ANALYSIS OF TRANSPORT CONTROL PROTOCOL MECHANISM WITH SPANNING TREE FOR SMART METERING INFRASTRUCTURE

[1]M. RAJIV SURESH, [2]V. SUBEDHA

[1]Research Scholar, CSE, St. Peter's University, India
[2]Professor & Head/CSE, Panimalar Institute of Technology,India
E-mail: [1]m_rajivsuresh@yahoo.com, [2]subedha@gmail.com

Abstract - In this paper, the effectiveness of TCP congestion control mechanism is investigated against smart meters. The conventional congestion control mechanism leads to packet loss rate and that disrupts the flow of traffic in shared and metered network, respectively. The performance analysis of proposed aggregated TCP mechanism is studied and takes into concern spanning tree for mapping the data to destination. This method uses Regional Collectors (RC) to acts as an aggregation device in transport layer. This helps to reduce the packet loss and optimises the traffic in Smart Metering Infrastructure (SMI). The performance of SMI is analysed in terms of loss rate, throughput and latency using extensive NS-2 simulation.

Index Terms - Smart Metering Infrastructure, Aggregated TCP, Spanning Tree, Transport Control Protocol

I. INTRODUCTION

In smart power grid, the Smart Metering Infrastructure (SMI) is been regarded as a noteworthy application. It is seen as the framework that empowers control and collection of data and analysis of data in a bidirectional way between a collection center, sensors and smart meters. The framework is portrayed by the sending a numerous data sources. The sources normally deliver the information at very low rates either through triggered events or in periodic manner.

The data center collects the data packets for decision making and processing. From the communication point of view, an enormous volume of information flows through a limited bandwidth capacity with the information requiring ensured end-to-end data reliability. Hence, this circumstance requires a TCP. However, the individual smart meters are not lowered due to the traffic transmission rate. Congestion mechanism in TCP is hence becomes ineffectual. The volume of traffic movement here originate from countless sources and not from single source. The absence of congestion control in transport leads to degraded performance and instability, for example, low throughput and high bundle drop rate. Hence in this paper, a TCP Aggregated protocol with spanning tree is proposed to improve the execution of TCP performance.

The proposed method makes utilization of smart devices introduced as a component, which is named as RC. RCs are regularly introduced on poles at defined areas for routing the smart meter readings through WAN or gateways and finally to the utility provider [6]. In the proposed method, the RCs are limited to transport layer i.e. layer 4 and that accomplishes better execution. In this way, not at all like the ordinary setup in which sensors and meters impart over particular sessions of TCP with the collector device. The proposed TCP aggregated mechanism uses the aggregation mechanism to aggregate each TCP connections. The paper gives a numerical model with an objective to capture the behaviour of application in smart metering device. This model joins spanning tree with the behavior of TCP single meter in an independent way and directs the analysis of deceive interaction in network using standard queuing framework.

This paper makes the following contributions:

- The author used intermediate devices to make it operatable at TCP level that gives an upgrade to congestion control performance in TCP, for example, enhanced throughput and lessened retransmission rate.
- It gives a scientific model that helps catch the behavior of SMI, where the models entirely depends on Spanning tree and queuing models.

Researchers investigated various SMI communication layers. Lower layer issues are summarized in [1] and [11]. The work [7] was thefirst to feature the TCP shortcomings in SMI. Allalouf et al. [2] further addresses the mechanism of congestion control blockage caused by larger number of smart meters' and it performs traffic reduction using multi-hop movement, where the data is required at intermediate device. They additionally expect that such device processes the application layer information.

A cross-layer routing protocol is used to reduce the data reduction. Kim and Thottan [8] avoids congestion rather than latency, however it factors out to find the TCP packet delay. In such manner, TCP is modified by avoiding delays for improving the delivery speed on delay-sensitive data. Kim et al. [3] studied the security part of TCP and uses pre-shared keys for symmetric cryptography is considered appropriate due to poor resources. The proposed

aggregate TCP method is considered a scalable one and it uses certain modifications to make it more reliable.

