be divided among sub-query incoherency bounds such that, besides satisfying the client coherency requirements, the chosen DA (where the sub-query is to be executed) is capable of satisfying the allocated sub-query incoherency bound. For example, in *plan1* allocated incoherency bound to the sub-query $50D1 + 150D3$ should be greater than 55 (=50*0.5+150*0.2) as that is the tightest incoherency bound which the aggregator *D1* can satisfy. We prove that the number of refreshes depends on the division of the query incoherency bounds among sub-query incoherency bounds.

Thus, what we need is a method of (a) optimally dividing client query into sub-queries and (b) assigning incoherency bounds to them; such that (c) selected sub-queries can be executed at chosen. And (d) total query execution cost, in terms of number of refreshes, is minimized.

II. Data Dissemination Cost Model

Cost of disseminating a data item at a certain given incoherency bound *C* can be estimated by combining two models:

a) Incoherency bound model

The incoherency bound model is used for estimating dependency of data dissemination cost over the desired incoherency bound. As per this model, we have shown in [13] that the number of data refreshes is inversely proportional to the square of the incoherency bound ($1/C2$). Similar result was earlier reported in [4] where the data dynamics was modeled as a random walk process.

$$\text{Data dissemination cost} \propto 1/C2 \qquad (4)$$

b) Data synopsis Model

The Data synopsis model is used for estimating the effect of data dynamics on number of data refreshes. We define a data dynamics measure called, sumdiff, to obtain a synopsis of the data for predicting the dissemination cost. The number of update messages for a data item is likely to be higher if the data item changes more in a given time window. Thus we hypothesize that cost of data dissemination for a data item will be proportional to data synopsis, called sumdiff, defined as:

$$R_s = \sum_i \left(s_i - s_{i-1} \right) \qquad (5)$$

Where S_i and S_{i-1} are the sampled values of the data item at i^{th} and $(i-1)^{th}$ time instances (consecutive ticks). Data sumdiff can be maintained at the source or aggregators. For calculating this quantity, the data source can accumulate the absolute value of changes in data items or the data aggregator can estimate this quantity using changes in pushed values. Next we use this result for developing the query cost model.

Consider a case where a query consists of two data items *P* and *Q* with weights w_p and w_q respectively; and we want to estimate its dissemination cost. If data items are disseminated separately query *sumdiff* will be:

$$R_{data} = w_p R_p + w_q R_q = w_p \sum | p_i - p_{i-1} | + w_q \sum | q_i - q_{i-1} | \qquad (6)$$

Instead, if the aggregator uses the information Instead, if the aggregator uses the information that client is interested in a query over *P* and *Q* (rather than their individual values), it makes a composite data item $w_p p + w_q q$ and disseminates that data item then the query *sumdiff* will be:

$$R_{query} = \Sigma | w_p(p_i - p_{i-1}) + w_q(q_i - q_{i-1}) | \qquad (7)$$

R_{query} is clearly less than or equal compared to R_{data}. Thus we need to estimate the *sumdiff* of an aggregation query (i.e., R_{query}) given the *sumdiff* values of individual data items (i.e., R_p and R_q). Only data aggregators are in position to calculate R_{query} as different data items may be from different sources.

III. Query Cost Model

For getting an estimation of the query dissemination cost what we need is R_{query} whereas we know R_p and R_q (in Equation (6) and (7). As different data items may be disseminated by different servers, R_{query} can be calculated only at data aggregators. If two data items are correlated such that if value of one data item increases other also increases, then R_{query} will be closer R_{data} ; whereas if the data items are inversely correlated then R_{query} will be much less than R_{data}. Thus, institutively, we can represent the relationship between R_{query} and *sumdiff* of individual data items involved using a correlation measure between data items. Specifically, if ρ is the correlation measure then R_{query} can be written as:

$$R^2_{query} \infty \left(w^2_p R^2_p + w^2_q R^2_q + 2\rho w_p R_p w_q R_q \right) \qquad (8)$$

The correlation measure is defined such that–1≤ρ≤ +1, so, *Rquery* will always be less than $|w_p R_p + w_q R_q|$ (as explained earlier) and always be more than $|w_p R_p - w_q R_q|$.

The correlation measure ρ can be interpreted as cosine similarity [19] between two streams represented by data items P and Q. Cosine similarity is a widely used measure in information retrieval domain where documents are represented using a vector-space model and document similarity is measured using cosine of angle between two document representations. For data streams P and Q, ρ can be calculated as:

$$\rho = \frac{\sum\left(p_i - p_{i-1}\right)\left(q_i - q_{i-1}\right)}{\sqrt{\sum\left(p_i - p_{i-1}\right)^2}\sqrt{\sum\left(q_i - q_{i-1}\right)^2}} \qquad (9)$$

a) Executing queries using sub queries

For executing an incoherency bounded continuous query, a query plan is required which includes the set of sub-queries, their individual incoherency bounds and data aggregators which can execute these sub-queries. We need to find the optimal query execution plan which satisfies client coherency requirement with the least number of refreshes. What we need is a mechanism to:

Task 1: Divide the aggregation query into sub-queries; and

Task 2: Allocate the query incoherency bound among them.

While satisfying the following conditions identified in Section 1.2:

Condition 1. Query incoherency bound is satisfied.

Condition 2. The chosen DA should be able to provide all the data items appearing in the sub-query assigned to it.

Condition 3. Data incoherency bounds at the chosen DA should be such that the sub-query incoherency bound can be satisfied at the chosen DA.

Objective: Number of refreshes should be minimized.

b) Minimum Cost

Figure 2 shows the outline of greedy heuristics where different criteria (ψ) can be used to select sub-queries. In this section we describe the case where the estimate of query execution cost is minimized in each step of the algorithm (min-cost) whereas in the next section we present the case where gain due to executing a query using sub-queries is maximized (max-gain).

c) Query Plan with Pre-decided Incoherency Bound Allocation

For the given client query (q) and mapping between data aggregators and the corresponding {*data-item*, *data incoherency bound*} pairs ($f: D \rightarrow (S, C)$) maximal sub-queries can be obtained for each data aggregator. Let A be the set of such maximal sub queries. In this set, each query a € A can be disseminated by a designated data aggregator at the assigned incoherency bound. For each sub-query a€A, its *sumdiff* Ra is calculated. Using the set A and sub-query *sumdiffs*, we use the algorithm outlined in Figure 2 to get the set of sub-queries minimizing the query cost. In this Figure each sub-query a € A is represented by the set of data items covered by it. As we need to minimize the query cost, a sub-query with *minimum cost per data item* is chosen in each iteration of the algorithm i.e., criteria ψ ≡ minimize ($Ra/Ca^2/|a|$).

All data items covered by the selected sub query are removed from all the remaining sub-queries in A before performing the next iteration.

Algorithm:

```
Result ←∅
 while A ≠ ∅
choose a sub-query a∊A with criteria ψ
        Result ←Result ∪a
       A←A-{a}
         for each data element e ∊ a
            for each b ∊ A
                 b←b-{e}
        if b =∅
              A←A-{b}
        else
             Calculate sumdiff for modified b
Return Result
```

Figure 2 : Greedy algorithm for query plan selection

The decision is taken based on client query information. The greedy method is the most straight forward method. It is popular for obtaining the optimized solutions. In the greedy method there are some important activities. (a) A selection of solution from the given input domain is performed. (b). The feasibility of the solution is performed and then all the feasible solutions are obtained. (c) From the set of feasible solutions, the particular solution that minimizes or maximizes the given objective function is obtained. Such a solution is called optimal solution. For an algorithm that uses greedy method works in stages. At each stage only one input is considered at a time. Based on this input it is decided whether particular input gives the optimal solution or not.

d) Maximum Gain

In this section we present an algorithm which, instead of minimizing the estimated query execution cost, maximizes the estimated gains of executing client query using sub-queries. In this algorithm, for each sub-query, we calculate the relative gain of executing it by finding the *sumdiff* difference between cases when each data item is obtained separately and when all the data items are aggregated as a single sub-query. (i.e., maximal sub-query).

IV. Related Work

We divide the related work on scalable answering of aggregation queries over a network of data aggregators in to two interrelated topics.

a) Answering Incoherency bounded aggregation queries

Various mechanism for efficiently answering incoherency bounded aggregation queries over continuously changing data items are proposed in the literature [3,4,9]. i.e., in this thesis, to develop and evaluate client-pull-based techniques for refreshing data so that the results of the queries over distributed data can be correctly reported, conforming to the limited incoherency acceptable to the users. Here considered the problem of answering queries for online decision making at web data aggregators.

Our work distinguishes itself by employing sub-query based evaluation to minimize number of refreshes. Pull based data dissemination techniques, where client or data aggregators pull data items such that query requirements are met, are described in [3]. For minimizing the number of pulls, both predict data values and pull instances. In comparison, we use push based mechanism to refresh sub-query values at the client. In [4], authors propose push based scheme using data filters at the sources. i.e., distributed data sources continuously stream updates to a centralized processor that monitors continuous queries over the distributed data. Based on we specified a new approach for reducing communication cost in an environment of centralized continuous query processing over distributed data streams.

This approach hinges on specifying precision constraints for continuous queries, which are used to generate adaptive filters at remote data sources that significantly reduce update stream rates while still guaranteeing sufficient precision of query results at all times. And enables users or applications to trade precision for lower communication cost at a fine granularity by individually adjusting precision constraints of continuous queries. Imprecision of query results is bounded numerically so applications need not deal with any uncertainty. To validate our approach we performed a number of experiments using simulations and a real network monitoring implementation approach in achieving low communication overhead. According to that work can an aggregation query, the number of refresh messages can be minimized by performing incoherency bound allocation to individual data items such that the number of messages from different data sources is the same. Instead we execute more dynamic assigning incoherency bounds. And minimizing the total number of messages send by DAs. Like us ,authors of [9],also assume that dissemination tree from sensor node[data source] to root[client]already exist; and they also install error filters on partial aggregates (similar to in coherency bound assign to sub queries) but, in our work each data aggregator can only discriminates data at some pre-specified incoherency bound depending on its capability where as such a constraints does not exist for [9].further, we also be give method to select partial aggregates (sub queries)to be used to answering the query.

