Intelligent Routing Using Time Series: CF – Prophet

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Abstract

Opportunistic network is an extension of Adhoc network, subclass of Delay Tolerant Network and derivation of Mobile Adhoc Networks. The main characteristic is an intermittent connectivity resulting in indefinite waiting time for path establishment due to which routing is a tedious task. Prophet improves the network performance but it does not resolve congestion and flow control issues which arises due to adverse choice of traditional nodes in routing mechanism. Many researchers proposed variants of Prophet but encountering the congestion and flow issues into account have not been proposed yet. We proposed a novel approach called CF – Prophet using time-series analysis wherein packet count taken sequentially and fits those into historical data for predicting the scope of congestion and flow control issues. We simulate and analyze the proposed approach by availing the network performance metrics i.e. Communication transmission ratio, Dormancy Ratio and Steering Dormancy Ratio.

Keywords: *Adhoc Network, CF – Prophet, Delay Tolerant Network, Epidemic, Opportunistic Networks, Prophet*

1. Introduction

Wireless infrastructure application has been implemented in the area where communication opportunities are very less or looking for an opportunity for making the routing possible such as in poor regions, military regions, disaster scenario, underwater sensor networks and so on **[1]**. The network categories that belong to Wireless Area Networks (WAN): Adhoc Network **[2]**, Delay Tolerant/Torrent Network **[3]**, Mobile Adhoc Network **[4]**, Interplanetary Network **[5],** Opportunistic Networks **[6]** and so on. In the direction for making the routing possible in such an environment where path establishment is not predetermined. OppNet is a subclass, type and an extension of Adhoc Network, Delay Tolerant Network and Mobile Adhoc Network respectively. OppNet derives the characteristics from former networks are intermittent connectivity, store – carry – forward fashion, movable nodes, dynamic network topology, flexible network connectivity and lenient to lengthy disruptions and high culpability regularity. The characteristics are explained below.

Intermittent connection: OppNet is an extension of MANET. OppNet inherits the feature of intermittent connectivity wherein the path establishment is not pre-determined between source and destination. In MANET, nodes are mobile which associated wirelessly inside in a self-designed network without having a settled network framework. Nodes move randomly in an environment due to which path connectivity among them is not pre-determined hence called as an intermittent connectivity.

Store – carry – forward: Sometimes there is a possibility that during routing mechanism source node straight fully emanates hooked on announcement assortment through destination node whenever a shortest interaction arises among them. But if there is no direct contact arises then transitional nodes need to wait for path establishment and forward the packet to destination.

Dynamic network topology: Network topology in an OppNet change sturdily and no ascetically fixed packet transmission way between nodes. This makes it troublesome to attain more productive execution based on the alter to arrange topology. Subsequently, a way to discover a steering convention with great routing performance is one of the foremost challenging issues in OppNet research.

Bundle Layer Protocol [7,8]: The protocol stack of an OppNet is layered architecture wherein a network layer has been partitioned into regions called as layers/regions **[7]**. Traditional nodes implement store – carry – forward fashion for message storage and transmission on finding an

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opportunity using a deposit called bundle layer located on uppermost. Bundle layer remains located between Application and Transport layer **[8]**.

Due to intermittent connectivity transitional nodes may not encounter other nodes frequently due to which nodes need to store a packet for an infinite time. Also, transitional nodes need to encounter other nodes for making the routing path establishment between source and destination node but due to long buffer storage of a packet causes the congestion in a network which in turn also affect the packet delivery ratio, high latency and routing overhead ratio respectively. As we know node mobility is unpredictable and non-random which results in predictable and reciting outline of node contact and connection time, as if two nodes met before during routing algorithm there is a probability that nodes often met with each other again. The encountering probability of two nodes is high and repeated in nature. Using former spectacle during packet forwarding and for predicting what will happen in future by using history and transitivity information. Based on node contact time, connection time and transitivity history information for improving the network performance Prophet **[9]** is proposed. Directing on inadequacy of Prophet steering **[10,11]**, following paper boons notion of protuberance congestion and flow control scheduled which we propose CF-Prophet. We propose the variant of Prophet in which it solves the issues of flow and congestion control of a network which improves the network performance along with the several factors such as transmission ratio and so on. In previous work proposed by many researchers **[10] [14-18]** solve the congestion issues but in our approach, we use the machine learning algorithm using time series analysis of double exponential algorithm which in turn improves the network performance but also make the routing path availability within short span of time. This paper presents our CF probabilistic routing with the simulation performed in ONE **[12]**. We introduce our proposed work followed by its presentation by means of Unit II offerings the related and associated work which explain Prophet variants proposed by researchers. Unit III explains the proposed approach CF-Prophet. Unit IV presents the simulation of our proposed approach with result analysis. Unit V presents inference besides forthcoming slog.