II. SYSTEM MODEL

The Figure 2 delineates the SMI that uses aggregated TCP spanning tree mechanism. The interconnection of various SMI components at transport layer is shown here. The main traffic sources are meters and sensors. A local wireless mesh networks is formed at lower layers, which is connected through proper gateways to WAN and at collection center. At transport level, the gadgets are allowed to interface with intermediate gadgets called RC [6] that works as aggregated TCP mechanism. The assumptions and characteristics of traffic in SMI is given below:

- Reliable report delivery sent by sensors or meter is needed, where each report has a small information with specific time and meter.
- Sensors and Smart meters are allowed to work as stationary nodes.
- The data reports are submitted through source scheduling using a pre-configured schedule. The TCP connections are made as long lived connections to avoid overhead due to tear down and connection setup.
- Data aggregation methods like min, max, median or mean is not used. However, some statistical measurements are made using above methods.
- Routing protocols are allowed to configure the smart meter for routing the data to the RC.
- The smart meters are allowed to support the TCP/IP.

III. OVERVIEW OF AGGREGATED TCP

A. Motivation

The huge number of information sources causes issues at the vehicle level. Congestion mechanism of TCP's depends on diminishing a transmission speed of source once the packets begin to drop at congested switch.

The high movement originate in SMIfrom a numerous sources rather than single source. Each packetstransmits at low speed. All things considered, speed reduction in network congestion isn't reasonable that prompts the failure of TCP's congestion.

The issue is comparable to supplanting source with one large traffic, for instance, one billion sources creating a similar traffic. If the network is congested, the congestion window is reduced in one source, which is considered as minimum. Regardless, if congestion window is reduced to one from one billion sources, an aggregate window size of one billion outcomes will be produced. More clarifications about the TCP weaknesses in SMI is shown in [9].

B. TCP Aggregation Mechanism

The proposed method for the above TCP inadequacies in a SMI is as per the following:

- The principle thought is part the TCP associations at a device called the Aggregator TCP and framing a TCP unified connection with data collector. In this manner, rather than one connection using TCP between collector and each smart meter, we have two hop connection between aggregator and aggregator and then between aggregator and collector.

- The end point TCP includes meters, data collector and TCP aggregators, is utilized without changes.
- Transport session are seemingly perpetual without connection setup overhead and termination of connection.

Figure 1 portray the possibility of one-jump TCP connection and Figure 2 portray the possibility of two-hop TCP connection. In Figure 2, the RC may go up with TCP aggregation connection rather than IP level forwarding.

TCP aggregation connection associations is similar to [4] for General Packet Radio Service that upholds improve fairness and link utilization. The data aggregation unifies TCP information state with a TCP connection set using single mobile device.

IV. MODELLING TCP AGGREGATIONS

The proposed method builds up a scientific model to capture the SMI behavior at TCP level and to have the capacity to examine the execution of proposed model. For instance, given an extensive number of sources, we will have the capacity to decide the correct number of RCs to accomplish the desired end-to-end delay and packet loss rate.

The main considerations impacting the performance includes TCP behaviour, meter application and network parameters like link capacity, buffering mechanism, buffering capacity and propagation delay. Figure 5 provides a large model with two phases that is an end to end architecture. The first stage has smart meters with LAN and it is divided into RB connecting to an aggregator in TCP. The aggregators group makes the second phase, since it gets interfaced with mutual WAN and single RC. We display each RBs independently and it join other RBs, where the traffic movement is accepted to take after Poisson distribution. Every RBs is displayed as various sources producing traffic movement as indicated by the congestion window system and the behavior of application.

This traffic movement is liable to bottleneck at intermediate node see Figure 6.

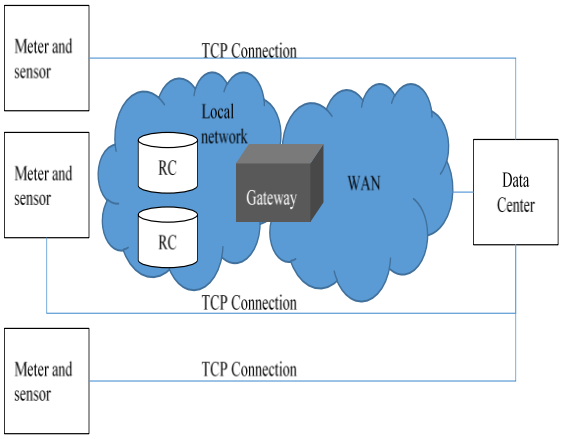


Figure 1: TCP connection with one hop communication

All accurately, we demonstrate the sources using spanning chain and the M/M/1/B queuing model is given as bottleneck. The M/M/1/B queuing model and spanning chain interacts as given in Figure 6 i.e. spanning tree computes the normal load of sources and it analyses the queue. The queuing model computes the load and then the packet loss probability and queuing delay is given as input to spanning tree, which is inspired from [10].