Authors propose using data filters at the sources; instead we assign incoherency bounds to sub-queries which reduce the number of refreshes for query evaluation, Further, we propose that more dynamic data items should be executed as part of larger sub-query. In [8], i.e., here discuss various techniques of reorganizing a data dissemination network when client requirements change. Instead, we try to answer the client query using the existing network. Reorganizing aggregators is a longer term activity whereas query planning can be done for short as well as long running queries on more dynamic basis.

Like us, author of [9] also assume that dissemination tree from sensor nodes (data- sources) to root (clients) already exists. In-network data aggregation has been recently proposed as an effective means to reduce the number of messages exchanged in wireless sensor networks. Nodes of the network form an aggregation tree, in which parent nodes aggregate the values received from their children and propagate the result to their own parents. However, this schema provides little flexibility for the end-user to control the operation of the nodes in a data sensitive manner. For large sensor networks with severe energy constraints, the reduction (in the number of messages exchanged) obtained through the aggregation tree might not be sufficient. In this thesis we present new algorithms for obtaining approximate aggregate statistics from large sensor networks. The user specifies the maximum error that he is willing to tolerate and, in turn, our algorithms program the nodes in a way that seeks to minimize the number of messages exchanged in the network, while always guaranteeing that the produced estimate lies within the specified error from the exact answer. And they also install error filters on partial aggregates. But in our work, each data aggregators can only disseminate data some pre-specified incoherency bound depending on its capability whereas such a constraint does not exist for [9].

Further, we also give a method to select partial aggregates (sub queries) to be used for answering the query. In [12] Pull based data dissemination techniques, where clients or data aggregators pull data items such that query requirements are met, are described in [3]. i.e., we develop and evaluate client-pull-based techniques for refreshing data so that the results of the queries over distributed data can be correctly reported, conforming to the limited incoherency acceptable to the users. For minimizing the number of pulls, both model the individual data items and predict data values. In comparison, we consider the situation where different sub-queries, involving multiple data items, can be evaluated at different nodes. Further, incoherency bound is applied over the sub-query rather than to individual data items, leading to efficient evaluation of the query.

Spatial and temporal correlations between sensor data are used to reduce data refresh instances in [5,6]. We also consider correlation in terms of cosine similarity between data items, but we use it for dividing client query into sub-queries.

b) Construction and maintenance of network of data aggregators

Authors of [1,2,8] describe Construction and maintenance of hierarchical network of data aggregators for providing scalability and fidelity in disseminating dynamic data items to large number of clients.. In these works, fidelity is defined as fraction of time when the client coherence requirements are met. Each data aggregators is given client requirements in the form of data items and their respective incoherency bounds. Instead we use such networks for efficiently answering client's aggregation queries. One can use client queries to optimally construct a network of data aggregators while, on the other hand, one can also use a given network of aggregators to efficiently answer client queries. Authors of [1,2,8] deal with the first part where as we have studied the second part. Changes in data dynamics may lead to reorganization of the network of data aggregators which, in turn necessitate changes in query plans. Whereas query plan can change more often depending on data dynamics.

Instead of optimizing fidelity of data items at data aggregators, as proposed in [2], using our work, one can optimize fidelity all the way up to client queries. Fidelity of a data item can be approximately calculated as number of dissemination messages multiplied by the total delay in the message transmission. Author of [2] assume that each client's requirements are fulfilled by a single data aggregator. But in case of data aggregators may need to disseminate a large number of data items which will lead to processing large number of refresh messages, hence increase in delay. Thus , each client getting all its data items from a single data aggregators(using a single sub-query) is optimal from number of messages point of view but not necessarily from the query fidelity point of view. By using our work, one can model expected number of messages for client query. Thus, our work can complement the of [2] for end-to-end (source-to-client) fidelity optimization.

V. Conclusion and Future Work

In this literature presents a cost based approach to minimize the number of refreshes required to execute an incoherency bounded continuous query. For optimal execution we divide the query into sub-queries and evaluate each sub-query at a chosen aggregator. Performance results show that by our method the query can be executed using less than one third the messages required for existing schemes. Further we showed that by executing queries such that more dynamic data items are part of a larger sub-query we can improve performance. Our query cost model can also be used for other purposes such as load balancing various aggregators, optimal query execution plan at an aggregator node, etc.

Developing efficient strategies for multiple invocations of our algorithm, considering hierarchy of data aggregators. Another area for future research is changing a query plan as data dynamics changes. Another area of our future work is using the cost model for these applications and developing the cost model for more complex queries.

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Techniques to Enhance Lifetime of Wireless Sensor Networks: A Survey

By Jyoti Saraswat, Neha Rathi & Partha Pratim Bhattacharya
Mody Institute of Technology & Science (Deemed University), Lakshmangarh, Dist. Sikar, Rajasthan, India

Abstract - Increasing lifetime in wireless sensor networks is a major challenge because the nodes are equipped with low power battery. For increasing the lifetime of the sensor nodes energy efficient routing is one solution which minimizes maintenance cost and maximizes the overall performance of the nodes. In this paper, different energy efficient routing techniques are discussed. Here, photovoltaic cell for efficient power management in wireless sensor networks is also discussed which are developed to increase the lifetime of the nodes. Efficient battery usage techniques and discharge characteristics are then described which enhance the operational battery lifetime.

Keywords : Wireless sensor network, energy efficient routing, asleep protocol, photovoltaic cell, battery lifetime modeling.

GJCST-E Classification : C.2.1

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Strictly as per the compliance and regulations of:

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Jyoti Saraswat [α], Neha Rathi [σ] & Partha Pratim Bhattacharya [ρ]

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Keywords : Wireless sensor network, energy efficient routing, asleep protocol, photovoltaic cell, battery lifetime modeling.

I. Introduction

Wireless sensor network (WSN) consists of a large amount of small battery powered devices which perform tasks like processing, radio transmission-reception, sensing and actuating. Wireless sensor network devices have limited energy to complete large tasks. Energy consumption still remains the limitation of this field.

Wireless sensor network comprise of thousands of motes which are used to exchange information with the user either directly or through the external base-station (BS). Each of these sensor nodes sense data from environment surrounding the sensors and send it to the outside world through the external base station. A base station is a mobile node or may be a fixed node which has a capability of connecting the sensor network to an existing communications infrastructure or to the internet [1].

An ordinary node performs two major tasks. Firstly, it senses physical phenomenon and performs some computation and forwards it to other nodes, if necessary. Secondly, it also acts as relay point for other sensor nodes to route the data [2]. Sensor nodes have many applications such as target field imaging, intrusion detection, weather monitoring, security and tactical surveillance, distributed computing, detecting ambient conditions (e.g. temperature, movement, sound, light) or the presence of certain objects, inventory control, and disaster management. Placement of the sensor nodes in these applications is random in nature or these can be placed manually. For example, in a disaster management application, a large number of sensors can be dropped from a helicopter. These sensors nodes can assist rescue operations by locating survivors, identifying risky areas, and making the rescue team more aware of the overall situation in the disaster area.

The structural view of sensor network is shown in figure 1. Sensing unit, processing unit, transmission unit, and power unit are the four major constituent of sensor nodes assigned with dissimilar jobs. Sensing unit is used to trace the physical environment and tells the CPU to compute and store the data it sensed. Transmission unit is tasked to receive the information from CPU and transmit it to the outside world. Power unit regulate battery power to sensor node.

There are different ways to achieve better lifetime which include energy efficient routing, battery characteristics etc. Routing in wireless sensor networks is very challenging due to several characteristics that distinguish these networks from other wireless networks like mobile, ad hoc networks or cellular networks. These include dense deployment of sensor nodes, significant data redundancy, limited bandwidth and limited transmission power, etc. In section 2, the energy efficient routing techniques are discussed which helps in raising the energy efficiency of the node. In section 3, different characteristics of the batteries are discussed which helps in enhancing the battery backup. The battery discharge characteristics, which are used to increase the lifetime of the battery is discussed in section 4.

Author α σ ρ : Department of Electronics and Communication Engineering, Faculty of Engineering and Technology, Mody Institute of Technology & Science (Deemed University), Lakshmangarh, Dist. Sikar, Rajasthan, Pin – 332311, India.
E-mail α : jyotisaraswat.mit@gmail.com
E-mail σ : neharathi17@gmail.com
E-mail ρ : hereispartha@gmail.com

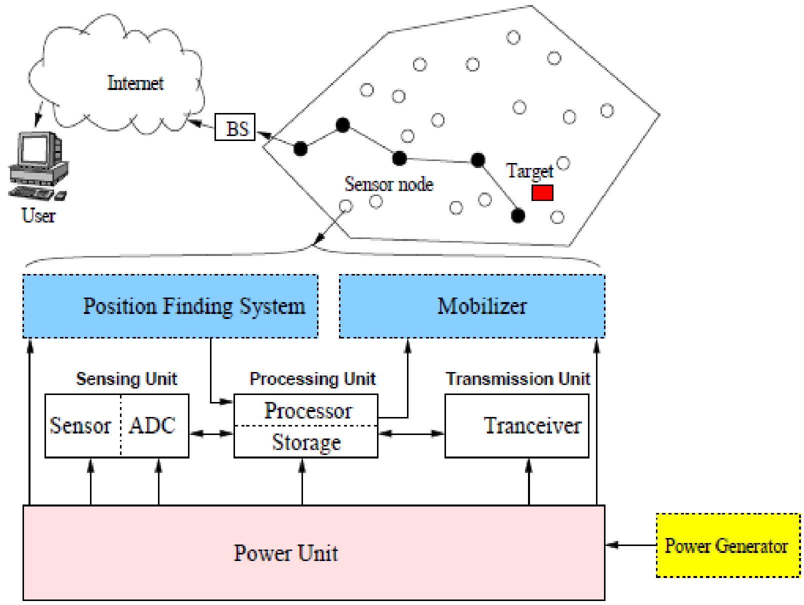

Figure 1 : Structural view of sensor network

II. Energy Efficient Routing

The sensor nodes are constrained to limited resources itself, so the main target is how to design an effective and energy awareness protocol in order to enhance the networks lifetime for specific application environment.

Routing protocols are classified into three categories: Flat-based routing (Flooding), Hierarchical-based routing (Clustering) and Location-based routing (Geographic), depending on the network structure in WSNs.

a) Flat Based Routing

In flat-based routing, all nodes are typically equal and act the same functionality. It is not possible to assign global identifiers to each node in wireless sensor networks because of dense deployment and dynamic environment of sensor nodes.

