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New Delay-based Fast Retransmission Policy for CMT-SCTP

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***Abstract*—**Concurrent Multipath Transfer (CMT) uses multi-homing feature of Stream Control Transmission Protocol (SCTP) to transfer data concurrently over the multiple paths. CMT provides bandwidth aggregation, fault tolerance, and reliability in multipath data transfer. In multipath data transmission, each path has different delay and bandwidth. Therefore, destination receives unordered data which causes receiver buffer blocking and unwanted congestion window (*cwnd*) reduction. Both the problem degrades the CMT performance significantly. Thus, this paper proposes a new delay-based fast retransmission policy to adjust the transmission rate of each path according to path delay. Simulation results show that the proposed approach achieves better throughput, reduces the number of the timeout and improves the *cwnd* growth. The proposed approach improved throughput up to 16% in variable packet loss and 18% in variable network delay environment.

***Index Terms*—**SCTP, CMT, Multipath, Multi-homing, Congestion window.

I. Introduction

A device is having more than one network interface, like Laptop or smartphones, is called multi-homed device. The multi-homing offers a pair of devices to establish the logical connection over the multiple interfaces [1]. The advantage of multi-homing devices is that they provide the backup path in case of network failure. The SCTP [1] is a transport layer protocol, provide message-oriented, full duplex, connection-oriented, and multi-homing services. SCTP offers elective reliability and ordering in a stream, multi-homing, multi-streaming and protection against SYN attacks. SCTP assumes one IP as a primary path while remaining treated as the secondary path. SCTP uses the transmission sequence number (TSN) to ensure the ordered data delivery. To take advantage of multi-homing, Iyengar et al. [2] proposed a CMT to transfer the data over the multiple paths concurrently. It provides bandwidth aggregation, robustness, and reliability in multipath data transfer. However, due to dissimilar path delay and bandwidth, multipath data transmission leads unordered data packet delivery at the receivers end. It causes unnecessary retransmissions, unwanted *cwnd* reduction, and receiver buffer blocking [3]. To minimize the receiver buffer blocking, Iyengar et al. [2] suggested the five retransmission path selection policies. However, these policies do not improve the buffer blocking in dissimilar bandwidth and delay network. To mitigate the unordered data chunk delivery, we suggested a new delay-based adaptive data chunk scheduling policy [24] to distribute data over the multipath according to the path delay and available bandwidth. The suggested policy improves the network utilization but still suffers from unwanted fast retransmission problem.

During fast retransmission [2], whenever CMT receives four duplicate SACKs, treats it as network congestion, reduces the *cwnd* and *ssthresh* to half of the current *cwnd*. However, destination also sent the SACKs when it receives unordered data. Therefore, the cause of unordered data delivery is dissimilar delay and bandwidth of each path. The maximum numbers of duplicate SACKs are generated due to unordered data delivery. Thus, the blind half reduction in *cwnd* is not appropriate for CMT and CMT-PF because it degrade the performance of CMT and CMT-PF significantly [3-4].

Therefore, this paper proposes a new delay-based fast retransmission policy to mitigate the receiver buffer blocking and *cwnd* growth problem. The new approach uses SRTT (Smooth Round Trip Time) as congestion window reduction factor. This factor reduces the *cwnd* in the small amount when RTT (round trip time) is small and reduces the *cwnd* in the significant amount when RTT is large.

The rest of the paper is organized as follows: Section 2 presents literature reviews of various CMT policies while section 3 presents a new delay-based fast retransmission technique for CMT. The performance evaluation of the proposed approach is presented in section 4 while section

5 concludes the overall performance of proposed method.

II. Related Work

Iyengar et al. [2] identified the spurious retransmission problem of CMT and proposed a solution called Split Fast Retransmit (SFR) algorithm. It improves the performance of CMT concerning retransmission but suffers from unnecessary *cwnd* reduction when destination receives unordered data chunk due to dissimilar path delay and bandwidth. Iyengar et al. [2] suggested another algorithm, which maintains the separate congestion window for each destination to grow independently. It improves the *cwnd* growth but has the same problem of unnecessary *cwnd* reduction. The SCTP decrease the acknowledgment traffic by delaying acknowledgment until at least two can be sent collectively [2]. However, SCTP sends an immediate acknowledgment, when it receives unordered data chunk. Because of frequent unordered data chunk delivery, the reordering acknowledgment increase regularly. Delayed Ack for CMT (DAC) was included into SFR to minimize the acknowledgment traffic [2].

Ye et al. [4] proposed IPCC-SCTP to reduce the false retransmissions. It uses the unique path sequence number (PSN) for each path, which decides the ordered or unordered delivery of chunk for each destination. IPCC-SCTP improves the retransmission but suffers from buffer blocking problem. Dreibholz et al. [5] suggested a Sender Buffer Splitting approach which splits the sender buffer according to the number of paths. The author claims that proposed approach improved receiver buffer blocking but suffers from local blocking due to the dissimilarity of the path. Authors [3, 6] investigated the CMT and identified unnecessary fast retransmissions, crippled window growth, excessive network traffic; receive buffer blocking and naive scheduling problems.

Natarajan et al. [7] identified receiver buffer blocking problem due to path failure and suggested the solution (a new state for each destination) called Potentially-Failed (PF). This state indicates that the destination is not reachable due to congestion or link failure. Thus, all the new data transmitted over the available alternate path. It minimizes the packet loss due to link failure but suffers from receiver buffer blocking due to dissimilar bandwidth and delay of each path.

The CMT suffers from receiver buffer blocking due to dissimilar path delay and bandwidth causes unordered data chunk delivery. Yilmaz et al. [8] suggested a non-renegable selective acknowledgment (NR-SACKs) to free the receiver buffer. The NR-SACK simply removes the segment without bothering about reordering. Shailendra et al. [9] suggested an MPSCTP (Multipath SCTP) as a solution to unnecessary retransmission and window growth. The author claims better throughput and reduced retransmissions but suffers from buffer blocking problem. Shailendra et al. [10] proposed delay-based transmission adjustment policy to reduce the average packet delay of over the multiple paths. It minimized the buffer blocking problem but suffers from low bandwidth utilization. Shailendra et al. [11] suggested a Tx-CWND retransmission destination selection policy to improve the performance of MPSCTP in terms of receiver buffer blocking. Xu et al. [12] suggested a Quality-aware adaptive concurrent multipath data transfer in heterogeneous wireless networks (CMT-QA) to send data according to path quality. However, path quality estimation provides incorrect path quality value due to dissimilar path delay and bandwidth always have variable trends.

Authors also investigated soft computing based approaches [20-22, 29-30] to optimize network performance in wireless network. However, Thang and Tao [31] investigated the IPv6 routing protocol performance for Wireless Sensor Networks (WSN). Sharma and Kumar [23] suggested an adaptive congestion control scheme in mobile ad-hoc networks to improve the utilization of network.

MP-TCP [13] is another key connection-oriented protocol supports multi-homing. Likewise, SCTP does. MP-TCP works on the principal of distributing traffic over multiple paths. MP-TCP provides transparency in between top layer (application) to multiple connections. Moreover, MP-TCP works perfectly fine with the integrations of middle-boxes in today's Internet architecture [14-18]. MP-TCP offers better performance (comparing with conventional TCP) with data segments tearing middle-boxes in Internet's architecture. Consequently, MP-TCP offers better deployment capability with modern Internet architecture. In recent years, many of the un-coupled (independent congestion control between different sub-flows) strategies [25-26] were introduced. Nevertheless, the policy of controlling congestion independently (by sub-flows) leads to unfairness issue in the system. For this, MP-TCP introduces adaptive coupled congestion control policy by appropriately transforming congestion window growth policy concerning each sub- flow's network state [27-28].

Recently, various techniques have been presented to improve the MPTCP performance [14-18]. However, during the fast retransmission, all the suggested techniques reduce the *cwnd* to half of the current *cwnd* blindly which significantly degrade the performance of MPTCP.

III. Proposed Work

In this section, we present a new delay-based fast retransmission policy to minimize the *cwnd* growth problem in multipath concurrent data transfer using CMT-SCTP. The multipath concurrent data transfer sends the data over the multiple paths while each path has different bandwidth and delay. Due to dissimilar path characteristics, data packet arrived out-of-order at the destination. When destination receives unordered data packet, it immediately sends gap information to the source. Four-time continuous reception of gap report concludes congestion on the path. Thus, source reduces the *cwnd* and *ssthresh* to half of current *cwnd*. However,

network is not congested. Therefore, such reduction causes significant performance degradation while path is not congested.

When network congestion increases, RTT also increases, whereas unordered data chunk delivery may not increase the RTT. If, we include path delay as a factor of *cwnd* reduction, then it will control the reduction in *cwnd* and *ssthresh* appropriately instead of reducing to half blindly.

A. Effect of delay on cwnd reduction

The path delay plays a significant role in multipath data transfer because each path has different bandwidth and delay. Each path delay varies when path traffic intensity changes. If we reduce the *cwnd* according to path delay variation, then it may minimize the *cwnd* growth problem. The delay of the path is large if path is having high traffic intensity while delay is small when path has normal traffic intensity. If, reduction of the *cwnd* is made using the product of current path delay and *cwnd*, then it reduces the *cwnd* in a small amount when delay is small and reduces *cwnd* with large amount when delay is large.

Let, RTT and *cwnd* is the delay and congestion window of the path-1. According to proposed approach, *cwnd* can be reduced by the product of path delay and *cwnd*. Therefore, the formula of *cwnd* reduction when path-1 has normal traffic intensity is as:

$$cwnd_{i+1} = cwnd_i - (cwnd_i \times RTT_i) \quad (1)$$

Let, RTT of path-1 is RTT_1 when path is not congested then Eq. (1) is as

$$cwnd_{i+1} = cwnd_i - (cwnd_i \times RTT_1) \quad (2)$$

As congestion increases the RTT of the path also increases. Therefore, let the RTT of path-1 is RTT_2 when network is having high traffic intensity. Thus, the RTT_2 must be greater than RTT_1. Therefore, *cwnd* reduction to be done according to Eq. (3) is as:

$$cwnd_{i+1} = cwnd_i - (cwnd_i \times RTT_2) \quad (3)$$

If, $RTT_2 > RTT_1$.Then, the product of $cwnd_i$ and RTT_2 is also greater than the product of $cwnd_i$ and RTT_1. Hence, the reduction amount in *cwnd* is as

$$cwnd_i \times RTT_2 > cwnd_i \times RTT_1$$

This relation shows that when delay is large, reduction in *cwnd* is large while reduction is small when delay is small.

B. Path delay estimation

CMT uses round trip time (RTT) to estimate the delay of the each path. The estimation of RTT of each path includes queuing delay, transmission delay, processing delay, and propagation delay as:

$$RTT_{\min} = P_d + P_s + T_d + Q_{\min} \quad (4)$$

$$RTT_i = P_d + P_s + T_d + Q_i \quad (5)$$

where, RTT_i is a current RTT, RTT_{min} is a minimum RTT, P_d is propagation delay, Td is a transmission delay, Ps is the processing delay, Q_{min} is a minimum queuing delay, and Q_d is a current queuing delay of path. Our proposed method uses average path delay to reduce the error in RTT estimation. For average delay estimation, we use SRTT (smooth round trip time) can be estimated as:

$$SRTT_i = \begin{cases} RTT_i & first\ RTT \\ (I - RTO.Alpha) * SRTT_i + RTO.Alpha * RTT_i & current\ \ RTT \end{cases} \quad (6)$$

where, the recommended value of *RTO.Alpha* is 0.25 [1], RTT_{min} is the first RTT and RTT_i is the current RTT measured by source.

C. Congestion window reduction policy

Let P_i= {P_1, P_2, P_3…….P_n} be the paths used for multipath transmissions, and the round trip delay of each path is defined as D_i = {D_1, D_2, D_3……..D_n}. If delay of i^{th} path changes, it means that traffic on the path also changes. If we include path delay as a factor of *cwnd* reduction, then it will control the reduction in *cwnd* and *ssthresh* appropriately instead of reducing to half blindly. Thus, the proposed method includes the current path's *cwnd* and SRTT as a *cwnd* reduction factor. This factor has been independently estimated for each path while receiving four duplicate SACKs. It reduces the *cwnd* of current path with large amount if congestion occurs while reduces with small amount in case of unordered data chunk delivery.

$$ssthresh_i = \max(cwnd_i - (cwnd_i \times SRTT_i), 4 \times MTU) \quad (7)$$

$$cwnd_i = ssthresh_i \quad (8)$$

where, MTU is the maximum transmission unit of SCTP. Eq. (7) and (8) show the formula for *cwnd* and *ssthresh* reduction. The algorithm of proposed fast retransmission policy is shown in Algorithm-1. The Algorithm-1 have two method, first is fast retransmission algorithm and second one is retransmission timeout (RTO) algorithm. Fast retransmission algorithm adjusts the transmission

rate of path when source receives four duplicate SACKs. However, retransmission timeout algorithm adjusts the transmission rate of the path when retransmission timer expires. In multi-homing sinario, source calculates a separate RTO for each destination.

Algorithm-1: Fast retransmission and retransmission timeout algorithm

For every SACK received (at sender side for each destination):

Requirement: SRTT, MTU
Initialization: SRTT=RTT of current path, MTU=1500Byte
//Fast retransmission/recovery
If (four duplicate received)
    $ssthresh_i=max(cwnd_i-(cwnd_i*SRTT_i)\ ,4*MTU)$
    $cwnd_i=ssthresh_i$
End If
//Retransmission timeout
If (timeout occurred)
    $ssthresh_i=max(cwnd_i/2)\ ,4*MTU)$
    $cwnd_i=1*MTU$
End If

IV. Performance Evaluation

In this section, we compare the performance of proposed retransmission policy with well known CMT [2] fast retransmission policy. The whole simulation has been performed by using NS-2.35 [19]. Fig. 1 shows the network topology used for simulation. The topology has one SCTP source with two network interfaces S1&S2, and one SCTP destination with two network interfaces D1&D2. Initial bandwidth and delay of each link are shown in Fig. 1. The delay and bandwidth of each link may change according to simulation requirements. In this simulation setup, path-1 has fixed packet loss rate 1%, while path-2 has variable packet loss rate which varies from 1% to 10%. The SCTP source connected with FTP traffic generator and simulation time of this setup is 200sec.

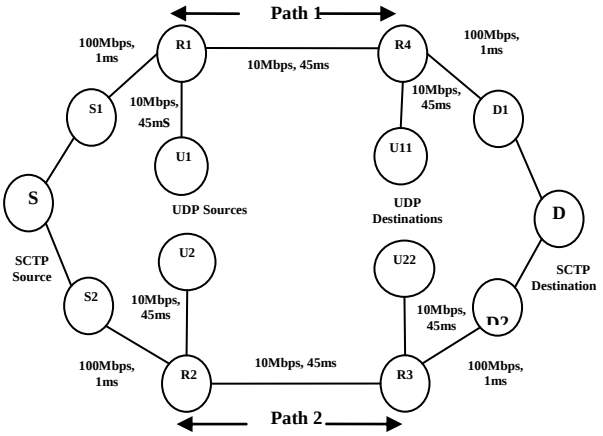


Fig.1. Simulation topology

The simulation topology also has two UDP sources U1, U2 and two UDP destinations U11, U22 respectively. The U1 and U11 are connected to router R1 and R4 while U2, U22 are connected to R2 and R3 respectively. This simulation setup is configured with drop tail queuing policy and default queue size is 50 packets. This simulation setup configured with recommended RTX-CWND retransmission path selection policy.

Fig. 2, 3 and 4 show the analysis of throughput, average throughput and retransmission timeout of proposed method, CMT and CMT-PF. In this simulation, receiver buffer size is 64KB; simulation time is 200 seconds and packet loss rate of path-2 varies from 1% to 10%. Rest of the network configuration is according to Fig. 1.

Fig. 2 demonstrates the throughput variation of CMT variants with variable packet loss rate. It shows that as packet loss rate increases the throughput of all CMT variants decreases. CMT and CMT-PF show the similar and linear throughput degradation because they use same cwnd and ssthresh reduction policy when congestion occurs, or unordered data chunk receives by destination. However, proposed method uses delay-based cwnd and ssthresh reduction policy which reduce the cwnd and ssthresh according to delay of the path. When path delay variation is large, it means that the traffic intensity is high, and if path delay variation is small, it means traffic is smooth. Thus, the proposed method use delay as factor of cwnd reduction which directly affect the cwnd reduction amount. Therefore, the proposed method shows the better cwnd growth and throughput for each packet loss rate.

Fig. 3 shows the average throughput of CMT variants with variable packet loss rate. It shows that CMT has least utilization as compared to CMT-PF and proposed method. However, the proposed method achieves improved throughput as compared to CMT and CMT-PF. The proposed method throughput improvement is 16% as compared to CMT and 15% as compared to CMT-PF.

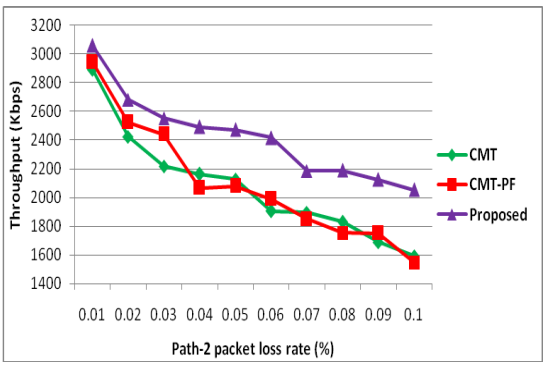


Fig.2. Packet loss rate Vs throughput

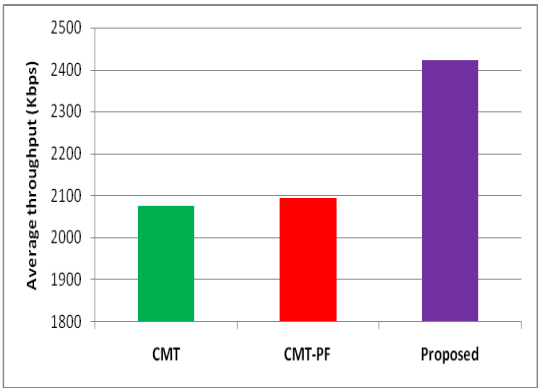


Fig.3. Average throughput of CMT variants

We also estimated the confidence interval for this simulation result. For 95% confidence level, the confidence interval of proposed method, CMT and CMT-PF are 2234.96-2611.63, 1837.27-2311.50 and 1830.40-2357.39 respectively. The confidence interval of all the CMT variants demonstrates that proposed method has better confidence interval as compared to CMT and CMT-PF.

Fig. 4 shows the average retransmission timeout of proposed method, CMT, and CMT-PF. It shows that CMT has highest number of timeout while proposed method shows the least number of timeout as compared to CMT and CMT-PF. It confirms that the delay-based *cwnd* and *ssthersh* reduction policy is a better approach as compared to halve the *cwnd* and *ssthresh* blindly. The proposed method average timeout improvement is 19% as compared to CMT and 6% as compared to CMT-PF. We also calculate the confidence interval for this simulation results. For 95% confidence level, the confidence interval of proposed method, CMT and CMT-PF are 7.74-16.45, 10.84-19.35 and 8.27-17.72. It is evident from confidence interval that proposed method has lower confidence interval concerning timeout as compared to CMT and CMT-PF.

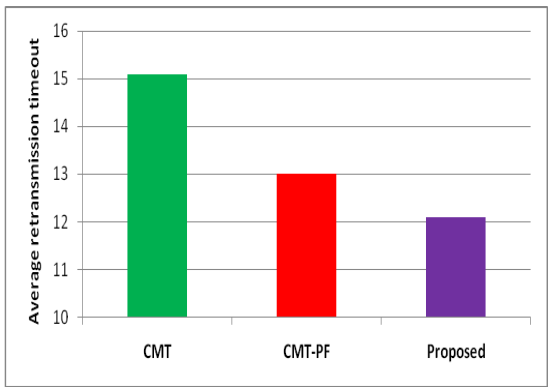
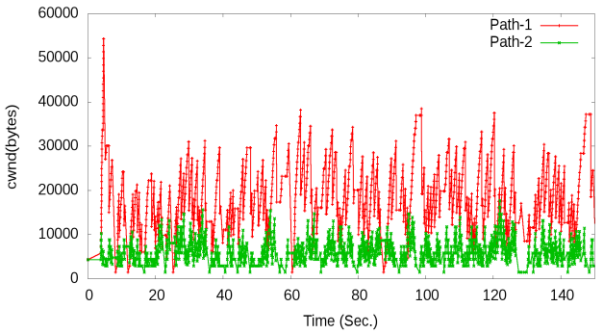
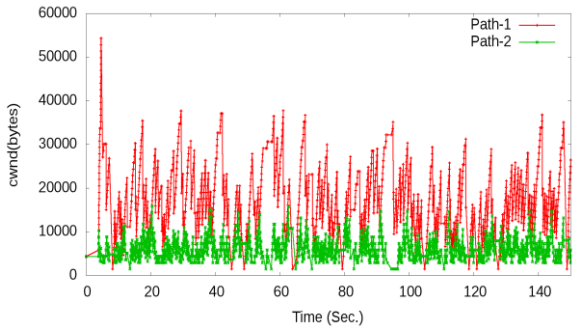


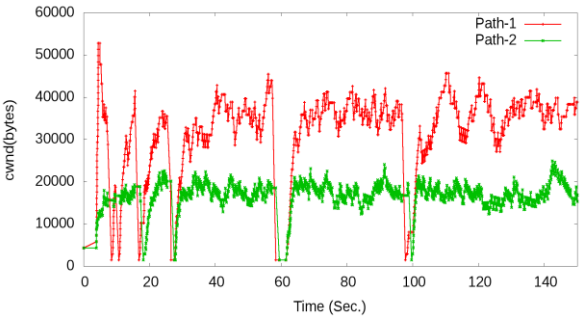
Fig.4. Average retransmission timeout of CMT variants



(a) CMT



(b) CMT-PF



(c) Proposed

Fig.5. Congestion window growths Vs time while packet loss rate of path-1 is 1% and path-2 is 10% (a) CMT (b) CMT-PF (c) Proposed

Fig. 5 (a)-(c) show the *cwnd* growth of proposed method, CMT, and CMT-PF while path-1 has 1% and path-2 has 10% packet loss rate. In this simulation setup, simulation time is 150 seconds and rests of the configuration parameters are same as given in Fig.1. This simulation study demonstrates the *cwnd* growth and reduction when packet loss or timeout occurs. The CMT and CMT-PF reduce the *cwnd* and *ssthresh* to half of current *cwnd* to adjust the transmission rate when source receives four duplicate SACKs. Therefore, CMT and CMT-PF suffers from *cwnd* growth problem. The proposed method uses the delay-based *cwnd* reduction approach to adjust the transmission rate. Therefore, proposed method reduces the *cwnd* is the small amount when the reason of *cwnd* reduction is unordered data chunk delivery. However, proposed method reduces the *cwnd* in the large amount when congestion occurs. Thus, the proposed method achieves better *cwnd* growth as compared to CMT and CMT-PF.

In next simulation, we analyze the effect of variable path delay on throughput and retransmission timeout. In this simulation setup, RTT of path-1 (100ms) remains constant while path-2 has variable RTT varies from 50-400ms. The packet loss rate of path-1 is 1% while path-2 has 5% packet loss rate. Rest of the simulation configuration remains same according to Fig. 1.

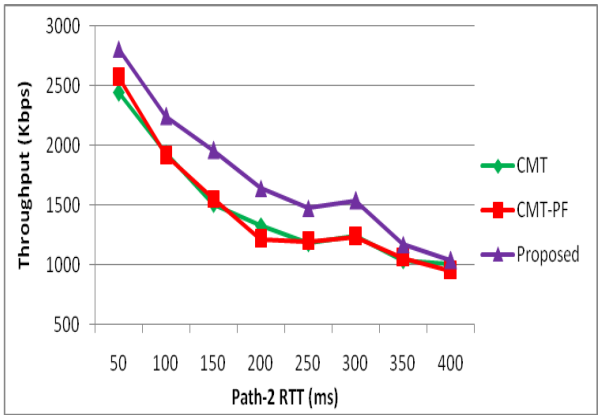


Fig.6. RTT Vs Throughput

Fig. 6 shows the throughput variation of CMT variants in variable RTT network environment. It demonstrates that as RTT increases, the throughput of the CMT variants decreases. The CMT and CMT-PF show the similar and linear trend in throughput drop. However, the proposed method demonstrates the higher throughput as compared to CMT and CMT-PF. The proposed method use path delay as *cwnd* reduction factor which reduces the *cwnd* according to path traffic conditions. On the other hand, CMT and CMT-PF reduce the *cwnd* to half of current *cwnd* blindly. As a result, proposed method achieves better throughput as compared to CMT and CMT-PF. The proposed method average throughput improvement is 18.83% as compared to CMT and 18.64% as compared to CMT-PF. Fig.7 shows the average retransmission timeout of CMT variants in variable RTT network. It demonstrates that the CMT-PF suffers from more timeout as compared to CMT. However, the proposed method has less timeout as compared to CMT and CMT-PF due to its delay-based *cwnd* reduction policy. The proposed method average timeout improvements are 23% and 34% as compared to CMT and CMT-PF respectively.

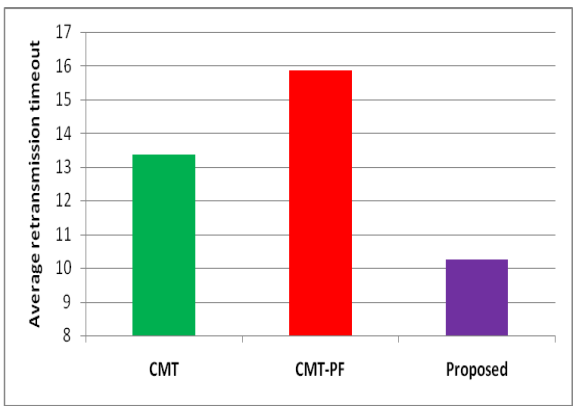
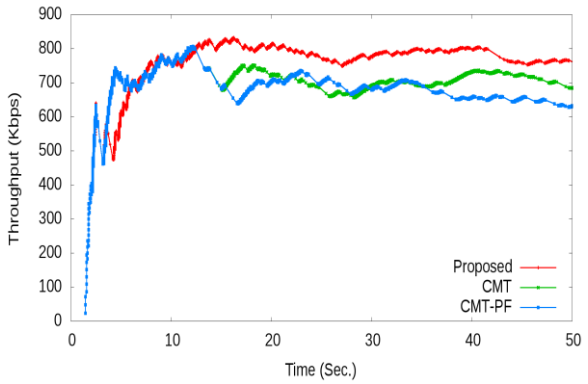
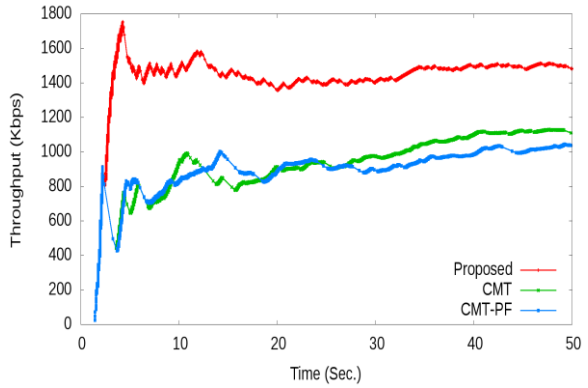


Fig.7. Average retransmission time of CMT variants

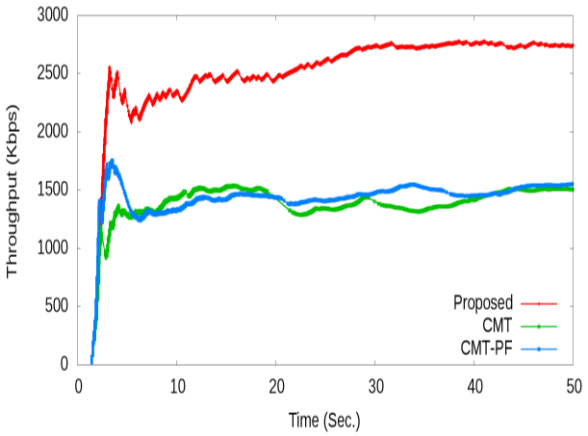
In another simulation, we analyze the effect of different receiver buffer (rbuf) on the performance of CMT variants. Fig.8(a)-(c) show the throughput of CMT, CMT-PF and proposed method with receiver buffer 32KB, 64KB, and 128KB. In this simulation setup, the packet loss rate of path-1 and path-2 are 1% and 5%. However, the propagation delay of path-1 and path-2 are 50ms and 150ms respectively. Rest of the simulation configurations remains same according to Fig.1.



(a) 32KB rbuf



(b) 64KB rbuf



(c) 128KB rbuf

Fig.8. Comparison of throughput using different receiver buffer sizes

It has been observed from Fig. 8(a)-(c), that the throughput of all CMT variants increases with the increase of receiver buffer size. At the start, the throughput of CMT variants increases rapidly because CMT variants probe the network capacity. After reaching network capacity, the throughput of CMT variants experiences variation due to packet loss detection (caused by congestion or unordered data delivery), then *cwnd* adjustment and fast retransmission. The proposed method differentiates the *cwnd* adjustment cause by either packet loss or unordered data delivery using delay-based *cwnd*

adjustment policy. Therefore, the proposed method reduces the *cwnd* in a small amount when packet loss detected due to unordered data delivery while *cwnd* reduction is large when packet loss detected due to congestion. Such type of *cwnd* reduction improves the network utilization and reduces the timeout. As a result, the proposed method achieves better throughput as compared to CMT and CMT-PF for all receiver buffer size.

V. Conclusion

In this paper, we proposed a novel fast retransmission approach for CMT to adjust the *cwnd* and *ssthresh* based on path delay. The proposed approach uses the product of SRTT and *cwnd* as a *cwnd* reduction factor. This approach reduces the *cwnd* in the large amount when network is congested while it reduces the *cwnd* in the small amount when reduction caused by unordered data chunk delivery. The simulation results show that the proposed method achieves better throughput, reduces the retransmission timeout and has better *cwnd* growth as compared to CMT and CMT-PF. The proposed method average throughput improvement is 16% in variable packet loss rate and 18% in variable path delay environment.

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A TECHNICAL APPROACH FOR CLEANER INDIA

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ABSTRACT

As seen, municipality is taking many steps to maintain the cleanliness of the cities. Increased attention has been given by the government in recent years to handle this problem in safe and hygienic manner. But waste management is becoming a severe problem due to the increased industrial activities and rapid urbanization. To avoid such situations we are planning to make a microcontroller based system, which can continuously monitor the status of the bins placed at public places. So in this paper we are presenting a technical solution to solve the above mentioned problem.

Keywords: Microcontroller, Ultrasonic Sensor, RF Transmitter, RF Receiver, GSM.

I. Introduction

Dustbin is a very common and basic need everywhere in the world. But because of the irregular removal of the garbage present in the dustbin the garbage in the dustbin get accumulated. This results in the improper waste management which in turn causes the air pollution and soil contamination. This has an adverse effect on the human health. According to a survey garbage accumulation causes 41% of the air pollution. Air pollution causes various respiratory problems like asthma, chronic obstructive pulmonary disease (COPD) etc. Accumulation of garbage also leads to the breeding of mosquitoes and houseflies which causes various disease such as malaria, dengue etc. there are about 235 million people currently suffering from asthma for which foul smelling of garbage is also a vital reason [1]. Almost 90% of the COPD occur in low and middle income countries which are caused by foul smelling. More than 3 million people died of COPD in 2005 [1].