2. Related and Associated Work

Owing towards sporadic connection and protuberance's flexibility routing and forwarding trendy an OppNet is a thought-provoking chore. Finding direction-finding route among nodes is most captivating chore **[13]**. Consequently, it becomes essential towards propose a novel approach towards direction for improving the communication transmission, dormancy (latency) and steering dormancy (routing) ratio respectively along with it also improves the congestion and flow control issues. Many researchers **[10,15-19]** have proposed variants of Prophet **[15-19]** which solves the network performance but also resolve an issue of congestion and flow control issues.

In **[10]** we analyzed an intermittent network where a part of modern applications vouching for an energizing future in the event that the fundamental mechanisms are present. Subsequently, it is used for steering in intermittently connected networks namely much advanced in comparison with prior approaches, utilizing node past meetings and transitivity towards performance upgrading completed prevailing approaches. simulations demonstrated that Prophet enhances network performance in comparison per Epidemic **[14]** by reducing the number of packets which in turn also enhance network performance and several parameters.

In **[15]** minimize the scope of packet cost and transfer adjournment although continuing with large possibility of packet distribution effectiveness among nodes through contact opportunities. Using Prophet parameters those **[10]** helps in evaluating a weighted function also called as delivery predictability. Delivery predictability value moderates in accordance with the environment factors and assumption of hypothesis. Prophet+ performs well trendy in message distribution and delay ratio respectively but it doesn't take into consideration of congestion and flow control issues.

In **[16]** Dhurander et al. anticipated an energy – efficient routing algorithm which employs in estimating the best routing path on the basis of node context information in regarding with the neighboring nodes group. Characteristically, an initialization for group of random nodes is done and in future node updated

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on the basis of selection and crossover mechanisms using genetic algorithm. For finding the best routing path and choosing a best neighboring node for packet forwarding is done using fitness function.
In **[17]** Ji Fang et al. proposed an advanced prophet routing scheme to resolve the network router jitter issue by using the average of delivery predictability values.
In **[18]** researcher proposed a utility – based routing algorithm Max – Util for making a right decision by computing the node utility and exploiting historical information of a node that has in packet forwarding. Node history information is used in encountering node contact duration and remaining buffer size after packet forwarding to the destination.
[19] Lee at al. proposed a routing algorithm DProphet (Distance Prophet) in which distance value among nodes computed using the using cross layer implementation. Drawbacks arises in this scheme is poor packet delivery and delay ratio respectively for the case where two nodes transfer equivalent delivery predictability value.

Former routing protocols resolves the network performance by reducing the number of packets generated using Epidemic **[14]** routing protocol and improving packet delivery values but it also has been observed that congestion and flow control issues not taken into account. However, for finding the precise value of delivery predictability in improving the packet delivery ratio is not informal. Hence for optimizing the delivery predictability value which in turn also resolve the issue of congestion and flow control issues we propose CF-Prophet.
In Table 1, we summarize the features, parameters performance, merits and demerits of former mentioned routing protocols.

3. PROPOSED APPROACH

In our proposed approach CF-Prophet the routing algorithm is divided into three steps: Calculation of delivery predictability ratio, Determination of node congestion level and Packet forwarding process.