In data-centric routing [3], sinks send queries to certain regions and waits for data from sensors located in the selected regions. To facilitate data-centric characteristics of sensor queries, an attribute-based naming scheme is used to specify the properties of data.

i. *Flooding and Gossiping*

Flooding and gossiping [4] are the most traditional network routing. In flooding mechanism, each sensor receives a data packet and then broadcast it to all neighboring nodes. When the packet arrives at the destination or the maximum number of hops is reached, the broadcasting process is stopped. Although flooding is very easy, it has several drawbacks like implosion, overlap and resource blindness problem.

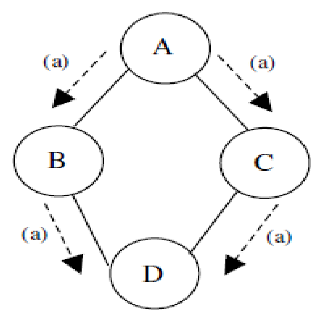

Figure 2 : The implosion problem

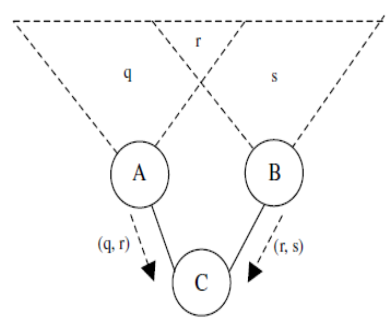

Figure 3 : The overlap problem

Implosion is caused by duplicate message sent to same node as shown in figure 2. 'A' starts by flooding its data to all its neighbors. Two copies of data eventually end at node 'D' due to this system wastes energy and bandwidth.

Overlap occurs when two nodes sensing the same region send similar packets to the same neighbor and resource blindness by consuming large amount of energy without consideration for the energy constraints. Overloading problem shown in figure 3.

Gossiping avoids the problem of implosion by sending information to a random neighbor instead of classical broadcasting mechanism sending packets to all neighbors.

ii. *SPIN*

Joanna Kulik *et al.* in [4] proposed a family of adaptive protocol, called SPIN (Sensor Protocol for Information via Negotiation) that efficiently disseminates information among sensors in an energy-constrained wireless sensor network and overcome the problem of implosion and overlap caused in classic flooding. Nodes running a SPIN communication protocol name their data using high-level data descriptors, called metadata. SPIN nodes negotiate with each other before transmitting data. Negotiation helps to ensure that the transmission of redundant data throughout the network is eliminated and only useful information will be transferred.

The disadvantage of SPIN [5] protocol is that it is not sure whether the data will certainly reach the target or not and it is also not good for high-density distribution of nodes. Other drawback is that if the nodes that are interested in the data are far away from the source node and the nodes between source and destination are not interested in that data, such data will not be delivered to the destination at all. Therefore, SPIN is not a good choice for applications.

iii. *Directed Diffusion*

A popular data aggregation paradigm for wireless sensor networks called directed diffusion is proposed by Ramesh Govindan *et al.*[6]. Directed diffusion is data-centric and all nodes in a directed diffusion-based network are application-aware. This enables diffusion to achieve energy savings by selecting empirically good paths and by caching and processing data in-network (*e.g.,* data aggregation).

SPIN protocol allow sensors to advertise the availability of data and the nodes which are interested, query that data but in Directed Diffusion the sink queries the sensor nodes if a specific data is available by flooding some tasks.

The main advantages of directed diffusion are:

1) Since it is data centric, all communication is neighbor-to-neighbor with no need for a node addressing mechanism. Each node can do aggregation and caching, in addition to sensing. Caching is a big advantage in terms of energy efficiency and delay.
2) Direct Diffusion is highly energy efficient since it is on demand and there is no need for maintaining global network topology.

Directed Diffusion is not a good choice for the application such as environmental monitoring because it require continuous data delivery to the sink will not work efficiently with a query-driven on demand data model.

iv. *Energy-Aware Routing*

Energy aware routing protocol is efficient method to minimize the energy cost for communication and can increase the network lifetime. Unlike directed diffusion, data transmission is done through several optimum paths at higher rates instead of transmitting through one optimal path. The transmission path selection is done by choosing a probability value of each path. The probability value balanced the initial network load and enhanced the network lifetime.

The disadvantage is that energy-aware routing needs to exchange local information between neighbor nodes and all nodes have a unified address, which enlarges the price of building routing paths.

v. *Fermat Point Based Energy Efficient Geocast Routing Protocol*

Geocast routing protocol is used to deliver packets to a group of nodes that are within a specified geographical area, i.e., the geocast region. Fermat point based protocols are adapted for reducing the energy consumption of a WASN by reducing the total transmission distance in a multi hop-multi sink scenario. Congested environment around a WASN expand the chance of multipath propagation and it in turn acquaint multipath fading. In [7], the effects of both of these factors are considered on the performance of I-Min routing protocol designed for WASNs. Both these parameters are considered to find out the degree of variation on the performance of a protocol that doesn't consider either of these two parameters. Here, the geocast routing protocol under consideration is the I-MIN protocol. I-MIN has been discussed in [7].

I-MIN is the energy efficient scheme as it increases the probability that a node with higher residual energy is selected even if its distance from destination is somewhat more as compared to that for another node with a lesser value for residual energy.

After modifying the radio model of with considerations for changed propagation environmental effects and multipath fading, the consumption of energy in a geocast routing protocol will vary considerably [7]. Higher the number of geocast regions, larger is the total distance that a data packet has to travel and thereby greater is the effect of propagation environment combined with the effect of multipath fading on the performance of an energy aware algorithm.

vi. *Gradient-Based Routing*

The algorithm makes an improvement on Directed Diffusion, in order to get the total minimum hop numbers other than the total shortest time. In the traditional gradient minimum hop count algorithm, hop count is the only metric, which measures the quality of route. Li Xia *et al.* [8] proposed a new gradient routing protocol which not only consider the hop count but also use the remaining energy of each node while relaying data from source node to the sink. This scheme is helpful in handling the frequently change of the topology of the network due to node failure.

b) Hierarchical-Based Routing (Clustering)

Hierarchical routing is a guarantee approach for point-to- point routing with very small routing state [9]. It is well known technique with special advantage of scalability and efficient communication. Nodes play different roles in the network. Hierarchical routing maintains the energy consumption of sensor nodes and performs data aggregation which helps in decreasing the number of transmitted messages to base station. The whole wireless sensor network is divided into a number of clusters in term with the specific rules. Some hierarchical protocols are discussed here.

i. *LEACH*

LEACH [10] stand for Low-Energy Adaptive Clustering Hierarchy and was one of the first hierarchical protocols. When the node in the network fails or its battery stop working then LEACH protocol is used in the network. Leach is self-organizing, adaptive clustering protocol in which sensor nodes will organize themselves into local clusters and cluster members elect cluster head (CH) to avoid excessive energy consumption and incorporate data aggregation which reduces the amount of messages sent to the base station, to increase the life time of the network. Therefore this algorithm has an effect upon energy saving.

Two-Level Hierarchy LEACH (TL-LEACH) is a modified form of the LEACH algorithm which consists of two levels of cluster heads (primary and secondary) instead of a single one. The advantage of two-level structure of TL-LEACH is that it reduces the amount of nodes that transmit information to the base station, effectively reducing the total energy usage.

ii. *PEGASIS and Hierarchical-PEGASIS*

PEGASIS (Power-Efficient Gathering in Sensor Information Systems) is optimal chain-based protocol that is an improvement over LEACH. Instead of forming multiple clusters, PEAGSIS construct a node chain when nodes are placed randomly in a play field then each node communicates only with a close neighbor, take turns and transmit data to the base station, thus reducing the amount of energy spent per round [11]. The chain construction is performed in a greedy way. Figure 4 shows node 0 connected node 3, node 3 connecting to node 1, and node 1 connecting to node 2. When a node fails, the chain is reconstructed in the same manner by avoiding the dead node. For gathering data in each round, each node receives data from one neighbor, aggregates with its data, and transmits it to the other neighbor in the chain.

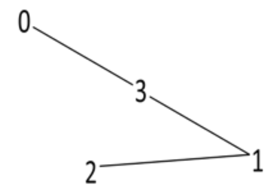

Figure 4 : Chain construction using the greedy algorithm

Although PEGASIS performs better than LEACH by eliminating the overhead of dynamic cluster formation, because transmission is asynchronous, the time of transmission will be prolonged too much. Hierarchical-PEGASIS makes a further improvement; it allows concurrent transmission when the nodes are not adjacent.

Compared with LEACH, the two algorithms eliminate the overhead of forming cluster, but both of them do not take the energy condition of next hop into consideration when choosing a routing path, so they are not suitable for heavy-loaded network. When the amount of nodes is very large in WSNs, the delay of data transmission is very obvious, so they do not scale well and also are not suitable for sensor networks where such global knowledge is not easy to obtain.

iii. *TEEN and APTEEN*

TEEN stands for Threshold sensitive Energy Efficient sensor Network protocol and it is the first protocol developed for reactive networks [12]. It is used in temperature sensing application. Based on LEACH, TEEN is based on hierarchical grouping which divide the sensor nodes twice for grouping cluster in order to detect the scene of sudden changes in the sensed attributes such as temperature. After the clusters are formed, TEEN separates the Cluster Head into the second-level Cluster Head and uses Hard-threshold and Soft-threshold to detect the sudden changes. The model is depicted in Figure 5.

Thus, the hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The soft threshold further reduces the number of transmissions by eliminating all the transmissions which might have otherwise occurred when there is little or no change in the sensed attribute once the hard threshold.

The main drawback of this scheme is that it is not well suited for applications where the user needs to get data on a regular basis. Another possible problem with this scheme is that a practical implementation would have to ensure that there are no collisions in the cluster. TDMA scheduling of the nodes can be used to avoid this problem but this causes a delay in the reporting of the time-critical data. CDMA is another possible solution to this problem. This protocol is best suited for time critical applications such as intrusion detection, explosion detection etc.