Garbage consists of various unwanted materials which are generated from industrial, commercial, agricultural or mining operations or from the household activities. India generates about 60 million tons of trash every year [2], out of which 10 million ton of garbage is generated by the metropolitan cities like Delhi, Mumbai, Chennai, Bangalore, Hyderabad and Kolkata. There is lack of proper facilities to collect, treat and dispose the waste generated. Due to this the management of municipal solid waste is going through a critical phase. The generated waste is released in the nearby empty places without taking any precaution or operational control which adversely affects the environment of the places near to it and thus affects the health of the people. Waste management is a big challenge for almost all the countries in the world. An efficient method for the waste management is required to maintain the safe and green environment.

"Swachh Bharat Abhiyan" by honorable Prime Minster of India Shri Narendra Modi is a step in making India a clean country and it aims to teach citizens to reduce the generation of waste and to keep their surrounding clean. The project proposed in this paper is a way to contribute in making India clean. In this paper we are proposing a technical method for maintaining a clean environment. This project is related to "Smart City" by using "Smart Dustbins". Implementation of this Smart Dustbin can prevent littering of garbage on the roads due to overflow of dustbins and thus can prevent various diseases to a great extent and results in the clean environment in the city. Cleanliness is needed for Smart Lifestyles and it begins with the Garbage Bins. This project is based on the Microcontroller, ultrasonic sensor and RF transmitter and receiver. The ultrasonic sensor would be placed in the common garbage bins which continuously monitor the level of garbage. The level of the garbage will be recorded by the microcontroller and the controller with the help of the RF transmitter receiver sends the data to the server side which is located at some authority office. When the level of garbage reaches above a threshold level it will indicate to the concerned authority that the garbage bin needs to be empty.

II. Literature Survey

Kanchan Mahajan et al., proposed a system which consists of Zigbee, GSM and ARM7 controller. In this system the sensors are placed in the bins. When the garbage reaches the level of the sensor, then the sensed data will be given to the

controller. The controller will give the indication to the driver of garbage collection truck about which garbage bin is completely filled. The processor will also send message using GSM [3].

Md Shafiqul Islam et al., introduced a system consisting of Radio Frequency Identification (RFID), Global Position System (GPS), General Packet Radio Service (GPRS), Geographic Information System (GIS) and web camera. Each bin is mounted with a RFID tag, which could help the RFID reader in collection truck to retrieve the information from the dustbin. All the information of the center server would updated automatically through GPRS communication system [4].

Ch Raghumani Singh et al., in their paper highlighted an overview of the current municipal solid waste management system of Thoubal Municipality and the aim of the study is to determine the characterization of waste and current study of management activities and they also give some suggestions which may be beneficial to the authorities [5].

Vikrant Bohr, proposed a model which can monitor the level of the garbage with the help of the sensors and can communicate the information to the authority with the help of a GSM system. These sensors and GSM are interfaced using a microcontroller. A GUI is also developed to monitor the desired information of the dustbins placed at different locations [6].

Narayan Sharma et al., presented a system for managing the waste management system of entire city with the help of smart bins. These smart bins are equipped with number of sensors and a PIC microcontroller is used which helps to record the status of the solid waste collected in the bins. It is also equipped with GSM SIM900 with the help of which the information related to the level of the garbage is end to the authorities [7].

Bundela P.S. et al., in their paper they have given a agricultural application of municipal solid waste as a nutrient source for plant and as a soil conditioner. It is cost effective option of management of municipal solid waste over traditional methods like land filling or incineration etc. [8].

Narendra Kumar G. et al., proposed a method to dispose waste is designed with the help of wireless sensor networks (WSN), using VANETs (Vehicular Ad-hoc Network). Multicast routing is proposed to be implemented in garbage collecting vehicles and IEEE 802.11p protocol has been adopted. This project is not economical [9].

Gaikwad Prajakta et al., presented a model in which the dustbins are equipped with a camera along with a load sensor to monitor the status and weight of the garbage present in the garbage bins. A threshold level is set by which the output of the camera and the load sensor is compared and the information could be transmitted to the authorities according to the comparative results [10].

Arunkumar.G et al., proposed an advanced method for the purpose of automated waste management. In this proposed model sensors are placed in garbage bins placed at the public places, when the garbage in the bins reaches to the level of the sensors a indication is given to ARM 7 controller. The controller will give the indication to the garbage picking vehicle that the garbage bin is completely filled and it needs an urgent attention [11].

Sayali Bharate et al., proposed a system which consists of GSM module and Webcam. This system will provide garbage tracking and monitoring with the help of MATLAB database, this system can also give information about minimum path and available vehicle. This system provides real time monitoring of garbage bin using a Webcam based application [12].

Kanika Rastogi et al., they discussed about the waste management and problems related the waste management. They also focus on different policies initiated by government for waste management. The solution for improving the waste management problem is by moving towards automation. They also proposed 3 methods which could be achieved in future. They are-

1. By providing a robotic arm in the dustbins which could pick up the waste littered on the ground around the bins.
2. A technology which could detect the E-Waste and scrap it out from the dustbin as it radiates a harmful radiation which becomes hazardous for the humankind.
3. A sensing technology which could sense the level of the waste in the bins and trigger the concerned authority regarding it so that they can take an action at that very moment [13].

Akash Diwakar et al., proposed a model for detecting the garbage level with the help of ultrasonic sensors. They have used a ultrasonic along with a microcontroller and a LCD is connected for the display purpose. With the help of microcontroller necessary calculations could be performed and the level of garbage is indicated in percentage on the LCD display[14].

III. Problem Identification

Now-a-days we see that dustbins are getting overflow and the garbage litters on the road. This causes unsanitary conditions which are responsible for various diseases as accumulation of garbage results in bad smell and breeding of mosquitoes and houseflies. Moreover the concerned authorities don't get information about this within time. Sometime it happens that the garbage collecting trucks goes to the site where the bin is placed but the bin is empty this result in wastage of fuel. Till now there is no system which records and maintains the data about the garbage regularly. There is a need of a system which can monitor this garbage and make a record simultaneously so that the waste management team can do its work more efficiently on the basis of the real time data recorded by the system. Manually maintaining the record is a typical task and requires a number of individuals to do it. So there is an urgent need of automated system.

Disadvantages of current systems

1. Inefficient systems as number times garbage picking vans goes to the site where the bin is already empty. This causes wastage of fuel and human efforts.
2. Littering of garbage results in unhealthy environment.
3. Current automated systems are expensive

4. In current systems citizens can't check about waste management status.

Advantages of the proposed system

1. Real time information about the level of the garbage will be send to the concerned authority.
2. Cost of the system is minimized.
3. Helps in avoiding the unsanitary conditions caused due to littering of garbage.
4. Provide information to the citizen about the waste management status with the help of a webpage.

IV. Proposed Solution to the Problem

With the above discussion we can see that the first and foremost problem arises at the initial stage to continuously monitor the level of garbage. It's impossible for a human to do so, a combination of sensors and controller could be used for this purpose. A correctly configured system can solve the problem in real time.

The hardware consists of microcontroller (Arduino Board), ultrasonic sensor, RF transmitter, RF receiver, GSM module. Microcontroller has two onboard inbuilt counters one of which is employed with ultrasonic sensor for the purpose of detecting the level of garbage. Microcontroller also has serial communication pins Rx pin and Tx pin, these two pins are connected to the GSM module to make the communication possible with the authorities at the receiver side. Block diagram of the proposed system is shown in fig. 1.

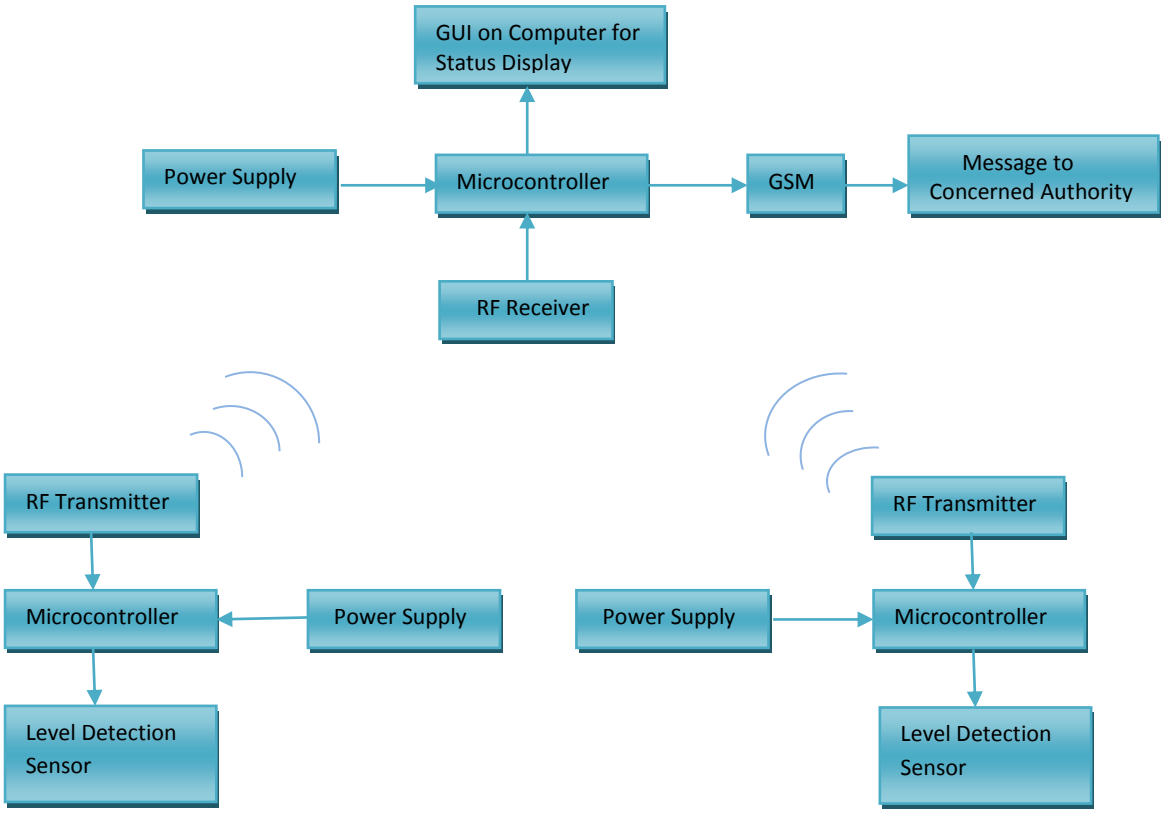

Figure 1. Block Diagram of the proposed system

Many approaches are there to indicate the level of garbage, like leaf switch, weighing machine, using a web cam or some other sensors like ultrasonic sensor which can measure the distance of the obstacle. Each system has its own advantages and disadvantages, on studying these systems we opted ultrasonic sensor for the monitoring purpose of the level of garbage. Ultrasonic sensor has four pins (trigger, echo, ground and V_{cc}) which are connected to the pins of microcontroller accordingly. When a trigger pulse is applied to the trigger pin of ultrasonic a sound wave having frequency 40 KHz is emitted by the ultrasonic sensor, at the same time timer of the controller is enabled which starts counting the time lapse between transmission of sound wave and reception of ECHO. ECHO pin is turned high when the ultrasonic is triggered, and the status of ECHO pin is continuously monitored and when the sensor receives the ECHO the ECHO pin is switched to a low level. The timing diagram for ultrasonic sensor is shown in fig. 2 Calculated time is divided by 2 as the sound wave travels twice the distance and the necessary calculations are completed with the help of microcontroller. Calculated time can be used to compute the distance with the help of the following formula

$$D = \{(t*v)/2\}*100$$

where D is the distance of the obstacle, t is the time taken by the sound wave from sensor to obstacle and back to sensor and v is the velocity of the sound wave.

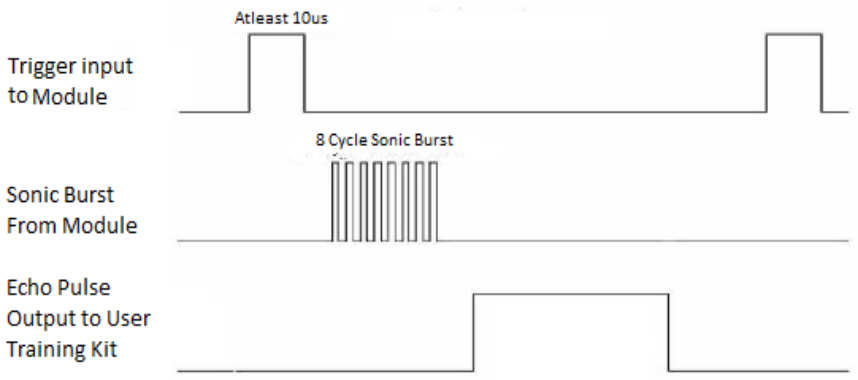

Figure 2. Timing diagram of ultrasonic sensor

In our system we have used RF module for signal transmission between garbage bin and the server. Transmission in RF module is based on ASK (Amplitude Shift Keying), OOK (On-Off Keying) and FSK (Frequency Shift Keying). RF module consists of a transmitter and a receiver which operates at 434 MHz frequency. In RF module there is only one way communication i.e. from transmitter to receiver. The data is transmitted serially from transmitter to receiver. The transmitter converts the data in to serial form and sends it through RF to the receiver which is placed away from the transmitter in the range of 100 meters. The receiver receives the signal and passes it to the microcontroller.
For sending the signal to the concerned authority GSM is used. GSM is a digital mobile telephony system. It digitizes and compresses data, then sends it through a channel. It operates at either the 900 MHz or 1800 MHz frequency. GSM module is provided by a SIM which uses the mobile service provider. It can be used for making a call, receiving a call, sending SMS or receiving SMS etc. In our project we are using the GSM for sending a SMS to the concerned authorities when the garbage in the bin reaches to the threshold level.

V. Results and Discussion

The proposed system aims to provide a cost effective and automated way to continuously monitor the level of the garbage. This can be achieved by properly configuring the ultrasonic with the controller. Challenge occurs at the stage when the status of the level of garbage is to be monitored from a place which is away from the site where the garbage bin is being kept. For this purpose a RF module is to be employed, a GSM is also employed which directly sends the message to the authority when the garbage reaches to a threshold level.
But it is very tedious and challenging to synchronize multiple garbage bins and to provide each bin a different identity, to identify at the receiver section that which bin is full. This can be achieved by making certain logics in the programming in the microcontroller. For this purpose logic is to be added to the programming of each garbage bin that it sends its identity code along with the status of garbage. A database is provided at the receiver section and to the authority which have the code of the garbage bin along with the location at which the bin is placed.
In this way the identified problem could be solved effectively, as the system is autonomous and it will itself send all the desired information to the authority. A GUI on computer is also provided for status display, so that a single individual can monitor all the bins simultaneously by sitting at the same place.

VI. Conclusion

To make the city clean is one of the major problems faced by the Indian government. Numbers of programs like 'Swachh Bharat Abhiyan' were started by the government to move forward in this direction. In this paper number of related technical and non technical works done by the government and different peoples was discussed along with it a possible solution to the problem is also proposed.
The proposed solution is a combination of different sensors, wireless transmitters and receivers, GSM and a microcontroller. Microcontroller is programmed to perform various calculations and to synchronize the working of these different modules. This proposed system is cost efficient and it is a possible solution to the problem to solve it in real time.

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Intelligent System for Two-Wheelers along with Rider Safety

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ABSTRACT:
The increment in thefts of two wheelers and the alarming number of road accidents and the death rate of people as a result of such accidents, calls for the need of a system that could both prevent the theft of the vehicle as well as ensure the safety of the rider. One way of enhancing the security of the system could be replacing the traditional lock and key system with biometrics system. And the safety of the rider can be ensured by the fact that the system must incorporate in it an intelligent system which does not allow the rider to start the ignition of the vehicle if he is not wearing a helmet or is not sober. The system requires firstly to authenticate the rider from the preloaded fingerprints from the database of the microcontrollers also making it compulsory for the rider to wear the helmet as per the government guidelines. The system consist of alcohol sensor. Microcontroller ATmega328 is used for the performing the efficient working of system. RF module performing the communication part along with the help of IR sensor.

Keywords: Alcohol sensor, Microcontroller, IR sensor, RF module, GPS, GSM.

I. INTRODUCTION

As a matter of fact two wheeler sales in the past six to seven years has increased at a very fast rate. In fact market experts claim that India's two-wheeler industry is set to record its fastest growth in the next five years. However the two most important aspects related to two wheelers are security of the vehicle and safety of the rider still seem to be overlooked.

Despite tall claims made by law-enforcement agencies about their success in controlling automobile thefts, statistics reveal that as many as 1.65 lakh vehicles were stolen in a single year--2013. Uttar Pradesh achieved the dubious distinction of leading the states with the highest number of vehicle theft cases. The alarming increase in the number of two wheeler road accidents has also been a matter of great concern globally because two wheeler users are directly exposed and come in direct contact with the impacting vehicle or obstacle during a collision resulting in severe injuries and fatality.

Our project aims at designing a system that ensures not only the security of the vehicle but also the safety of its rider. This system uses several intelligent modules which provide this complete security. The safety of the bike is enhanced by adding a new module with the conventional key lock system which is the fingerprint identification system which allows only the authorized rider to get access of the bike. The other module is of the smart helmet which makes several checks depending on which it provides ignition to the rider. This module makes a check whether the rider has consumed alcohol or not and whether the rider is wearing a helmet or not. If the rider has not consumed alcohol and wearing helmet the rider get the ignition but if the required conditions are not met the rider fails to get the ignition.

II. LITERATURE SURVEY

Sudharsana Vijayan etal [1] in this paper the authors have laid emphasis on reducing the number of accidents caused by the carelessness of the riders (i.e. driving in a drunken condition or not wearing a helmet while riding a two wheeler). The authors have tried to implement an electronic technique which does not makes it very easy to bypass the basic rule of wearing a helmet & not consuming alcohol while riding.

The authors have designed a system which checks two conditions before turning ON the ignition of the bike. It includes an alcohol sensor (MQ3) and a helmet sensing switch which is used to detect whether the biker is wearing helmet or not. Alcohol sensor is used to detect whether the biker is drunk or not. The output of these two checks are fed to the microcontroller if both the checks give digital 1 the bike gets its ignition ON, if both or any one of the checks fail to give digital 1 there is no ignition.

The surface of the sensor is sensitive to various alcoholic concentrations. It detects the alcohol from the rider's breath; the resistance value drops leads to change in voltage (Temperature variation occurs).Generally the illegal consumption of alcohol during driving is 0.08mg/L as per the government act. Except for demonstration purpose, we have a tendency to program the drink limit as 0.04 mg/L. An ear lobe detector sense that is fitted with the helmet unit senses the blood flow

within the ear lobe region. So the wearing of helmet is confirmed by our system and similarly alcohol sensor fitted in the mouth piece of the helmet.

Manjesh N etal [2] the authors have proposed a model for the accident prevention which states when the system is switched on, LED will be ON indicating that power is supplied to the circuit. The RF is used to start the two wheeler firstly it check whether the driver is drunken or not if drunken it will not allow to start two wheeler .The small voltage of ignition of the two wheeler is grounded. In normal condition when the helmet is used the pressure sensor is senses pressure and the RF transmitter radiates the FM modulated Signal. The RF receiver is connected with the two wheeler which is receive the radiated signal and activate the relay .The relay is remove the ignition wire from the ground and connected with the starter switch now the two wheeler will start. When driver met with accident vibration sensor sends message to microcontroller. The GPS receives the location of the vehicle that met with an accident and gives the information back. This information will be sent to a mobile number through a message. This message will be received using GSM modem present in the circuit. The message will give the information of longitude and latitude values. Using these values the position of the vehicle can be estimated.

Priyanka Rani etal [3] Fingerprint authentication is most sophisticated method of all biometric techniques & has been thoroughly verified through various applications. A finger print occurs uniquely to an individual & remains unchanged for lifetime.
Priyanka Rani (M.Tech Scholar) and Pink Sharma (Assistant Professor) of H.C.T.M Kaithal, Haryana India worked on finger print identification system & on the basis of their study & research they published a Review Paper titled" A Review Paper on Finger Print Identification system". Their paper defines various aspects & methods to be used for finger print identification. In this paper, they have shown different methods & techniques which can be used to identify a person through his fingerprint. These methods conclude that fingerprint is fast, secure, accurate & reliable system. Gabor filter method is applied for feature examination. Methodology for this technology is represented with the help of block diagrams & flowcharts. Future research can be carried out to improve quality of image for image enhancement and to develop better matching techniques.

Arsalaan. F. Rashid etal [4] the authors of the paper entitled "Biometric Finger Print Identification- Is It a Reliable Tool or Not?" presented a study which was undertaken on the employees and students of a University undergoing biometric verification for purpose of attendance. A total of 3250 staff and non-staff members of this University campus who were taking biometric identification for daily attendances were analyzed for this study. The key tool of their study was the biometric fingerprint identification method which compared to a visual comparison of signatures or photo IDs is more accurate and less time consuming making it less fallible and potentially much faster.
As a result of this study, it was observed and noted that the error rate in biometric identification significantly increases with increase in age group because aging results in loss of collagen. Compared to younger skin, aging skin is loose and dry, and decreased skin firmness directly affects the quality of fingerprints acquired by sensors. An important conclusion of the study is that biometric identification is not infallible and is prone to non-correctable errors. Wearing down of fingerprint pattern was found to be a major source of errors in registering biometric fingerprint attendance.
Also in agrarian rural economies like India where hard manual labor may be the only means of subsistence for a large population, this inaccuracy can be a source of problems for poor and hardworking people. Databases developed by such methods are prone to limitations which have to be thoughtfully corrected before the system is fully institutionalized. Therefore the authors concluded that, excessive reliability on such systems needs to be re-evaluated and possible corrections should be made in technology to address these problems.

Nimmy James etal [5] the authors of this paper reveals how an alcohol detector provides a unique method to curb drunken people. The designed system detects the content of alcohol in the breath of the rider and thus it attempts to clamp down alcoholics. This device provides much advanced facilities in the present day life as it can easily be implemented in vehicles. The alcohol sensor, which detects ethanol in the air is one of the straight forward gas sensors so it works almost the same way with other gas sensors. Typically, it is used as part of the Breathalyzer or breath testers for the detection of ethanol in human breath.
This sensor measures the content of alcohol from the breath of drunken people. The sensor delivers a current with linear relationship to the alcohol molecules from zero to very high concentrations. Output of the sensor is directly proportional to the alcohol content. When the alcohol molecules in the air meet the electrode that is between alumina and tin dioxide in the sensor, ethanol burns into acetic acid and more current is produced. So more the alcohol molecules, more will be the current produced. Because of this current change, different values from the sensor are obtained. Output of the sensor is then fed to the microcontroller for comparison. The output of the sensor is in the analog nature which needs to be converted into digital format. This is done by the analog to digital converter of the microcontroller unit. The microcontroller controls the entire circuit.
When embedded in automobiles, each time the driver starts ignition, the sensor measures the content of alcohol in his breath and if the driver is found drunk, the system automatically switches off the vehicle which will stop the drink and

driving offenders. Thus alcohol related road accidents can be reduced and hence these kinds of detectors have a great relevance. They can also be used in schools, colleges, offices and some public places such as hospitals, libraries etc.

Ashutosh U. Jadhav etal [6] automotive electronics sector is nowadays becoming more in demand due to its increasing technology. As more and more applications are available on vehicle information system, connection between the vehicle bus network and information system is becoming a trend. The proposed system presents the development and implementation of a digital driving system for a semi-autonomous vehicle to improve the driver vehicle interface. The system is able to monitor road lane violation, drowsiness and alcohol with the help of camera and sensor.
On July 7 2015, Ashutosh U Jadhav and N.M Wagdarikar PG Student[VLSI & Embedded system], dept. of E & TC, smt Kashibai Navale College of Engineering-Pune, Maharashtra, India studied & worked on this system.
The main objective of this system is to provide safety to avoid road accidents. The system uses two ARM microcontroller that is Master for detection and Slave for controlling the parameters. CAN protocol is used for communicating between microcontrollers. A system is developed on which camera is mounted for lane detection sensor for alcohol and drowsiness detection and a GPS & GSM Modules are also mounted for tracking purposes.
Future work research can be done on driver's health monitoring system.

III. **PROBLEM IDENTIFICATION**

Because of increasing number of theft cases of the two wheelers there is a need to enhance the security level of the bikes. Traditional and commonly used key locks available in the bikes are well known to the thieves and thus it can be easily unlocked by the professional thieves. With the help of master key it becomes very easy to unlock the lock of the bikes by the thieves.
This creates the demand of such type of lock which is new and provides an additional security level. The new and modern lock must be unique in itself i.e. it must be only unlocked by special and specific key. This type of feature is available in the biometrics locks i.e. the lock which can only be locked and unlocked by the human body features. Of all these type of special biometric recognition techniques the fingerprint recognition is the most widely used. Thus fingerprint recognition locking system can provide better reliability than the traditional locks and also is cheaper and easy than the other biometric locking system.
This is not the only problem for the society the other one is the rapid increase in the number of accidents taking place and moreover the number of loss of life related with them. The traffic authorities give a lot of instructions to the vehicle operators. But many of them do not obey the rules. Nowadays most of the countries are forcing the motor riders to wear the helmet and not to use the vehicles when the rider is in drunken condition. But still the rules are being violated by the riders.
To find a solution to these problems we have designed a prototype which covers all the above mentioned problems.

IV. **DESIGN AND IMPLEMENTATION OF MODEL**

The proposed model of this project is an intelligent two wheeler ignition system with an additional intelligent helmet for the safety of the rider. The system ensures the safety of the vehicle and the rider both at the same time. The system requires firstly to authenticate the rider from the preloaded fingerprints from the database of the microcontrollers also making it compulsory for the rider to wear the helmet as per the government guidelines.

A module fixed on the helmet will synchronize with the module fixed on the vehicle's side. The system will show the following functions:

- To start the vehicle at the initial the rider has to firstly authenticate through fingerprint. It will ensure that the rider has worn the helmet, if he fails the bike will not get started.
- It will also ensure that the rider has not consumed alcohol. If the rider is drunk then the bike won't start.
- If unknowingly the bike gets drifted it will immediately sends a text message to the owner of the bike that the bike is shifted also giving the coordinates of the present location of the bike.

The model will consist of two modules:

1. Bike Module
2. Helmet Module

The signal will be transmitted wirelessly to the bike receiver and accordingly the microcontroller will take the actions to control the other blocks of the system.

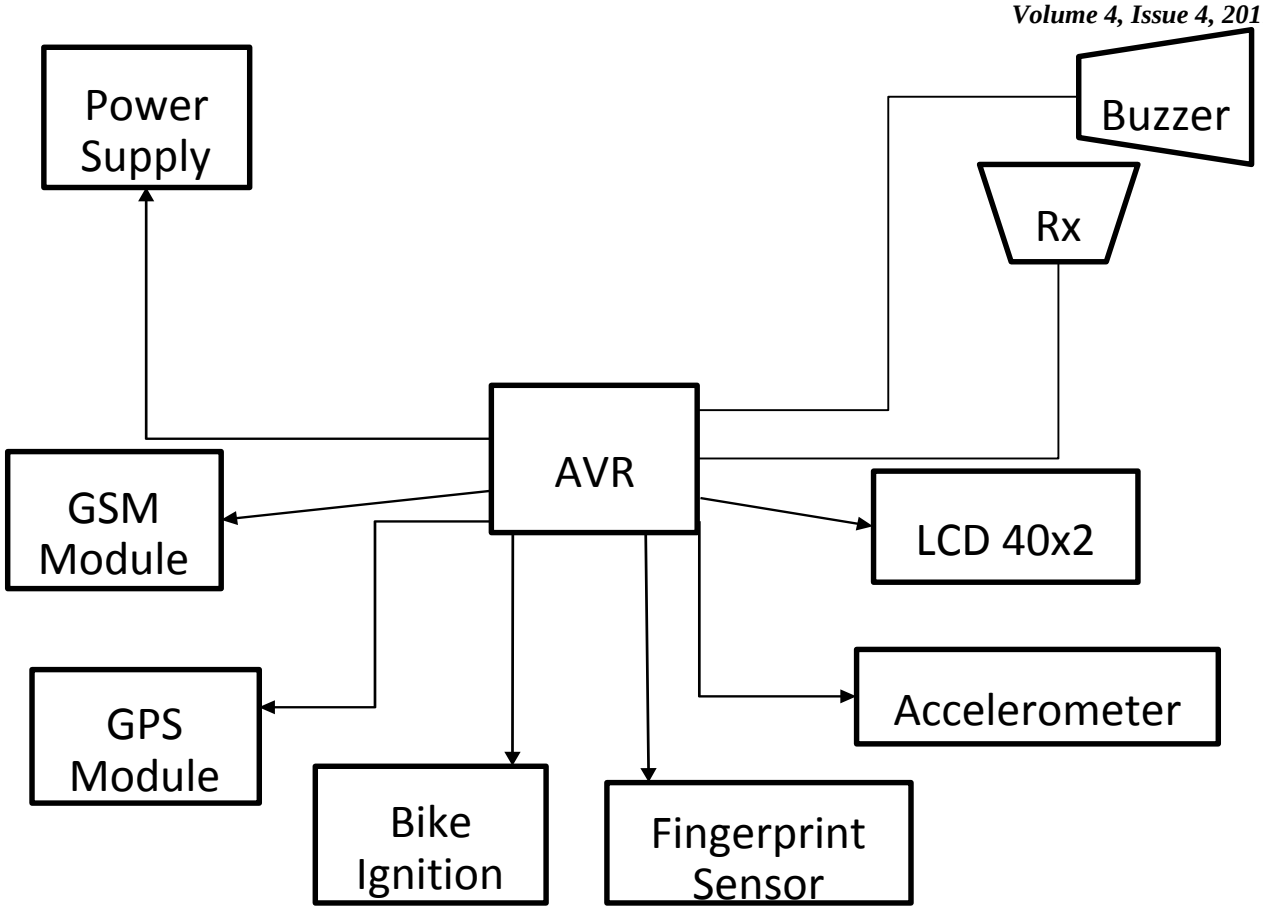


Figure 1*- Bike module*

This above shown figure 3 is the block diagram of the transmitter side attached to the bike side. Power block is the power supply supplied to the circuit. Alcohol block is the alcohol sensor attached used to sense the content of alcohol consumed by the rider. Buzzer is used as an alarming device used in case of theft. Rx is the receiver attached to receive signals from the helmet. GSM is the cellular module used to send a text message to the number predefined. LCD is used to show the status of the system. GPS module is used to get the information of the position of the bike giving the information of the longitude and the latitude of the bike. Accelerometer is used to detect the tilting (change in its state) of the bike also if the bike is dragged then it will also detect it. Ignition is the bike's ignition. Fingerprint is the fingerprint testing module used to detect the authenticity of the rider.