The interaction between the Markov and queuing models continues the total iterations till it reach a stable state that gives the average round trip time and packet drop probability.

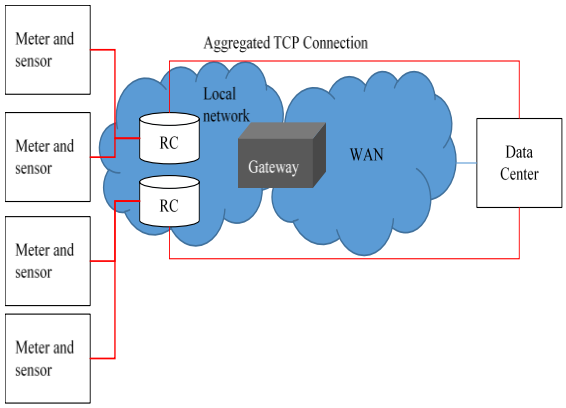


Figure 2: TCP connection with two hop communication

V. SIMULATION OF SA-TCP

To show the advantage of re-outlining the TCP to incorporate a TCP aggregator level using NS-2. The two systems are shown in Figure 1 and Figure 2 simulated using NS-2 within the range of 10,000m for comparing the two models that watching execution measures of two models, in particular, packet retransmission rate and packet delivery latency.Two scenarios are compared using NS-2. The first model without TCP aggregators, which is proportionate to having the same number of aggregators as there are meters, each going about as its own aggregator. The second situation utilizes just a single TCP aggregator.

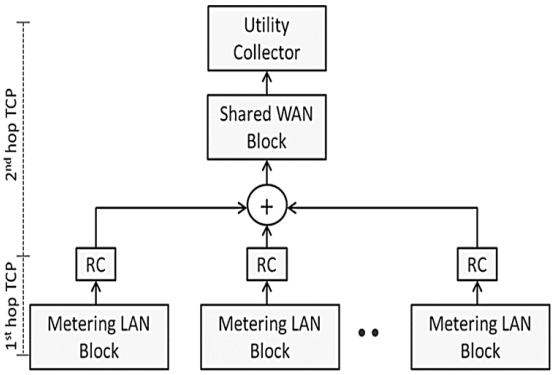


Figure 3: Overview of proposed TCP aggregation model

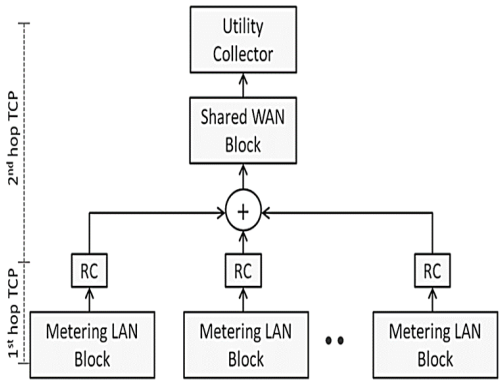


Figure 4: Interaction between the source meter and the network

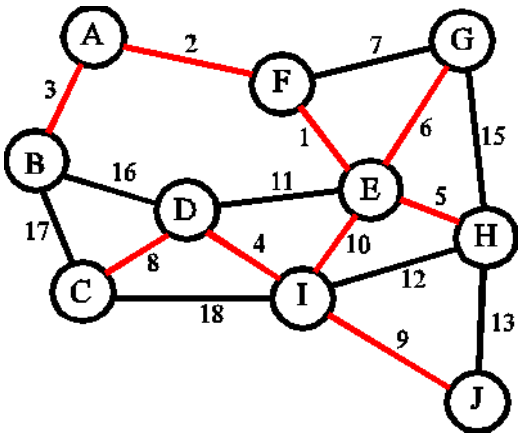


Figure 5: Spanning tree Model

On account of one TCP aggregator, Figure 4 demonstrates a change in the rate of retransmission that drops around 120% to less than 1%. However, Figure 3 shows that latency is further reduced. The delayed reports percentage increased from 1% to 30%.The objective of the proposed system is achieved using two objectives that includes retransmission rate and latency. They suggest that a solution is found by optimal choosing of TCP aggregators. The performance of proposed model is performed using extensive validation using network simulator NS-2. The model is validated asin Figure 6 for LAN metering blocks as shown in Figure 5. The

parameters for simulation is shown in table below. The simulation is performed using three parameters that includes throughput, packet loss rate and packet latency.