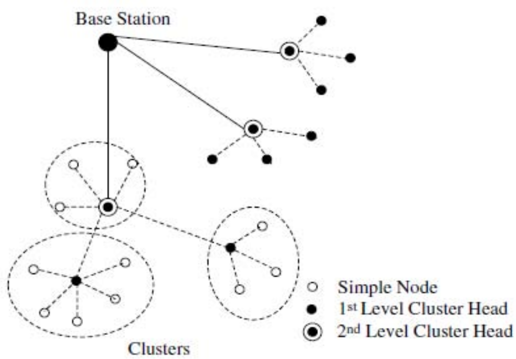

Figure 5 : Hierarchical clustering in TEEN and APTEEN

The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) is an extension to TEEN and aims at both capturing periodic data collections and reacting to time critical events. The architecture is same as in TEEN. In APTEEN once the CHs are decided, in each cluster period, the cluster head broadcasts the parameter such as attributes, threshold and count time to all nodes [13].

The performance of APTEEN lies between TEEN and LEACH in terms of energy consumption and longevity of the network. While sensing the environment, TEEN only transmits time critical data. APTEEN makes an improvement over TEEN by supporting periodic report for time-critical events. The main disadvantages of the two algorithms are the overhead and complexity of forming clusters.

c) Location-Based Routing

Most of the routing protocols require location information for sensor nodes in wireless sensor networks. Location information is required to calculate the distance between two particular nodes on the basis of signal strength so that energy consumption can be estimated. It is also utilized in routing data in energy efficient way when addressing scheme for sensor network is not known. It is worth noting that there have been many location-based protocols in Ad Hoc networks and it makes great effects when we transplant those research achievements for wireless sensor networks in some ways.

i. *MECN and SMECN*

Minimum energy communication network (MECN) [14] sets up and maintains a minimum energy network for wireless networks by utilizing low power GPS. Although, the protocol assumes a mobile network, it is best applicable to sensor networks, which are not mobile. MECN assumes a master site as the information sink, which is always the case for sensor networks.

MECN identifies a relay region for every node. The relay region consists of nodes in a surrounding area where transmitting through those nodes is more energy efficient than direct transmission. The relay region for node pair (*i, r*) is depicted in Figure 6.

The enclosure of a node *i* is then created by taking the union of all relay regions that node *i* can reach. The main idea of MECN is to find a sub-network, which will have less number of nodes and require less power for transmission between any two particular nodes. In this way, global minimum power paths are found without considering all the nodes in the network. This is performed using a localized search for each node considering its relay region.

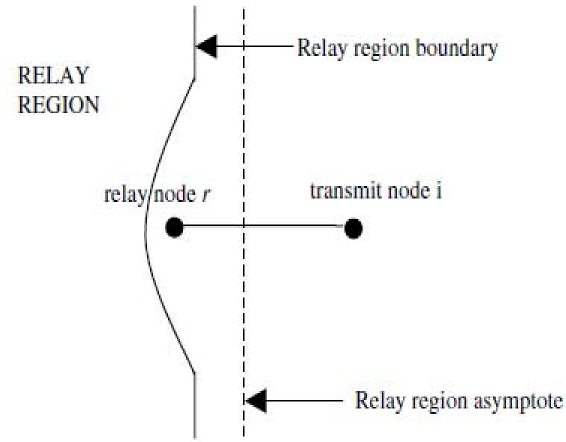

Figure 6 : Relay Region of transmit relay node pair (*i, r*) in MECN

MECN is self-reconfiguring and thus can dynamically adapt to nodes failure or the deployment of new sensors. Between two successive wake-ups of the nodes, each node can execute the first phase of the algorithm and the minimum cost links are updated by considering leaving or newly joining nodes.

The small minimum energy communication network (SMECN) [15] is an extension to MECN. In MECN, it is assumed that every node can transmit data to other nodes, which is not possible every time. In SMECN possible obstacles between any pair of nodes are considered. However, the network is still assumed to be fully connected as in the case of MECN. The sub-network constructed by SMECN for minimum energy relaying is probably smaller (in terms of number of edges) than the one constructed in MECN if broadcasts are able to reach to all nodes in a circular region around the broadcaster. As a result, the number of hops for transmission will decrease. Simulation results show that SMECN uses less energy than MECN and maintenance cost of the links is less. However, finding a sub-network with smaller number of edges introduces more overhead in the algorithm.

ii. *GEAR*

The aim is to reduce the number of Interest in Directed Diffusion and add geographic information into interest packet by only considering a certain region rather than sending Interest to the whole network by means of flooding. GEAR uses energy aware and geographically informed neighbor selection heuristics to route a packet towards the target region [16]. Therefore, GEAR helps in balancing energy consumption in this way and increase the network lifetime. When a closer neighbor to the destination exists, GEAR forward the packet to the destination by picking a next-hop among all neighbors that are closer to the destination. When all neighbors are far away, there is a hole then GEAR forward the packet by picking a next-hop node that minimizes some cost value of this neighbor. Recursive Geographic Forwarding algorithm is used to disseminate the packet within the region.

GEAR is compared to a similar non-energy aware routing protocol GPSR, which is one of the earlier works in geographic routing that uses planar graphs to solve the problem of holes. The simulation results show that for uneven traffic distributions, GEAR delivers 70% to 80% more packets than GPSR. For uniform traffic pairs, GEAR delivers 25 - 35% more packets than GPSR.

iii. *GAF and HGAF*

GAF [17] is adaptive fidelity algorithm in which large numbers of sensor nodes are placed in observed area and only few nodes in the observed area are selected to transmit messages, while the other nodes sleep. In this way, GAF reduces the number of nodes needed to form a network and saves node battery.

Hierarchical Geographical Adaptive Fidelity (HGAF) saves much more battery by enlarging the cell of GAF by adding a layered structure for selecting an active node in each cell. GAF saves battery power by enlarging the size of the cell. The connectivity between active nodes in two adjacent cells must be guaranteed because active nodes works as cluster heads to deliver packets between cells. Because of this limitation, GAF needs an active node in every area whose maximum size is $R^2/5$.

HGAF limits the position of active node in a cell and synchronizes the position in each cell among all cells. Through this modification, the connectivity between active nodes in two adjacent cells can be guaranteed for a larger cell than in GAF.

Simulation result shows that HGAF outperforms GAF in terms of survived nodes and the packet delivery ratio when the node density is high. The lifetime of dense and randomly distributed networks with HGAF is about 200% as long as ones with GAF.

III. Efficient Battery Usage for Wireless Sensor Network

Wireless sensor network consist of a large number of small batteries. By nature wireless sensor network devices have limited available energy to perform a wide range of demanding tasks. In order to maximize their operation lifetime, optimal resource management is an important challenge and its success requires methodical modeling of the factors contributing to the overall power consumption. Therefore, it is necessary to study the discharge rate of battery taking into consideration the battery type, capacity, discharge pattern and other physical parameters.

a) *Battery Lifetime Prediction Model*

Fotis Kerasiotis *et al.* [18] mainly focus on the issue of battery lifetime prediction which is addressed for a WSN platform, namely the TelosB .The main advantage of this approach is that it follows a structured methodology for modelling the battery lifetime of TelosB. This is done by decomposing the operation pattern in time periods of discrete elementary power consumption levels.

i. *Battery Energy and Lifetime Modelling*

A battery depletion profiling approach based on discrete basic operation which can be performed by a wireless sensor network (WSN) device. The behavior of battery depends on the corresponding average current drawn, where each HW module [18] is uniformly utilized during the lifetime duration of node in a wireless sensor network. Therefore, the aim is to express the relation of the battery depletion with the imposed load in terms of lifetime and capacity characterizing a common AA alkaline battery.

ii. *Battery Characteristics*

The actual energy and the capacity that the battery can provide depend on the discharge rate. A specific discharge rate defined by the value of current in mA is the nominal capacity given by the constructor.

Here the various loads are considered and converted it into average current drawn. The time interval required for the battery to finally deplete varies inversely proportional to the applied load. Some other parameters that affect battery capacity are temperature, self discharging effect and recovery effect but they are less important factors under common conditions, because of the low currents flow by the low power HW modules of most of the wireless sensor network devices.

iii. *TelosB Platform Radio Supply Schematic*

The experiment consists of CC2420 radio module which is the most consuming component of the TelosB platform which draws current approximately up to 20mA. The accurate and the robust operation are needed from the radio point of view. Figure 7 shows the voltage regulator which provides voltage stability of 1.7 to 1.9 V and is used by the particular radio module. It is translated to highly stable power consumption despite the variation of the voltage as the batteries deplete.

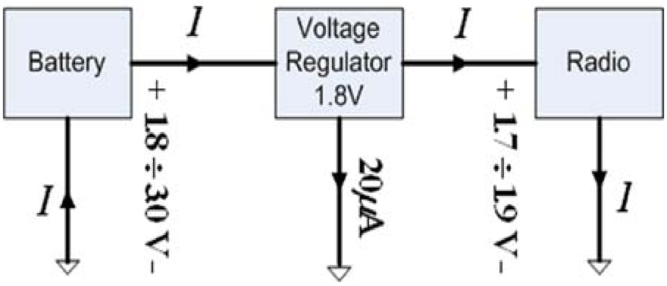

Figure 7 : Current drawn by the radio module and the voltage regulator

The topology used for the experiment consists of two motes, one connected to a PC receiving the available information from the second one, which is configured with the operation examined each time and powered either by a power supply generator or batteries. All the operations include CPU at LPM0 state as well as use of AD converter channel for the battery voltage measurement, which helps to increase the current drawn by almost 2.3 mA at 3V.