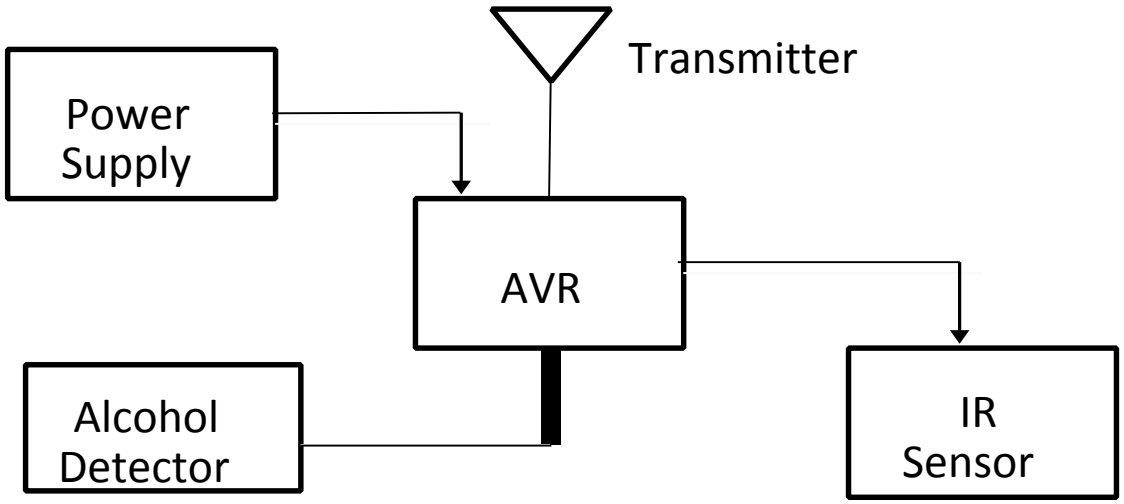


Figure 2 Helmet module

The above figure 4 shows the helmet side it contains power supply, the IR sensor to detect whether rider is wearing the helmet or not. The central block is of the microcontroller (Arduino NANO) that is being used here.

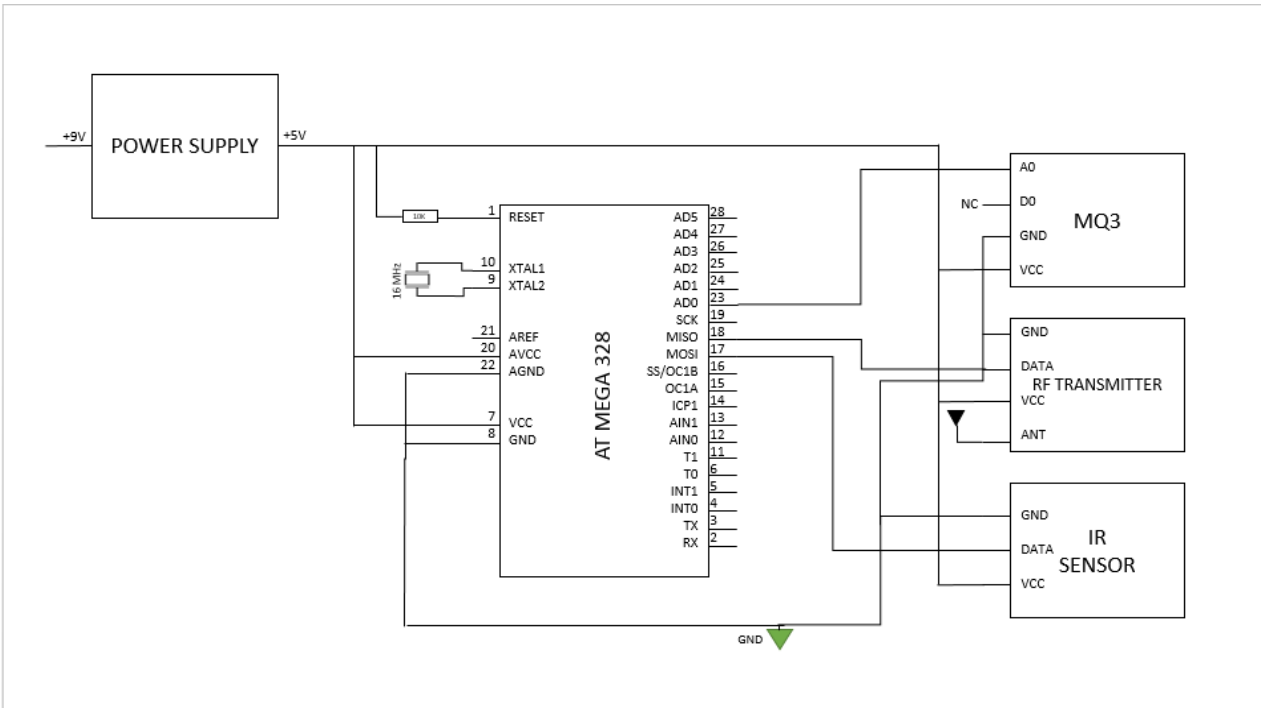


Figure 3- Circuit diagram of helmet side

The above shown figure is of the circuit diagram of the helmet side in which we have several components such as IR sensor, RF transmitter, alcohol sensor & ATMEGA328. All the components are connected to the microcontroller to obtain their proper functioning. The programming of the microcontroller is done using Arduino Mega board. This module also uses a 9v to 5v converter as the controller and components need 5v of power supply for their operation.

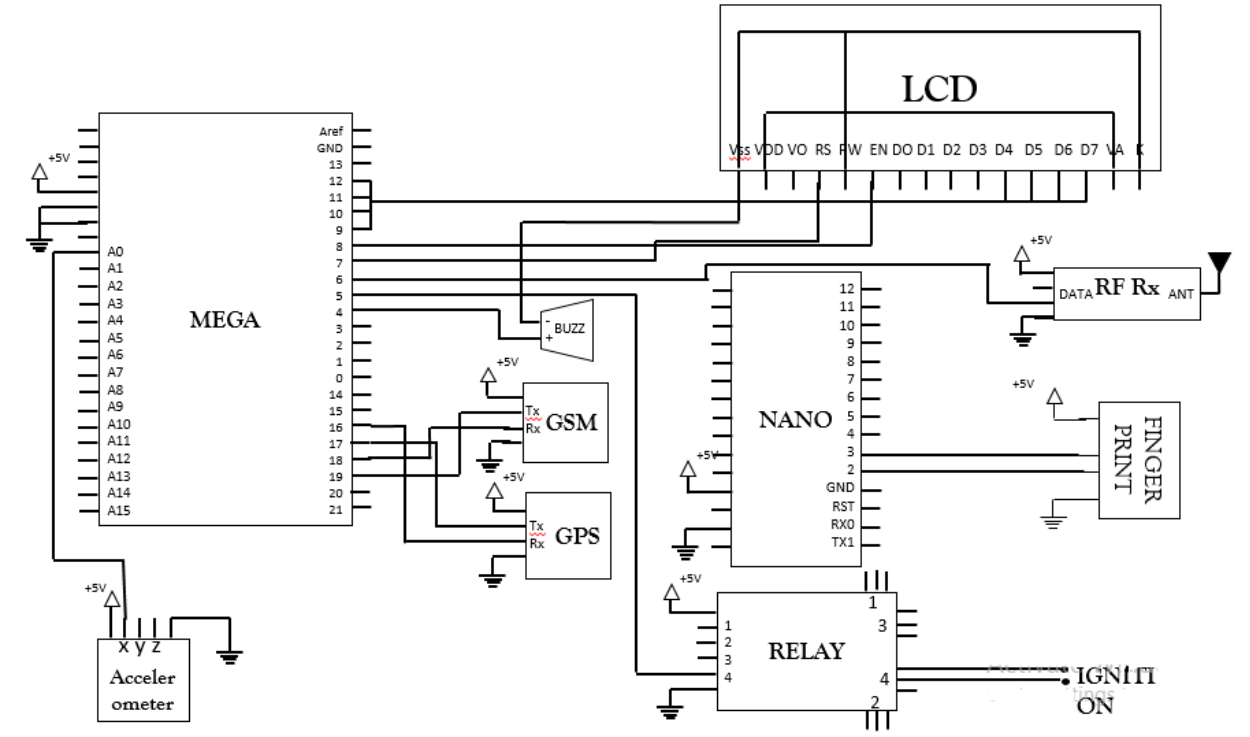


Figure 4- Circuit diagram of bike side

The above shown figure is of the circuit diagram of the bike side which includes GPS, GSM, accelerometer, fingerprint sensor, relay, buzzer, RF receiver, Arduino MEGA, Arduino NANO & LCD. The fingerprint sensor is interfaced using Arduino NANO & all other components using Arduino MEGA. The relay is basically used to perform the switching of the ignition of the bike depending upon the conditions of the helmet, alcohol consumed & fingerprint authentication. GSM is used to send the message to the user in any theft case. GPS basically tracks the location of the two wheeler. LCD displays all the status of the proceedings going on. Accelerometer is used to detect the change in any coordinate. Buzzer is used as an indicating device it gets on if the alcohol sensor senses alcohol in the rider's breath. Both the microcontroller boards are provided individual supplies.

V. **WORKING**

Helmet is interfaced with the complete system to monitor its access by the rider and also to monitor the rider's alcohol consumption. Helmet consist of an IR sensor attached on the outer side of the helmet at the top side & an alcohol detector (MQ3) which is attached on the front of the helmet. On bike side we have used the Arduino MEGA board for the interfacing of the board with GPS, GSM, Relay, Accelerometer, LCD & Arduino NANO is used to interface finger print The working of the complete system can be explained in two cases:

Case 1: Rider wearing the helmet

When the rider has worn the helmet then the path between the photo diode & the LED breaks as the head of rider comes in between the path. In this case the IR sensor sends a positive signal to the system which allows the vehicle to start as defined earlier. Now the rider will check the alcohol consumption by using the alcohol detector. The alcohol detector (MQ3 gas sensor) is placed on the front side of the helmet. Rider will blow the air from mouth on the alcohol detector. The air from the mouth is sensed and the alcohol percentage is calculated. During the sense, if the resistance value drops the voltage value changes which is fed to the comparator. This value is compared with the predefined threshold level (permitted level). If the value exceeds the predefined threshold level, comparator output goes high and the microcontroller takes action accordingly. If the value is found to be higher than the predefined value in the microcontroller then the rider won't be able to start the bike as the ignition of the bike will be cutoff & if the value of alcohol consumption is found to be negligible then the rider will match his/her fingerprint using the finger print module & on being matched the rider is able to start the bike as microcontroller will provide the ignition.

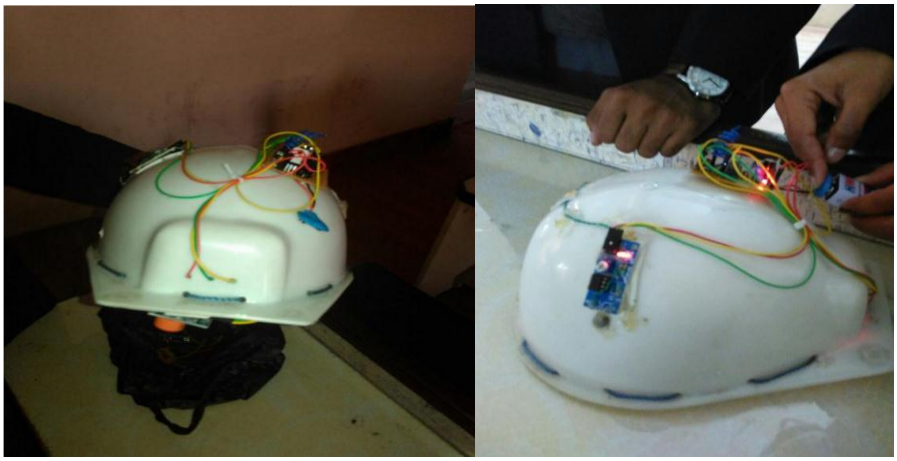
Case 2: Rider not wearing the helmet

If the rider does not wear the helmet then a negative signal will be sent to the microcontroller indicating that the rider has not wear the helmet. In such case the rider won't be able to start the bike as the vehicle ignition will be cutoff or in other words the bike's engine will remain locked. Once the rider wear the helmet then again rider has to go through the alcohol consumption check & as described in case1 if the alcohol value is found higher then predefined then also rider is unable to start the bike as the ignition will be cutoff & if the value is found lower than the predefined value then the rider will be able to start the bike & ignition is provided by the controller.

The entire communication between the helmet and vehicle part is done using RF transmitter and receiver. Thus starting or stopping the vehicle or also displaying the alert messages on the LCD display.

In both the cases the first & foremost condition for the rider is to wear the helmet. So this system makes mandatory for the rider to wear the vehicle to start the bike. So this system makes the life of ride safer & secure which results in lesser amount of accident cases & loss of lives.

VI. **RESULTS AND DISCUSSION**



(a) Idle state without power supply ***(b)*** Helmet with power supply

Figure 5

In the above figure 1(a) the helmet is shown in idle case that means no power supply has been provided to the helmet & the helmet is not weared by the rider whereas in Figure 1(b) the power supply is connected and it can be checked by the glowing LED's present on main circuit and IR sensor.

Figure 6- The hidden internal circuit installed in the bike

Now as it is clearly shown in the figure 2(a) that there is an obstacle (hand) in between the path of LED & photo-detector inside the helmet the system is giving a positive response to this & this has been shown by the LED getting off which indicates that the rider has weared the helmet whereas in the figure 2(b) the hand previously placed inside the helmet is now removed and which means that the rider is not wearing the helmet now.
The signal is received at the receiver side with the help of RF receiver which is LED in this case.

(a) LCD showing helmet ON
(b) LCD showing helmet OFF

Figure 7

Now the figure 3(a) showing the status of the system when the helmet is not weared. And as the the helmet is not weared the ignition of the vehicle is cut off, & the rider won't be able to start the vehicle. Figure 3(b) shows the status of the system when the helmet is weared & as it is clearly shown in the LCD that helmet is weared & alcohol consumption is also low (negative) then the rider goes for the 3rd layer security check after placing the finger on the finger print module then the ignition is provided to the rider & this is shown in the figure clearly.

VII. **CONCLUSIONS**

Intelligent two wheeler and rider safety system ensures the security of the vehicle which is a main issue in today's life also the security of the two wheeler as the number of accidents of the two wheeler riders have a great number. To start the bike it will make necessary for the rider to wear the helmet which is a very important substituent for the rider safety. It will also help in tracking the two wheeler if it gets stolen or dragged somehow by the thief by simply sending an SMS to the owner about the present location of the vehicle and the status that the vehicle is being touched by someone.

VIII. FUTURE SCOPE

The above described system has a very wide future scope as it has so many additional features that can be interfaced with the system such as interfacing a peltier module with the present system with result in the reduced temperature in the helmet. Sensors which can sense shock and blood can also be interfaced in order to detect whether the rider has suffered a hit on his helmet or not & check for the bleeding as well. A similar system including theft prevention & driver safety can also be designed for the cars & other heavy automobiles as well.

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Smart Helmet with Rider Safety System

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ABSTRACT:
Because of increasing number of theft cases of the two wheelers there is a need to enhance the security level of the bikes. Traditional and commonly used key locks available in the bikes are well known to the thieves and thus it can be easily unlocked by the professional thieves. The safety of the rider is also a matter of great concern. To overcome these issues a system is required that can help achieve the security of the vehicle and safety of the rider. An intelligent two wheeler ignition system with an additional intelligent helmet for the safety of the rider is proposed. The system ensures the safety of the vehicle and the rider both at the same time. The system requires firstly to authenticate the rider from the preloaded fingerprints from the database of the microcontrollers also making it compulsory for the rider to wear the helmet as per the government guidelines. The system consist of alcohol sensor. Microcontroller ATmega328 is used for the performing the efficient working of system. RF module performing the communication part along with the help of IR sensor.

Keywords: Alcohol sensor, Microcontroller, IR sensor, RF module, GPS, GSM.

I. INTRODUCTION

From past till the present scenario, safety and security remains an issue of utmost importance whether it is related to human life or the materialistic things. Despite tall claims made by law-enforcement agencies about their success in controlling automobile thefts, statistics reveal that as many as 1.65 lakh vehicles were stolen in a single year--2013. Uttar Pradesh achieved the dubious distinction of leading the states with the highest number of vehicle theft cases. The alarming increase in the number of two wheeler road accidents has also been a matter of great concern globally because two wheeler users are directly exposed and come in direct contact with the impacting vehicle or obstacle during a collision resulting in severe injuries and fatality. Every day as many as 140,000 people are injured on the world's roads; more than 3000 die and some 15,000 are disabled for life. The main reason behind the accidents being the carelessness of the riders or rash driving of the rider or riding vehicle when high on alcohol.

Our project aims at designing a system that ensures not only the security of the vehicle but also the safety of its rider. This system uses several intelligent modules which provide this complete security. The safety of the bike is enhanced by adding a new module with the conventional key lock system which is the fingerprint identification system which allows only the authorized rider to get access of the bike. The other module is of the smart helmet which makes several checks depending on which it provides ignition to the rider. This module makes a check whether the rider has consumed alcohol or not and whether the rider is wearing a helmet or not. If the rider has not consumed alcohol and wearing helmet the rider get the ignition but if the required conditions are not met the rider fails to get the ignition.

II. LITERATURE SURVEY

Achint Agarwal etal [13] the authors have considered security as one of the most important aspects & have laid mphasis on the security of the two wheeler & the rider as well. A prototype system is being proposed by the authors which is providing more security to two-wheeler systems with the help of biometrics system.

The main focus while developing the bike anti-theft system was to integrate the above features equally. The most significant feature is the vehicle security from theft and it has been ensured by providing two layers of anti-theft protection. First the entry to the vehicle is limited only to the authorized persons are stored into the database beforehand and at the time of entry to the vehicle, scanned fingerprints are being cross checked with the database.

The second layer of protection is produced by GSM (Global System for Mobile Communication) technology. It sends SMS (Short Message services) to the owner in case of misuse of bike. If anybody tries to steal the bike, the location of the vehicle is described by GPS tracker. GPS interfacing with the whole system is done such that if someone tries to steal the vehicle then the owner can detect the exact location of the vehicle by the message.

The system also consist of a rider safety system that ensures that the rider cannot start the vehicle if he is drunk or not wearing a helmet.

Aman Mishra etal [14] the authors have laid emphasis on reducing the number of accidents caused by the carelessness of the riders (i.e. driving in a drunken condition or not wearing a helmet while riding a two wheeler). The authors have tried to implement an electronic technique which does not makes it very easy to bypass the basic rule of wearing a helmet & not consuming alcohol while riding.
The authors reveal how on one hand the lack of deterrence has emboldened thieves so much that they use techniques and gadgets to override the lock and key systems (methods like using duplicate keys helps them unlock the vehicle in few minutes), the lack of awareness among the riders and their carelessness also exposes them to fatal accidents (which by fluke are survived only by few of the victims of such accidents).
Keeping in mind the above stated fact, the authors proposed a model of a system which is an intelligent two wheeler ignition system with an additional intelligent helmet for the safety of the rider. The system ensures the safety of the vehicle and the rider both at the same time. The system firstly, requires to authenticate the rider from the preloaded fingerprints from the database of the microcontrollers also making it compulsory for the rider to wear the helmet as per the government's guidelines. A module would also be fixed on the helmet which would synchronize with the module fixed on the vehicle's side. The entire model consists of two modules: Bike Module and the Helmet Module.
Furthermore, the authors believed that- this system can offer a number of advantages when implemented in two wheelers, like-only some authorized people will be able to ignite the vehicle. Because the access to the vehicle will be only granted to the user when his fingerprint matches with the one already stored in the database and only under the conditions that the user is wearing a helmet and has not consumed alcohol. Also the entire system on a whole would prove to be of great use to every person who owns a two wheeler as they can enjoy both the security of their vehicle and reduce the risk of being more prone to accidents. This system at a greater level will help reduce the rates of two wheeler thefts and most importantly the two wheeler accidents rate and the death rate.
This paper also incorporates in it the literature surveys carried out on several researches conducted on fingerprint locking system in two wheelers and some additional features related to the safety of the rider. It also gives its readers a vision of the entire system because the paper has a complete block diagram of the system.

R. Prudhvi Raj etal [15] concentrated their study on finding & eliminating the reasons due to which two wheeler riders don't prefer wearing a helmet while riding their vehicle.
The authors laid emphasis on the increase in number of deaths due to two wheeler road accidents. The main reason being severe head injuries. Despite of the fact that helmets are available everywhere, people are not wearing them.
One of the most important reason was due to inconvenience caused by excess heat generated inside it. The authors have designed a prototype for the same which consist of a peltier module that works on the principle of thermoelectric effect, it also has additional feature of tracking the location of the vehicle with the help of GPS fit in it.
One other special feature of this prototype is that if any bleeding occurs it can be clotted by the thermoelectric module so that the two wheeler rider can be rescued & treatment can be provided to it.
The LM35D temperature sensor senses the temperature in the area enclosed between the scalp of the rider and the interior of the helmet. If the sensed temperature exceeds the desired pre-set temperature by the rider, the Microcontroller sends output signal through the BC 547 NPN Bi-polar Junction Transistor (BJT) which is used for amplification of the signal, which controls the switching of the TEC-12706T125Peltier module, which is responsible for creating comfortable temperature**.**
During such an event, besides expediting the blood coagulating mechanism, the Microcontroller sends signal to the Global System for Mobile communications (GSM) module, which would send the precise location of the rider obtained from the Global Positioning System (GPS) module at the time of the generation of shock pulse, which is greater than the critical magnitude, in the form of a text message through a Subscriber Identity Module (SIM) card inserted externally to the GSM circuitry. The text message will be received by the SIM whose number is stored in the Microcontroller that gives the information about the precise latitude and longitude of the location of the rider. This entire circuit is powered through switching ON the limit switch when the rider wears the helmet.

Shanmuganathan J etal [16] in the automobile field, the security and theft prevention are one of the main areas in current scenario. This paper implements for theft prevention in two wheeler using GSM, GPS and Android technology. The vehicle can be tracked & monitored by this system. Despite the various technologies that have been introduced in recent years to detect car thefts and tracking, it was reported that as many as cars were stolen yearly across the world. According to National Crime Information Center (NCIC), in 2006, 1,192,809 motor vehicles were reported stolen, the losses were 7.9$ billion. The proposed security system in this project is designed to track and monitor vehicles and also to stop the vehicle if stolen and to track it online for retrieval. This system is an integration of several modern embedded and communication technologies.
The system has two main units. The first is security unit which is embedded in the vehicle. This unit consists of a GSM modem, GPS receiver, control relay, current sensor and Microcontroller. The current sensor will send an analog signal to the microcontroller when the car is running. The microcontroller will send SMS directly to the owner for conformation.
When the car is in motion, the client receives a confirmation SMS indicating the status. If this is illegal or any intruders tries to run the two wheeler, the owner can send SMS to switch off the two wheeler the system will also check the mobile number of the message sender, to confirm that the phone number is legal or illegal to access the system and if the phone number is legal the system will turn off the two wheeler.

In this paper, theft prevention system for two wheeler based on GSM is implement. Dedicated android application is designed for control the solenoid valves through the ATmega microcontroller. The GSM get the GPS value and it will send the location of the two wheeler to the owner mobile through SMS. Android application is designed for control the solenoid valve. Finally the theft is directly prevented by the two wheeler owner itself.

Akash R etal [17] in the present scenario we come across many problems faced by two wheelers. Fuel theft, vehicle theft, accidents due to alcohol consumption by rider and non-wearing of helmet, etc. Most people preferably use two wheelers over four wheelers but a survey in India 2013 on road accidents indicate that over 1.37 lakh were killed in road accident and 25% of the accident contributes to two wheelers.
The hike in the fuel price has led to fuel thefts in the recent days. Vehicle theft is another major problem.so to overcome this problem this prototype is developed to improve the features of two wheelers. The main feature is to indicate the amount of fuel present in the vehicle digitally i.e., an alpha-numeric fuel indicator and calculate the approximate distance the vehicle would travel using that fuel. In the modern world we encounter number of road accidents which leads to demise of a person especially due to severe brain injuries. Despite the fact that the helmets are made compulsory to be worn, most people neglect it.
This paper introduce a prototype which has a helmet module that is upgraded to monitor the rider's access to it. The prototype also contains GPS (Global Positioning System) locking system, alcohol detector. The alpha-numeric fuel indicator helps to get an accurate information about the fuel amount and calculate approximate distance that the vehicle can travel using the fuel present. Increase in accidents without helmet is a problem due to negligence which is monitored using the proximity sensor to make sure the rider wears the helmet during his ride.

Thus this paper discuss two prototype modules:-
Helmet module
Vehicle module

This system "Accessing System for Two Wheeler and Improved Road Safety (ASTIR)" is advance & reliable system for safety mechanism of people driving two-wheelers vehicles. I believe that this system will reduce accident cases & loss of life of people is minimized to some extent.

S. Priyadharshini etal [18] the author implement theft prevention system in two wheeler using GSM, GPS and Android technology. The proposed system can track, monitor and stop the stolen two wheeler too. The two wheeler position is obtained by the GPS module, which is send to the microcontroller, which then sends the message to the user smart phone through the GSM module. Here PIC microcontroller, air solenoid and water solenoid valves are interfaced with GSM modem and GPS module which will be fixed in the two wheeler. User can stop the vehicle under theft by android application. The paper includes android based tracking and theft prevention system.
Vehicle tracking is done using Global positioning system (GPS) which finds out the position and location of the vehicle around the world. Also the peltier unit is attached to the exhaust system with a Thermal electric generator which converts heat energy into electricity using peltier effect. This electricity is then stored in batteries used in two wheelers. With the help of GPS we can calculate the distance with respect to time. These data will be transferred to the GSM module using PIC microcontroller by digital modulation techniques and will transmitted to the receiver which will be an android device. The android mobile will be used to control the power chords, air and water solenoids.
The system is capable of providing various information such as:

1. Security Related
    i. Vehicle theft information
    ii. Key reminder information

2. Vehicle Related
    i. Vehicle Mileage
    ii. Fuel Leakage
    iii. Break light Damage
    iv. Battery Power
    v. Vehicle Tracking
    vi. Service Reminder

The vehicle can be stopped via solenoids which can be activated through android mobile which cuts the petrol supply to the engine.
This proposed system is very efficient to use but still lacks in rider safety prospective.

III. PROBLEM IDENTIFICATION

Because of increasing number of theft cases of the two wheelers there is a need to enhance the security level of the bikes. Traditional and commonly used key locks available in the bikes are well known to the thieves and thus it can be easily unlocked by the professional thieves. With the help of master key it becomes very easy to unlock the lock of the bikes by the thieves.

This creates the demand of such type of lock which is new and provides an additional security level. The new and modern lock must be unique in itself i.e. it must be only unlocked by special and specific key. This type of feature is available in the biometrics locks i.e. the lock which can only be locked and unlocked by the human body features. Of all these type of special biometric recognition techniques the fingerprint recognition is the most widely used. Thus fingerprint recognition locking system can provide better reliability than the traditional locks and also is cheaper and easy than the other biometric locking system.

This is not the only problem for the society the other one is the rapid increase in the number of accidents taking place and moreover the number of loss of life related with them. The traffic authorities give a lot of instructions to the vehicle operators. But many of them do not obey the rules. Nowadays most of the countries are forcing the motor riders to wear the helmet and not to use the vehicles when the rider is in drunken condition. But still the rules are being violated by the riders.

To find a solution to these problems we have designed a prototype which covers all the above mentioned problems.

IV. DESIGN AND IMPLEMENTATION OF PROPOSED MODEL

The proposed model of this project is an intelligent two wheeler ignition system with an additional intelligent helmet for the safety of the rider. The system ensures the safety of the vehicle and the rider both at the same time. The system requires firstly to authenticate the rider from the preloaded fingerprints from the database of the microcontrollers also making it compulsory for the rider to wear the helmet as per the government guidelines.

A module fixed on the helmet will synchronize with the module fixed on the vehicle's side. The system will show the following functions:

- To start the vehicle at the initial the rider has to firstly authenticate through fingerprint.
- It will ensure that the rider has worn the helmet, if he fails the bike will not get started.
- It will also ensure that the rider has not consumed alcohol. If the rider is drunk then the bike won't start.
- If unknowingly the bike gets drifted it will immediately sends a text message to the owner of the bike that the bike is shifted also giving the coordinates of the present location of the bike.

The model will consist of two modules:

1. Bike Module
2. Helmet Module

The signal will be transmitted wirelessly to the bike receiver and accordingly the microcontroller will take the actions to control the other blocks of the system.

(a) Idle state without power supply

(b) Helmet with power supply

Figure 1

In the above figure 1(a) the helmet is shown in idle case that means no power supply has been provided to the helmet & the helmet is not weared by the rider whereas in Figure 1(b) the power supply is connected and it can be checked by the glowing LED's present on main circuit and IR sensor.

(a) Hand placed inside helmet

(b) Hand removed from helmet

Figure 2

Now as it is clearly shown in the figure 2(a) that there is an obstacle (hand) in between the path of LED & photo-detector inside the helmet the system is giving a positive response to this & this has been shown by the LED getting off which indicates that the rider has weared the helmet whereas in the figure 2(b) the hand previously placed inside the helmet is now removed and which means that the rider is not wearing the helmet now.
The signal is received at the receiver side with the help of RF receiver which is LED in this case.

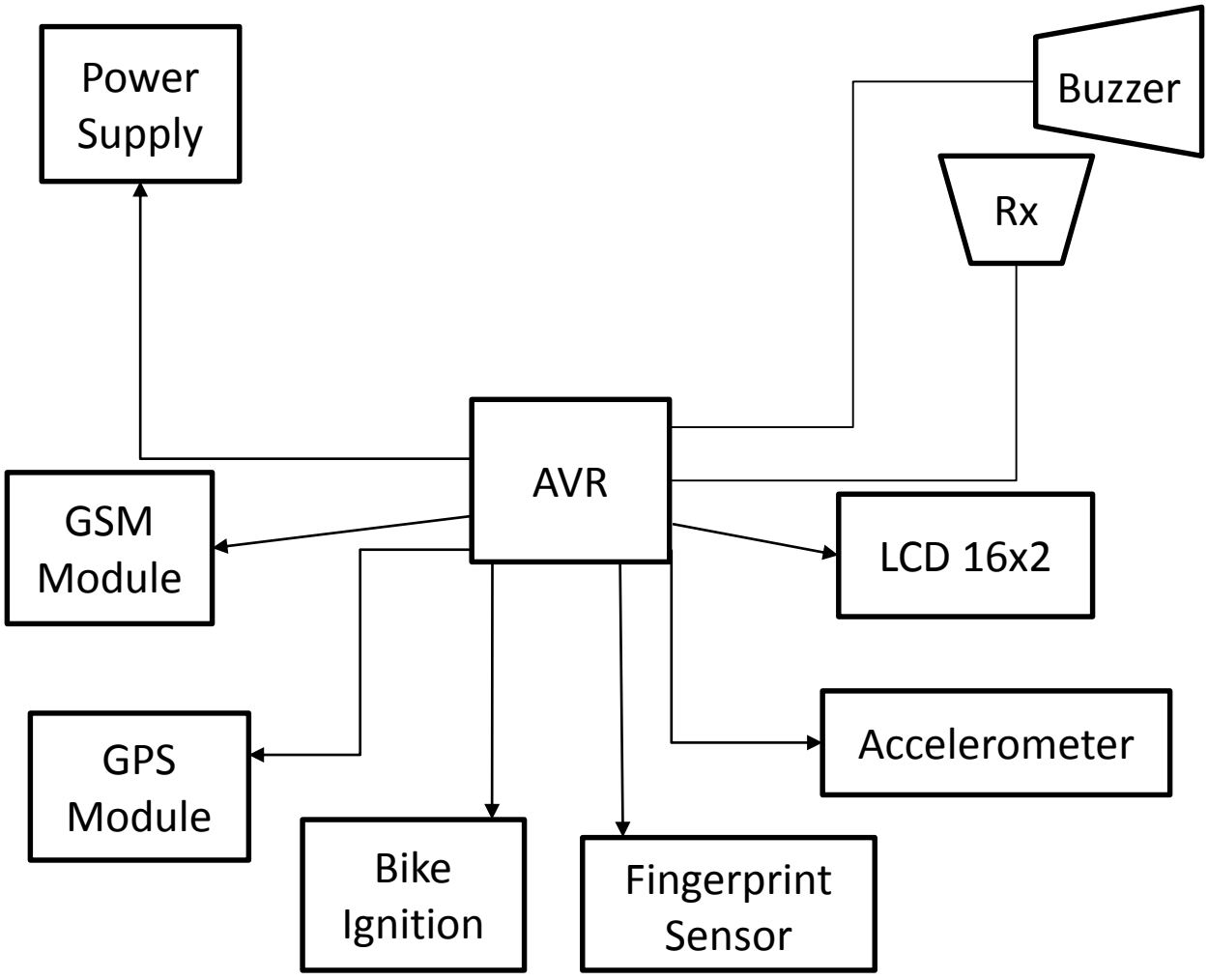

Figure 3- Bike module

This above shown figure 3 is the block diagram of the transmitter side attached to the bike side. Power block is the power supply supplied to the circuit. Alcohol block is the alcohol sensor attached used to sense the content of alcohol consumed by the rider. Buzzer is used as an alarming device used in case of theft. Rx is the receiver attached to receive signals from the helmet. GSM is the cellular module used to send a text message to the number predefined. LCD is used to show the status of the system. GPS module is used to get the information of the position of the bike giving the information of the longitude and the latitude of the bike. Accelerometer is used to detect the tilting (change in its state) of the bike also if the bike is dragged then it will also detect it. Ignition is the bike's ignition. Fingerprint is the fingerprint testing module used to detect the authenticity of the rider.