C. Validation of Smart Meter Spanning Tree Model

It is conceivable to approve the source model autonomously [5]. The meter spanning tree model exhibited in Figure 7 using round trip time and packet drop ratio to find the value of throughput. Accordingly, meter model in SMI is validated in the following regards. Initially, the round trip time, packet drop ratio and throughput is estimated and it is given as a input to spanning tree model to obtain estimated throughput. The Figure 8 provides the throughput comparison between proposed model and Markovian model. The estimation is carried out in 15,000 to 25,000m range that shares the bandwidth link of 1 Mbps, propagation delay of 50 msec, and buffer capacity of packet as 40. The meters are characterized in terms of average values of Ton/Toff of 1 minute. The model provides an improved results than Markovian model as the number of meter increases.

D. Validation of Complete blocks

A RB is considered as the source collection with a single collector and a network. The sources adjust the transmission rates based on the obtained feedback from queuing model and this continues until it reaches the steady state. After the steady state, the performance measures like loss rate, estimated throughput and latency is constant. The steady state is reached within 20 iterations. The Figure 9 – Figure 11 shows the accuracy rate of estimated throughput, loss rate and latency, when the queuing model interacts with spanning tree model. The proposed simulation considers the independent area with exponentially distribution of active states and inactive states for Ton and Toff, which is considered as 100msec and one minute, respectively. The source A produces the packets during the active state, where the shared link has a buffer capacity of 40 MSS, propagation delay of 50 msec and bandwidth of 1 Mbps. The correct statistics is obtained after the simulation run of 12000 runs.

E. Impact of Varying Number of Aggregators

The number of TCP aggregators is used for finding the influence over TCP protocol. A mathematical model is defined within the radius of 24.kms, which is divided into regions. Each region or block has a shared link with propagation delay of 50 msec and bandwidth of 1 Mbps. The E1 link for aggregators is propagation delay of 50 msec and bandwidth of 2 Mbps on WAN. The total number of aggregators is varied between 0 and 15 in one single hop communication. The results of figure shows the performance related to end to end communicator between smart meter and data collector, which includes latency and packet loss rate. The result shows that if the aggregators are null, the packet loss rate is high. The loss rate increases slightly if the aggregators increases and eventually the aggregators increase well the latency if it is null. The increase in latency is further due to limited buffers and the capacity of buffering is more if the aggregators increases further.