3.1. Calculation of delivery predictability ratio (DP) Using Prophet [10]

Using Prophet **[10]** delivery predictability (DP) ratio calculated within three steps, accordingly to which the node value updated.

$$\boldsymbol{X(Y,Z) = X(Y,Z)_{old} + (1 - X(Y,Z)_{old}) * X_{init}} \quad (1)$$

where $\boldsymbol{X_{init}}$ value lies between 0 and 1.

$$\boldsymbol{X(Y,Z) = X(Y,Z)_{old} * \lambda^{k}} \quad (2)$$

$\boldsymbol{\lambda}$: Decay Constant
k: Decay time from start to decay

$$\boldsymbol{X(Y,A) = (Y,A)_{old} + (1 - (Y,A))_{old} * X(Y,Z) * X(Z,A) * \beta} \quad (3)$$

where $\boldsymbol{\beta}$ is transitive factor value lies between 0 and 1

Table 1. Summarization of Proposed Routing Protocols [10,15-19]

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S.No.	Protocols	Features	Parameters Performance	Merits	Demerits
1.	Prophet **[10]**	Calculation of delivery predictability values	Communication overhead Latency ratio Packet overhead ratio Packet delivery ratio	Low overhead Low latency ratio	Less packet delivery ratio
2.	ProPhet+ **[15]**	Calculation of delivery predictability and weighted value	Packet delivery ratio Delay ratio	Good packet delivery ratio than Prophet	High delay
3.	GAER **[16]**	Determination of best node using fitness function	Packet delivery ratio Latency Delay ratio	High packet delivery ratio Less delay ratio	High latency
4.	Advanced Prophet in DTN **[17]**	Resolving the network jitter issues	Packet delivery ratio Overhead ratio	High packet delivery ratio	High overhead ratio
5.	Utility based routing **[18]**	Encountering node history information	Packet delivery ratio Overhead ratio Latency ratio	Low overhead ratio	Less packet delivery ratio High latency ratio
6.	Prophet CLN **[19]**	Determining node congestion level using exponential algorithm	Packet delivery ratio Overhead ratio Delay ratio	High packet delivery ratio	High overhead ratio High delay ratio

3.2. Determination of Node congestion level

For determining node congestion level in an OppNets, we use Double Exponential Algorithm which is a subclass of Machine Learning Technique of Time Series Analysis [20]. During message forwarding in OppNet when transitional nodes is a part of routing algorithm it stores the packet till it comes into destination node. But if transitional nodes don't come into communication range with destination node packet dropping start occurring due to which congestion occurs in a network.
In our approach for determining bottleneck possibility in node we must know the packets figure $'\boldsymbol{f}'$ initiated by a node $\boldsymbol{N_g}$ within a current time period $'\boldsymbol{T}'$ where $'\boldsymbol{N_r}'$ packets received by a node but if congestion $\boldsymbol{C(f)}$ occurs in a network then packets dropped by a node $'\boldsymbol{N_d}'$. In direction to depleting congestion level of a node in a network.

We define number of incoming messages$'\boldsymbol{I(f)}'$ and drop messages$'\boldsymbol{D(f)}'$ as follows:

$$\boldsymbol{I(f)} = \frac{\boldsymbol{N_g}}{\boldsymbol{N_r - N_d}} \tag{4}$$

$$\boldsymbol{D(f)} = \frac{\boldsymbol{N_d}}{\boldsymbol{N_g + N_r}} \tag{5}$$

For determining the congestion level of a node:

$$\boldsymbol{C_t(f) = \alpha D(f) + (1-\alpha)(C_{t-1} + b_{t-1})} \qquad \boldsymbol{0 \leq \alpha < 1} \tag{6}$$

$$\boldsymbol{b_{t(f)} = \gamma(Z_t - Z_{t-1}) + (1-\gamma)b_{t-1}} \qquad \boldsymbol{0 \leq \gamma \leq 1} \tag{7}$$

Specific parameters description shown in Table 2 for (1-7).

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3.3. Packet forwarding

Node 'Y' act a source node comes into communication range with the Node 'A' act as a destination node passing through Node 'Z'. Routing process for packet forwarding occur as follows:

a. When DP(Y,A)>DP(Z,A), represent that delivery predictability ratio of Y is greater than Z which shows that Y packet forwarding probability is greater than of Z i.e. Y not forward the packet to Z it will carry the message by itself to A.
b. When DP(Y,A)<DP(Z,A), shows that delivery predictability of Y is less than of Z.