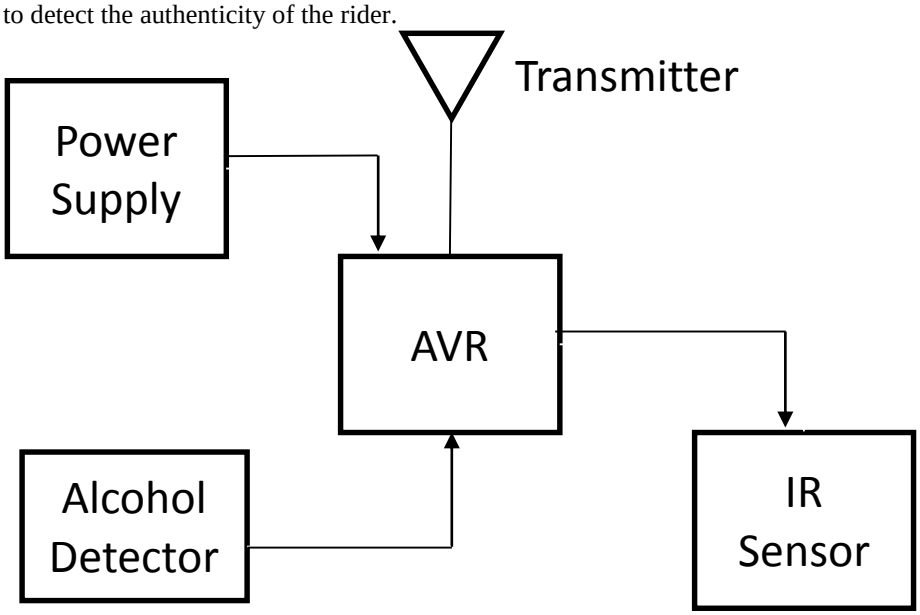

Figure 4- Helmet module

The above figure 4 shows the helmet side it contains power supply, the IR sensor to detect whether rider is wearing the helmet or not. The central block is of the microcontroller (Arduino NANO) that is being used here.

V. **WORKING**

Helmet is interfaced with the complete system to monitor its access by the rider and also to monitor the rider's alcohol consumption. Helmet consist of an IR sensor attached on the outer side of the helmet at the top side & an alcohol detector (MQ3) which is attached on the front of the helmet.
The working of the complete system can be explained in two cases:

Case 1: Rider wearing the helmet

When the rider has worn the helmet then the path between the photo diode & the LED breaks as the head of rider comes in between the path. In this case the IR sensor sends a positive signal to the system which allows the vehicle to start as defined earlier. Now the rider will check the alcohol consumption by using the alcohol detector. The alcohol detector (MQ3 gas sensor) is placed on the front side of the helmet. Rider will blow the air from mouth on the alcohol detector. The air from the mouth is sensed and the alcohol percentage is calculated. During the sense, if the resistance value drops the voltage value changes which is fed to the comparator. This value is compared with the predefined threshold level (permitted level). If the value exceeds the predefined threshold level, comparator output goes high and the microcontroller takes action accordingly. If the value is found to be higher than the predefined value in the microcontroller then the rider won't be able to start the bike as the ignition of the bike will be cutoff & if the value of alcohol consumption is found to be lower than the predefined value then the rider is able to start the bike as microcontroller will provide the ignition.

Case 2: Rider doesn't wear the helmet

If the rider does not wear the helmet then a negative signal will be sent to the microcontroller indicating that the rider has not wear the helmet. In such case the rider won't be able to start the bike as the vehicle ignition will be cutoff or in other words the bike's engine will remain locked. Once the rider wear the helmet then again rider has to go through the alcohol consumption check & as described in case1 if the alcohol value is found higher then predefined then also rider is unable to start the bike as the ignition will be cutoff & if the value is found lower than the predefined value then the rider will be able to start the bike & ignition is provided by the controller.
The entire communication between the helmet and vehicle part is done using RF transmitter and receiver. Thus starting or stopping the vehicle or also displaying the alert messages on the LCD display.

In both the cases the first & foremost condition for the rider is to wear the helmet. So this system makes mandatory for the rider to wear the vehicle to start the bike. So this system makes the life of ride safer & secure which results in lesser amount of accident cases & loss of lives.

VI. CONCLUSIONS

Intelligent two wheeler and rider safety system ensures the security of the vehicle which is a main issue in today's life also the security of the two wheeler as the number of accidents of the two wheeler riders have a great number. To start the bike it will make necessary for the rider to wear the helmet which is a very important substituent for the rider safety. It will also help in tracking the two wheeler if it gets stolen or dragged somehow by the thief by simply sending an SMS to the owner about the present location of the vehicle and the status that the vehicle is being touched by someone.

VII. FUTURE SCOPE

The above described system has a very wide future scope as it has so many additional features that can be interfaced with the system such as interfacing a peltier module with the present system with result in the reduced temperature in the helmet. Sensors which can sense shock and blood can also be interfaced in order to detect whether the rider has suffered a hit on his helmet or not & check for the bleeding as well. A similar system including theft prevention & driver safety can also be designed for the cars & other heavy automobiles as well.

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Electrical Simulation of Organic Solar Cell at Different Charge Carrier Mobility

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Abstract: *The organic photovoltaic device has been electrically simulated by GPVDM software model at different charge carrier mobility. Organic bulk heterojunction solar cell consists of the mixture of electron donor (P3HT) and electron acceptor (PCBM) materials as active layer, ITO (indium tin oxide) is a transparent electrode, PEDOT: PSS is electron blocking layer and Al is a back electrode. In this study the electrical simulation has been done at different charge mobility* 0.5×10^{-4} $m^2v^{-1}s^{-1}$, 0.5×10^{-5} $m^2v^{-1}s^{-1}$, 0.5×10^{-6} $m^2v^{-1}s^{-1}$ *and* 0.5×10^{-7} $m^2v^{-1}s^{-1}$ *respectively. It is observed that J-V characteristics are affected by charge carrier mobility and it is concluded that the best J-V characteristic is obtained at* 0.5×10^{-6} $m^2v^{-1}s^{-1}$ *carrier mobility.*

Keywords: *GPVDM software, Bulk heterojunction, Organic solar cell, charge carrier mobility*

I. Introduction

Photovoltaic cell is the electronic device that converts sun light directly into the electrical energy. Now day's organic photovoltaic (OPV) devices attract more and more interest for researchers. Organic semiconductors have proved to be quite different material for organic solar cell, as these have applications for thin film structure, room temperature processing, flexible substrate, light weight, and low cost fabrication [1]. Organic solar cells offer considerable promise for use in new solar energy technology, due to their flexible material properties and low–cost manufacture [2]. Organic solar cells based on a bulk heterojunction (BHJ) composites of conjugate polymers P3HT (poly 3-hexylthiophene) and PCBM (phynyl-C_{70} butyric acid methyl ester)that allow the maximum absorption of light and have been reported among the highest performing material for researchers investigation and studies [3-8] for improving their power conversion efficiencies. In organic solar cell, bulk heterojunction (BHJ) formed by an interpenetrating of a conjugate polymer and electron accepting molecules constitute a very promising route towards cheap and flexible solar cells [9-10] as recently exhibited in progress of automated roll-to-roll processing and solar cell stability [11-12]. The energy conversion efficiency of bulk heterojunction solar cell based on P3HT and $PC_{70}BM$ organic materials is nearly 6% and 6.1% efficiency achieved when using PCDTBT and $PC_{70}BM$ organic materials. The advantage of the BHJ structure is that the maximum photons are absorbed by the active layer and most of the generated excitons(electron-hole pair) reach a nearby donor - acceptor interface where they dissociate into free charge carriers (electrons and holes).These efficient excitons harvesting leads to higher power conversion efficiencies for BHJ solar cells. In BHJ solar cell the mobility is identified as one of the key factor, which affects j-v characteristics of organic photovoltaic devices through reduction of the efficiency of solar cell and fill factor [14]. The overall result of electronic transport mechanisms is recognized to have a good effect when thin active layer films are used to increase foe the harvesting of light [15]. While thin films of the active materials are able to exhibit almost conversion of absorbed photon into collected charge carriers [16]. For organic solar cell, in case of blends, it was assumed that the electron and hole mobility should be used. It has been observed that the charge carriers mainly governed by the recombination process in the blends, since the fastest charge carriers cannot cross the interface due to the energy between the donor and acceptor, it must wait for the slowest carriers in order to recombine [17]. The organic solar cell has two competing process, extraction and recombination of the charge carriers, both process are conducted by the mobility of the charge carrier. As increase charge carrier mobility would have a positive effect on transport, facilitating extraction, but on other hand it increases the bimolecular recombination. In this research article, we study the dependence of solar cell j-v characteristics on charge carrier mobility. We found electrical simulation of bulk heterojunction (BHJ) solar cell using GPVDM (General purpose photovoltaic device model) software at different charge mobility.

Bulk heterojunction:

In an organic solar cell, Bulk heterojunction is a mixture of interpenetrating of electron donor (P3HT) and electron acceptor conjugated molecules (PCBM) that allows light absorption, generation of excitons,

excitons splitting at donor-acceptor interface and efficiently transportation of positive and negative charges to opposite electrodes. Bulk heterojunction are mostly governed by forming a containing the two semiconductor organic materials, casting and then allowing separating the two phases, usually with the help of annealing process. The two conjugate organic materials will self assembled into an interpenetrating system connecting the two electrodes [18].The structure of bulk heterojunction ITO/PEDOT:PSS/ P3HT:PCBM/ Al solar cell is shown in figure-1 (a,b).

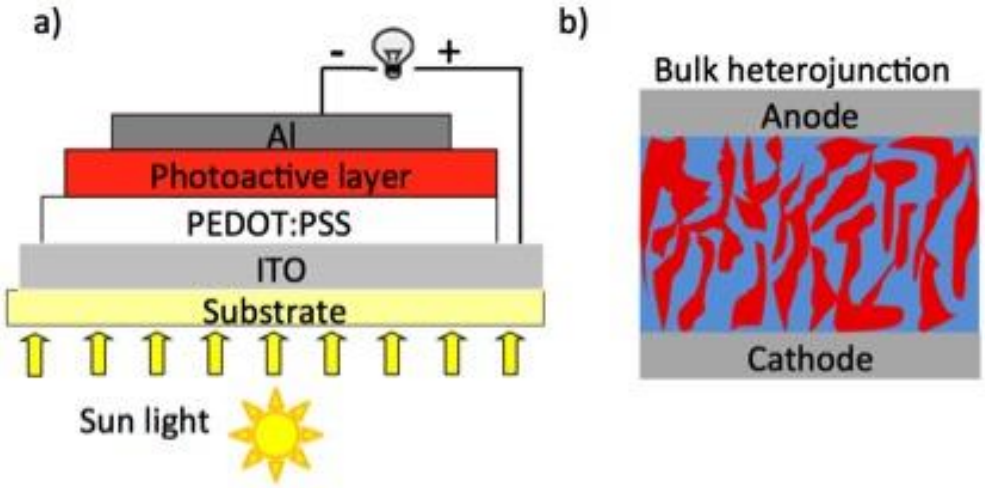

Figure- 1(a, b) Bulk Heterojunction solar cell

In ITO/PEDOT: PSS/P3HT: PCBM/Al bulk heterojunction solar cells, the active layer material P3HT (3-hexyl thiophene) is a good electron donor that effectively transports positive holes and PCBM ([6, 6]-phenyl C_{61}-butyric acid methyl ester) is a good electron acceptor. It efficaciously transports electrons from molecule to molecule. The Indium Tin Oxide (ITO) film is used as a transparent front electrode. Since, it has high transmittance in visible region and ability of conduction. PEDOT: PSS or poly (3, 4-ethylenedioxythiophene) poly (styrenesulfonate) is an electron blocking layer. PDOT: PSS may be used as buffer layers between the electrodes and active layer to block the electron and hole transfer in the wrong direction.

Electrical Simulation:

Bulk heterojunction solar cell ITO/PEDOT: PSS/P3HT: PCBM/Al is electrically simulated by the GPVDM software at different charge carrier's mobility. GPVDM software is specifically developed for the simulation of bulk heterojunction solar cells, which is based on the P3HT: PCBM materials. The model contains two types of properties like as electrical and optical; permitting both current- voltage characteristics to be simulated as well as optical properties [19-20]. The electrical simulation only covers the active layer of the device. In this electrical model, there are two types charge carriers like as electrons (holes), free electrons (holes) and trapped electrons (holes). The free electrons (holes) have a finite mobility of μ_e^o **(**μ_h^o **)** and trapped electrons (holes) cannot move at all and have a mobility of zero. To find the average mobility of the charge, the ratio of free to trapped carriers will multiply by the free carrier mobility then we found the equation

$$\mu_e\,(n) = \frac{\mu_e^o\, n_{free}}{n_{free} + n_{trap}}$$

Thus if all the charge carriers were free the average mobility would be μ_e^o and if all charge carriers were trapped the average mobility would be zero. It should be noted that only $\mu_e^o\,\mu_h^o$ are used in the model for computation and using μ_e (n) is an output parameter.

The electrical simulation window is shown in figure- 2.

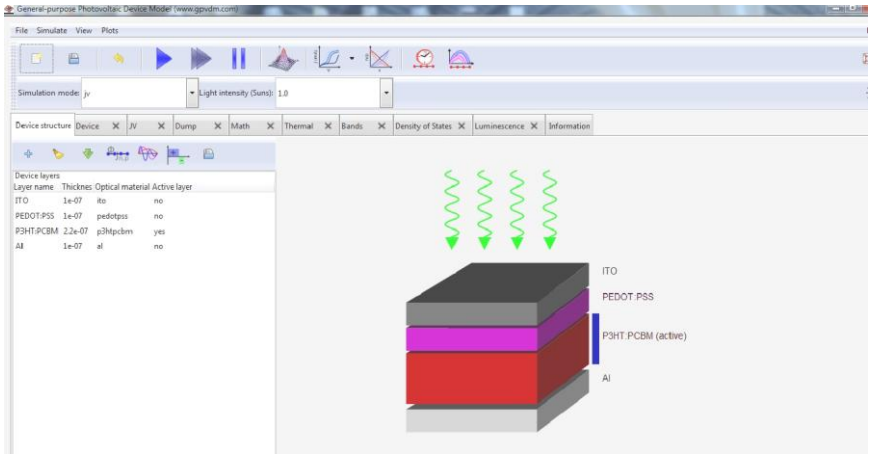

Figure- 2 GPVDM, Electrical Simulation window

II. Result And Discussion

In this research paper, we found the dependence j-v characteristics of solar cell at different charge mobility. In BHJ solar cell, in which the blend is treated as one effective medium with an effective band- gap given by LUMO (lowest unoccupied molecular orbit) of acceptor and HOMO (highest occupied molecular orbit) of donor [21]. We concluded that the best solar cell efficiencies are achieved in mobility range 10^{-6} to 10^{-4} $m^2v^{-1}s^{-1}$. For higher mobility, the efficient extraction of carriers strongly reduces the steady states charge carrier density leading to a reduction of the open-circuit voltage. The j-v characteristics curves at different electron and hole mobilities are shown in the figure- 3 & 4.

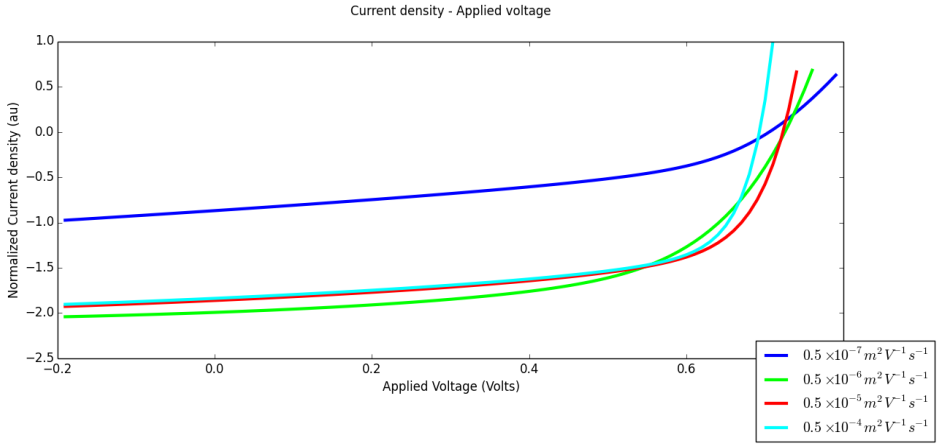

Figure- 3 J-V Characteristics at different electron mobility 0.5×10^{-4}, 0.5×10^{-5}, 0.5×10^{-6}, 0.5×10^{-7}

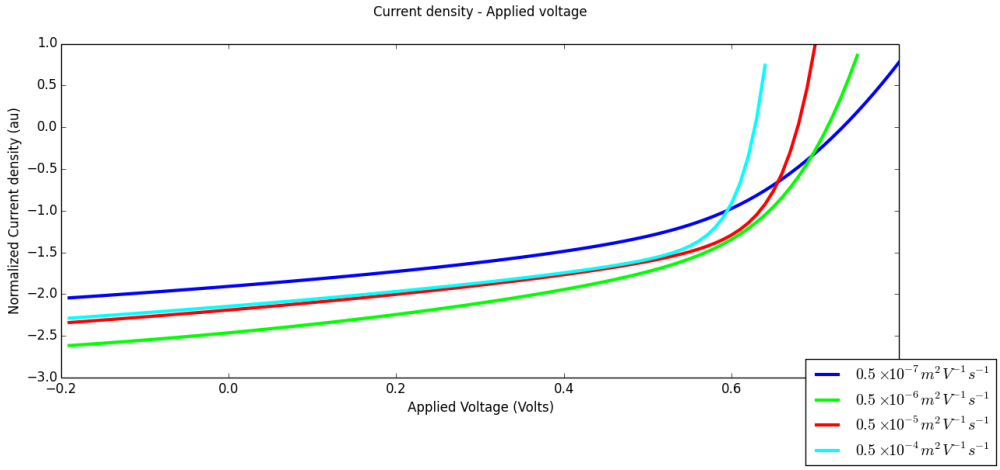

Figure- 4 J-V Characteristics at different hole mobility 0.5×10^{-4}, 0.5×10^{-5}, 0.5×10^{-6}, 0.5×10^{-7}

III. Conclusion

In this research work, the electrical simulation of the bulk heterojunction (P3HT: PCBM) organic solar cell has done. The J-V characteristics curve of organic solar cell varies with mobility of charge carriers. In this study, we obtained the maximum short circuit current at electron and hole mobility 0.5×10^{-6} $m^2v^{-1}s^{-1}$ due to maximum dissociation probability. If the mobility increased or decreased from 0.5×10^{-6} $m^2v^{-1}s^{-1}$, the dissociation probability decrease and the short circuit current also decrease. The optimum efficiency of organic solar cell is obtained at 0.5×10^{-6} $m^2v^{-1}s^{-1}$ charge mobility. It is concluded that the j-v characteristics of organic solar cell affected by the mobility of the charge carrier.

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Matlab Based Theft Detection

Izram Atique, Mugdha Mishra, Abhishek Sameer, Aakash Arora

Abstract

In this innovative project we are going to present security system that is based on IR Sensor which is interface with the MATLAB software. It displays the status of security on the computer screen also. When any person comes in the range of IR then this security system will automatically detect that person and at the same time it captures the image of that person. It will alert the owner by sending him the text message on his mobile phone. The person will get the information about the unknown detected person through captured image that is been stored in the software. This system is beneficial for preventing and detecting theft at banks, security system at the border of the country, home security, office security etc.

Matlab Based Theft Detection

Full Text:

PDF

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An adaptive data chunk scheduling for concurrent multipath transfer

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ABSTRACT

Concurrent Multipath Transfer (CMT) is a transport layer protocol which provides concurrent data transfer over the multiple paths. CMT improves the available bandwidth utilization, fault tolerance, robustness and reliability of the network. However, in multipath data transfer, destination receives out-of-order data chunk due to dissimilar delay and bandwidth of each path. It causes the serious problem of receiver buffer blocking, unwanted congestion window (*cwnd*) reduction and unnecessary retransmission, which significantly degrades the performance of CMT. Thus, this paper proposes an adaptive data chunk scheduling for CMT (A-CMT). The proposed method uses path delay and bandwidth as a factor of data chunk scheduling to adapt path conditions. The simulation results show that proposed method achieves better performance in terms of throughput; file transfer time and congestion window growth. The proposed method improves average throughput up to 13%.

1. Introduction

In last few decades, network traffic increases exponentially due to the huge popularity of multimedia applications. It creates tremendous demand for high bandwidth, low delay, and reliable network services. To fulfill these demands, Internet Engineering Task Force (IETF) standardizes a new transport layer protocol called Stream Control Transport Protocol (SCTP) [1]. The SCTP provides reliable, message-oriented, multi-homing, full duplex, connection-oriented services. The multi-homing is the new feature of SCTP, which offers a pair of devices to establish a logical connection over the multiple interfaces having a unique IP address. The SCTP also offers elective reliability and ordering in a stream, protection against SYN attacks and use of SACK (Selective Acknowledgement) is compulsory for SCTP. Fig. 1 shows the multi-homing scenario of SCTP. Initially, SCTP uses the multi-homing feature to improve the reliability of the network when the primary path is not reachable due to congestion or link failure. To take advantage of multi-homing feature of SCTP, Iyengar et al. [2] proposed CMT (Concurrent Multipath Transfer) to transfer the data packet concurrently over the multiple paths. CMT improves the bandwidth utilization, robustness, and reliability of the network. However, each path has different delay and bandwidth; hence the data packets receive out of order at the destination. Due to unordered data packet delivery, CMT suffers from unwanted retransmissions, unnecessary congestion window (*cwnd*) reduction, receiver buffer blocking, and improper data packet scheduling [3,4]. Moreover, the multipath TCP (MPTCP) [22,23] was introduced to incorporate the advantages of TCP and CMT. The MPTCP used coupled congestion control policy concerning network state of each sub-flow. Therefore, slower path affect the performance of the faster path.

The CMT has tremendous potential for handling fault tolerance, aggregation of bandwidth and load distribution over the multiple paths. However, CMT [2] and CMT-PF [7] use the round robin data chunk scheduling policy to transmit data over the multiple paths. This scheduling policy transmits an equal amount of data on each path without considering the path delay and bandwidth. However, each path has different bandwidth and delay, therefore this scheduling policy causes the serious problem of out-of-order data delivery. As a result, CMT suffers from inappropriately available bandwidth utilization, receiver buffer blocking and unwanted *cwnd* reduction which significantly degrade the performance of CMT.

This paper proposes an adaptive data chunk scheduling policy for CMT (A-CMT), which uses path delay and bandwidth as a factor of data chunk scheduling. The delay of the path change as path traffic intensity changes. The lower delay variation path has low traffic intensity while large delay variation path may have high traffic intensity or congestion. The proposed method adjusts the path *cwnd* to adapt the network status. Therefore, proposed method transmits more amounts of data on minimum delay and high bandwidth path to achieve better network performance.

The rest of the paper is organized as follow: Section 2 presents the analysis of various CMT policies while Section 3 presents the new delay based data chunk scheduling policy. The performance evaluation of the proposed method has been presented in Section 4 while Section 5 concludes the overall performance of the proposed method.

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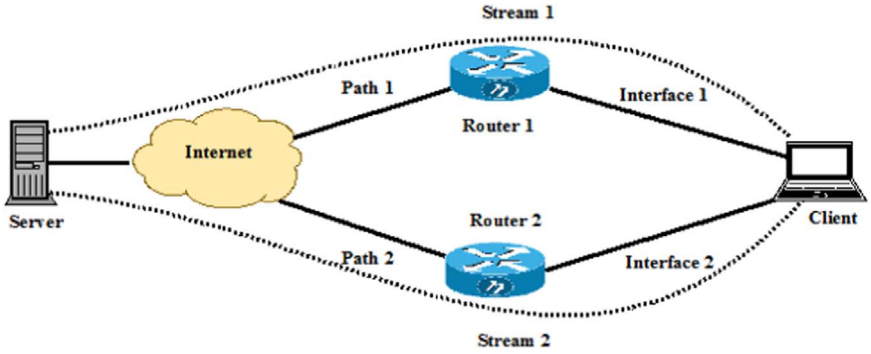

Fig. 1. SCTP multi-homing scenario.

2. Related work

In the past few years, CMT has gained academic research attention due to more popularity of multi-homing devices like laptop, smartphones, etc. In [3,4], authors investigated the CMT-SCTP and identified challenges are receiver buffer blocking, improper scheduling, unwanted *cwnd* reduction, and unnecessary fast retransmission. Iyengar et al. [2] identified the retransmission problem in CMT and suggested a solution called Split Fast Retransmit (SFR) algorithm. The SFR maintains the record of highest TSN acknowledged by the receiver for each destination. The author suggested another algorithm, cwnd Update for CMT (CUC), which maintain the separate congestion window, for each destination to grow independently.

Dreibholz et al. [5] gave a Sender Buffer Splitting approach which splits the sender buffer according to the number of paths. The author claims that suggested approach improved receiver buffer blocking but suffers from local blocking due to the dissimilarity of the path. Ye et al. [6] presented an Independent per Path Congestion Control SCTP (IPCC-SCTP) which tries to reduce the false retransmission. It uses the unique path sequence number (PSN) for each path, which decides the ordered or unordered delivery of chunk for each destination.

Natarajan et al. [7] identified receiver buffer blocking due to path failure and suggested the solution by introducing a new state called Potentially-Failed (PF). This state indicates that the destination is not reachable due to congestion or link failure. Thus, all the new data is transmitted over the available alternate path. In [8,9], the problem of receiver buffer blocking [3,4] has been analyzed and suggested another retransmission path selection policy to improve the performance of CMT. Yilmaz et al. [10] suggested a non-renegable selective acknowledgment (NR-SACKs) policy to free receiver-side buffer to minimize the receiver buffer blocking due to unordered data chunk delivery. The acknowledgment policy simply removes the segment without taking care of reordering and *cwnd* growth.

Shailendra et al. [11] suggested an MPSCTP as a solution of reordering and crippled congestion window growth. Author claims for improved throughput and reduced retransmissions compare to CMT. The authors were later revised MPSCTP [12] to adjust the transmission rate on each path according to the total delay of the path. This method reduces the average packet delay over the different path but suffers from available bandwidth utilization problems due to its equal bandwidth sharing policy. Shailendra et al. [13] introduce Tx-CWND retransmission destination selection policy to improve performance of MPSCTP in terms of receiver buffer blocking. Xu et al. [16] suggested a Quality-aware adaptive concurrent multipath data transfer in heterogeneous wireless networks (CMT-QA) to schedule data according to path quality. Authors claim that CMT-QA achieves better performance during the transmission of video data over the multiple paths. However in [17], authors further improved CMT-QA in heterogeneous network environment and suggested network coding based CMT (CMT-NC). Arianpoo et al. [18] suggested another network coding based multipath transport protocol (coded SCTP-CMT) utilizes Q-learning approaches [19,20]. This technique reduces probability of buffer blocking to a certain extent. However, in [21] authors suggested a cross-layer approach based design to improve the performance of multipath transmission in terms of video delivery over heterogeneous wireless networks.

MP-TCP [22] is another TCP extension for multipath concurrent transfer over the multiple paths, provides connection-oriented multi-homing services. MP-TCP works perfectly fine with the integrations of middle-boxes in today's Internet architecture [23,24]. In [25], authors investigated the performance of CMT-SCTP and MPTCP for latency sensitive traffic. The results conclude that CMT-SCTP and MPTCP reduce the communication latency significantly in symmetric path delay and packet loss environment. However, in asymmetric path delay and loss environment, multipath transmission (CMT-SCTP and MPTCP) latency reduction is not significant but the applications may still take advantage of other feature of multipath transmission without increasing the latency. Singh et al. [26] investigated routing over multiple paths and traffic splitting problems. In addition, they present detailed facts to improve network performance by organize multipath technology across networks. However, Li et al. [27] make a comprehensive study about the state-of-the-art multipath transmission techniques; discussed their pros, cons and future directions. In addition, authors suggested that CMT can enhance performance by reducing the effects of reordering and improve congestion window growth effectively.

3. Proposed work

In multi-homing environment, CMT source sends a data chunk over the multiple paths to yield better throughput while each path may not have the same bandwidth and delay. Therefore, it is important to perform data chunk scheduling on multiple path according to the path bandwidth and delay.

The path delay is a key factor in multipath transfers due to different delay and bandwidth of each path. Each path delay changes when path load changes. Path delay includes propagation delay, processing delay, queuing delay and transmission delay. Let $P_i = \{P_1, P_2, P_3 \ldots\ldots P_n\}$ be the paths used for multipath transmissions and the round trip delay of each path is defined as $D_i = \{D_1, D_2, D_3 \ldots\ldots D_n\}$. If delay of i^{th} path changes, it means that traffic on the path also changes. A path having a minimum delay delivers the data chunk more frequently than other available paths. Delay based multipath data rate adaptation needs a scheduling policy to send the data over multiple path according to path delay and bandwidth.

The delay based data chunk scheduling should have following property. First, it should have an aggressive *cwnd* growth policy when network is under-utilized. Second, *cwnd* should be stable when network is fully utilized. Last, it should also deal with packet loss. Therefore, we introduce delay and bandwidth adaptive scheduling which incorporates these features for concurrent multipath data transfer. A delay-based congestion control algorithm [14], adapts the

transmission rate according to path delay and bandwidth. This approach reduces packet loss and utilizes available bandwidth efficiently. Therefore, we use this approach in proposed CMT to schedule the packet over multiple paths.

The proposed method uses delay and bandwidth of path as a factor of data chunk scheduling to transmit data over multiple paths concurrently. The proposed method estimates the expected transmission rate and actual transmission rate for each individual path. The estimation of these rates uses $cwnd_i$ (congestion window), RTT_i (round trip time) and RTT_{min_i} (minimum round trip time) of i^{th} path.

$$A_{rate\_i} = \frac{cwnd_i}{RTT_i} \quad (1)$$

$$E_{rate\_i} = \frac{cwnd_i}{RTT_{min\_i}} \quad (2)$$

$$D_i = (E_{rate\_i} - A_{rate\_i}) * RTT_{min\_i} \quad (3)$$

where A_{rate_i} is actual rate, E_{rate_i} is an expected rate and D_i is a difference between expected rate and the actual rate of i^{th} path.