The battery lifetime can be estimated by incorporating the coefficient *DCx*, which represents the time proportion, where x current demand, is enabled .The proposed formula is presented in (1), where $E_{offered}$ is the energy capacity offered by the batteries, t_{max} is the battery lifetime, $I_{average}$ is the average current drawn corresponding to the node's lifetime [18]:

$$t_{max} = \frac{E_{offered}}{I_{average}} \quad (1)$$

$$= \frac{E_{offered}}{\sum_{x=1}^{x=number\ of\ different\ current\ demands} DC_x \times I_{x\_average}}$$

Let a node configured with radio on RX operation and assuming that low power operation is enabled, the measurable lifetimes estimated by t_{max} for duty cycles of 80%, 67% and 40%, respectively, are very close to the experimental results shown in figure 8(a), despite the estimated of the battery energy recovery effect. The estimated error for the three respective duty cycle configurations is given in eqn. (2), (3), (4) [18], where I_{ADC} is the current drawn by AD converter, I_{CPU_LPM3} is the current drawn by CPU in LPM3 mode :

$$t_{max\ 80\%\ DC} = \frac{E_{offered}}{DC_{80\%} \times I_{RX\_average} + I_{ADC} + I_{CPU\_LPM\ 3}}$$

$$= \frac{3100\,mAh}{15.36\,mA} = 201.8h \rightarrow error: 2\% \quad (2)$$

$$t_{max\ 67\%\ DC} = \frac{E_{offered}}{DC_{67\%} \times I_{RX\_average} + I_{ADC} + I_{CPU\_LPM\ 3}}$$

$$= \frac{3100\,mAh}{12.95\,mA} = 239.1h \rightarrow error: 2.6\% \quad (3)$$

$$t_{max\ 40\%\ DC} = \frac{E_{offered}}{DC_{40\%} \times I_{RX\_average} + I_{ADC} + I_{CPU\_LPM\ 3}}$$

$$= \frac{3100\,mAh}{7.95\,mA} = 390h \rightarrow error: 3\% \quad (4)$$

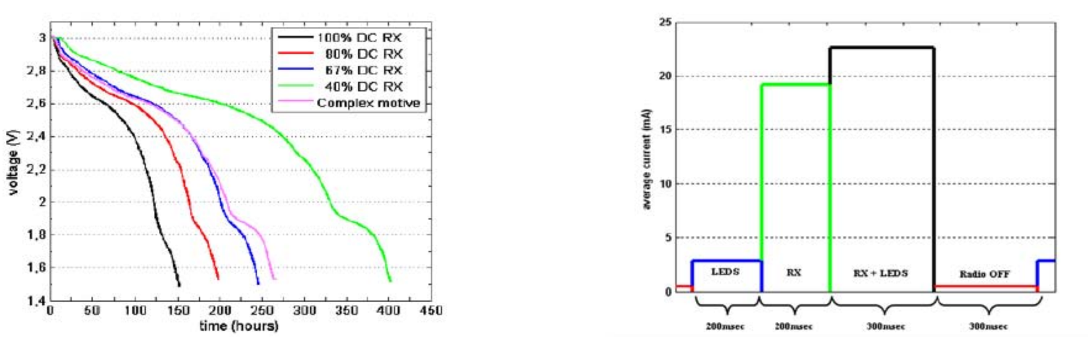

Figure 8 : a) Experimental results of validation experiments b) complex operation motive

At last, the periodic interchange among four different operations corresponding to four different current demands. The pattern recorded is similar as in figure 8(b). In this, equation (5) produced a small estimated error of 2.7% [18], which proves the significant accuracy of the equation (1) used in predicting the battery lifetime.

$$t_{max\ oper} =$$

$$= \frac{E\ offered}{(I_{LEDS\_average} + I_{RX\_average})20\% + (I_{RX+LEDS\_average})30\% + I_{ADC} + I_{CPU\_LPM\ 3}}$$

$$= \frac{3100\,mAh}{11.29\,mA} = 274.5h \rightarrow error: 2.7\% \quad (5)$$

IV. Battery Discharge Characteristics

In order to maximize the operating life of battery-powered systems such as sensor nodes, it is important to discharge the battery in such a way that maximizes the amount of charge extracted from it. A systematic experiment is conducted to quantify the impact of key wireless sensor network design and environmental parameters on battery performance [19]. Test bed on which this experiment is conducted consists of MICA2DOT nodes, a commercial lithium coin battery, and techniques for measuring battery performance. For many electronics systems, achieved battery life is not only the function of the energy consumed by the system, but also the manner in which the system drains the battery, and battery specific characteristic.

Many techniques have been proposed in recent years for estimating battery lifetime. A variety of strategies is used to exploit battery characteristics for designing more "battery friendly" systems and communication. In addition, most work in this area relies on simulation of generic battery models and does not place emphasis on quantitative results about actual hardware platforms and batteries. Chulsung Park et al. [19] conducted an experiment with a commercial lithium-ion cell in which fixed transmission power levels are assumed and the influence of temperature is not considered. Secondly, they did not calculate the impact of battery characteristics on network-level trade-offs. One of their findings was that the capacity extracted from the battery is significantly degraded by the voltage converter that is typically used to supply power to the sensor node.

a) Factors Affecting Battery Discharge

Lithium-ion batteries are considered here because they are commonly used in the scope of portable electronics, including sensor networks. Simplified view of a lithium/thionyl chloride battery is shown in Figure 9. The battery consists of an anode (*Li*), a cathode (carbon), and an electrolyte. During discharge, oxidation at the anode (*Li*) releases electrons, which flow through the load system, and positively charged ions ($Li+$), which migrate through the electrolyte flow towards the cathode by diffusion. At available reaction sites in the cathode, Li^+ ions combine with negatively charged ions (Cl^-) to create an insoluble compound, *LiCl*. Cathode sites where *LiCl* is deposited become inactive, or unavailable for further reaction. As discharge proceeds, more reaction sites become unavailable, eventually leading to a state of complete discharge.

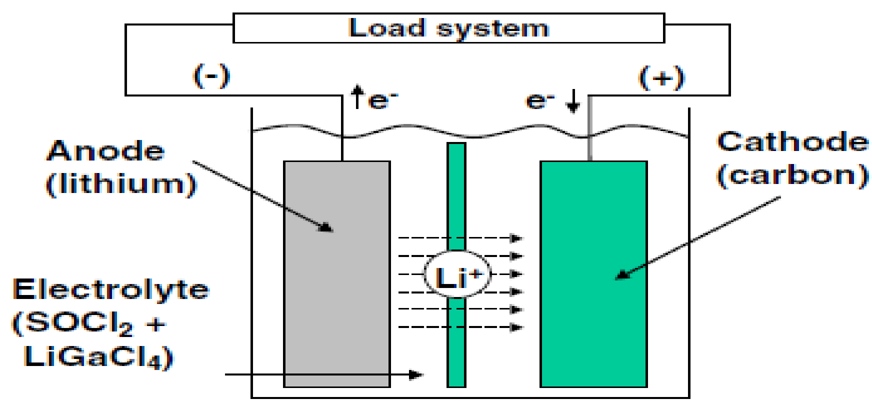

Figure 9 : Simplified view of a lithium/thionyl chloride battery

The standard or rated capacity of a battery (usually expressed in current-time units, e.g. mAh) is a measure of the total charge that can be extracted from a battery when discharged under standard load conditions. Manufacturers may specify a rated current, a constant discharge rate that corresponds to the standard load conditions. For example, a battery may be rated at 500 mAh capacity under a rated current of 100 mA, at 25◦C. The delivered capacity of a battery is the capacity that the battery delivers under a given load and operating environment, and is an indicator (along with battery life) of the efficiency with which the battery is discharged. Capacity (usually expressed in mAh) and energy (expressed in Joules) are used interchangeably. Several electrochemical effects make the delivered capacity sensitive to the characteristics of the discharge profile and the environment. Hence, in practice, the delivered capacity may differ significantly from the rated capacity. Only those characteristics that have been demonstrated to play a significant role in affecting the efficiency of lithium-ion batteries are considered.

i. *Rate Capacity Characteristic*

Battery life depends largely on the availability of active reaction sites throughout the cathode. At low discharge current, throughout the volume of the cathode inactive reaction sites gets uniformly distributed. During interval when the discharge current is large, making many internal active sites unreachable, the outer surface of the cathode gets covered with inactive sites. These

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rate capacity effects lead to an overall reduction in battery capacity at higher rates of discharge.

ii. *Recovery Effect*

When current started flowing from the battery, the positively charged ions are consumed at the cathode-electrolyte interface, and are replaced by new ions that diffuse through the electrolyte from the anode. When the current drawn is large in amount, the rate of diffusion does not able to keep up with the rate at which ions are consumed at the cathode. As a result, the concentration of ions decreases near the cathode and increases near the anode, it decreases the battery output. If the battery is allowed to keep idle for some period of time, then due to diffusion the concentration gradient decreases, due to which charge recovery is taken place. As a result, the capacity and lifetime of the battery increases [19].

iii. *Thermal Effects*

The effect of ambient temperature on battery efficiency depends strongly on the specific battery chemistry being considered. Most batteries perform well at room temperature. Higher temperature allows for increased mobility of the electrolyte materials, which result in lower internal resistance. This has the effect of increasing the effective capacity of the battery. However, continuous exposure to elevated temperatures have other undesirable effects, such as shortened cycle life (the number of times the battery can be charged/discharged), and an increased rate of self-discharge (the irreversible loss of charge that occurs when no current is drawn from the battery). At lower temperatures, increased internal resistance of the battery leads to reduced capacity.

The disadvantage of lithium-ion batteries is that over time, the capacity of the cells diminished. The increase in internal resistance reduces the cells ability to deliver current. This problem is more pronounced in high-current applications. Due to this disadvantage the battery replacement and maintenance cost increases.

b) Solar Cell Battery

The method for achieving extended lifetime for a wireless sensor network is to exploit the possibility of energy harvesting from the environment, where energy harvesting from the sun gives the best performance which is proposed by L. Hanssen and J. Gakkestad [20].

i. *Power Model of a Wireless Sensor Network Node*

The block diagram of typical wireless sensor network node is shown in figure 10 which consists of microcontroller (MCU), a radio, a sensor block and a power module. When powered with a solar cell, a local charge storage or a battery is needed to store surplus energy for periods when sun irradiation is low or absent e.g. during the night, on overcast or rainy days.

The MSP430 MCU and the CC2420 radio from Texas Instruments are used in [20]. The MCU has certain sleep modes, but it is assumed that the real time clock (RTC) must be running in sleep mode in order to make the node wake up itself at given points in time. For such short range radios as the CC2420, the maximum power consumption is in the receive mode. The transmit power is programmable and the power output can be lowered for short ranges. The radio will be in listen or receive mode for network to operate where each node can hear many neighboring nodes. Three states for the node are defined as active, running and sleeping.