- if $0 < C(f) < 1$, no congestion in a network
- if $0 < C(f) \leq 1$, insignificant congestion in a network
- if $0 < C(f) > 1$, significant congestion in a network

From Figure 1. It shows the working of CF-Prophet in flow chart representation. Due to rapid construction period among the nodes it leads toward failure in Prophet **[10]** ultimately lead for packet delivery failure. CF – Prophet overcome this disadvantage of packet dropping in short connection time by encountering node congestion level which is helpful in making the short connection time routing possible. It also overcome following disadvantages:

- Utilization of network resources in optimal way.
- Node congestion level reduced to zero.
- Improving the network parameters **[10]**.

4. Experimental Analysis

Simulation of proposed CF – Prophet has been demonstrated in two parts: Parameters background and simulation setting, Result analysis of parameters and mathematical analysis of performance metrics

4.1. Parameters background and Settings

In our proposed approach, we use ONE simulator **[13]** for performing the simulation in Helsinki map whose size is 5000m*4500m. In the given scenario 146 nodes are present in the simulation area wherein message generated within interval 35 – 45 seconds and packet size are 250 – 450k. Table 3 gives the parameter values which kept constant during the simulation. The 146 nodes have been classified into three groups: Amblers, Cars, Trams respectively. All these specific node settings have been displayed below in Table 4.

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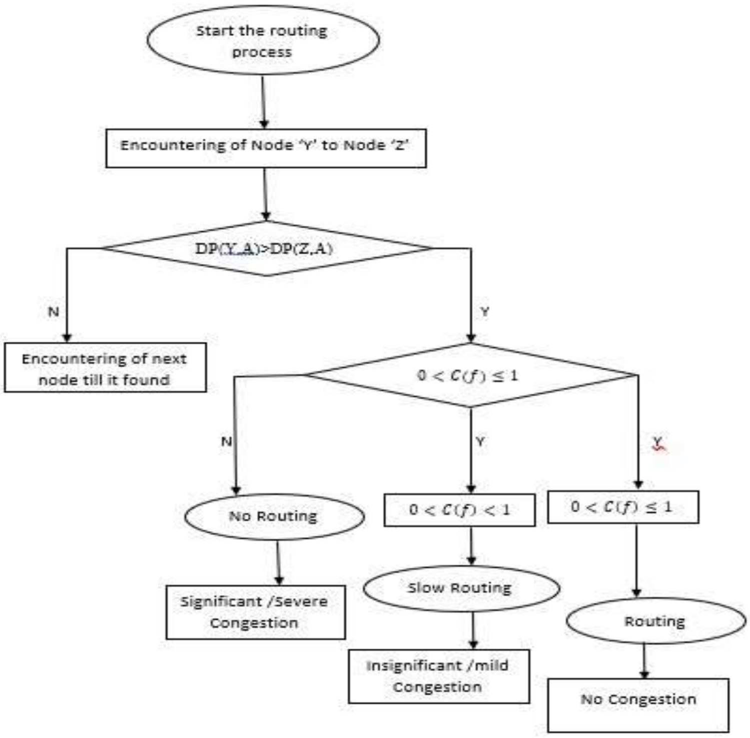

Figure 1. Working of CF – Prophet

Table 3. Parameters constant value

S.No.	Parameter	Value
1.	A	0.50
2.	γ	0.75
3.	β	0.25
4.	X_{init}	0.98

Table.4 Parameter Settings

Node Category	**Ambler**	**Car**	**Tram**
Total No. of Nodes	100	20	26
Range of Node Speed (m/sec)	[0.5-1.5]	[2.5-7.5]	[5-9]
Node Communication Range (m)	5	5	10
Buffer Space (M)	8	8	25

Using Table 3 and Table 4, we evaluate network recital CF – Prophet cutting-edge relations: Communication transmission ratio, Dormancy ratio (Latency) and Steering (routing) dormancy ratio respectively. Also, we compare the proposed approach with the Prophet **[10]**, Epidemic **[14]** and CF – Prophet respectively.

4.2. Result Analysis

In this section of result analysis, we present the analysis of parameters that has been obtained after performing simulation on ONE [12]. The parameters on which result analysis is one are: Communication Transmission Ratio, Dormancy Ratio and Steering Dormancy Ratio respectively that has been explained below.
Along with it, we also compare the performance metrics of CF – Prophet with the Epidemic [14] and Prophet [10] respectively. After conducting the result analysis, it has been observed that the performance of CF – Prophet is better than existing ones [10] [14].