E_{rate_i} is the theoretical rate of i^{th} flow when network is not congested. However, A_{rate_i} represents the actual traffic intensity of i^{th} path. If, traffic intensity of i^{th} path changes, the difference between E_{rate_i} and A_{rate_i} also change. If the difference is large, it means that the path traffic intensity is high. However, if the difference is small, it represents the low traffic intensity. Thus, D_i represents the load of i^{th} path. When, the traffic of i^{th} path increases, the value of D_i increases. Therefore, the proposed approach uses D_i as a path load factor to schedule the data chunk over multiple paths.

3.1. Threshold estimation

Two threshold variable λ and δ have been used to decide the path traffic intensity. The values of λ and δ have been decided based on E_{rate_i}. If A_{rate_i} and E_{rate_i} difference is large, it means that traffic rate is around the path capacity, which implies that transmission rate should not be more than current A_{rate_i} for i^{th} path. In this case, δ threshold triggered. However, when A_{rate_i} is too close to E_{rate_i}, the traffic intensity of this path is very low. In this case, λ threshold variable triggered to increase the transmission rate. The initial values of λ and δ are decided according to [14] threshold estimation policy. In practice, the value of λ and δ represents how many extra buffers are in use of current path. The value of λ and δ are 1 and 3 obtained from number of experiments (simulations). These experiments are performed in Network Simulator-2 (NS-2.35) [15] to examine the optimal value for both the threshold variables. Network topology used for simulation is shown in Fig. 2. In this topology, path-1 and path-2 packet loss rate are 1% and 2% respectively. The simulation was run for 200 seconds.

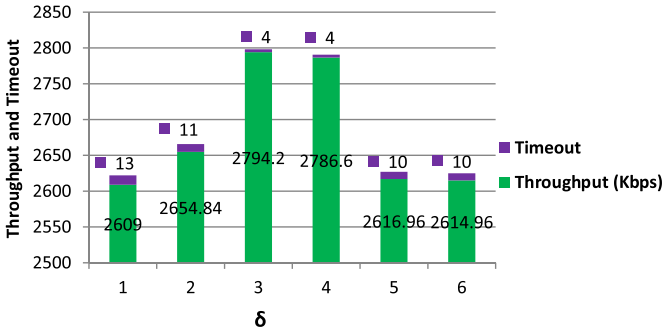

Fig. 3. Throughput and timeout variation for different value of δ.

The bandwidth and delay of both the paths (destination) are shown in Fig. 2. The SCTP source S has two interfaces S1 and S2 while SCTP destination D has two interfaces D1 and D2. The source S sends the FTP traffic to the destination D. During the simulation, SCTP receiver configured with 64KB receiver buffer size (default). However, the queue size of the link is 50 packets with drop tail queuing policy.

In proposed method, δ has been used as upper bound while λ treated as lower bound. Therefore, we first examine the δ (upper bound). During the simulation, we fixed the value of λ to 1 while δ varies from 1 to 6. Fig. 3 shows the throughput and timeout of proposed method for different values of δ. As earlier we discussed that the value of λ and δ represents how many extra buffers are in use of current path. The extra buffers are limited. Thus, we have to determine the value of buffer at which CMT achieves better throughput and suffers from less number of timeout. Fig. 3 shows that at δ=3, CMT provides better throughput and less or equal timeout as compared to other δ values.

Fig. 4 shows the throughput and timeout of CMT when δ=3 and λ varies from 0 to 2.5. As we discussed earlier that if, A_{rate_i} is too close to E_{rate_i}, it means that traffic intensity of this path is very low. In this case, λ threshold variable triggered to increase the transmission rate. Thus, we have to determine the value of λ which maintain the path traffic intensity stable. Fig. 4 shows that at λ=1, CMT achieves better throughput and less number of timeout as compared to other value of λ. Therefore, after analysis the Figs. 3 and 4 for different value of δ and λ, we conclude that the best value of δ=3 and λ=1.

3.2. Data chunk scheduling policy

Iyengar et al. [2] used round robin data chunk scheduling policy to send data chunk over multiple paths. This scheduling policy does not consider the path bandwidth and delay while sending the data chunk over multiple paths. Thus, we introduce a new data chunk scheduling

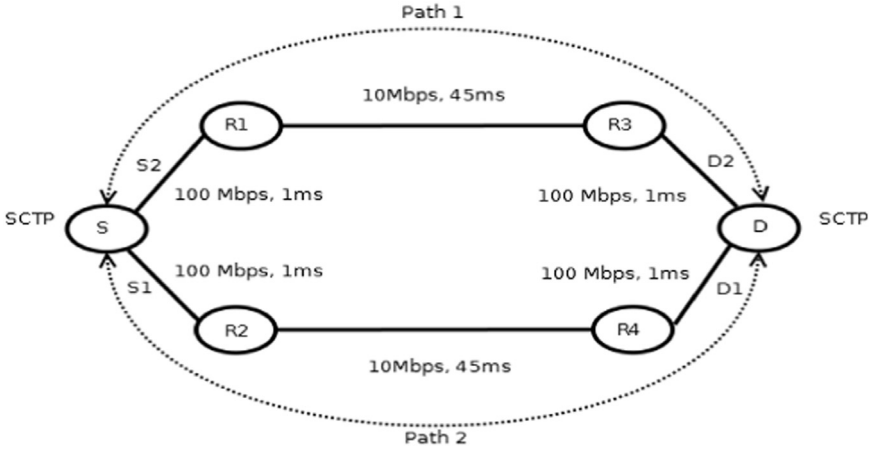

Fig. 2. Simulation topology.

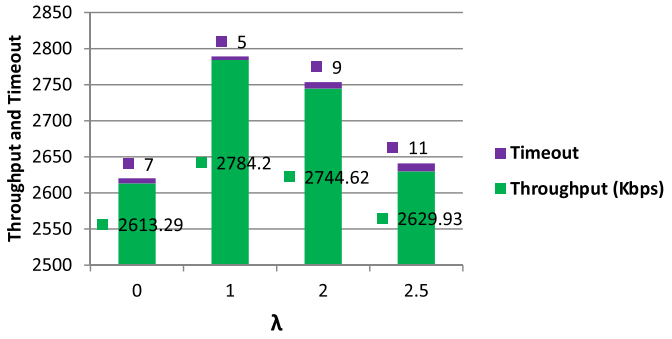

Fig. 4. Throughput and timeout variation for different value of λ.

policy to adjust the data transmission rate according to the path load. In this policy, source estimates the expected transmission rate and actual transmission rate for each destination. The difference of expected rate and the actual rate is estimated by Eq. (3).

Algorithm 1:. Data chunk scheduling policy.

For every SACK received (at sender side for each path):

1. **Begin**
2. $\text{Expected}_{\text{rate\_i}} = \text{cwnd}_i / \text{RTT}_{\text{min\_i}}$
3. $\text{Actual}_{\text{rate\_i}} = \text{cwnd}_i / \text{RTT}_i$
4. $D_i = (\text{Expected}_{\text{rate\_i}} - \text{Actual}_{\text{rate\_i}}) \times \text{RTT}_{\text{min\_i}}$
5. **If**($D_i < \lambda$)
6. $\text{cwnd}_{i+1} = \text{cwnd}_i + \text{MTU}$
7. **Else If** ($D_i > \delta$)
8. $\text{cwnd}_{i+1} = \text{cwnd}_i$
9. **Else**
10. $\text{cwnd}_{i+1} = \text{cwnd}_i + \text{MTU}/2$
11. **End If**
12. **End**

If D_i is less than λ, the path has smooth traffic; therefore, the *cwnd* may be increased by one MTU (maximum transmission unit). If D_i is greater than δ, the path carrying enough traffic, hence no increment is required in *cwnd*. However, if D_i is greater than λ and less than δ, then *cwnd* increases with half of the MTU of current path. This method controls the growth of *cwnd*, offers the time to settle down the congestion, and minimizes the receiver buffer blocking. Algorithm for data chunk scheduling is shown in Algorithm 1. The Algorithm 1 runs on the sender side for each destination (path) to compute the expected and actual rate and difference D_i. The proposed method dynamic *cwnd* can be estimated as

$$cwnd_{i+1} = \begin{cases} cwnd_i & if D_i > \delta \\ cwnd_i + (\frac{MTU}{2}) & if \lambda < D_i < \delta \\ cwnd_i + MTU & if D_i < \lambda \end{cases} \quad (4)$$

3.3. Analysis

To better understand the performance of proposed multipath transmission method, we assume that path-1 and path-2 are two paths used for multipath transmission and the round trip times of the paths are RTT_1 and RTT_2 respectively. However, CMT maintains the separate congestion window ($cwnd_1$ *and* $cwnd_2$) for each path. Thus, the relation between throughput and *cwnd* are as

$$throughput(x) = \frac{cwnd}{RTT} \quad (5)$$

The queuing delay of the path can be estimated as

$$Q_{delay} = RTT - RTT_{min} \quad (6)$$

Each flow in-flight packets in bottleneck queue can be estimated as

$$Q = Q_{delay} * throughput(x)$$

$$Q = \frac{RTT - RTT_{min}}{RTT} \times cwnd$$

In multipath data transmission environment, each path has different bandwidth and delay. Let, path-1 is more congested as compared to path-2. Therefore, the delay of path-1 must be greater than path-2 and the path-1 flow in-flight packets in bottleneck queue are also less than or equal to path-2 in-flight packets in bottleneck queue. Therefore, the queue length of the in-flight packets in bottleneck queue of each CMT flow can be expressed as Q_1, Q_2 and relation between them are

$$Q_1 \leq Q_2$$

Now, we can replace the Q_1 and Q_2 by using Q in the form of each path congestion window and round trip time as

$$cwnd_1 \times \frac{RTT_1 - RTT_{\min\_1}}{RTT_1} \leq \quad cwnd_2 \times \frac{RTT_2 - RTT_{\min\_2}}{RTT_2}$$

Now, we can put the value of Eqs. (5) and (6) in above relation as

$$throughput(x)_1 \times Q_{delay\_1} \leq throughput(x)_2 \times Q_{delay\_2} \quad (7)$$

Eq. (7) shows that the throughput of path-1 is less than or equal to the throughput of path-2. Hence, we can say that long delay path utilization is less as compare to short delay path. For validation of this principle, we test this scenario in NS-2.35 [15] and set simulation environment according to our assumptions. Fig. 5 shows the path-1 and path-2 throughput variation when path-1 and path-2 have 1% and 2% packet loss rate. The simulation topology used for this test is shown in Fig. 2, while delay of both the path is different. It has been observed from Fig. 5 that the throughput of both the path increases with the increase of time. At the start, the throughput of path-1 and path-2 increases rapidly because CMT probes the network capacity. After reaching network capacity, the throughput of both the paths experiences variation due to packet loss detection (caused by congestion or unordered data delivery), then *cwnd* adjustment and fast retransmission. As earlier we assumed that the path-1 is more congested as compared to path-2. If congestion of the path increases, delay of the path also increases. Therefore, path-1 available bandwidth utilization is less as compared to path-2.

4. Performance evaluation

In this section, we compare the performance of proposed A-CMT with well known CMT [2] and CMT-PF [7]. The whole simulation has been performed by using NS-2.35 [15]. Fig. 6 shows the network topology used for simulation. The topology has one SCTP source with two network interfaces S1 & S2, and one SCTP destination with two network interfaces D1 & D2. The bandwidth and delay of each link are shown in Fig. 6. In this simulation setup, path-1 has fixed packet loss rate 1%, while path-2 has variable packet loss rate varies from 1% to 10%. The SCTP source connected to FTP traffic generator. The simulation topology also has two UDP sources U1, U2 and two UDP destinations U11, U22 respectively. The U1 and U11 are connected to router R1 and R4 while U2, U22 are connected to R2 and R3

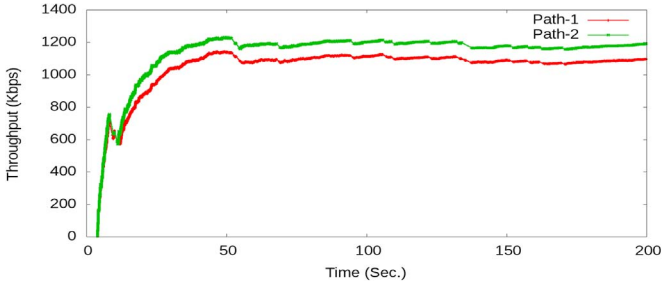

Fig. 5. Throughput variation of path-1 and path-2.

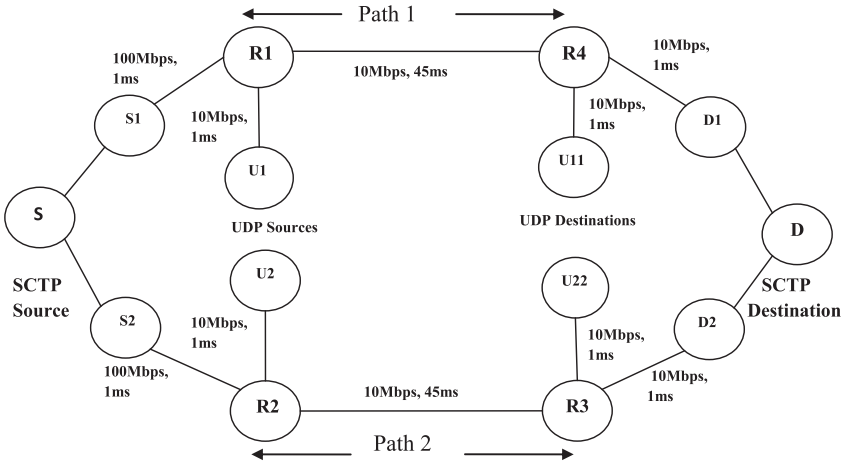

Fig. 6. Network topology.

Table 1
Simulation parameters.

Parameter	Values
SCTP Maximum Segment Size (MTU)	1500 byte
SCTP Data Chunk Size	1468 byte
SCTP Receiver Buffer Size	64KB
SCTP Sender Buffer Size	64KB
SCTP Application	FTP
SCTP RTX Policy	RTX-CWND
Queuing Policy	Drop-tail
Queue Size	50 Packet
Path Packet Loss Rate	Path-1: 1%, Path-2: 1–10%
Bottleneck Bandwidth	10Mbps
Path Propagation delay	47ms
Simulation Time	200 s
Background Traffic	UDP
UDP Application	CBR (path-1:150 Kbps, path-2:400 Kbps)

respectively. This simulation setup is configured with drop tail queuing policy and default queue size is 50 packets. In this simulation setup, all the CMT variants configured with RTX-CWND retransmission path selection policy. This policy selects the path for packet retransmission which is having highest *cwnd* amongst all the paths. We do not include extremely low traffic during the simulations. Table 1 summarizes the simulation parameter used for performance evaluation.

First, we analyzed the throughput of proposed A-CMT and compare with well known CMT and CMT-PF. In this simulation setup, path-1 has 1% packet loss rate while path-2 has variable packet loss rate varies from 1% to 10%. Simulation time of this setup is 200 sec. Fig. 7 shows the throughput variation of CMT variants when packet loss probability of psth-2 changes. It shows that as packet loss rate increases, the throughput of all the CMT variants decreases. CMT and CMT-PF show the similar and linear throughput variation pattern because both the method use round robin data chunk scheduling policy for scheduling the data chunk over the multiple paths. This scheduling policy transmits the equal amount of data on each path while each path has different packet loss rate. Thus, CMT and CMT-PF are not able to utilize the available bandwidth of the path. The A-CMT uses the path bandwidth and delay as a factor of data chunk scheduling and sends more data on a path having lower delay and higher bandwidth. Therefore, A-CMT achieves better throughput as compare to CMT and CMT-PF.

We also calculate the confidence interval for this simulation results. For 95% confidence level, the confidence interval of A-CMT, CMT and CMT-PF are 2133.84–2565.95, 1837.29–2311.50 and 1830.41–2357.39 respectively. The confidence interval of all the CMT variants confirms that the A-CMT has better confidence interval than CMT and CMT-PF. The A-CMT shows 95% confidence that the simulation throughput must be in between 2133.84–2565.95. Fig. 8 shows the average throughput of CMT variants. It also shows that A-CMT achieve higher throughput than CMT and CMT-PF. The A-CMT average throughput improvement is 13% as compared to CMT and 12% as compared to CMT-PF.

In concurrent multipath data transfer environment, retransmission timeout occurred either by packet retransmission timer expires or by retransmitted packet gets dropped (if retransmitted packet gets dropped then CMT recovers this loss by means of timeout). As retransmission timeout occurs, *cwnd* of current path reduced to one MTU and *ssthresh* reduced to half of current *cwnd*. Therefore, more timeout reduces the performance of CMT. Thus, we analyze the retransmission timeout when packet loss rate of path-1 is 1% and path-2 packet loss rate varies from 1% to 10%. Rest of the simulation configuration remains same according to Fig. 6. Fig. 9 shows the average retransmission timeout of A-CMT, CMT, and CMT-PF. The figure shows that the CMT has highest number of timeout due to its

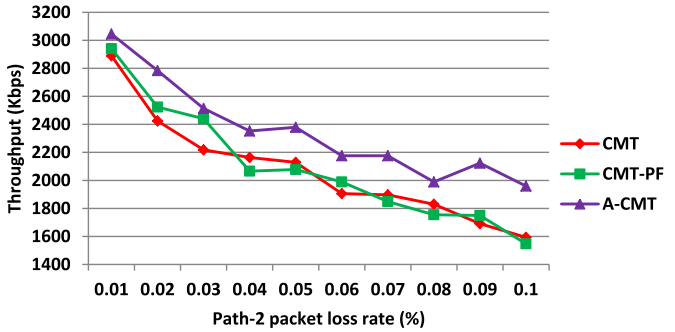

Fig. 7. Throughput Vs Packet loss rate.

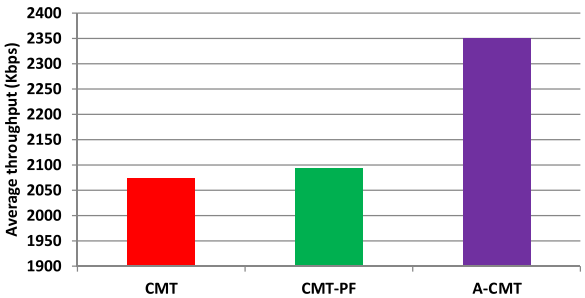

Fig. 8. Average through of CMT, CMT-PF and A-CMT.

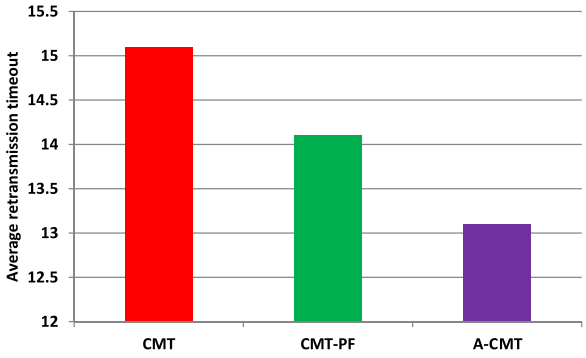

Fig. 9. Average retransmission timeout of CMT, CMT-PF and A-CMT.

packet scheduling approach. Therefore, CMT has a lower average throughput which is shown in Fig. 8. However, CMT-PF has less number of timeout than the CMT, which improves the CMT-PF utilization as compared to CMT. But A-CMT shows the lowest timeout due to its delay based data chunk scheduling policy. As a result, A-CMT achieves higher average utilization than CMT and CMT-PF shown in Fig. 8. A-CMT average improvement in retransmission timeout is 13% as compared to CMT and 7% as compared to CMT-PF. For 95% confidence level, the confidence interval of this simulation results are 9.45–16.74, 10.84–19.35 and 9.79–18.40 for A-CMT, CMT, and CMT-PF respectively. The confidence interval of all CMT variants confirms that A-CMT has a lower confidence interval for timeout. It means that proposed method has 95% confidence that the timeout must be in between 9.45–16.74.

In next simulation, we analyze the effect of symmetric and asymmetric packet loss rate on file transfer time. First, we analyze the file transfer time for symmetric packet loss rate. In this simulation setup, both the path has 1% packet loss rate while remaining simulation configuration remains same according to Fig. 6. Fig. 10 shows the file transfer time of CMT variants while file size varies from 10MB to 90MB. It shows that as file size increases, file transfer time also increases. From the Fig. 10, CMT takes more time to transmit each size of the file due to its packet scheduling policy while CMT-PF takes less time than CMT and more time than A-CMT. However, A-CMT takes the least time to transmit each size of file as compared to CMT and CMT-PF. For 95% confidence level, the confidence interval of this simulation results are 87.64–179.02, 90.56–188.98 and 89.95–186.71 for A-CMT, CMT, and CMT-PF respectively. It concludes that A-CMT has lowest file transfer confidence interval as compared to CMT and CMT-PF. Fig. 11 shows the average file transfer time while average file size transmitted by the source is 45 MB. It shows that A-CMT takes the least time to transmit 45MB file as compared to CMT and CMT-PF. A-CMT average file transfer time improvement is 4.6% as compared to CMT and 3.6% as compared to CMT-PF. Thus, the overall performance of A-CMT in symmetric packet loss environment is better as compared to CMT and CMT-PF.

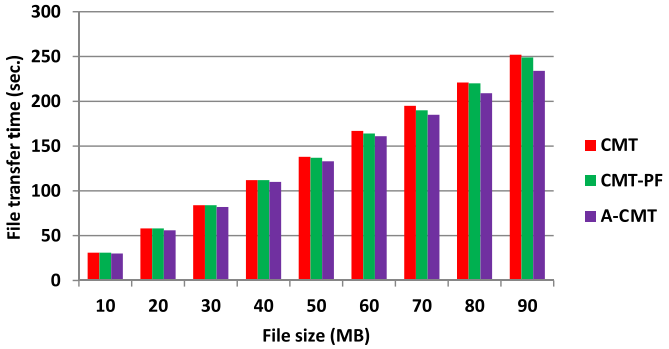

Fig. 10. File transfer time Vs Variable size file for symmetric packet loss rate.

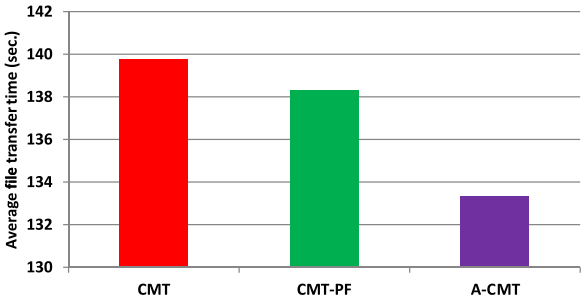

Fig. 11. Average file transfer time for symmetric packet loss rate.

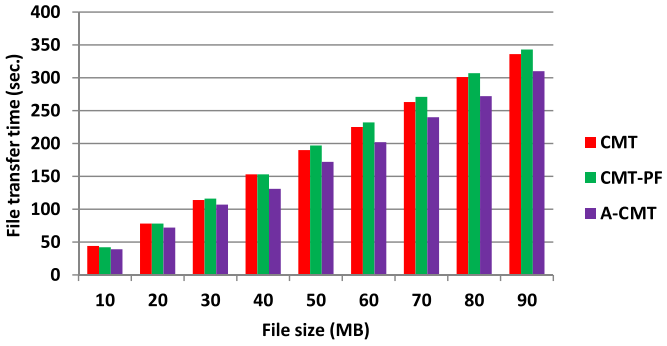

Fig. 12. File transfer time Vs Variable size file for asymmetric packet loss rate.

Now, we analyze the effect of asymmetric packet loss on file transfer time. In this simulation setup, path-1 has 1% packet loss rate while path-2 has 5% packet loss rate. The rest of the simulation setup is same, according to Fig. 6. Asymmetric packet loss rate affects the performance of the overall network. Therefore, CMT and CMT-PF suffers from significant performance degradation in asymmetric packet loss environment which is shown in Fig. 12. The CMT and CMT-PF use round robin scheduling for multipath concurrent data transfer, which transmits the equal amount of data on each path. However, each path has different bandwidth and delay. A-CMT uses bandwidth and delay aware scheduling to transmit data over multiple paths which improve the network utilization. Thus, A-CMT takes less time to transmit the each size of file as compared CMT and CMT-PF.

We also calculate the confidence interval for this simulation results. For 95% confidence level, the confidence interval of the A-CMT, CMT and CMT-PF are 111.36–231.97, 123.51–255.15 and 125.22–261.22 respectively. It shows that A-CMT has 95% confidence that the 45 MB file transfer time in between 111.36–231.97, while CMT and CMT-PF show higher file transfer time confidence interval 123.51–255.15 and 125.22–261.22 respectively. Fig. 13 shows the average file transfer time for 45MB file size in asymmetries packet loss rate environment. It shows that CMT-PF takes maximum time amongst all three CMT variants while A-CMT takes the least time to transmit 45MB file. A-CMT average file transfer time improvement is 9.33% as compared to CMT and 11.15% as compared to CMT-PF.

In Fig. 14(a)–(c), we have compared the *cwnd* growth of A-CMT,

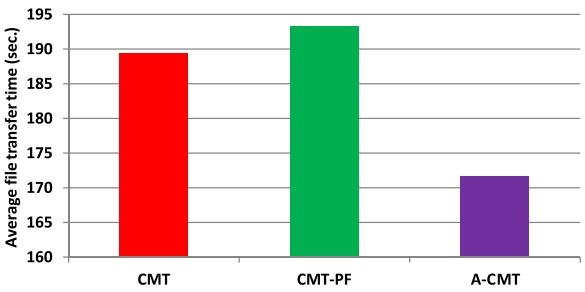

Fig. 13. Average file transfer time for asymmetric packet loss rate.

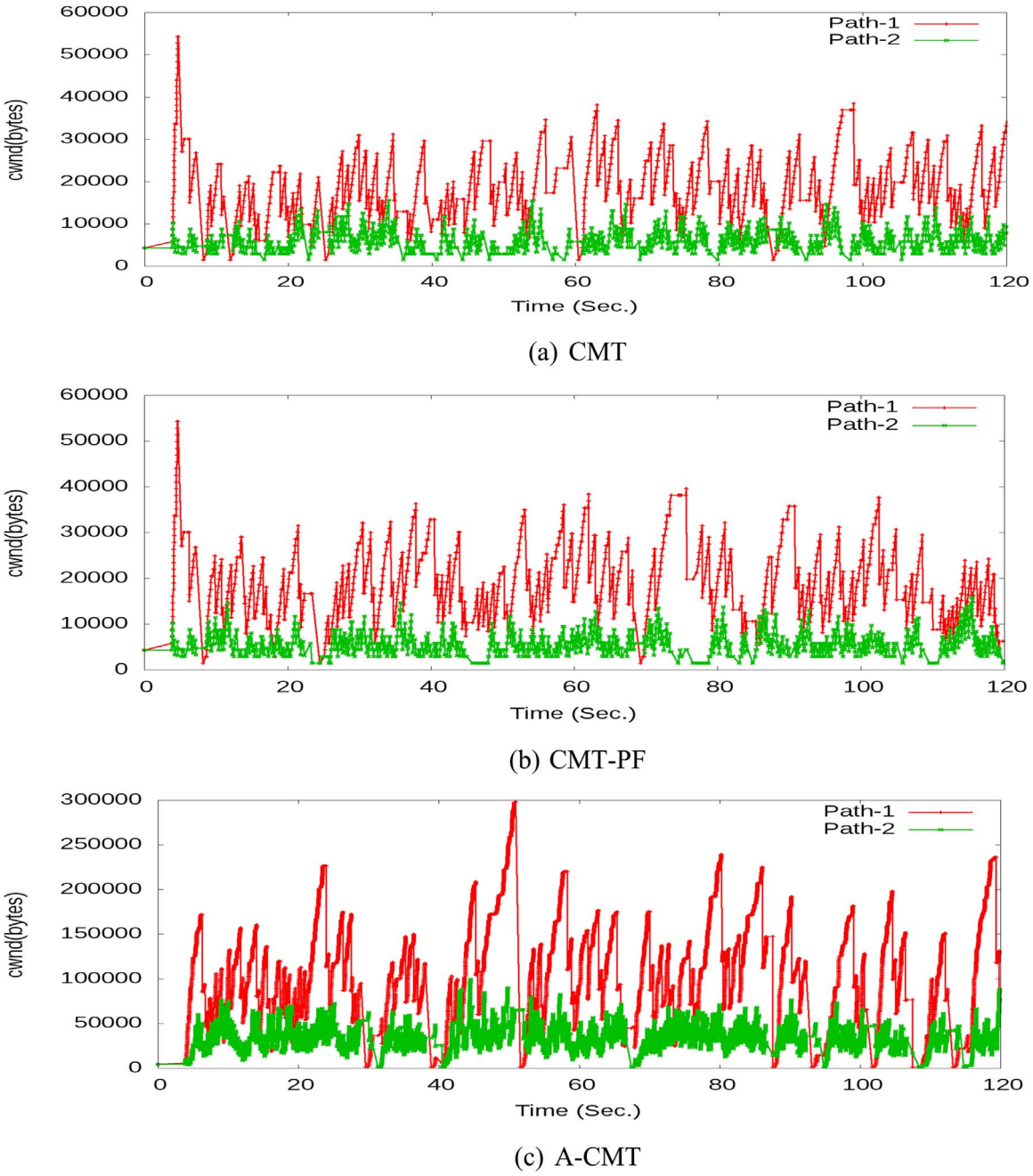

Fig. 14. Congestion window growth with respect to time.

CMT, and CMT-PF. In this simulation setup, path-1 has 1% packet loss rate while path-2 has 10% packet loss rate. The simulation time of this setup is 120 seconds. The rest of the simulation configuration are same as given in Fig. 6. Fig. 14(a)–(c) show that path-1 has larger *cwnd* as compared to path-2 because path-2 has high packet loss rate. The high packet loss rate affects the growth of *cwnd* due to CMT fast retransmission policy. Both CMT and CMT-PF use round robin scheduling policy to schedule without considering the path bandwidth and delay while A-CMT uses the delay and bandwidth of the path as a factor of data chunk scheduling. As a result, A-CMT schedules a large amount of data on the minimum packet loss rate path. Therefore, A-CMT path-1 has better *cwnd* growth as compared to path-2. However, overall *cwnd* growth of A-CMT is better compared to CMT and CMT-PF.

Available bandwidth is a dynamic factor of path. As traffic intensity of path changes, available bandwidth also changes. Therefore, CMT needs to adapt the network bandwidth dynamically. Thus, we analyze the performance of CMT variants to observe the effect of variable bandwidth. In this simulation setup, path-1 bottleneck bandwidth is 10 Mbps while path-2 bandwidth varies from 0.25 Mbps to 2.0 Mbps. However, path-1 and path-2 packet loss rate are 1% and 2% respectively. Rest of the simulation configuration remains same according to Fig. 6.

Fig. 15 shows that as bandwidth of the path increases, throughput of all CMT variant increases. The CMT and CMT-PF use equal data distribution policy on each path without considering path available bandwidth. However, both the path has different bandwidth. Therefore, CMT and CMT-PF shows the similar utilization during entire simulation. However, the proposed A-CMT use adaptive data chunk scheduling policy to transmit data over the each path. Therefore, A-CMT achieves better throughput as compared to CMT and CMT-PF. Fig. 16 shows the average throughput of all CMT variants with variable bandwidth environment. It shows that CMT and CMT-PF achieves

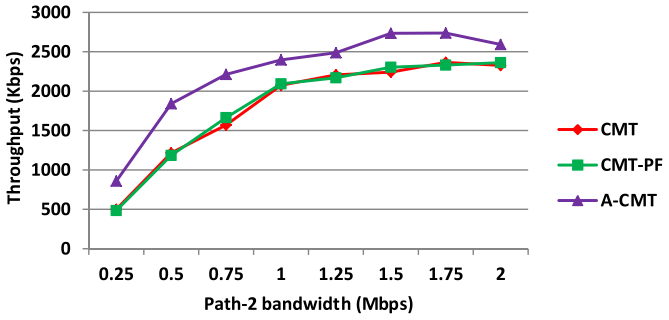

Fig. 15. Bandwidth Vs Throughput.