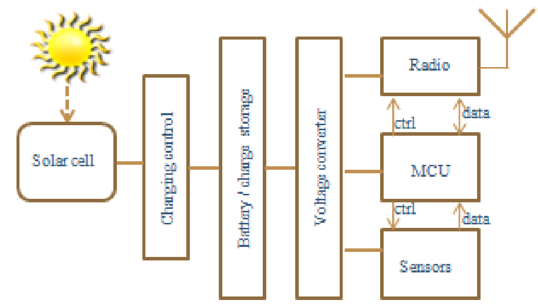

Figure 10 : Block Diagram of Typical WSN node

In active state the node can participate in networking. In sleep mode only the RTC in the MCU is running. Many wireless sensor network implementations are based on IEEE 802.15.4 and ZigBee. Here, super frame structure is used, and all local communication is performed within one frame.

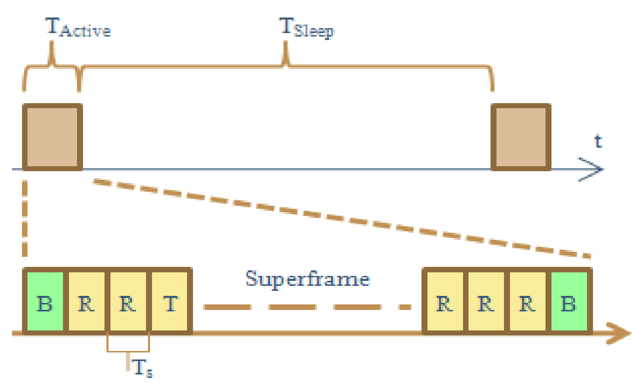

Figure 11 : Active sleep period with a super frame containing beacons (B),receive periods I and one transmit period (T)

One super frame consists of 16 slots (NF), and the length of one slot (TS) is determined by the number of bytes for address and data. This is shown in Figure 11 with one active and one sleep period. The active period consists of a super frame with beacons (B), receive (R) and transmit (T) slots.

ii. *Solar Battery Modeling and Analysis*

Alcaline and Li-Th-Cl are not chargeable, which means that a wireless sensor network equipped with such batteries has a limited lifetime. When the node is powered with a solar cell panel, a chargeable battery or another charge storage element is needed to average the energy received during daytime over the whole 24 hours. The charge storage capacity, i.e. the size of the battery, should be adapted to the 24 hours irradiance if we want to minimize it.

a. *Battery Mechanisms*

Two main mechanisms of batteries are considered, rate capacity effect and recovery effect [21]. These two mechanisms are dependent on the discharge profile of a specific battery. Discharge profile means the amount of time battery voltage fall to a certain threshold voltage, i.e. the amount of time the battery discharged or reaches "empty" state.

The battery is an electrochemical device which allows storage of energy using the battery's chemical characteristics to store the energy. During discharge of the battery, it is attached to some load which provides path to the charge to follow. In rechargeable type of batteries, an externally applied current can be applied to the battery to reverse the chemical process of discharging. The batteries are classified according to their rated capacity which is defined as the amount of charge a battery can store i.e. measured in A-hours (3600 coulombs). This capacity is dependent on the amount of current charge being supplied as well as in the current charge state of the battery. The capacity is not equal to the amount of charge delivered to the load. Self-discharge also occur which decreases the capacity of the battery. Rechargeable batteries exhibit more self-discharge rate than standard batteries (about 2-3% a day). That is why rechargeable batteries are not enough to replace a standard alkaline battery in a network environment. Rate capacity fading is also affect the capacity of the batteries.

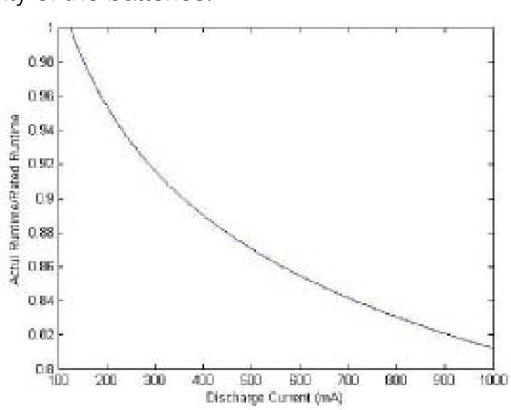

Figure 12 : Rate capacity fading

As the discharge current increases, the difference between the actual runtime and rated runtime also increases as shown in figure 12.

b. *Solar Energy*

The amount of solar energy which is provided by photovoltaic cell is depending on certain factors. Solar energy is a natural resource so it depends on the environmental condition. The dependence of solar energy on the temperature is neglected. The parameter on which John Paul M et al. focused is the relationship between time and the amount of energy provided by the photovoltaic cell. Here equation is considered that describes the flux intensity for photovoltaic cell. The flux intensity is defined as [21]:

$$I(z) = I_0 e^{c(\sec z)s} \quad (6)$$

Where

$I(z)$ = Flux Intensity in kW/m^2

I_0 = Exo atmospheric solar flux ($1.353\ kW/m^2$)

z = zenith distance

c = 0.357

S = 0.678

Solar flux intensity is a measure of the energy which is absorbed by a photovoltaic cell. S and c are empirical data numerical constants while I_0 is the flux intensity outside the earth's atmosphere. The solar flux intensity data can be used to know that how much energy is provided by the cells. At constant voltage, increasing the amount of solar flux intensity would also increase the amount of current supplied to the load. By knowing this one can determine the amount of current being supplied to charge a rechargeable battery.

The zenith distance is the angular distance from the position of the sun directly above a spectator. This parameter is dependent on day time.

$$\cos z = \sin\alpha.\sin\partial + \cos\alpha.\cos\partial.\cos t \quad (7)$$

$$t = (360/24)\,T \quad (8)$$

Z is the zenith distance, α is the latitude of the collector site and ∂ is the solar declination. Solar declination is angle between the earth-sun line and the equatorial plane. Due to a 23.45^0 tilt of the earth's equatorial line with earth's orbit, there would be variation of the solar declination throughout the year which causes seasons. The value of the declination angle can be at about approximate 25.50 during summer and -23.50 during winter.

V. Conclusion

In this paper, theoretical analysis of different ways by which we can improve the energy efficiency of the wireless sensor networks is presented. Routing is one of the most important ways that gives energy efficiency, and increases the network life. Routing protocols are based on three categories: Flat based routing, Hierarchical-based routing and Location-based routing on the basis of network structure. Many issues and challenges like effectiveness, scalability, adaptability etc. still exist that need to be solved in the sensor networks. Battery characteristics such as recovery effects, thermal effects, discharge characteristics etc. are the most important aspects for increasing the lifetime of the battery.

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Design of Simulator for Finding the Delay Distribution in Delay Tolerant Networking

By Dr.P.K.Suri & Lokesh Pawar

Kurukshetra University, HCTM Kaithal, India

Abstract - To find out the delay distribution in a disruption tolerant network between the nodes when there are randomly distributed several numbers of replications of packets on each node. This delay distribution function can help us with a guideline on how to set the lifetime of a message. As the number of replicas on the nodes increases the delay increases. Up to our best knowledge it is the first time ever work has been done on simulating the delay distribution environment using the replicas in for finding the delay in DTN. With different number of nodes in a network where each node consists of several number of replicas of the same packet the delay difference is obtained and has been compared with the network consisting of a fewer more number of nodes.

Keywords : *DTN, TCP/IP, S-C-F, PROPHET, DSR.*

GJCST-E Classification : *C.2.m*

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Strictly as per the compliance and regulations of:

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Dr.P.K.Suri [α] & Lokesh Pawar [σ]

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I. Introduction

Delay-tolerant networks (DTNs) have the great potential to connecting devices and regions of the world that are presently under-served by current networks. A vital challenge for Delay Tolerant Networks is to determine the routes through the network without ever having an end to end, or knowing which "routers" will be connected at any given instant of time. The problem has an added constraint of delay at each node. This situation limits the applicability of traditional routing techniques which categorize lack of path as failure of nodes and try to seek for existing end-to-end path. Approaches have been proposed which focus either on epidemic message replication or on previously known information [2] about the connectivity schedule [1]. We have considered that the protocol have the previous knowledge of routing and computed delay on the basis of replication on the nodes and on the basis of total time to transfer the packets from one node to other node. DTN is an environment for the intermittent connectivity for mobile wireless networks in which the connectivity between the nodes changes frequently. DTN routing follows an approach of S-C-F [2]. It stores the packets on the nodes and carry them until the communication between two nodes take place. DTN simulations abstract from the details of the wireless link characteristics and simply assume that two nodes can communicate when they are in range of one another [3]. Delay and disruption-tolerant networks (DTNs) are characterized by their lack of connectivity, resulting in a lack of instantaneous end-to-end paths. But a main reason of delay in the environment is due to un-optimized replicas of the packets on the nodes. Applications of DTNs include large-scale disaster recovery networks, sensor networks for ecological monitoring [4], ocean sensor networks [8, 5], people net [6], vehicular networks [7, 10], and Digital Study Hall [11], One Laptop per Child [9] to benefit developing nations. Intermittent connectivity can be a result of mobility, power management, wireless range, scarcity, or malicious attacks. The inherent uncertainty about network conditions makes routing in DTNs a challenging problem [3]. The existing TCP/IP based Internet service model provides end-to-end inter-process communication using a concatenation of potentially dissimilar link-layer technologies [12]. We have also discussed the comparative study between the two types of network working in the same conditions but with a different number of nodes. Prophet uses an in-band control channel to exchange acknowledgments for delivered packets as well as metadata about every packet learnt from past exchanges. For each encountered packet i, prophet maintains a list of nodes that carry the replica of i, and for each replica an estimated time for direct delivery. Metadata for delivered packets is deleted when an acknowledgement is received.