4.2.1. Communication Transmission Ratio

Communication Transmission Ratio can be defined as "count of packets transmitted over network."
From Figure 2 below we understand that communication transmission ratio in CF Prophet upsurges within time 12 seconds and continues till 30 sec but for 36 sec the packet delivery ratio is almost same as of Prophet and Epidemic. which denotes that it led to the congestion issues in a network is 0.01% and 0.11% within comparison of Epidemic and Prophet respectively.
On 42 sec the communication transmission ratio again improves for CF – Prophet which denotes that proposed approach has resolves the congestion and flow matters cutting-edge system. The aforementioned analyze that CF – Prophet is improvement over Epidemic and Prophet. therefore, using Time series analysis the communication transmission ratio has been made by encountering the value on various time periods.

4.2.2. Dormancy (Overhead) Ratio

Dormancy ratio (Latency) can be defined as "Amount of delay in time during routing algorithm." After Figure 3, it can be seen that the latency ratio of CF – Prophet is less in comparison with Epidemic. On 6sec, we see that the latency in CF prophet has been improved over Prophet and Epidemic by 0.9% and 0.3% respectively. It has been improved continuously till 18sec, but at 24sec it is almost same as of Prophet but improved over Epidemic with 1.061% respectively. Again, it continues to improve till 42sec which proves that the packet flow issues in a network has been improved using CF – Prophet.

4.2.3. Steering (Routing) Dormancy Ratio

Steering dormancy ratio well-defined as "number of packets drop during routing."
Figure 4 shows the steering (routing) dormancy ratio of CF – Prophet has been improved in comparison with Epidemic by 1.69% on 6sec but increased in Prophet by 0.8% respectively. But on 18sec CF – Prophet again degrade by 0.2% in comparison with Prophet. But as time increases performance of CF – Prophet continues to improve till 42 sec. hence, it represents that after 18sec, CF – Prophet continues to stop packet dropping which shows that it resolves the congestion issue in a network.