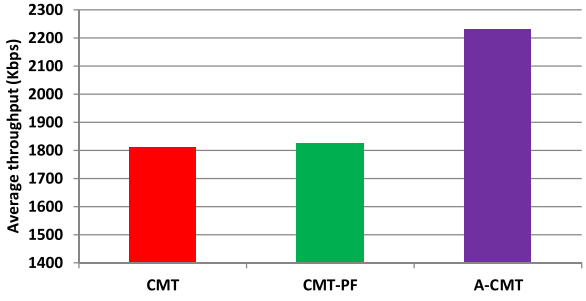

Fig. 16. Average throughput of CMT, CMT-PF and A-CMT.

similar average throughput while A-CMT shows better throughput due to adaptive data chunk scheduling policy. The A-CMT average throughput improvement is 23% and 22% as compared to CMT and CMT-PF respectively.

5. Conclusion

In this paper, we proposed an adaptive data chunk scheduling policy for CMT (A-CMT). The proposed method uses the delay and bandwidth of the path as a factor of data chunk scheduling. A-CMT estimates delay and *cwnd* of each path separately and adapt the path condition by adjusting *cwnd*. Simulation result shows that A-CMT achieves better throughput, lower timeouts, and have less file transfer time in symmetric and asymmetric packet loss environment. The proposed method also has better *cwnd* growth as compared to CMT and CMT-PF. A-CMT average throughput improvement is up to 13% in asymmetric packet loss environment.

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Design of Systems on a Chip: An Introduction

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***Abstract*- the objective of this paper is to provide an overview on the present state of design technology for SoC. Attempt has been made to capture the basic issues regarding SoC design. The paper describes the SoC components, explores present day architecture of SoC and the issues involved in the SoC design process. SoC design offers many advantages, there are still the familiar challenges of designing a complex system, now on a chip. The ever-shortening time-to-market augments further to these challenges. Without a major advance in productivity, designers will be able to consider only a very few high-level systems designs and will have to limit their product differentiation to the software running on a standard embedded processor.**

Keywords: SOC, Embedded System, Integrated System on chip

I. INTRODUCTION

As silicon technology continues to advance, designers are finding that they can implement most of their product on a single chip. Still designing efficient SOCs is a challenge. The functional and layout designs need to be modular and hierarchical, as flat design is no longer an option for very large chips. With growth in components density on chip, the on-chip interconnects are also increasing drastically and are becoming hierarchical, we refer to this as Network-On-Chip or NOC. In order to reduce time-to-market and use external expertise, we try to get large modules being imported and reused. The latter design practice has divided the IC design community into major sections 'core providers' and 'SOC integrators' [1]. Testing SOCs brings forward new challenges as well. The only viable way to contain the growing complexity of SOCs is to apply a modular test approach. Modular testing is required

1. For heterogeneous SOCs, which contain non-logic modules, such as embedded memories, analog and RF modules, e-FPGAs, etc.
2. For black-boxed third-party cores, for which the test is developed by the core provider, but applied by the SOC integrator. However, modular testing also has precious benefits in terms of:
    a. Reduced test pattern generation efforts due to "divide-n-conquer".
    Test reuse over multiple generations of SOCs.

The research challenges related to a modular test approach are as following:

- Design and test development is distributed over multiple parties, companies, geographical locations, and time. This brings with it challenges with respect to the transfer of "test knowledge" from core provider to SOC integrator.
- Cores and other modules are typically deeply embedded within the SOC, without direct access to SOC pins or other test resources. Hence, we need to add an on-chip test access infrastructure, that enables proper testing of the SOC, but that is as much as possible transparent when not in test mode.
- The fact that there is no longer one monolithic chip test, but many smaller tests instead, brings with it many optimization issues with respect to test coverage, test application time, power dissipation during test, silicon area used by the on-chip infrastructure, etc. Designers and test engineers need support to make the right choices in this complex matter, where everything seems to be related with everything.

The scenario for SoC design today is primarily characterized by three forms [1]:

1. **ASIC vendor design:** This refers to the design in which all the components in the chip are designed as well as fabricated by an ASIC vendor.

2. **Integrated design:** This refers to a design by an ASIC vendor in which all components are not designed by that vendor. It implies the use of one or multiple cores obtained from some other source such as a core/IP vendor or a foundry. The fabrication of these designs is done by either the ASIC vendor or a foundry company.

3. **Desktop design:** This refers to the design by a fabless company that uses cores which for the most part have been obtained from other sources such as IP companies, EDA companies, design services companies, or a foundry. In the majority of cases, an independent foundry company fabricates these designs.

Because of the increasing integration of cores and the use of embedded software in SoC, the design complexity of SoC has increased dramatically and is expected to increase continuously at a very fast rate [2]. Conceptually this trend is shown in Figure 1.

The rest of this paper is organized as follows: related work is given in Section 2, whereas Section 3 depicts and discusses in detail present day architecture of SOC while section 4 discusses the design challenges of a SOC, whereas section 5 gives the design flow of SOC finally section 6 concludes the paper.

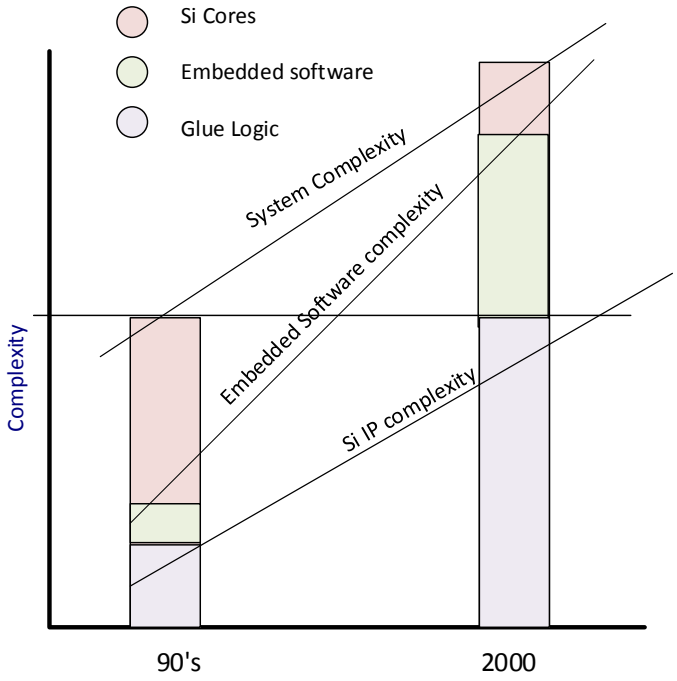

Fig 1: Trends towards increasing complexity due to integration

Every three years, silicon complexity quadruples following Moore's law [3]. This complexity accounts for the increasing size of cores and the shrinking geometry that makes it necessary to include more and more parameters in the design criterion. For example, a few years ago it was sufficient to consider functionality, delay, power, and testability. Today, it is becoming increasingly important to also consider signal integrity, electro-migration, packaging effects, electomagnetic coupling, and RF analysis.
In addition to the increasing silicon IP complexity, the embedded software content has increased at a rate much higher than that of Moore's law. Hence, on the same scale, overall system complexity has a much steeper slope than that of silicon complexity [4].

II. RELATED WORKS

S. Ray et al. in their paper titled system-on-chip platform security assurance: architecture and validation identified gaps in current resiliency and analysis architectures and proposed design and validation solutions to address them [5]. G. Du et al. in their paper titled work-in-progress: SSS: self-aware system-on-chip using static-dynamic hybrid method presented a system-on-chip field gate programmable array (FPGA)-based video processing platform for human detection in complex scenes.

A paper titled Work-in-progress: SSS: self-aware system-on-chip using static-dynamic hybrid method was presented in international conference on compilers, architectures and synthesis for embedded systems. Paper showed a self-aware SoC (SSS) can reduce the peak temperature by up to 30.64%. FPGA prototype shows the effectiveness and smartness of SSS in reducing hot-spots temperature [6]. M. Faisal and S. Montenegro proposed in their paper titled porting a real-time objected oriented dependable operating system (rodos) on a customizable system-on-chip monitoring the thermal distribution or self-state sensoring. Further they said Combining the state of the art silicon chip with a Real Time Operating Systems (RTOS) gives an Engineer full power and all degree of freedoms to design end-use applications with an unparalleled performance characteristic as far as speed, Security, Simplicity, Flexibility and reliability [7].

M. Ricco et al. in their paper titled system-on-chip implementation of embedded real-time simulator for modular multilevel converters proposed implementation of an Embedded Real-Time Simulator (ERTS) for Modular Multilevel Converters (MMCs), using low-cost System-on-Chip (SoC) platform L. Feng et al. in their paper titled VLSI design of SVM-based seizure detection system with on-chip learning capability gave portable automatic seizure detection system based on SOC very convenient for epilepsy patients to carry [8]. L. Akcay et al. in their paper titled design and implementation of an open RISC system-on-chip with an encryption peripheral proposed OpenRISC SOC [9]. S. Azimi et al. in their paper titled accurate analysis of SET effects on Flash-based FPGA System-on-a-Chip for satellite applications proposed a methodology for executing simulation using analytical models for the execution of SET propagation on System-on-a-Chip implemented on Flash-based FPGAs [10].

W. Yueh et al. in their paper titled Active Fluidic Cooling on Energy Constrained System-on-Chip Systems presented design, experimental characterization, and feasibility analysis of integrated in-package fluidic cooling for mobile systems-on-chips (SoCs) [11]. L. Mutauranwa and M. Nkomo in their paper titled design and realization of a compact low cost system-on-chip based digital audio oscilloscope presented detailed investigation, design and development of a low-cost digital oscilloscope on a single chip [12]. E. Lagorio in his paper titled System on chip architecture for Auger Prime surface detector electronics upgrade of the pierre auger observatory designed with a new generation of component, called SOC for System On Chip [13]. K. Sengupta and X. Wu in their paper titled THz silicon systems on chip: EM-Circuits-Systems codesign approach, proposed Silicon-based integrated circuit technology provides a great platform for enabling compact, efficient, low-power, chip-scale THz systems for new applications in sensing, imaging and communication [14].

K. Boikos and C. S. Bouganis in their paper titled a high-performance system-on-chip architecture for direct tracking for SLAM tested with a Zynq System-on-Chip that can process and track more than 22 frames/second with an embedded power budget and achieves a 5× improvement over previous work on FPGA SoCs [15]. G. Breaban et al. in their paper titled time synchronization for an asynchronous

embedded CAN network on a multi-processor system on chip evaluated their method on a FPGA platform and showed that it can achieve a minimum accuracy of 860 ns and a precision of minimum 2 μs [16]. Y. Alazzawi and S. Chakrabartty in their paper titled Self-powered system-on-chip for substrate computing and ultrasonic communications demonstrated the energy-harvesting, regulation functionalities along with the bi-directional telemetry functions needed to implement a complete transceiver for substrate computing [17]. W. Pamuła et al. in their paper titled application of System on Chip (SoC) devices for the design of a smoke detector working with megapixel image streams presented the design of a smoke detection system used for evaluating the advantages and drawbacks of using such SoC solutions [18].

R. Gutiérrez et al. in their paper titled System-on-Chip for Real-Time Satellite Photovoltaic Curves Telemetry presented a System-on-Chip design for real-time satellites photovoltaic curves telemetry [19]. W. Kim et al. in their paper titled On-line monitoring of system health using on-chip SRAMs as a wear out sensor gave the estimation of the remaining life is helpful in monitoring potential chip failures in the near future, to ensure safe operation of SOC [20].

IV. ARCHITECTURE OF THE PRESENT-DAY SOC

In all SoC designs, pre-designed cores are the essential components. A system chip may contain combinations of cores for on-chip functions such as microprocessors, large memory arrays, audio and video controllers, modems, Internet tuner, 2D and 3D graphics controllers, DSP functions, and so on [10]. These cores are generally available in either synthesizable high-level description language (HDL) form such as in Verilog /VHDL, or optimized transistor-level layout such as GDSII. The flexibility in the use of cores also depends on the form in which they are available.

- Soft cores: These are reusable blocks in the form of a synthesizable RTL description or a netlist of generic library elements. This implies that the user of soft core (macro) is responsible for the actual implementation and layout.
- Firm cores: These are reusable blocks that have been structurally and topologically optimized for performance and area through floor planning and placement, perhaps using a range of process technologies. These exist as synthesized code or as a netlist of generic library elements.
- Hard cores: These are reusable blocks that have been optimized for performance, power, and size, and mapped to a specific process technology. These exist as a fully placed and routed netlist and as a fixed layout such as in GDSII format.

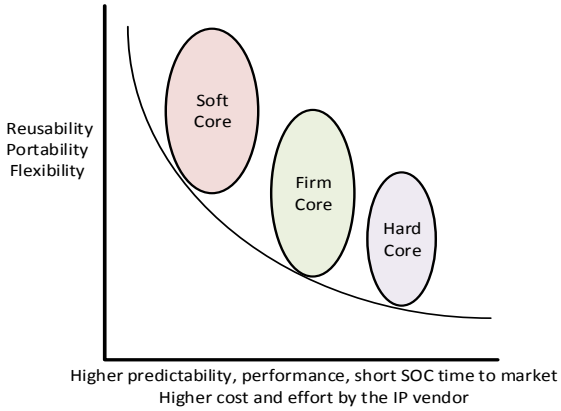

Fig 2: Trade -offs among soft, firm and hard core

The tradeoff between different cores is shown in figure 2.

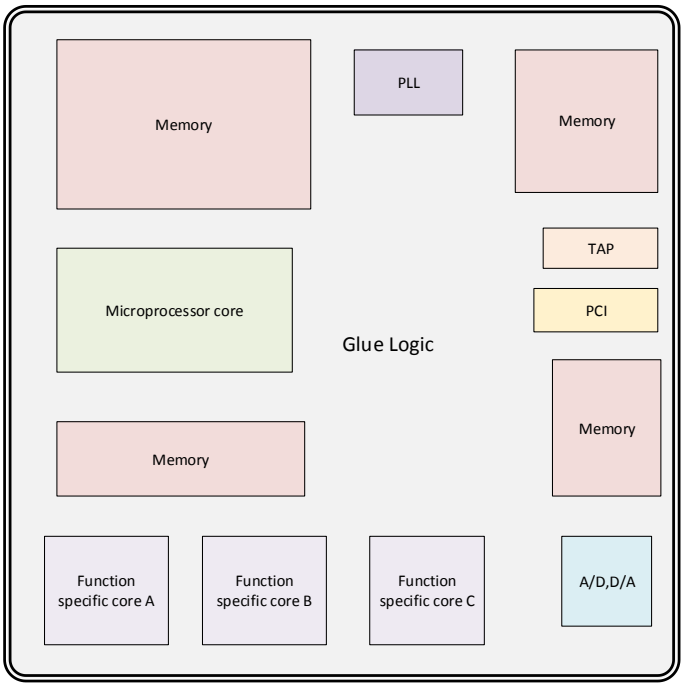

Fig 3: General architecture of SOC

A generalized structure of SoC can be shown as given in Figure 3.

Figures 3 illustrate examples of common components in today's SoC: multiple SRAM/DRAM, CAM, ROM, and flash memory blocks; on-chip microprocessor/microcontroller; PLL; sigma/delta and ADC/DAC functional blocks; function-

specific cores such as DSP; 2D/3D graphics; and interface cores such as PCI, USB, and UART.

V. DESIGN ISSUES OF SOC

Due to the use of various hard, firm, and soft cores from multiple vendors, the SoC design may contain a very high level of integration complexity, interfacing and synchronization issues, data management issues, design verification, and test, architectural, and system-level issues. Further, the use of a wide variety of logic, memory, and analog/mixed-signal cores from different vendors can cause a wide range of problems in the design of SoC.

Portability Methodology

- Non-netlisted cores;
- Layout-dependent step sizes;
- Aspect ratio misfits;
- Hand-crafted layout.

Timing Issues

- Clock redistribution;
- Hard core width and spacing disparities;
- Antenna rules disparities;
- RC parasitics due to chip layers;
- Timing re-verification;
- Circuit timing

Processing and Starting Material Difficulties

- Non-industry-standard process characteristics;
- N-well substrate connections;
- Substrate starting materials;
- Differences in layers between porting and target process.

Other Difficulties

- Mixed-signal designs are not portable;
- Accuracy aberrations in analog;
- Power consumption.

In such a vertically-integrated environment, a large number of CAD tools are required and it is expected that most of the engineers have some knowledge of all the tools used by the team.

VI. DESIGN FLOW

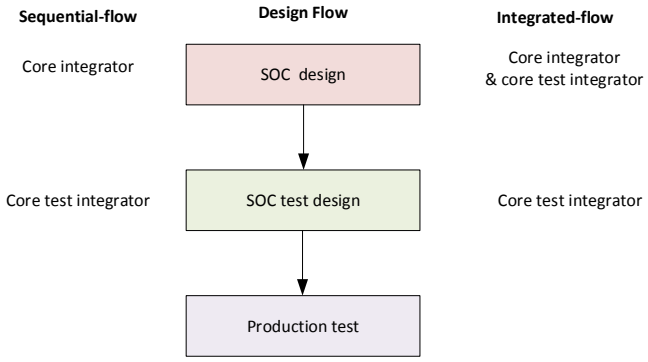

Fig 4: SOC design flow

SoC designs require an unconventional design methodology because pure top-down or bottom-up design methodologies are not suitable for cores as well as SoC [12]. The primary reason is that during the design phase of a core, all of its possible uses cannot be conceived. A pure top-down design methodology is suitable when the environment in which the core will be used is known a priori and that knowledge is used in developing the functional specifications [16]. Because of the dependency on the core design, the SoC design methodology is a combination of bottom-up and top-down philosophies that look like an interlaced model based on hardware. This design methodology is considerably different than the traditional ASIC design philosophy in which design tasks are done in sequential order. Such design flow is described in a horizontal/vertical model as shown in Figure 4 & 5.

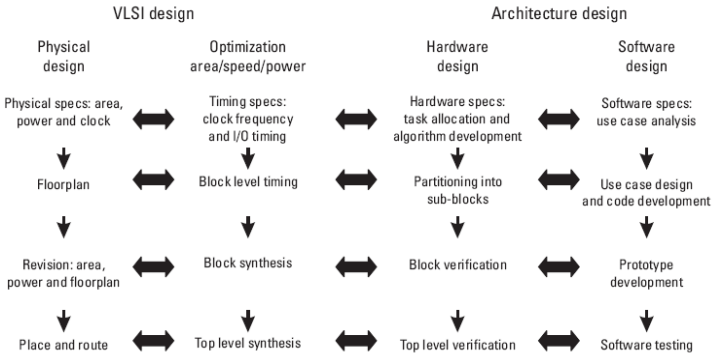

Fig 5: Interlaced horizontal/vertical co-development design methodologies.

Various challenges while designing a SOC are as follows:

1. To get desired operating frequency
2. Designing lower technology nodes
3. Low power requirements

4. Verifying designs
5. Time to market
6. Complexity handling
7. Placement and back end routing
8. Third party IP integration
9. Co-ordination among design Teams
10. Identifying bugs
11. Integrating new technology

These design challenges are depicted percentagewise in figure 6

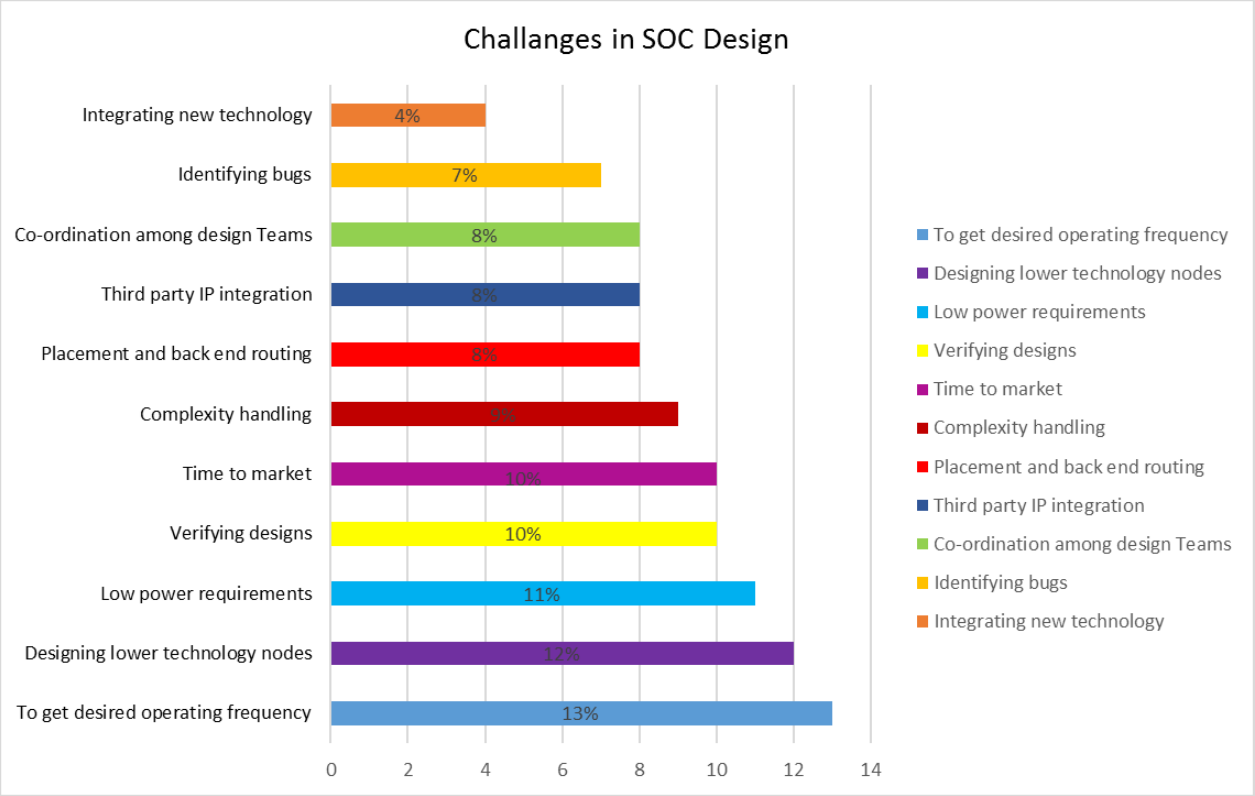

Fig 6: SOC design challanges

VII. CONCLUSION & FUTURE WORK

With the advancement in the VLSI technology designers are trying to integrate more and more components on a single chip. The design techniques involve the use of various cores for the design of SoC which results in varying amount of flexibility and reusability in the design. The benefits of this ongoing integration are obvious: (1) a smaller form factor, as we want small products that fit our pockets, (2) higher performance, as our needs to do, hear, see more with micro-electronics seem insatiable, and (3) lower power, as these portable, mobile products work of batteries with a limited energy budget. There are several opportunities and open design challenges addressed in this paper. Future developments will see advances in these open issues addressed in this paper to improve the performance, flexibility, power-efficiency, functionality of etc. of SOCs.

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An Analysis of IoT Congestion Control Policies

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Abstract

The Internet of Things (IoT) is common platform provide connectivity between various type of devices are having communication capability. Main objective of IoT is to deploy effective and high-quality smart services which offer different type services. Therefore, IoT need an advanced protocol stack which provides inter-communications between different types of devices have different service requirements. IoT uses TCP and UDP as transport layer protocols to achieve the quality of service (QoS) required by different IoT devices. The XMPP (Extensible Messaging and Presence Protocol), MQTT (MQ Telemetry Transport) and RESTful HTTP are IoT application protocols which use TCP as a transport layer protocol. The transport layer protocol offers service point addressing, flow control, congestion control and segmentation, reassembling. As a number of different types of device increases over the Internet, network congestion also increases. In current internet scenario, TCP is responsible for congestion control over the Internet. However, current available TCP versions are not enough capable to handle different type of devices to fulfil the need of IoT. Therefore, this paper provides a survey of various congestion control algorithms used at transport layer. This paper includes available congestion control algorithms, their advantages, disadvantages and existing problems with TCP in IoT domains.

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Keywords: IoT, Congestion, Smart City, TCP, Network.

1. Introduction

Internet of Things (IoT) gaining huge research attention due to requirement of different type of network integration. The objective of IoT is to connect wide-range of devices and services that share data and information to each other's. Now the days, each and every person connected with internet using different type of communication devices. The idea of IoT [7] comes into picture in last two decades and various researchers and industries are working on it. The aim of IoT is to make easy our daily lives and society. IoT covers various scenarios such as smart grid [1], smart city [2], environment monitoring [3], and healthcare monitoring systems etc. According to a prediction done by CompTIA, number of devices connected to internet will reached up to 50 billion by 2020[6]. This can change the entire network communication and computing scenario. However, the majority of such connected devices have low processing power, limited storage capacity and energy constraints [4-5]. Therefore, it is essential to make standard protocols that enable these features. The architecture of IoT is shown in Fig. 1.

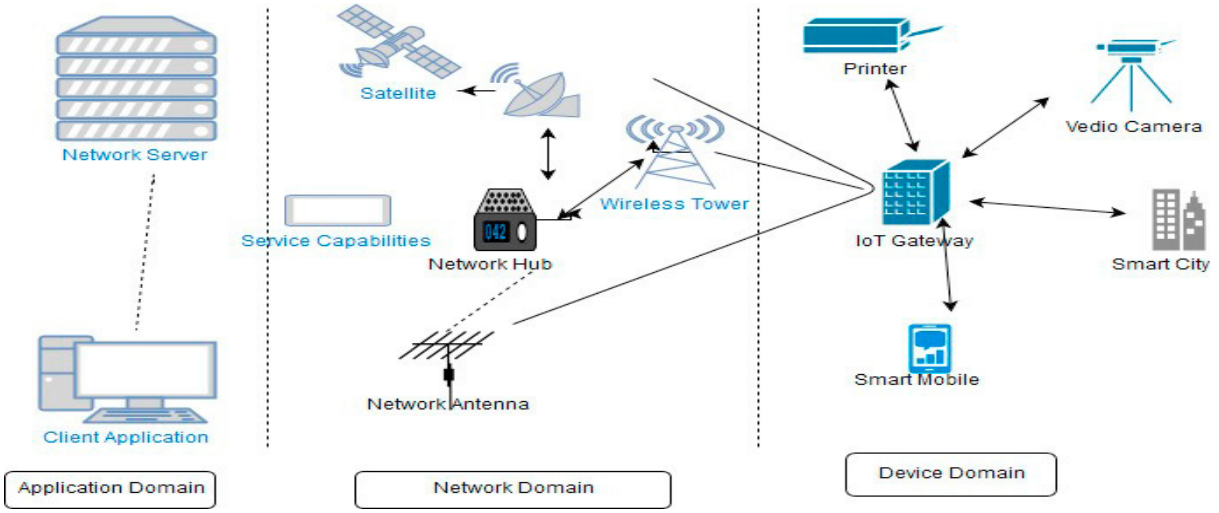

Fig. 1: IoT architecture

Network Congestion is the basic problem identified by various researchers in every era of computer network. Now, IoT connect everything with Internet. As number of connected devices increases over the Internet, network congestion also increases. The XMPP (Extensible Messaging and Presence Protocol) [9], MQTT (MQ Telemetry Transport) [10] and RESTful HTTP [11] are IoT application protocols which use TCP (Transmission Control Protocol) [12] to offer the congestion control services. TCP provides reliable, host-to-host, connection-oriented service. Thus, the role of TCP is very important in the growth of IoT. Various researcher proposed many congestion control technique [13-36] and adapt the transmission rate of path according to traffic intensity of the path. But, IoT has variety of devices and each device has different requirement (reliable and un reliable data transmission, high speed and low speed data transmission, etc.). Therefore, IoT need a congestion control policy which handle all requirements of different devices.

An analysis [39] presented that the number of connected devices over the internet passed the human population. This analysis shows that the IOT adaptation rate is much faster than other technology. Figure 2 shows the analysis and trend of IoT adaptation. This trend shows that as the number of connected devices increases over the Internet, they generates huge amount of traffic on the communication path. This huge amount of traffic creates congestion on

communication path. To manage communication path congestion, we need a congestion control policy which adapt the communication path traffic more effectively and adjust the transmission rate accordingly.

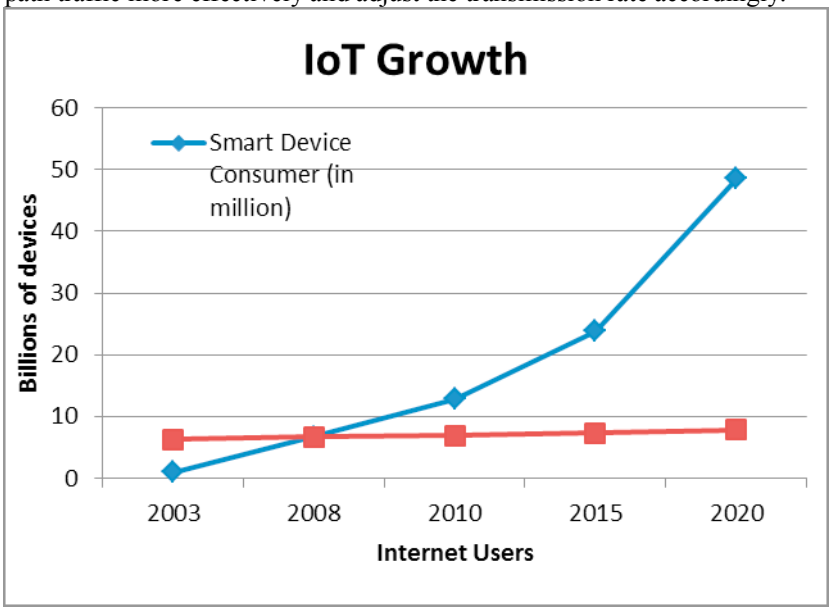

Fig. 2: Growth of IoT

This paper provides the detailed analysis of congestion control algorithm available in current scenario, there advantage and disadvantages, and applicability to IoT domain. This paper also identifies the major problem available with TCP in IoT domain.

The rest of the paper is organized as follows. Section 2 presents a brief review of different type of congestion control algorithms. Section 3 discusses the problems associated with the IoT in terms of congestion control and section 4 presents the conclusion of this paper.

2. Congestion in IoT

IoT is the global network platform which provides interconnection between different types of devices having the capability to transmit data over the network. The devices can be personal computers, tablets, smartphones, and other objects having a unique identity (IP address) over the Internet. Major applications of IoT [8] are smart homes, smart cities, smart grids, industrial monitoring systems, healthcare monitoring systems, and environment monitoring systems etc. To implement the IoT, it requires a set of protocols to control the communication over the Internet. There are many types of application protocols supported by IoT to provide data transmission between different devices. The XMPP (Extensible Messaging and
Presence Protocol) [9], MQTT (MQ Telemetry Transport) [10] and RESTful HTTP [11] are IoT application protocols which use TCP (Transmission Control Protocol) [12] to offer the data transmission. TCP provides reliable, host-to-host, connection-oriented service. Thus, the role of TCP is very important in the growth of IoT.