Author α : Professor & Dean, Department of Computer Science And Engineering, Kurukshetra University, HCTM Kaithal, India.
E-mail : pksurikuk@rediffmail.com
Author σ : M.Tech Student, Department of Computer Science And Engineering, Kurukshetra University, HCTM Kaithal, India.
E-mail : lokesh.pawar@gmail.com

II. Proposed Algorithm

To estimate delay distribution we assume that the packets are delivered directly to the destination. Sample Inputs are generated by using several algorithms which were designed for the requirement to solve the problem statement. We have generated several inputs and these inputs are further feeder to the simulator we designed and fetch the results. In each case we have done several simulation runs. Which lead us to the following results. There are few steps to be followed for the generation of the samples. For generating the samples for delay distribution we require randomly generated input samples. Let these time samples work as inputs for the delay distribution and we obtain the delay distribution by following the steps mentioned in the flowchart. The sample inputs for the replications of the packets are generated randomly as integer values. These replicas are responsible for increasing delay and decreasing it too. If the replications are made in a optimal manner the delay produced will be lesser.

a) Flowchart for Delay Distribution

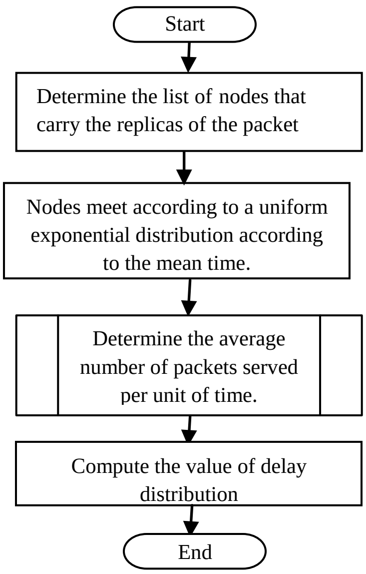

Figure 2.1 : Flowchart of Delay Distribution

b) Algorithm for Delay Distribution

1. Let us assume that for each encountered packet (i), Prophet maintains a list of nodes that carry the replicas of (i).
2. Suppose all the nodes meet according to a uniform exponential distribution with mean time $1/\lambda$.
3. The average number of packets served per unit of time is an independently randomly generated integer value.
4. Determine the delay distribution for delay tolerant networking using:

$$A(i) = (\lambda/n_1 + \lambda/n_2 + \ldots\ldots\ldots\ldots + \lambda/n_k)^{-1}$$

Step [1] in the algorithm is asking to assume that each encountered packet (i) is been maintained in a list by the prophet routing protocol, this is an hypothesis that we assumed it. Step [2] describes that all the nodes in the environment meet according to a uniform exponential distribution with mean time $1/\lambda$ (where λ in our case represents the average number of packets per unit of time). Step [3] the average number of packets served per unit of time is a random value. Step [4] in this step we calculate our results for the inputs provided. Each node maintains a separate queue of packets Q destined to each node sorted in decreasing order of time since creation—the order in which they would be delivered directly. The insight of the delay distribution function can help us in the design of redundancy based routing in DTN's. The delay distribution function can provide us with a guideline on how to set the lifetime of a message.The graph plotted shows us the delay distribution for several nodes when they have number of replicas of several packets taken on an average. We have taken a scenario where 5 nodes are willing to send the messages to each other keep in notice that not each node is interested to deliver the packets to the other node.The Simulator designed for finding the results for delay distrbution describes the results for the several inputs where the average number of process served per unit of time is given as input to the simulator and then the number of replicas on the nodes is fed to the simulator and we have generated the output for delay distribution or the delay distribution itself. This graphical scenario represents delay vs. the average number of replications for transferring one packet.

III. Results

1. We have simulated the whole environment of DTN network with the help of C.
2. After several Simulation runs in each case we have got the results for delay distribution in the DTN network.
3. Delay distribution is directly proportional to the number of replications of the packet i and mean time.
4. Comapritively delay on 10 number of nodes is less than the delay on 5 nodes even when the average number of replicas are larger on the 10 nodes.

The average number of packets served per unit of time are assumed to be the same in every case but the number of replications of the packets variate independently. We have considered an environment where no node failure. All the nodes have same moving speed and same communication range.The initial position of nodes, replicas and time are randomly chosen by the random generations. We have find out the delay distribution for the Disruption Tolerant Networking Environment where the delay is directly proportional to the number of replicas of the packets to be delivered on each node. This delay variant even when we change the value of replica on a single node and if the number of replicas is changed on different nodes the value of delay variants accordingly as shown in the table. Replicas on the nodes are randomly generated by using the simulator; we are able to find out the delay distribution for the environment.

Table I : Delay Distribution for 5 Nodes

Serial No	Average No. of Replications	Delay Distribution
1	2.8	0.084000
2	6.4	0.302158
3	8.4	0.365854
4	10.6	0.421123
5	11.2	0.538491

(NOTE: Not all nodes want to send the data to other node few are not desired to send packet to each node but desired to send to fewer nodes).The table I describes the figure 3.1 as the table consists of the actual values against which the graph has been plotted. Take case 1 in the table as there is 2.8 average number of replicas in the case for 5 nodes in the environment. The delay shown by a low number of average is minor which is 0.084000 where the number of replications of packets are also very less which is 2.8.

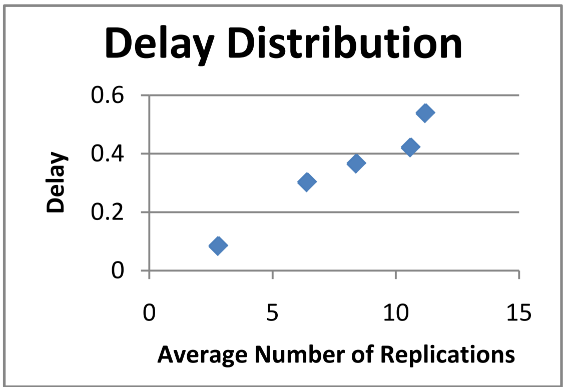

Fig. 3.1 : Graph for Delay Distribution for Five Nodes

As the number of replications of the packets increases on the nodes the delay increases i.e. delay is directly proportional to the number of replicas on the nodes. This is not true in the case of estimated delivery delay. Since with the help of optimum replicas in the delay tolerant networking environment the delay ratio can also be decreased. The graph 3.1 shows us the delay distribution for the values shown in the table I Graph has been plotted delay vs average number of replications on the node because number of replicas are the major factor for increasing the delay on the nodes.The graph tells us that as the number of replicas on the nodes increases the delay factor also increases delay is directly proportional to number of replica of the packet (i).We simulated for 10 nodes in each case with different number of replications of the packets on each node and the tabulated form of data as shown in table II will depict all the information about the figure 3.2 which displays the delay distribution for 10 number of nodes.

Table II : Delay Distribution for 10 Nodes

Serial No.	Average No. of Replications	Delay Distribution
1	4.9	0.081196
2	5.5	0.085354
3	8.6	0.097013
4	9.7	0.203696
5	11.6	0.263826

(NOTE: Not all nodes want to send the data to other node few are not desired to send packet to each node but desired to send to fewer nodes). The delay for case 1 where average number of replicas are 4.9 and dealy distribution is 0.081196 now if we compare the results of table I with table II we get that as in table I we have case number 5 with average number of replications 11.2 and the delay obtained by this average number of replicas is 0.538491 and if we compare it with the case number 5 in table II we obtained that average number of replicas on the nodes is 11.6 and the delay obtained is 0.263826 which is comparatively lesser than the delay obtained in the case of 5 nodes in a network. The in delay between them is 0.274665. Figure 3.2 is a graph depicting delay vs. average number of replications. When Average number of replications are 4.9 on each node the the delay fetched is 0.081196. As in second case when we have average number of replicas are 5.5 and delay fetched is 0.085354. This table II and figure 3.2 explains and speaks themselves about the delay fetched.

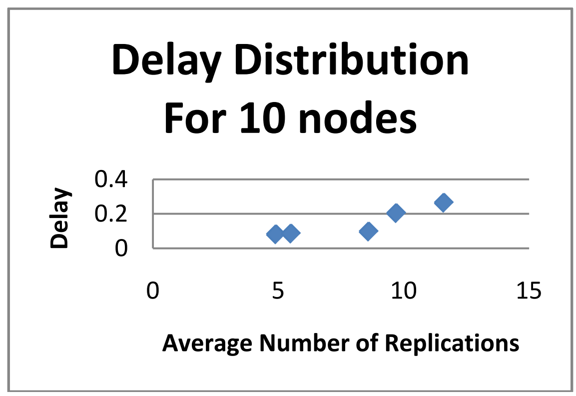

Figure 3.2 : Graph for Delay Distribution for Ten Nodes

a) Comparison Between Delays

The Delay obtained in the cases assumed for 10 nodes in a case is exactly the half the delay obtained by sample inputs in the cases assumed for 5 nodes in a case with same number of replications or the same average number of replications on the nodes.

Table III : Comparative Delay Distribution

Serial No.	Average Replicas	Delay 5 Nodes	Delay 10 Nodes
1	2.8	0.084000	0.042000
2	6.4	0.30216	0.151079
3	8.4	0.36585	0.182927
4	10.6	0.42112	0.210561
5	11.2	0.53849	0.269245

As it has been shown in the table III we define the case 1 as the average number of replicas in the case 1 is 2.8 the delay obtained for 5 nodes in the network willing to send the packets to the nearest neighbor or to the desired destination is 0.084000 and the delay for the 10 nodes in the network willing to send the packets to the nearest neighbor or to the desired destination is 0.042000 which is exactly the half the delay we obtained for 5 nodes in the network. (NOTE: Not all nodes want to send the data to other node few are not desired to send packets to each node but desired to send to fewer nodes in the network.)A graphical representation may clear the picture of the delay distribution difference between the two scenarios. The graph displays the delay difference the between the cases of 5 nodes in a network and 10 nodes in a network with the same average number of replicas. The delay has been gradually decreased or we can say it is exactly the half of the delay as compared to 5 nodes in a network.

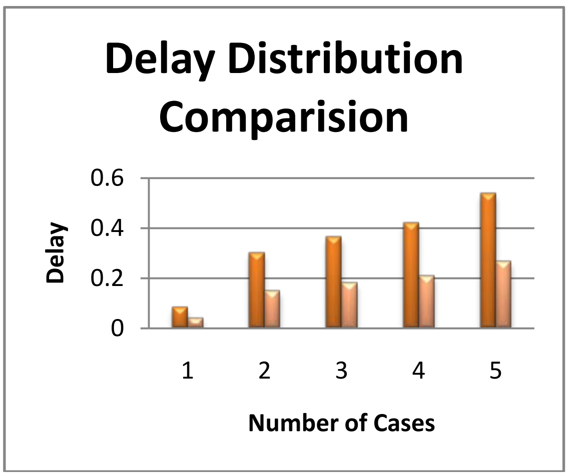

Figure 3.2 : Graph for Delay Distribution Comparison

These results concludes us with finding that if we increase the number of nodes in the network with same number of replicas of the packets we are able to decrease the delay to an optimum value which is tolerable.