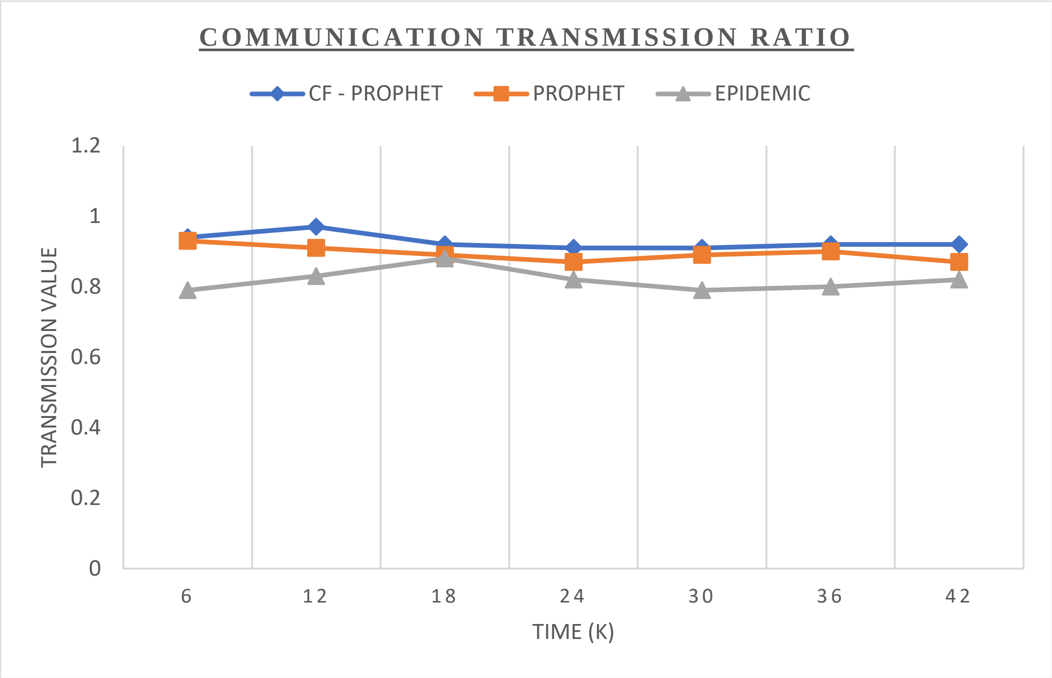

Figure 2. Communication Transmission Ratio

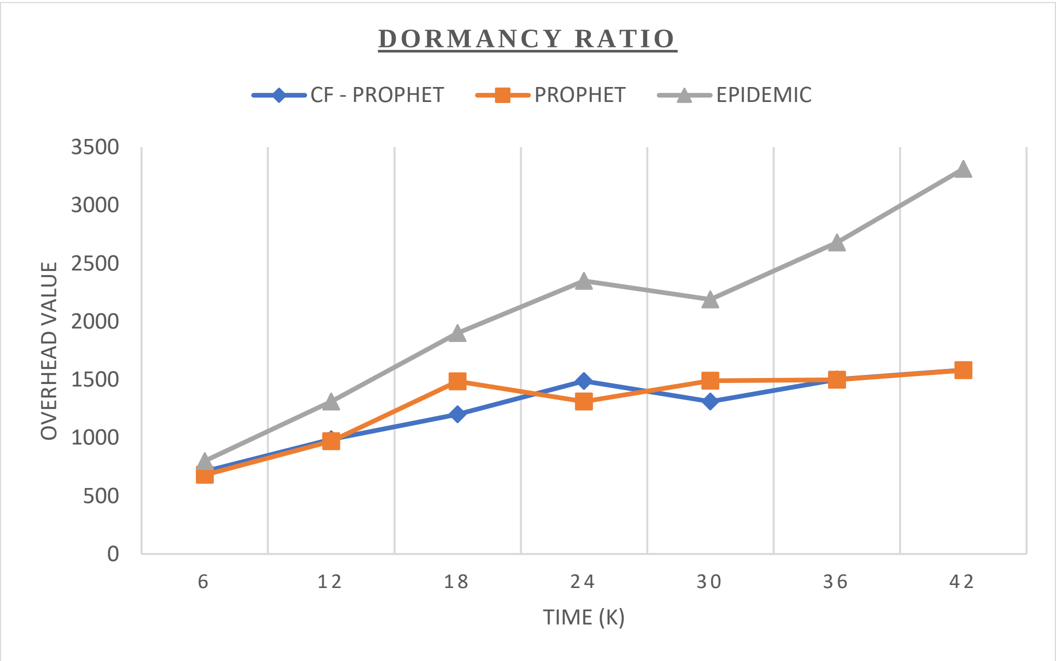

Figure 3. Dormancy (Overhead) Ratio

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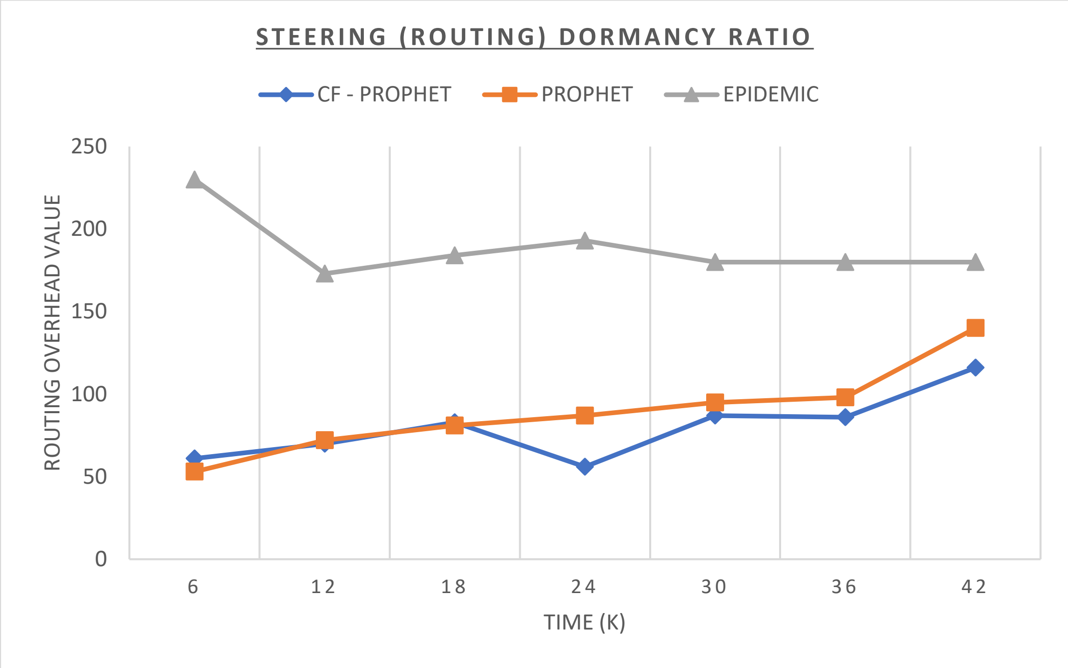