As number of connected devices increases, Internet congestion also increases. Therefore, TCP needs modification according to IoT requirements to start connection with marginally good capacity, adjust the transmission rate as congestion increases and make transmission rate stable when network resources are stable. Transport layer congestion control protocol can be categories in two groups according of their congestion control policy.

2.1. Loss based congestion avoidance algorithm

Such type of congestion avoidance algorithm uses packet loss as a signal of congestion. Initially, loss

based congestion control algorithm for TCP protocol has been proposed by Jacobson [13] and based on this algorithm Fast Retransmit and Fast Recovery technique proposed in [14] is called TCP Reno.

TCP Reno has vulnerabilities when more than one packet lost due to congestion then Fast Recovery suddenly transform into exponential congestion window decrease. Floyd et al. [15, 16] recognize this problem and proposed a new technique called TCP New Reno to overcome the Fast Recovery problem. New Reno only modifies the Fast Recovery algorithm by improving its response when multiple packet loss detected for a single congestion event.
Another solution of multiple loss is proposed by Mathis et al. [17] is called TCP SACK. This protocol provides the ability for the receiver to report the number of successfully delivered data packets. By using this information, the TCP sender can calculate block of the lost packet (gap in sequence number of the acknowledgement) and retransmit it quickly.

Mathis and Mahdavi [18] proposed another technique based on SACK with new congestion control mechanism. FACK (forward acknowledgement) maintain three state variables, H-highest sequence numbers, F-forwarded most sequence number and R-number of retransmitted packets. A relation of H-F+R can be utilized by the sender to decide either sends new data or not. Simulation results confirm that FACK is faster than recovery process of TCP Reno and TCP New Reno but it has same property for fairness.

Floyd [20] recognizes the efficiency problem of high speed network and proposed High Speed TCP (HS-TCP) for same. The HS-TCP uses α for congestion avoidance and β as a decrease factor during minor loss detection. HS-TCP achieves high bandwidth utilization and has intra-fairness quality but it suffers with the fairness of RTT with different flows.

An alternative of HS-TCP is proposed by Kelly [21] named Scalable TCP (STCP) to solve the effectiveness problem in high speed long delay network. STCP introduced a new concept of congestion window growth called Multiplicative Increase and Multiplicative Decrease (MIMD). MIMD increases the *cwnd* by a factor α and decrease it by β. STCP grow *cwnd* very quickly, but it experiences a critical problem of inter-fairness and constant congestion.

Leith et al. [22] proposed another congestion control algorithm called HTCP which remove the inter-fairness problem of STCP and HS-TCP. The main idea of HTCP is that congestion window increases in n steps in Congestion Avoidance phase should be elapse time Δ before last congestion event.

Rhee and Xu [24] proposed a TCP-CUBIC for congestion control which is an enhanced version of BIC-TCP [23]. TCP-CUBIC grows its window to the midpoint between the last maximum window size where the packet was lost and the last minimum window size; it did not loss any packet. TCP-CUBIC has two profiles concave and convex for window increase. It uses RTT-independent growth function that maintains scalability, RTT-fairness and Intra-fairness, but it is not able to utilize available network resources and suffers with more number of packet losses.
Wang et al. [25] attempted the problems of TCP-CUBIC and proposed CUBIC-FIT. It is based on the model of delay-based TCP to extend the TCP-CUBIC framework. CUBIC-FIT simulates *N* plain CUBIC flows using only one window. It increases network utilization and maintains friendliness with the TCP-CUBIC algorithm.

2.2 Delay based congestion avoidance algorithm

Such type of congestion control uses network delay as a factor of congestion. When delay increase, means congestion increases and when delay decreases, means network congestion decreases. Many flavors of delay calculate by the authors to deal with congestion like Round Trip Time (RTT), queuing delay, One-way delay etc.

Brakmo and Peterson [26] proposed a delay based congestion control algorithm called TCP Vegas. This technique is based on estimation of expected rate and actual rate by using Congestion Window (*cwnd*), Round Trip Time (RTT) and minimum Round Trip Time (RTT_{min}). It adjusts the cwnd according to difference of expected and actual rate. Author clams better network utilization and reduce packet loss, but it suffers with problem of fairness.

Hasegawa et al. [27] recognized this serious unfairness problem of TCP Vegas and proposed a new TCP is called Vegas+. It assumes initially Vegas friendly environment and apply bottleneck buffer size estimation to control the congestion window. A state variable use to monitor the increased RTT and congestion window. When Vegas+ detect an unfriendly environment, Congestion Avoidance uses TCP Reno algorithm. Under some network conditions, Vegas+ is not able to handle aggressiveness of the transmission and have uncertainty about the packet loss.

Mascolo et al. [28] proposed TCP Westwood which estimates the available bandwidth based on acknowledgement arrival rate. TCP Westwood provides bandwidth estimation based on a fixed pole filter. But the

pole filter cannot provide unbiased value of bandwidth like the arithmetic average of bandwidth is not equals to pole average bandwidth.

TCP Vegas also suffer with fairness and low available bandwidth utilization problem. Byun and Lim [13] proposed another version of TCP Vegas to resolve the fairness problem and maintain bottleneck queue stable. It uses ECN (Explicit Congestion Notification) on the bottleneck router to analyze the queue status. But this technique is not applicable if there is more than one bottleneck in between the source and destination.

Jin et al. [35] introduced a queuing delay based congestion control algorithm known as FAST-TCP. It has four components are Data control, Window control, Burstiness control and Estimation. All components are independent and functions asynchronously. The data control component provides information about which packet is transmitted. Window control component update the *cwnd*. Burstiness control component examines the network condition and send packets accordingly. The authors claim better results in terms of intra-fairness, RTT fairness, stability and scalability. Apart from these advantages, it has some limitation like highly dependent on minimal RTT and unfair with other TCP.

Wang et al. [36] introduced another congestion control technique which is based on TCP Vegas expected rate and requested rate. According to Vegas variables it calculate appropriate rate for dynamic adjustment of *ssthresh*. It also estimates the difference of RTT_{max} and RTT_{min} and finds variation of RTT. It adjusts the *cwnd* on the basis of variation of RTT with variable amount. Author clams that it provides better results in terms of throughput in different network condition.

Wang et al. [38] proposed a TCP-friendly and fair congestion control algorithm for multimedia applications. This algorithm works in two modes are starting phase and transmission phase. Starting phase analyzes the own-way delay and second phase adjust the transmission according to available bandwidth. Author claims that the proposed approach have fair bandwidth utilization without obstructing the performance of the other existing TCP applications.

TCP-FIT [31] is another congestion control algorithm that uses both loss and delay based technique to control *cwnd*. It uses AIMD to adjust the *cwnd* according to bottleneck queue size estimated on the basis of RTT_{min}, RTT_{avg} and current *cwnd* size. It improves the throughput and fairness with respect to TCP-Reno, CUBIC and FAST-TCP.

Wang et al. [32] plan to take the advantage of FAST-TCP and TCP-FIT, and proposed a new congestion control algorithm called FAST-FIT. It uses the FAST-TCP growth function to maintain data flow and uses a TCP-FIT technique to adjust the *cwnd*. It shows better results in terms of inter protocol fairness (with TCP-Reno), high bandwidth utilization in wired and wireless environments.

After analysis of these protocols, we conclude that loss based TCP utilized available bandwidth, but it suffers with packet loss and retransmission, while delay based TCP try to reduce the packet loss and retransmission but they are not able to utilize available bandwidth as much as possible. Both types of TCP variants also suffer with inter protocol fairness and data transfer rate adaptation in variable transmission rate.

4. Discussion

In IoT, different devices have its own requirements of communication speed, delay, and reliability. Due to exponential growth of smart devices in IoT, Internet congestion control [37] is an open issue of computer networks. As number of connected devices increases over the internet, the network congestion also increases. After analysis of the various TCP variants [13-34], we conclude that loss-based TCP utilizes the available bandwidth, but not appropriate for applications which work in low bandwidth environments. However, delay-based TCP attempts to reduce the packet losses and retransmissions, but not able to utilize the available bandwidth. Therefore, we need a transport layer protocol which adapt the IoT communication environment and provide services according to requirement of different devices.

In current IoT development scenario, various researchers contributed allot in terms of protocol stack, IP addressing, security protocols, congestion control protocols and many more. But, there are still some technical problems available with IoT to prevent it to make a standard.

In IoT communication scenario, some devices require the high speed data transfer with energy efficient protocol without reliability. On the other hand, some IoT devices need fast connection with reliability. Thus IoT need a protocol which support both reliable and unreliable data transfer services.

Another challenge is to handle the large amount of data generated by IoT devices. In IoT communication, each IoT devices (like sensor nodes) generate huge amount data to be stored in some storage device. As number of IoT devices increases, the storage requirement also increases which is also an important issue for IoT.

IoT has verity of devices. Therefore, to design a protocol architecture for IoT is a big challenge where different type of devices have different protocol requirement (reliability, scalability, processing and data transfer speed) [7]. As a result, IoT protocol architecture may suffers from performance and cost related problems. IoT is most complex mixed network platform which connect various type of devices with different commutation technology. Bandyopadhyay and Sen [8] investigated and specified that addressing, identification and optimization of protocol is a big issue in IoT communication platform.

4. Conclusion

The network congestion is major problem of Internet in each era of computer network which also continues in IoT era. The objective of IoT is to connect the huge number of devices over the Internet. As a result, if number of connected devices over the Internet increases, network congestion also increases. This paper presented a survey of various congestion control algorithms used at transport layer. IoT is having variety of devices and each device have different requirement of reliability. However, TCP (transport layer protocols) are not having such capability to offer such type elective reliability according to need of devices. Therefore, IoT need a transport layer protocol which offers congestion control, flexibility and reliability according to requirement of devices.

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Performance characteristics of a new hybrid solar cooker with air duct

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ABSTRACT

A new hybrid solar box cooker (SBC) has been developed and tested for thermal performance evaluation in climatic condition of western Uttar Pradesh, India. The uniqueness of new box cooker is an integrated trapezoidal duct and its other integrated elements. The objective of the study is to enhance the heat transfer rate and to reduce the cooking timings by consumption of minimum heat energy. For this purpose, a 200 W halogen lamp has been placed inside the duct to enhance the heat transfer. Besides this, 450 of small hollow balls of copper have also been used to improve thermal performance of SBC especially on forced convection mode. The performances testing have been carried to evaluate the thermal efficiency, figures of merit (F_1 and F_2), cooking power, heat transfer and overall heat loss coefficient. After completion of experiments, thermal efficiency of SBC has been observed 45.11%, cooking power is estimated to be 60.20 W and overall heat loss coefficient is obtained around 6.01 W/m^2 C. Results shows that the present design follow the BIS standards and can cook almost edibles in poor ambient conditions by consuming only 210 W. Discussion has also been made on the significance of the use of copper balls, fan and halogen lamp over the performance of SBC. The present solar cooker has been found as first kind of SBC which can efficiently perform on forced convection in any type of climatic conditions.

1. Introduction

Cooking is primary need of the people and a major household activity for different households. In India, fuels like; LPG, electricity, kerosene, fuel-wood and dung cakes, are generally used for cooking (Saxena et al., 2013). At present, people from different countries are attracting towards solar energy and using solar applications like; solar cookers, water heaters, solar lights etc. Besides cooking, solar cookers are also having some ecological and economic benefits such as; it saves other conventional fuels used for cooking as well as through solar cooking one can also reduce environmental pollution. Solar cooking has been introduced in 1767 in the world, while in 1876 in India. From 1767 to 2017, numerous designs of solar cookers have been successfully developed by several researchers and pioneers of the field (Saxena et al., 2010a) and some good designs are still in use, around the world. Commonly, there are two types of solar cookers; first one is a solar dish cooker, which is a concentrating type cooker and required a tracking mode for effective cooking. Second is non-concentrating cooker i.e., is a box type solar cooker. A box type cooker is simple in design (construction) and consists of an insulated blackened box carrying two to four cooking utensils, a double or triple glazing and a mirror booster (Saxena et al., 2010a,b). Previous literature on the solar cooking not only show 'the efforts and contribution of researchers' but also present the excellent use of solar energy and importance of solar cookers to save the conventional fuels as well as to keep a pollution free environment.

Besides this, it has been experimentally observed that box cookers have low thermal efficiency in comparison of dish cookers. But, some good methods or techniques are there by which one can easily improve the performance of a SBC, such as; improving the design of cooker or cooking vessel, by using some quality heat storage materials or by making them "hybrid" (a cooker which can perform on dual fuel). Some good designs of cookers (on the basis of attaining maximum T_p in low ambient conditions) are listed in Table 1. It can be seen from previous research works (Table 1) that a lot of research work have been conducted on box type solar cookers to improve the cooking efficiency or cooking power, to minimize heat losses, to reduce the cooking timings and to modify the system for performing during the off sunshine hours by using thermal heat storages or by performing on auxiliary power back up. But, there is no such type of SBC (as the present one) or no research has been conducted on forced convection in previous. This is the uniqueness of the present design of SBC that it can perform on forced convection even in poor ambient conditions or in the night, round the globe. However, Chaudhuri (1999) has been theoretically estimated the electrical backup load for a SBC but some major parameters like; cooker or vessel design, ambient conditions, optimum load range, nature of cooking substance etc., are not shown or discussed in the article.

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Nomenclature

ASAE	American society of agricultural engineers
BIS	Bureau of India standard
F_1	first figure of merit (m^2 °C/W)
F_2	second figure of merit (m^2 °C/W)
h	heat transfer coefficient (W/m^2 °C)
U_L	overall heat loss coefficient (W/m^2 °C)
U_T	top heat loss coefficient (W/m^2 °C)
U_S	side heat loss coefficient (W/m^2 °C)
U_d	duct heat loss coefficient (W/m^2 °C)
U_b	bottom loss coefficient (W/m^2 °C)
P	cooking power (W)
SBC	solar box cooker
TES	thermal energy storage
PCM	phase change material
C/S	cross-section
$\dot{m}$	mass flow (kg/s)
T	temperature (°C)
N	number of cooking vessels
m	mass of the cooking fluid (kg)
C_p	specific heat of cooking fluid (J/kg K)
ΔT	temperature difference between fluid to ambient (°C)
I	solar radiation (W/m^2)
τ_g	glass transmissivity
α_g	absorptivity of the glass
α_v	absorbitivity of the cooking vessel
A, A_{sc}	aperture area of the cooker (m^2)
A_{vb}	surface area of the lid (base) of vessel (m^2)
A_{vs}	surface area of the sides of vessel (m^2)
A_{vwf}	surface area of the vessel walls wetted by the fluid (m^2)
h_{rlug}	radiative heat transfer coefficient from lower to upper glass (W/m^2 °C)
h_{rvlg}	radiative heat transfer coefficient from vessel to lower glass (W/m^2 °C)
h_{rugs}	radiative heat transfer coefficient from upper glass to sky (W/m^2 °C)
h_{rplg}	radiative heat transfer coefficient from absorber to lower glass (W/m^2 °C)
h_{cuga}	convective heat transfer coefficient from upper glass to ambient (W/m^2 °C)
h_{clug}	convective heat transfer coefficient from lower to upper glass (W/m^2 °C)
h_{cealg}	convective heat transfer coefficient from enclosure air to lower glass (W/m^2 °C)
h_{cdea}	convective heat transfer coefficient from duct walls to air enclosure (W/m^2 °C)
h_{cpae}	convective heat transfer coefficient from absorber plate to air enclosure (W/m^2 °C)
h_{cvwea}	convective heat transfer coefficient from lateral vessel walls to enclosure air (W/m^2 °C)
h_{cvf}	convective heat transfer coefficient from vessel to cooking fluid (W/m^2 °C)

Greek letter

η	efficiency

Subscripts

a, amb	ambient
ea	enclosed air
in	input
therm	thermal
w	water
p	plate
lg	lower glass
ug	upper glass
s	sky
p	plate
v	cooking-vessel
f	cooking fluid
diw, dw	duct walls

2. Materials and methodology

In the present work, a SBC has been fabricated by local available materials for thermal performance evaluation. All the experimental testing has been carried out in Moradabad (Latitude is 28°58′N and Longitude is 78°47′E), western Uttar Pradesh. Table 1 shows some novel designs of solar cookers but the present design is quite different from all other available designs in comparison of various aspects like fast cooking response, improved thermal efficiency on forced convection and cooking power etc. The specifications of the present system are shown in Table 2. Followings are some important design considerations for present solar box cooker.

1. A aluminium made trapezoidal duct (commonly used in solar air heaters) has been designed and fabricated as a channel for forced convection. The sheet thickness was 0.2 mm.
2. The length of the duct is around 75 cm (Fig. 2b) and it contains two ends. The small end of the duct is 14 × 14 cm^2 and other end is 1.0 × 51 cm^2.
3. Small end of the duct has been closed while other end is directly connected to the front wall of SBC. For this particular, a small cross section area (1.0 × 51 cm^2) is cut from the front wall of SBC to connect the duct (Fig. 1).
4. A 10 W fan (generally used in air conditioners) has been used for forced convection and placed inside the duct nearby small end at a distance around 10 cm (Fig. 1). It is notable that the small end is completely closed.
5. A halogen lamp (200 W of Phillips™) has been placed inside the duct (Figs. 1 and 2c) to produce a high flux to enhance heat transfer rate inside the solar cooker (discuss in upcoming sections).
6. Apart this, 450 (copper made) hollow balls of 4 mm diameter (approximated) have been placed on the absorber tray of SBC to act like a lug for cooking vessels and improve the heat transfer rate because of higher thermal conductivity (Fig. 1) for fast cooking (Richardson, 1997). The total weight of the balls is 1.98 kg. Although the solid spheres can also be placed but the system will take much time to attain the steady state.

For experimentation, total four different configurations have been developed to the present system. In first case, the system has been tested for stagnation (1st configuration) and sensible testing (2nd configuration) by using copper made balls inside SBC (spread on absorber tray). Testing has been carried out only on natural convection through radiant energy by the sun in first two configurations. In 3rd and 4th configuration, a especially designed duct is used for forced convection and for supplying hot air to the cooking chamber. It is remarkable that a fan and a halogen lamp have been placed inside the duct for enhancing heat transfer rate and to reduce the cooking time. Because the duct has reflective walls from inside, the air inside the system attained a high range of temperature due to high flux generated by halogen lamp that has been placed inside the duct (Fig. 2c). Figs. 1 and 2(a–c) shows the schematic and experimental diagram of the

Table 1
Some novel designs of previous developed hybrid solar box cookers.

Reference	Design	Results
Hussain et al. (1997)	A hybrid SBC integrated with a built-in heating coil (150 W) inside the SBC or a retrofit electric bulb in blackened cylinder	F_1 (0.17) and F_2 (0.32) was found as per standard and cooking was possible in cloudy season
Chaudhuri (1999)	A simple designed SBC with BIS was tested	Electrical load was estimated around 160 W for standard cooking
Oturani et al. (2002)	A modified movable SBC with TES (engine oil) and two reflectors was tested	Cooking efficiency was improved and observed around 42%
Rao and Subramanyam (2003)	A cooking vessel along with lids was designed for improving the heat transfer process to the food. Levitation the vessel by providing a few lugs will make the bottom of the vessel a heat transfer surface	This modification improves the performance of the SBC by improving the heat transfer rates. The times to reach saturation temperature and cooking were remarkably reduced
Nandwani (2007)	A multi-purpose hybrid solar food processor was designed and tested. The electrical energy was not estimated	The effective efficiency was estimated around 24%. The system was feasible for cooking, drying and distillation
Kurt et al. (2008)	Two different models of SBC for rectangular and cylindrical geometries were constructed tested for different load to investigate the effects of box geometries on the cooker performance	The η was observed around 36.98% for the cylindrical model and 28.25% for the rectangular model with reduced cooking time. The cylindrical model was found better
Saxena et al. (2010b)	A BIS standard SBC along with a modified cooking vessel (lugs in a curvature form) was tested to improve heat transfer.	Cooking power was increased up to 79.80 W and cooking time was reduced up to 30 minutes
Misra and Aseri (2011)	The SBC consists of an 8 V, 0.33A DC fan inside the cooker for forced convective environment through a solar PV panel	F_1 and F_2 was found as per standard and cooking time was reduced by 30.6%
Rao et al. (2001)	A conventional SBC was tested for three types of cooking vessels, i.e. conventional vessel, vessel with central annular cavity and vessel with rectangular fins in the central annular cavity (to increase the heat-transfer rate to the cooking vessel)	The hot-air circulation through the annular cavity with fins improves the heat transfer between the water and vessel as well as reduction in cooking times. The cooking vessel placed on lug helps to increase the heat transfer
Saxena et al. (2012)	A simple designed SBC was modified and tested with sand and granular carbon as thermal heat storage mediums	F_1 and F_2 met to standard, cooking time was reduced and SBC was feasible for late hours cooking
Cuce and Cuce (2013)	Two SBCs with ordinary and finned absorber plates were theoretically investigated for thermodynamic performance evaluation	η and η_{ex} of SBCs were plotted versus time for different cases. Some recommendations were made to enhance the power outputs of SBCs
Sethi et al. (2014)	An inclined SBC was tested along with a new designed parallelepiped shaped cooking vessel for improved heat transfer	Figures of merit for the model-1 were estimated as 0.16 & 0.54, respectively. As compared to 0.14 & 0.43 for model-2. 'P' was 37% less and 40% more respectively in parallelepiped shaped cooking vessel of inclined cooker as compared to conventional cooker
Geddam et al. (2015)	A simple designed SBC was tested with two a TES and different cooking vessels for various parameters for optimum load	F_1 and F_2 indicate that the SBC can be used for consecutive cooking on a sunny day for the largest cooking load
Joshi and Jani (2015)	A small capacity hybrid SBC was developed with the help of 75 W of solar PV panel was tested for performance	η of improved IS-SBH was around 38% and estimated cost was around ($120)
Esen (2004)	A solar cooker was integrated with vacuum-tube collectors and heat pipes filled with refrigerant	Three different refrigerants (R-134a, R-407C & R-22) were used along with water inside the system among which R-407C was found more efficient to reduce the cooking times
Sharma et al. (2005)	A prototype solar cooker with evacuated tube solar collector filled with PCM (erythritol)	By using PCM inside the solar cooker, evening cooking was also possible under the climatic conditions of Japan
Hussein et al. (2008)	An indirect type solar cooker with outside elliptical C/S, wickless heat pipes and flat-plate collector which performs on PCM	Magnesium nitrate hexahydrate improves the late hours cooking. The unit can be used for heating or keeping food hot at late night.
Kumar et al. (2010)	A truncated pyramid geometry type non-tracking multipurpose solar cooker	Two figures of merits F_1 and F_2 were estimated for the values 0.117 °C m^2/W and 0.467 °C m^2/W. The design meets to BIS standards for SBC
Panwar et al. (2010)	A masonry animal feed solar cooker made of bricks, glass covers, cement & a mild steel collector plate	The η of cooker varies between 1.12% and 29.78%, and the exergy efficiency varies from 0.07% to 1.52% during the same period
Harmim et al. (2012)	A new box-type solar cooker equipped with an asymmetric compound parabolic concentrator	The experiments conducted in winter and summer seasons, showed a successful performance of a laboratory cooker model. The performance was rated by using the figure of merits, F_1 = 0.1681 and F_2 = 0.35, respectively.
Singh et al. (2014)	A solar cooker with inbuilt TES unit was connected to evacuated tube collector via connecting pipes	Water and engine oil were used as a heat transfer fluid while acetanilide was used as PCM. The cooker was found feasible for cooking in the evening
Soria-Verdugo (2015)	A simple SBC with BIS standards	Study of SBC reveals that the convective coefficients of heat transfer model were as 12 W/m^2 K for absorber to the interior air, 3 W/m^2 K for the interior air and interior wall surfaces and 4.5 W/m^2 K for external convection between the walls and atmosphere
Mahavar et al. (2017)	A solar cum electric cooker has been developed and tested with introducing a new testing parameter for SBC	The cooker was feasible to cook the food within 80 minutes on power back-up (about 170 W)
Saxena and Karakilcik (2017)	A simple SBC with low cost sensible heat storage medium	The experiments conducted in summer seasons, showed a successful cooking program. The performance was rated by using the figure of merits, F_1 = 0.13 and F_2 = 0.44, respectively. Efficiency was found as 37.1%

present system. There is no power consumption in first and second configuration. In third and fourth configuration, total 210 W (200 W of lamp + 10 W of fan operated on A.C. mains) has been consumed for forced convection. This unique feature makes the system 'hybrid' and permits the system for a year round efficient cooking in poor ambient conditions, round the globe.

Apart this, to fix the location of the lamp, a halogen lamp of 100 W has been used and placed inside the duct at different locations from four to five times to attain a maximum fluid temperature. Finally, the lamp is located at around 41 cm from the opening end (i.e., 34 cm away from the cooker's C/S). At this distance, the maximum inside air temperature is noticed around 71.5 °C of SBC during the off sunshine hours, while the temperature inside the duct is around 109 °C. In this configuration some heat losses are observed due to bare surface of the duct. To overcome this problem, the duct has been insulated by a thin elastomeric closed cell foam insulation sheet (generally used in HVAC systems) to minimize the heat losses (Fig. 1). But, still the achieved temperature is not appropriate for a fast cooking response. Therefore, a

Table 2
Specifications of the solar box type cooker (without modification).

Dimensions of outer box	640 × 640 × 200 mm^3
Material for outer casing of SBC	Fibre
Aperture area	485 × 515 mm^2
Glazing	522 × 548 mm^2
Depth of the tray from glazing	80 mm
Emissivity of absorber plate (Al made and blackened)	0.90
Thickness of absorber plate	0.60 mm
Thickness of glass covers	2 mm
Spacing in between glazing (double glazed)	10 mm
Emissivity of the glass	0.91
Insulation	Glass-wool
Thermal conductivity of insulation	0.05 W/m °C
Thickness of insulation from all sides	50 mm
Cooking vessel height (Al made and blackened) and diameter	65 mm and 160 mm
Mirror booster	522 × 548 mm^2

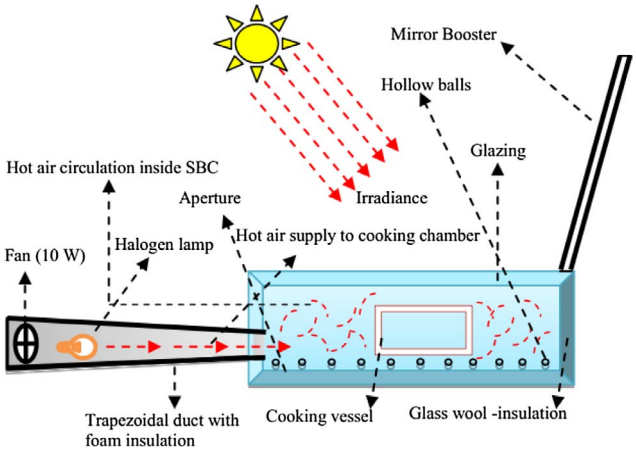

Fig. 1. Schematic diagram of the modified SBC.

200 W halogen lamp was considered for the same purpose. At this time, the maximum inside air temperature is noticed around 111 °C of the SBC during the off sunshine hours, while the temperature inside the duct is around 167 °C. It is notable that the T_{amb} has been noted around 26.1 °C at the same time.

If one can talk about the role of copper balls in present experiments than it is notable that these small balls worked as 'lugs' for cooking vessels in case of natural or forced convection cooking. In natural convection operation, all small copper balls became hot being in contact of direct irradiance and conduction through both the side walls and absorber tray. Apart this, when the cooking vessel is kept on small copper balls, the circulation of hot air between bottom of cooking vessel and the base of SBC improves convective heat transfer to the cooking substance inside cooking vessel, since the effective area by which heat is transferred to the cooking substance has been increased significantly. Therefore, the cooking time is observed to be reduced during the cooking of different edibles (Table 5). The air tightness has also been assessed by measuring water mass before heating and after heating. It has also been observed that there is approximately 16% loss in mass of water due to evaporation in 08 hours duration (from 09:00 am to 05:00 pm).

Overall, following efforts have been made in the present work;

(i) To improve heat transfer rate of the cooking system
(ii) To enhance η of the present cooking device
(iii) To make an efficient solar cooker for cooking in low ambient conditions
(iv) To make an solar cooker for a continuous and un-interrupted cooking
(v) To make an efficient solar cooker for cooking different edibles, round the globe

For experimentation, one kg of fresh water has been considered as a cooking substance. All experiments have been conducted for a stagnation testing (no load condition) and sensible testing (on load condition) for both the configurations of SBC. All the necessary performance parameters such as; thermal efficiency, cooking power, figures of merit, heat transfer coefficient, overall heat loss coefficient has been calculated through experimentation with the help of following equations mentioned in upcoming Section 3 (Saxena et al., 2010a; Garg and Prakash, 2009).

Besides this, variation in temperatures has been measured by using an array of 06 sensors (K-type) thermocouple meter with an accuracy of ± 1 °C. A commonly used device 'Suryamapi' (CEL-201™) with accuracy of 1 W/m^2 has been used to measure irradiance (W/m^2). The wind velocity (m/s) is monitored through an anemometer with accuracy of 1%. The measured variables are recorded at time intervals of 20 min as per ASAE standard (ASAE S580, 2003) (and discussed on an hourly basis of actual reading values). The experiments have been conducted at a fixed flow rate i.e., 0.28 kg/s. All measuring devices/instruments have been checked properly for an error before conduction of experimentation. All experiments have been started at 11:20 h and finished at 13:20 h.

3. Theory and analysis

The schematic diagram (Fig. 3) shows the heat transfer mechanism for hybrid box cooker. They energy balance equations are written for the different components of solar cooker which includes upper and lower glass covers, enclosed air, absorber tray, cooking vessel and cooking fluid. Following assumptions are made for modelling, as follows;

1. Heat capacities of air enclosure, cooking vessel, glass covers and insulation are negligible
2. The components temperatures are uniform but depend upon ambient conditions (i.e., with change in ambient conditions, a change in components temperature is possible)
3. Reflectivity of the glass is neglected
4. Solar irradiance absorbed by the air enclosure and that received by the vessel's wall inside the cooker is negligible
5. No temperature change across the cooking vessel and glass cover
6. There is an identical temperature distribution with in fluid by time 't'.

Energy balance equations for;
For the upper glass

$$I_{in}\alpha_g A_{sc} + (h_{rlug} + h_{clug})\cdot A_{sc}(T_{lg} - T_{ug}) = h_{rugs}\cdot A_{sc}(T_{ug} - T_s) + h_{cuga}\cdot A_{sc}(T_{ug} - T_{amb}) \quad (1)$$

For the lower glass cover

$$I_{in}\tau_g\alpha_g A_{sc} + h_{rplg}(A_{sc} - N\cdot A_{vb})(T_p - T_{lg}) + h_{vlg}\cdot N\cdot(A_{vs} - A_{vb})(T_v - T_{lg}) + h_{cealg}\cdot A_{sc}(T_{ea} - T_{lg}) = (h_{rlug} + h_{clug})\cdot A_{sc}(T_{lg} - T_{ug}) \quad (2)$$

For the enclosed air

$$h_{cdea}\cdot(A_{sc} - N\cdot A_{vb})(T_{dw} - T_{ea}) + h_{cpea}(A_{sc} - N\cdot A_{vb})(T_p - T_{ea}) + h_{cvwea}\cdot N(A_{vs} - A_{vb})(T_v - T_{ea}) = h_{cealg}\cdot A_{sc}(T_{ea} - T_{lg}) \quad (3)$$

For the absorber tray (here, the total aperture area (A_{sc}) is submission of cross-section area of copper ball and area of absorber tray)

(a)

(b)

(c)

Fig. 2. The SBC and its components (a) experimental set-up, (b) modified duct and (c) halogen lamp inside the duct.