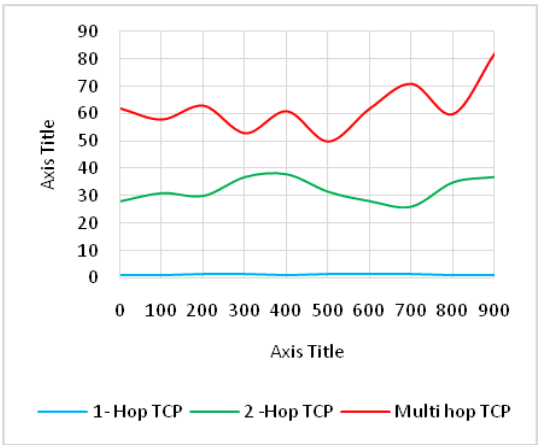


Figure 6: Reports of delayed meter percentage

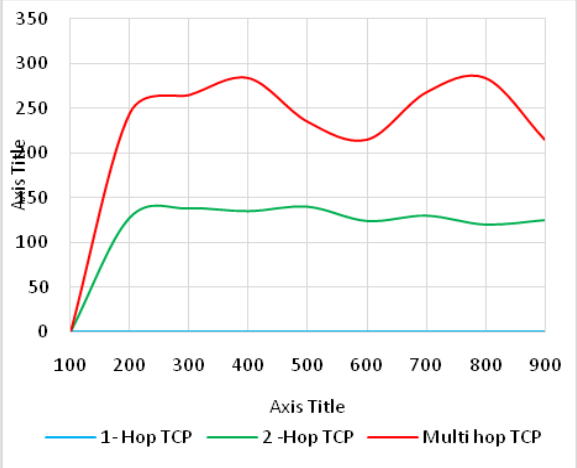


Figure 7: Reports of meter retransmission percentage

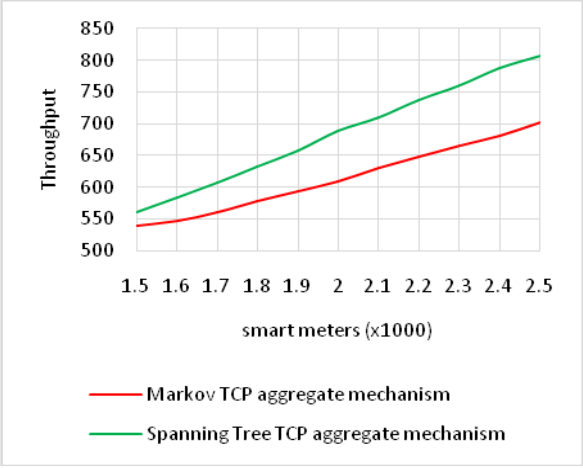


Figure 8: Throughput of Meter

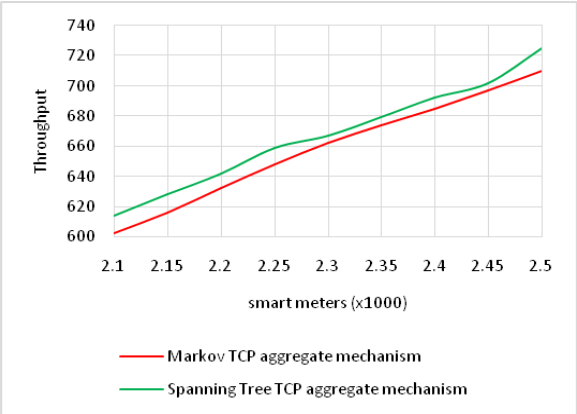


Figure 9: Throughput of Block

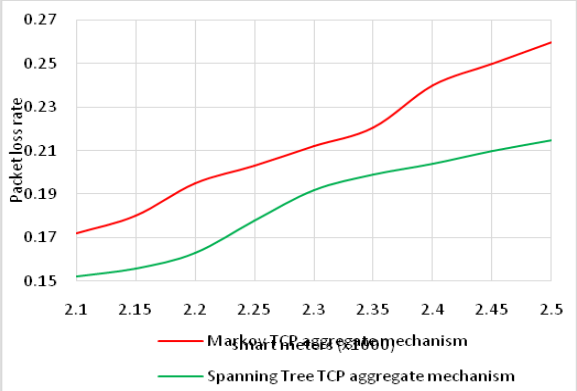


Figure 10: Packet loss rate of Block

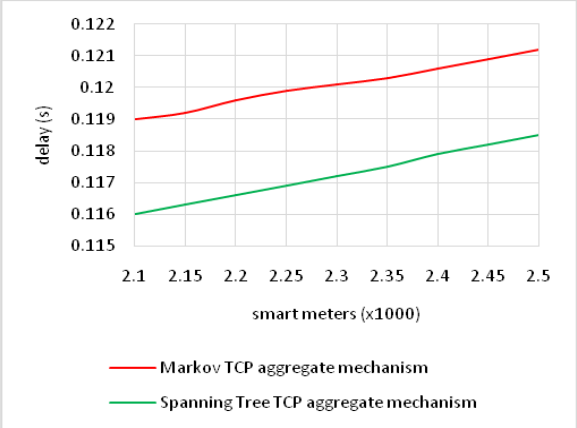


Figure 11: End-to-end delay of block

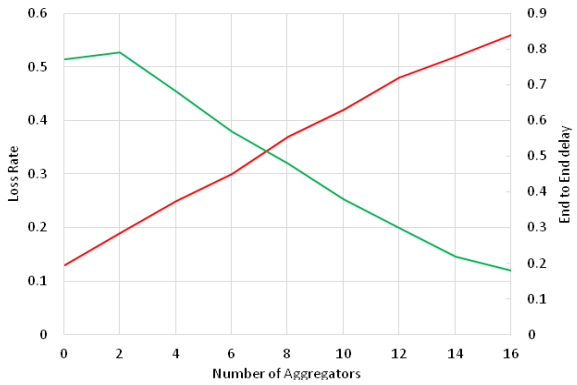


Figure 12: Effects of TCP aggregators

CONCLUSIONS

In this paper, TCP aggregator spanning tree model is used to improve the performance of TCP that lets congestion control that operates effectively. The proposed technique used numerical system based on the TCP aggregation behavior that considers the behavior of application, number of meters, network settings and RCs.The proposed method is better than other method in terms of end-to-end delay, throughput and loss rate. The simulation analysis led to conclusions that proposed TCP aggregation improves the performance of TCP system in SMI.

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