Figure 4. Dormancy (Overhead) Ratio

4.3. Mathematical analysis of performance metrics

After studying the result analysis of network performance metrics, we also present the mathematical analysis of performance metrics wherein we observe the behaviour of them.

4.3.1. Communication Transmission Ratio

We can conclude from Figure 2 that the communication Transmission Ratio of our proposed approach "CF – Prophet" is better in comparison with Prophet and Epidemic. The simulation done has been presented below in Table 5 from which we can say that on 50,100,150 nodes the performance seems to be increasing but it becomes constant on 200,250 nodes again it starts increasing but only with 0.01%. Hence, it can be concluded that on 200 and 250 number of nodes the CF – prophet might be congested but still its performance is good within comparison with Epidemic and Prophet.

Table 5. Comparison of Communication Transmission Ratio

TIME(K)	NO OF NODES	CF PROPHET	PROPHET	EPIDEMIC
	50	0.94	0.93	0.79
12	100	0.97	0.91	0.83
18	150	0.92	0.89	0.88
24	200	0.91	0.87	0.82
30	250	0.91	0.89	0.79
36	300	0.92	0.9	0.8
42	350	0.92	0.87	0.82

4.3.2. Dormancy (Overhead) Ratio

We can conclude from Figure 3 that Dormancy (Overhead) Ratio of our proposed approach "CF – Prophet" is better in comparison with Prophet and Epidemic. The simulation done has been presented below in Table 6 from which we can say with 50,100,150,200,250 number of nodes dormancy ratio seems to be increasing but it becomes constant on 300 and 350 number of nodes which shows that the congestion issue has been resolved and also its performance is good in comparison with Epidemic and Prophet respectively.

Table 6. Comparison of Dormancy (Overhead) Ratio

TIME(K)	NO OF NODE	CF PROPHET	PROPHET	EPIDEMIC
6	50	710	680	800
12	100	985	970	1310
18	150	1200	1485	1900
24	200	1289	1310	2350
30	250	1679	1490	2189
36	300	1812	1498	2680
42	350	1823	1580	3312

4.3.3. Steering (Routing) Dormancy Ratio

We can conclude from Figure 4 that Steering Dormancy Ratio of our proposed approach "CF – Prophet" is better in comparison with Prophet and Epidemic. The simulation done has been presented below in Table 7 from which we can say that with 50,100,150 number of nodes steering dormancy ratio seems to be increasing but at 200 it start decreasing which shows that at this point buffer consumption is less again it start increasing on 250 by 3.1% and continue to increase but its performance is good in comparison with Epidemic and Prophet respectively.

Table 7. Comparison of Steering (Routing) Dormancy Ratio

TIME(K)	NO OF NODES	CF - PROPHET	PROPHET	EPIDE MIC
6	50	61	53	230
12	100	70	72	173
18	150	83	81	184
24	200	56	87	193
30	250	87	95	180
36	300	86	98	180
42	350	116	140	180

5. Conclusion and Future Work

From planned tactic CF – Prophet, we improve the traditional Prophet algorithm by adding the flow and congestion issues in routing algorithm. We enhance the flow and congestion issues by observing the parameters using time series analysis keep on observing node congestion level on different time

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intervals. The proposed approach not only improves the congestion level issues of a node but also enhances the communication transmission ratio and reduce network dormancy ratio respectively.
For forthcoming work, we can explore planned approach characteristic in different mobility models via changeable nodes number, buffer dimensions and so on. Also, we can explore the improvement of proposed approach on more effectively buffer management schemes which enhances the network improvement by reducing network dormancy and increasing communication transmission ratio respectively.

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