IV. Conclusion

By delay distribution algorithm we can derive the message delivery delay distribution which can be a rich source of information for improving the performance of redundancy-based routing schemes.The insight of the delay distribution function can help us in the design of redundancy-based routing in DTN's. The delay distribution function can provide us with a guideline on how to set the lifetime of a message. If the delay distribution function shows that 90% of delays are less than T, we can say that most of the messages are likely to be successfully delivered when we set the message lifetime to T. This delay distribution will help us in transferring the data packets and reshuffling the data packets according to the noise on the node for the time being. These findings helps us to decrease the delay by increasing the number of nodes in the network.

V. Future Work

These results for delay distributions can be used for acknoledgement to remove the extra replicated packets on the network and to save the unnecessary wastage of resources. How to increase the number of nodes in the network to an optimum value will be much more focused as if we increase the number of nodes with an optimum value we will have the delay as negligible for the packets to be transferred.

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Use of Ethernet Technology in Computer Network

By Zobair Ullah
Sam Higginbottom Institute of Agriculture,Technology and Sciences, Allahabad

Abstract - This paper explains the basic functionality of Ethernet and how it can be utilized at home and business networks. This paper includes types of Ethernet, how Ethernet works with OSI modal and cable? , specifications of Ethernet with respect to different types of cables and distance between two points, networking devices supported by it and the topology used by it.

Keywords : Ethernet, History of Ethernet, Ethernet devices, OSI modal used, working of Ethernet, Ethernet topology and protocols and types of Ethernet.

GJCST-E Classification : C.2.5

USE OF ETHERNET TECHNOLOGY IN COMPUTER NETWORK

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I. Introduction

In this paper, Ethernet is introduced as one of the oldest but still the largest form of technology being used for networking. For many years, Ethernet has proven itself as a very popular, fast and relatively inexpensive LAN technology.

Actually, it would be difficult to think of the presence of computer network without Ethernet. So keeping the immense relevance of Ethernet in mind, Ethernet is defined as under.

II. Definition

Ethernet is a protocol that controls the way data is transmitted over a local area network (LAN). The name Ethernet came from the combination of words "Ether" and "Net". Ether, meaning "light bearing", stands for the use of light as a means of data carrying medium whereas Net is a short form of network that means the community or a group of linked computers. It is not a wireless technology because it uses physical media generally called wires. Predominantly, Ethernet specifications define low level data transmission protocols.

III. Brief History of Ethernet

The concept of Ethernet was formulated and introduced by XEROX PARC, now simply known as PARC (Palo Alto Research Centre).This agency proposed to develop a form of system that would permit/allow computers and devices to be connected with one and other using coaxial cables. Engineers Bob Metcalfe and D.R Boggs developed Ethernet beginning in 1972. In 1976, a connection two computers were made and data transfer fruitfully took place with the speed of 3MB/second. In 1980, industry standards based on their work were established under IEEE 802.3 set of specifications. In 1990's ,fast Ethernet technology came into existence fulfilling the objective of a) increasing the performance of previous traditional Ethernet b) avoiding the need of completely re-cable existing Ethernet networks.

IV. Ethernet Devices

Ethernet Devices include a) Ethernet network adapters b) Repeater c) Hub d) switches e) Bridges f) RJ-45 connector

a) Ethernet network adapters

To install or connect Ethernet cables to a computer, a person generally uses a network adapter, also known as a network interface card (NIC) or Ethernet network adapters. Ethernet adapter interfaces directly with a computer's system bus. The cables in turn utilize RJ-45 connector used with modern telephones. Ethernet network adapters exist in multiple forms: a) PCI cards: most popular for desktop computers b) PCMCIA ("credit cards"): most popular for notebooks or laptops c) USB Ethernet adapters exist for both desktops and laptops d) Wireless Ethernet adapters

b) Repeaters

A Repeater in Ethernet networking is a device that allows multiple cables to be joined and greater distances to be spanned.

c) Bridge

A Bridge device can join an Ethernet to another network of a different type, such as a wireless network.

V. How Ethernet works?

Ethernet works by linking computers and other devices using cables. One end of the Ethernet cable is connected to the computer whereas the other is connected to a connector such as repeater, hub and switch. As far as sending signal is concerned, Ethernet basically works by chain reactions. One computer generates and sends a signal of its desired action. The signal passes through the cables, and then through the connector, then to cables again and finally to their designated receiving computer. Also, Ethernet uses an algorithm based on random delay times to determine the proper waiting period between retransmission. In traditional Ethernet, the protocol for broadcasting,

Author : Sam Higginbottom Institute of Agriculture,Technology and Sciences, Allahabad.

listening and detecting collisions is known as CSMA/CD (Carrier sense multiple access/collision detection).

When collisions occur, cause both transmissions to fail and require both sending devices to retransmit.

a) Disadvantage of CSMA/CD

By design, as a performance trade-off, the Ethernet standard does not prevent simultaneous transmission.

b) Remedial measure adopted

In order to avoid/overcome this problem, some newer forms of Ethernet have been developed that uses full duplex Ethernet protocol. This Ethernet supports point to point simultaneous transmission, sends and receives signal with no listening required.

VI. Relation of Ethernet With OSI Modal

In the OSI model, Ethernet technology operates at the physical and data link layers- layers one and two respectively. The physical layer of the network focuses on hardware elements, such as cables, repeaters and network interface cards. As far as data link layer is concerned, here the data packets are sent from one node to another. Ethernet uses an access method called CSMA/CD (carrier sense multiple Access/collision detection). This is a system where each computer listens to the cable before sending anything through the network. If the network is clear the computer will transmit. If some other node is already transmitting on the cable, the computer will wait and try again when the line is clear. The CSMA/CD access rules are summarised by the protocol's acronym:

Carrier sense: Each station continuously listens for traffic on the medium to determine when gaps between frame transmissions occur.

Multiple access: Stations may begin transmitting any time they detect that the network is quiet (there is no traffic).

Collision detection: If two or more stations in the same CSMA/CD network (collision domain) begin transmitting at approximately the same time, the bit streams from the transmitting stations will interfere(collide) with each other, and both transmission will be unreadable. If that happens, each transmitting station must be capable of detecting that a collision has occurred before it has finished sending its frame. Each must stop transmitting as soon as it has detected the collision and then must wait quasirandom length of time (determined by a back-off algorithm before attempting to retransmit the frame).

a) Indication of worst situation

The worst case situation occurs when the two most distant stations on the network, both need to send a frame and when the second station does not begin transmitting until just before the frame from the first station arrives. The collision will be detected almost immediately by the second station, but it will not be detected by the first station until the corrupted signal has propagated all the way back to the station.

b) Methods to detect worst case collision

a) A maximum network diameter is chosen (about 2500 meters).
b) The minimum frame length is set to ensure detection of all worst case collision.
c) Slot time method is used to detect time spent during collision. It is the maximum time required to detect collision. It is roughly found to be equal to twice the signal propagation time between the two most distant stations on the network.

Ethernet supports all popular network and higher level protocols, principally IP.

VII. Ethernet Topology and Protocols

Ethernet supports a bus, star and tree topologies. Traditionally Ethernet employs a bus topology, meaning that all devices or hosts on the network use the same shared communication line. Each device possesses an Ethernet address, also known as MAC address. Sending devices use Ethernet addresses to specify the intended recipient of messages. Data sent over the Ethernet exists in the forms of frames. An Ethernet frames contains a header, a data section and a footer having a combined length of no more than 1518 bytes. Data sent over the Ethernet is automatically broadcast to all devices on the network.

VIII. Types of Ethernet

Presently, there are different variants of the Ethernet technology that are available. The earliest ones are the 10 Bases (the very first standard).

a) Thicknet (10Base 5)

It was the first incarnation of Ethernet technology. The industry used thicknet in the 1980's.

b) Thinnet

It was thinner as compared to thicknet (5 millimeters vs 10 millimeters), more flexible cabling, and easy to install office buildings for Ethernet.

As per the Ethernet specifications, manufacturers of Ethernet equipment must meet the below minimum specifications/standards for short distance segment length. Here segment means a network connection made by a single unbroken network cable.

Name	Max.segment length	Types of cable
10 Base 5	500m/1640ft	RG-8 or RG-11 coaxial
10 Base 2	185m/606ft	RG-58A/U or RG58c/u coaxial
10 Base T	100m/328ft	Category 3 or better UTP

The most common form of traditional Ethernet is 10-BaseT. 10Base T offers better electrical properties than thicknet or thinnet because it utilizes UTP wiring rather than coaxial. Also it is more cost effective than fiber optic cable.

c) Fast Ethernet

Fast Ethernet standards include:

- 100Base T—(100 Mbps over 2-pair category 5 or better UTP cable). It is a standard that includes 100Base-TX(category 5 UTP),100Base-T2(category 3 or better UTP) and 100Base-T4(100Base-T2 cabling modified to include two additional wire pairs)
- 100base FX—100 Mbps over fiber cable
- 100Base SX—100 Mbps over multimode fiber cable
- 100Base BX-- 100 Mbps over single mode fiber cable
- 1000Base-LX--100Mbps,baseband,long wavelength over optical fiber cable

d) Cable standards/Terms/Symbols used

Common twisted pair standards are 10Base-T, 100Base-T and 1000Base-T. The number (10/100/1000) stands for the speed of transmission (10/100/1000 megabits/second). The "Base" stands for "baseband" meaning it has full control of the wire on a single frequency, and the 'T' stands for "twisted pair cable".

e) Ethernet cable in current use

The most popular Ethernet cable in current use is category 5 or CAT 5, supports both traditional (supports data transfers at the rate of 10Megabits/second) and fast Ethernet (category 5e or CAT 5e supports data transfers at the rate of 10Gigabits/second or 10000Mbps). Gigabit Ethernet still remains an active area of research.

IX. Conclusion

This paper describes basics of Ethernet technology, how Ethernet can be utilised in industries and businesses. Efforts have been made to lucidly discuss the use of Ethernet and its relationship with OSI modal and the future use of Ethernet.

X. Acknowledgement

I express my heartiest and deep gratitude to my elder brother **Khalid Ebad Ullah, Research scholar at Aligarh Muslim University, Aligarh, Department of Mathematics** for the invaluable support, encouragement and continuous motivation to start research activity in computer science. At last I would like to thank God for giving me energy to conduct this activity and explore the vast ocean of computer science in an elegant and organised manner.

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14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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