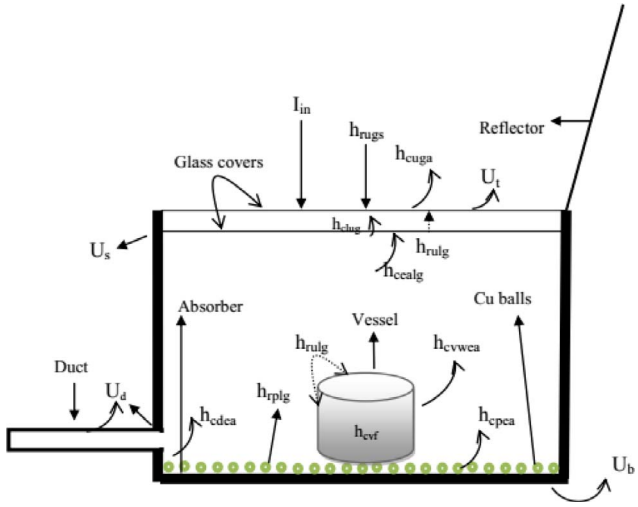

Fig. 3. Heat transfer mechanism of solar cooker.

$$I_{in}\tau_g^2\alpha_p(A_{sc}-N\cdot A_{vb}) = h_{rplg}\cdot(A_{sc}-N\cdot A_{vb})(T_p-T_{lg}) + h_{cdea}(A_{sc}-NA_{vb})(T_{dw} - T_{ea}) + h_{cpea}\cdot(A_{sc}-NA_{vs})(T_p-T_{ea}) + U_b\cdot A_{sc}(T_p-T_{amb}) \quad (4)$$

For the cooking vessel

$$I_{in}\tau_g^2\alpha_v A_{vb}N + U_b N\cdot A_{vb}(T_p-T_v) = h_{cvf}\cdot N\cdot A_{vf}(T_v-T_{vf}) + h_{rvlg}\cdot N(A_{vs}-A_{vb})(T_v-T_{lg}) + h_{cvwea}\cdot N\cdot(A_{vs}-A_{vb})(T_v-T_{ea}) \quad (5)$$

For the cooking substance

$$h_{cvf}\cdot N\cdot A_{vwf}\cdot(T_v-T_f) = m\cdot C_p\cdot\Delta T \quad (6)$$

After substituting the values of the temperature of glass cover, plate and ambient temperature as per assumptions from Eqs. (1)–(4) in Eq. (5), this can be re-written as

$$\frac{dT_f}{dt} + aT_f = f(t) \quad (7)$$

By using initial condition, $T_f = T_{f0}$ at $t = 0$, Eq. (7) can be re-written as

$$T_f = \frac{\overline{f(t)}}{a}(1-e^{-at}) + T_{f0}e^{-at} \quad (8)$$

[where ***a*** is constant and depends on different heat transfer coefficients].

Now, with the help of 1st law of thermodynamics and energy balance equations for the box cooker (Saxena et al., 2010a), energy input can be estimated as:

$$E_{in} = I_{avg}\cdot A_{sc} \quad (9)$$

While, the energy output (on load conditions) for the SBC can be estimated through Eq. (2), as:

$$E_o = \frac{m_w C_{p-w}(T_{wf}-T_{if})}{t} \quad (10)$$

where 't' is the time in seconds to reach final temperature (T_{wf}) from initial temperature (T_{if}), I_{avg} is the value of global solar radiation perpendicular to solar collector and A_{sc} is aperture area of SBC facing the sun (assumed perpendicular in this equation). 'm_w' is mass of water in cooking vessel.

Now, having the value of above parameters in Eqs. (9) and (10), one can easily estimate the value of thermal energy efficiency of the present system by:

$$\eta = \frac{m \cdot C_p \cdot \Delta T}{t \cdot I_{avg} \cdot A_{ap}} \tag{11.a}$$

But in the present case, an additional flux (I_L) is available through halogen lamp then Eq. (11.a) becomes

$$\eta = \frac{m \cdot C_p \cdot \Delta T}{t \cdot (I_{avg} + I_L) \cdot A_{ap}} \tag{11.b}$$

Along with this, the cooking power has been estimated by Saxena et al. (2010a):

$$P_{sbc} = m \cdot C_p \frac{(T_{wf} - T_{iw})}{600} \tag{12}$$

Eq. (12) is divided by 600 to account for the number of seconds in each 10 minutes interval as per recommendation (Saxena et al., 2010a).

In case of FPCs, water is working fluid inside the tubes at different temperatures and readings are noted in steady state to obtain the heat loss factor, experimentally. While, in the case of SBC there is no control over the temperature and obviously the operation is in transient state. Once the stagnation is attained, the quasi-steady state is maintained (Mullick et al., 1987). The energy balance for a SBC under no load conditions at quasi-steady state or stagnation is

$$\eta_o \cdot I_{in} = U_L (T_p - T_{amb}) \tag{13}$$

where η_o and U_L are the optical efficiency and the heat loss factor, respectively. These two parameters are desirable for a low value of heat loss and a high optical efficiency for efficient performance of solar cooker and serve as a figure of merit for thermal performance for SBC (Mullick et al., 1987; Tiwari, 2008). This figure of merit is termed as first figure of merit and can be expressed as;

$$F_1 = \frac{\eta_o}{U_L} = \frac{(T_p - T_{amb})}{I_{in}} \tag{14}$$

The second figure of merit can be obtained through the sensible heating test of water up to 100 °C. Assuming the time interval 'dt' is required to raise the temperature 'dT_w' of 'M' mass of water of specific heat capacity 'C_p' and given by;

$$dt = \frac{(m \cdot C_P)'_w \cdot dT_w}{Q_u} \tag{15}$$

where Q_u is the rate of net heat gain by water and $(m \cdot C_p)'_w$ is the heat capacity of the water including cooking vessel. If the 'Q_u' can be defined as net heat gain and 'A' is the cooker surface area and F′ is the heat exchange factor then

$$dt = \frac{(m \cdot C_P)'_w \cdot dT_w}{AF' [\eta_o \cdot I - U_L (T_w - T_a)]} \tag{16}$$

Now, substituting the value of first figure of merit for ratio of η_o/U_L, Eq. (16) can be re-written as;

$$dt = \frac{(mC_P)'_w \cdot dT_w}{A \cdot F' \cdot \eta_o \left[I - \frac{1}{F_1}(T_w - T_a) \right]} \tag{17}$$

Now, assuming the ambient temperature and solar insolation to be constant and the Eq. (17) is integrated over the time 't' which is required to raise the water temperature from T_{w1} to T_{w2}.

$$\Rightarrow \quad t = \frac{-F_1 (m \cdot C_P)'_w}{A \cdot F' \cdot \eta_o} In \frac{\left[I - \frac{1}{F_1}(T_{w2} - T_a) \right]}{\left[I - \frac{1}{F_1}(T_{w1} - T_a) \right]} \tag{18}$$

In the above Eq. (18), the time 't' is not a exclusive property of solar cooker (depends upon ambient conditions-irradiance and ambient temperature) then it can be re-written to obtain the expression for $F'\eta_o$ (a cooker parameter) as follows;

$$F'\eta_o = \frac{F_1 (m \cdot C_P)'_w}{A \cdot t} \mathrm{In} \frac{\left[1 - \frac{1}{F_1}\left(\frac{T_{w1} - T_a}{I}\right) \right]}{\left[1 - \frac{1}{F_1}\left(\frac{T_{w2} - T_a}{I}\right) \right]} \tag{19}$$

However, the value of $F'\eta_o$ can't not be evaluated since the value of $(m \cdot C_P)'_w$ is not known (Mullick et al., 1987). Therefore by introducing the heat capacity ratio (CR = $\{(m \cdot C_P)_w/(m \cdot C_P)'_w\}$ an additional cooker parameter, Eq. (19) can be re-written as;

$$F'\eta_o C_R = \frac{F_1 (m \cdot C_P)_w}{A \cdot t} \mathrm{In} \frac{\left[1 - \frac{1}{F_1}\left(\frac{T_{w1} - T_a}{I}\right) \right]}{\left[1 - \frac{1}{F_1}\left(\frac{T_{w2} - T_a}{I}\right) \right]} = F_2 \tag{20}$$

The value of cooker parameter $F'\eta_o C_R$ can be estimated by Eq. (20) since the heat capacity of cooking substance is known. This new parameter serves as the second figure of merit (F_2) for SBC.

[where T_{wi} is the water temperature at state 1 (at starting), T_{wf} is the water temperature at state 2 (final temperature]

Now, heat transfer coefficient can be obtained by relationship given by Duffie and Beckman (2012):

$$h = \frac{Q_U}{A_p (T_p - T_f)} = \frac{\tau \cdot I_{avg} \cdot A_p}{A_p (T_p - T_f)} \tag{21}$$

Overall heat loss coefficient has been calculated by using following equation (Channiwala and Doshi, 1989)

$$U_L = \left[\frac{2.8}{\frac{1}{\varepsilon_P}\left(\frac{1}{N_c^{0.025} + \varepsilon_c} - 1\right)} + 0.825 (x_m)^{0.21} + a V_{win}^b - 0.5 (N_C^{0.95} - 1) \right] (T_{pm} - T_{amb})^{0.2} + \frac{k_i}{t_i} \tag{22}$$

where T_{pm} is the mean plate temperature, N_c is number of glazing, V_{win} is wind velocity, a and b is constant, $\varepsilon_p = 0.85$ and $\varepsilon_c = 0.81$ (Duffie and Beckman, 2012) is emissivity of the plate and glass cover, respectively and k_i is thermal conductivity of insulation (0.041 W/m·K) (Garg and Prakash, 2009) while, t_i is the thickness of insulation.

4. Results and discussion

All the experiments have been conducted in the month of June 2017 on four different sunny days at Moradabad. Water has considered as a cooking substance for load conditions. The set-up has been installed at the place of conduction of experiments at 11:00 h, while the reading is taken from 11:20 to 12:20, after attaining a steady state condition by the system (Mullick et al., 1987). It has been noticed that the present system achieve the maximum temperature (around 12:20 h) after one hour of starting of experimentation (this satisfy BIS standard for solar cookers).

It is also notable that the present system has been kept under observation up to 13:20 to observe thermal behaviour and significance of design parameters over the ambient parameters. After successful completion of experimental testing of new SBC, some edibles have also been cooked in the present solar cooker to monitor the time taken in cooking and for an optimum load range of cooking substance (in kg), which has been shown in Table 5. Although, it is notable that BIS standard has not been developed any standard for hybrid solar box cookers, but in the present investigation two figures of merit (F_1 and F_2) has been considered for testing of the present system.

4.1. Testing of SBC on first configuration

As seen in Fig. 4, on 1st June 2017, the stagnation test (no load condition) has been carried out on first configuration, in which 450 hollow blackened balls (4 mm diameter) of copper are spread on the absorber tray. The system has been placed southward for conduction of experiments at 11:00 h and T_{amb} is notified around 34 °C. The first reading has been taken at 11:20 h and T_{amb} is measured around 37.8 °C at this time, while irradiance is measured to be 710 W/m^2.

At 12:20 h, T_{amb} has been observed 41 °C and T_p is reached up to a maximum value of 136 °C. Irradiance is notified around 810 W/m^2 at that time. The first figure of merit (F_1) has been found within specified standard i.e., 0.12 m^2 °C/W (Kumar et al., 2010). At finishing of experiments (around 13:40 h), T_p is around 122 °C and T_{amb} is 37 °C. The temperatures of the plate of SBC generally increase with incident solar energy per unit inner surface area of SBC. There is heat loss from inner zone of SBC and this is largest in the plate which affects cooking performance directly and drastically. In order to improve the performance and increase the efficiency, one should minimize the losses appropriately.

4.2. Testing of SBC on second configuration

The sensible testing has been carried out on the load conditions (on 02.06.2017), for which 1 kg of fresh water is considered as cooking substance. The water is kept in four similar cooking vessels for an equal quantity i.e., 250 grams in each cooking vessel (total load 1 kg). Again the experiments have been started at 11:00 h, when T_{amb} is around 34.5 °C. The first reading is taken at 11:20 h. At this time T_{amb} and T_p are noticed around 36 °C and 104 °C, respectively and irradiance is observed as 675 W/m^2. In this configuration, T_p is reached up to a maximum value of 143 °C at 12:20 h and T_w has been observed around 97 °C, maximum.

The second figure of merit (F_2) has been estimated for a value of 0.41 m^2 °C/W. Maximum thermal efficiency (η) is notified around 38.1% at 12:20 h. The cooking power of SBC has been estimated for 55.31 W at the same time. Heat transfer coefficient was obtained around 34.51 W/m^2 °C and the overall heat loss coefficient has been estimated 5.10 W/m^2 °C. In the present experiment, minimum value of the temperature of cooking substance has been observed 89.2 °C at 11:00 h, while maximum value is around 97 °C at 12:20 h. It is notable that the minimum value of the hot water is 89.2 °C in the present case which is more than water pasteurization value. Therefore, it can be said that the cooking is safe at this configuration. Figs. 4 and 5 show the performance curves of first and second configuration for stagnation and sensible testing, respectively.

4.3. Testing of SBC on third configuration

Now, for forced convection operation, the present system has been again modified by attaching a trapezoidal duct carrying a lamp of 200 W inside it (Fig. 1). The cooker has been tested on 04.06.17 on the third configuration for stagnation testing i.e., the system is operated on forced convection without any load. The absorber plate carries copper made balls alike in previous experimentations to collect a maximum heat gain from solar energy and to be performed as lugs for cooking vessels. The pre-hot air (around 110.70 °C at T_{amb} = 30 °C) is supplied to the cooking chamber through a special designed duct. The entire system has been properly closed during the experimentation to avoid thermal losses.

As seen in Fig. 6, on 4th June 2017, the stagnation test (no load condition) has been carried out on third configuration for a improve heat transfer rate. The system has been placed southward for conduction of experiments. The first reading is taken at 11:20 h, when T_{amb} is around 37 °C and irradiance has been measured around 705 W/m^2. The duct inside wall temperature is found to be 166 °C. The plate temperature (T_p) and temperature of the enclosed air of SBC are measured around 111 °C and 105 °C, respectively. After one hour (at 12:20 h), T_{amb}, T_p and T_{ea} are noticed to be increased for 39 °C, 132 °C and 114 °C, respectively. The first figure of merit (F_1) is estimated for 0.12 m^2 °C/W. The last reading showed the value of T_p around 122 °C, when the ambient temperature is 34 °C.

4.4. Testing of SBC on fourth configuration

On the next day (05.06.17), the present system has been operated on fourth configuration to perform sensible testing. Experiments are repeated by considering 1 kg of water as a cooking substance (in four cooking vessels for an equal quantity i.e., 250 g in each vessel). The absorber plate carries copper made balls as in previous cases. The pre-hot air (around 111.5 °C) is supplied to the cooking chamber through the duct to enhance heat transfer and cooking efficiency. All small balls achieved a high temperature in comparison of stagnation testing. In this configuration, all the small hot balls of copper generated a current of the hot air inside SBC. The circulation of this hot air remains un-interrupted because a regular supply of the hot air through the duct, which results in enhance cooking efficiency and obviously a reduced cooking time. The heat transfer has been improved through circulation of the hot air inside SBC. The heat energy reached to the cooking substance via conduction to the side walls and bottom of cooking vessel, while directly by convection through the circulation of hot air inside the cooking system and also through solar radiant energy.

The experiments are started at 11:00 h, when T_{amb} is around 31.5 °C.

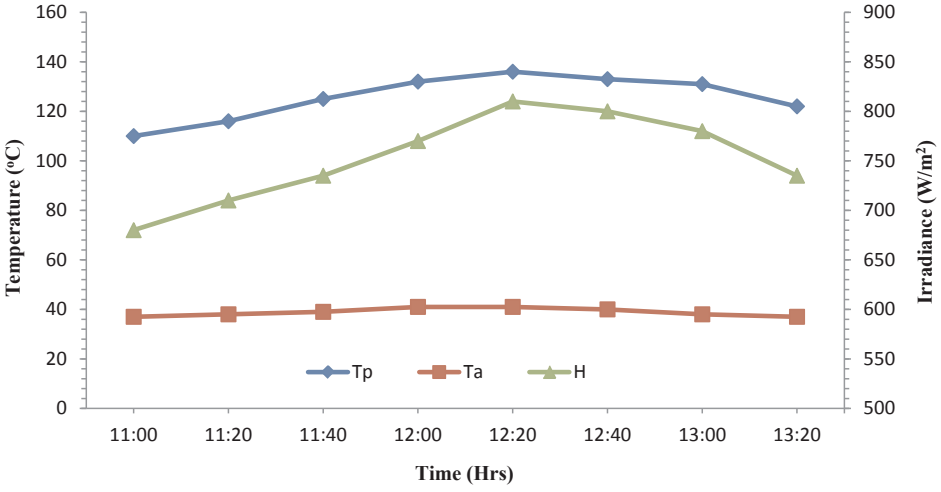

Fig. 4. Stagnation testing of new SBC on configuration 1.

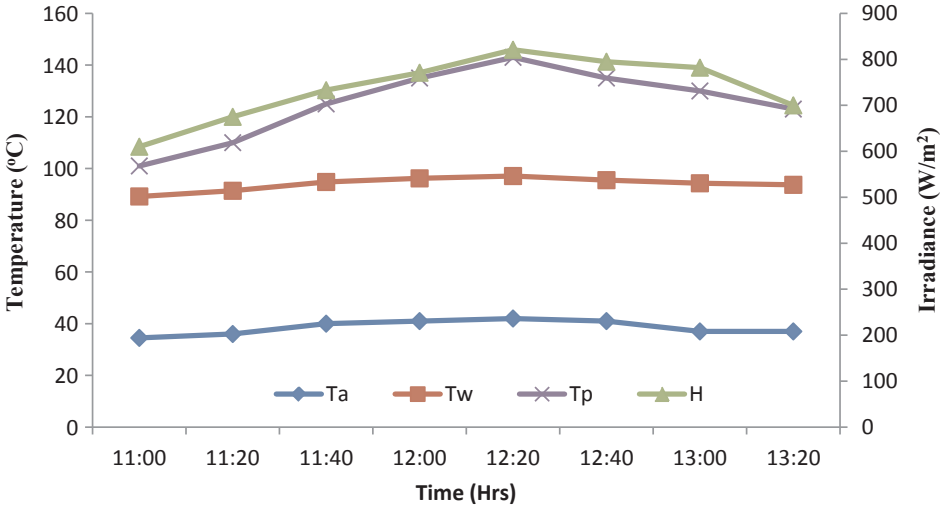

Fig. 5. Sensible testing of new SBC on configuration 2.

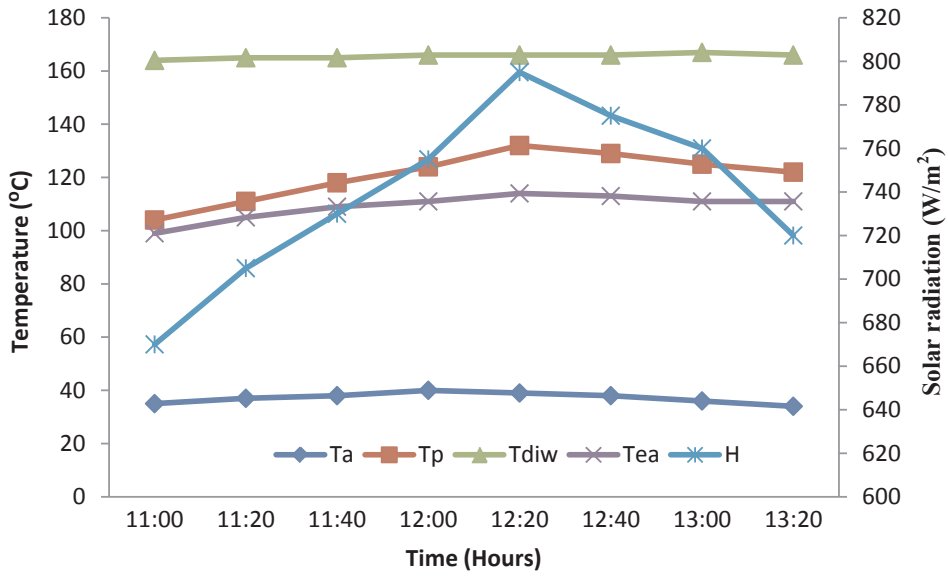

Fig. 6. SBC tested on 04.06.17 on the third configuration for stagnation testing.

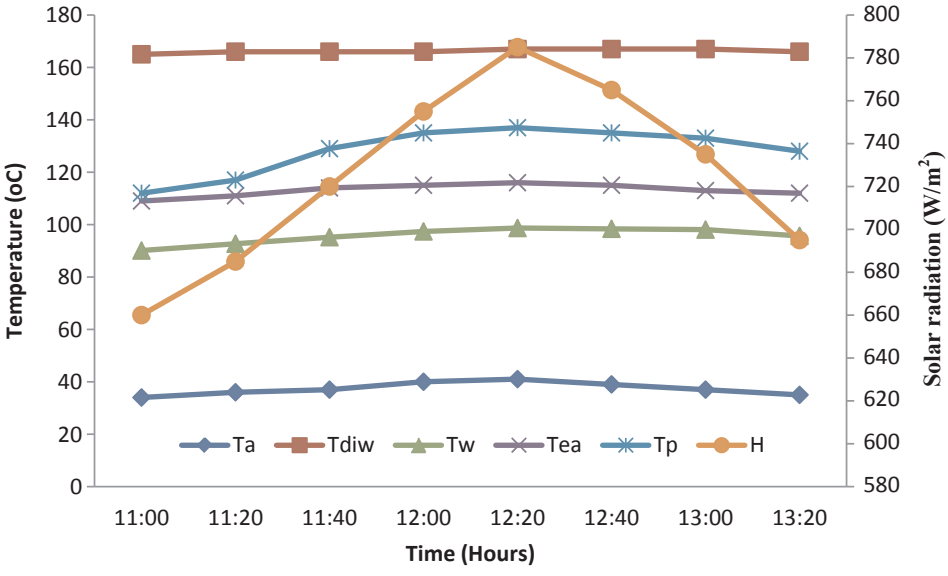

Fig. 7. SBC tested on 05.06.17 on the fourth configuration for thermal load.

The duct inside wall temperature has been found around 165.5 °C. The first reading is taken at 11:20 h when, T_{amb}, T_p, T_w and T_{ea} are around 36 °C, 117 °C, 92.7 °C and 111.5 °C, respectively. The solar irradiance is notified around 685 W/m^2. After one hour, the ambient air temperature and irradiance are reached up 41 °C and 785 W/m^2, respectively, while T_p and T_w are reached up to a maximum value of 137 °C and 98.7 °C, respectively. The second figure of merit (F_2) is estimated for 0.46 m^2 °C/W. Thermal efficiency (η) has been calculated maximum as 45.11% at 12:20 h, while the minimum value is observed 41.9% at starting of the experiments at 11:20 h. The cooking power of SBC is estimated for 60.21 W. Heat transfer coefficient is estimated around 46.86 W/m^2 °C and overall heat loss coefficient is obtained 6.01 W/m^2 °C. In the present experiment, minimum temperature of the cooking substance is observed 90.12 °C at 11:20 h, while maximum temperature is around 98.7 °C at 12:20 h. The temperature of the enclosed air of cooking chamber has been observed around 116 °C (maximum). The last reading shows the value of T_p around 128 °C, when T_{amb} is 35 °C. It is notable that the minimum temperature of the water is 90.1 °C which is better than previous configurations. Figs. 6 and 7 show the performance curves of third and fourth configurations for stagnation and sensible testing.

Apart this, the fourth configuration of present design has been observed better among all the configurations especially in comparison of second configuration (on sensible heating). At the fourth configuration, the efficiency of SBC is found to be improved by more than 7% and heat transfer coefficient is improved for more than 12% over the second configuration. This is because of the duct used for forced convection. The enclosed air increase the heat transfer rate (due to additional flux from the lamp) and provide a better cooking mode by reducing the cooking time. The water temperature has been observed near to be boiling temperature with increased cooking power (60.21 W) of solar cooker on fourth configuration.

Besides this, energy balance equations are solved by preparing a computer program and the estimated parameters has been shown in table 3. The convective and radiative heat transfer coefficients have been estimated with the help of equations presented by El-Sebaii et al. (1994).

Apart this, in order to perform uncertainty analysis of performance parameters, experiments have been repeated on the next day (06.06.2017) from 11:00 to 13:20 h. The uncertainty of different parameters is shown in Table 4. It has been found that the uncertainty at 95% level of confidence was ± 0.96% for thermal efficiency.

After successful experimentation of the present system, the system has been tested for some common edibles by cooking them on different days as well as for optimum load. Table 5 shows the various cooking loads and time taken by the cooker (fourth configuration). It also shows that the present system achieved the boiling temperature in a short span of time with respect to other models as well as feasible to cook a variety of edibles with reduced cooking times. It is notable that previous models of solar cookers (Hussain et al., 1997; Chaudhuri, 1999; Oturani et al., 2002; Rao and Subramanyam, 2003; Nandwani, 2007; Kurt et al., 2008; Misra and Aseri, 2011; Rao et al., 2001; Saxena et al., 2012; Cuce and Cuce, 2013; Sethi et al., 2014; Geddam et al., 2015; Joshi and Jani, 2015; Esen, 2004; Sharma et al., 2005; Hussein et al., 2008; Kumar et al., 2010; Panwar et al., 2010; Harmim et al., 2012; Singh et al., 2014; Soria-Verdugo, 2015; Mahavar et al., 2017) either performs on a quality thermal heat storage (sensible and latent) or direct electrical back-up for possible cooking. Although, evening cooking (for light stuffs only) is possible on a SBC by using PCM but it is a slow process and due to absence of solar irradiance or electrical back-up it could not be a long term process. This will work until the PCM gets completely discharge (i.e, 1–2 h only). There are few articles that demonstrate thermal performance improvement by improving the design of solar cooking unit or cooking vessels (Oturani et al., 2002; Rao and Subramanyam, 2003; Nandwani, 2007; Kurt et al., 2008). But the present improved design of solar cooker is better in terms of overall year round performance and can be efficiently used at any location of the world.

The quality of cooked food has also found good. It was totally safe and healthy. Another major benefit of the present design is that it can be functioned like a microwave oven to warm the cooked food during the off sunshine hours or night. For this, the present SBC has to be performed on forced convection by closing its lid (i.e., top cover with mirror booster), than it will act like a close chamber. The enclosed hot air with a temperature around 110 °C will keep the food hot inside the SBC. It is notable that a microwave oven consume around 1–1.5 kW of electricity for the same.

Although electrical backup solar cookers are a good option but the present design meets to consumer pattern of cooking. In the present work, the duct, fan and halogen lamp plays an important role in heat transfer. Here, forced convection has been created by using a fan of 10 W. This fan has been controlled in such a way that it blows the air for a minute and then stops for next 03 minutes. This cycle is continuously repeated for the smooth conduction of all the experiments. The fan blow the air which carry heat energy of halogen lamp inside the cooking cabinet through convection (which is an efficient method of heat transfer) and light from the lamp generates the artificial flux which is an add on to the direct exposure of sun energy and this results in efficient cooking. A convection cooking unit heats the food much quicker in comparison of an ordinary electric type cooker because there is a fan that blows the hot air around and this reduce the cooking times by 20%, compared with electric cookers. So, in the present design, a better heat transfer takes place through radiation, conduction and convection which results in efficient cooking within specified time while electric type cooker deals with conduction and convection (convection is not much high) only and therefore take much time for cooking in comparison of present system.

Overall, the concept of forced convection in solar box cooker has successfully assessed. By this design one can easily minimize the time spend in cooking as well as to keep the food hot after cooking. The use of trapezoidal duct is considerable as a key component for fast thermal response of solar cooker at forced convection mode and can't be neglected. Besides this, the same unit can also be considered a small capacity multipurpose solar cooker cum air heater for winters which can cook the food as well as provide the hot air in small rooms. One can get easily the hot air to the surrounding if the lid of the cooker is partially opened.

Overall, this is the first kind of solar box type cooker which performs on forced convection and feasible to cook almost types of edibles in poor ambient conditions by consuming only 210 W. Although BIS has not specified any standard for hybrid solar cooker but yet the present system follow the standard of BIS and therefore can be considered as a standard solar cooking device. It is also notable that some of the solar box type cookers with electrical backup existing in the Indian market had been evaluated in SPRERI (Evaluation of Solar Box Cooker with Electrical Backup, 1998). They have a power rating of 250–500 W and the present system is within this specified range.

5. Conclusion

A new type of solar box cooker has been designed and fabricated.

Table 3
Estimated values of some important parameters.

Parameters	Value (W/m^2 °C)	Parameters	Value (W/m^2 °C)
h_{rlug}	7.1	h_{cealg}	14.6
h_{rvlg}	9.2	h_{cdea}	31.1
h_{rugs}	5.9	h_{cpae}	16.9
h_{rplg}	9.8	h_{cvwea}	27.3
h_{cuga}	11.7	h_{cvf}	451.3
h_{clug}	5.5	–	

Table 4
Uncertainty of some major performance parameters.

Sr. No.	Parameters	Uncertainty
1	Solar radiation	± 0.31%
2	Ambient temperature	± 0.24%
3	Wind velocity	± 2.9%
4	Thermal efficiency	± 0.96%
5	Heat transfer	± 1.9%
6	Overall heat loss	± 2.1%
7	Plate temperature	± 4.6%

Table 5
Time taken in cooking of some edibles for various loads.

Date	Substance	m (kg)	T_{amb} (°C)	Time (minutes)	Efficiency	Results
07.6.17	Pulse	0.60	39	96	37%	Good ripped (tasty)
08.6.17	Rice	0.75	38	110	43.7%	Good ripped (tasty)
09.6.17	Boneless mutton	0.50	40	13	31.9%	Hard ripped (appetizing)
10.6.17	Egg	16 eggs	39	115	41%	Boiled
11.6.17	Potato slices	1.2	37	91	45.5%	Boiled

The present system has been tested on four different configurations for its thermal performance. In first two configurations the system has been operated only on solar radiant energy. The estimated parameters for first two configurations were as; first figure of merit – 0.12 m^2 °C/W, second figure of merit – 0.41 m^2 °C/W, thermal efficiency – 38.10%, cooking power – 55.31 W, heat transfer coefficient – 34.51 W/m^2 °C and overall heat loss coefficient is 5.10 W/m^2 °C. After the testing of SBC on above configurations, the system has been modified into a hybrid SBC and tested for third and fourth configurations. Subsequently the successful testing on these two configurations, it can be concluded that this is the first kind of SBC which can perform on forced convection with the help of a specially designed duct integrated with a 200 W halogen lamp and a low power fan. The system has been found adequate for almost all types cooking substance in poor ambient conditions. The system is found better on load conditions. The estimated parameters for third and fourth configurations are as; first figure of merit – 0.12 m^2 °C/W, second figure of merit – 0.46 m^2 °C/W, thermal efficiency – 45.11%, cooking power – 60.20 W, heat transfer coefficient- 46.86 W/m^2 °C and overall heat loss coefficient is 6.01 W/m^2 °C. Results shown that the present design successfully meet to the BIS standards and can cook almost edibles in poor ambient conditions by consuming only 210 W.

Besides the cooking performance can be enhanced and cooking time can be reduced by producing more artificial flux through using a more wattage of halogen lamp (say 400 or 500 W) or by providing some quality thermal energy storage (under the hollow balls) and by increasing number of mirror boosters (the work is under study for a year round performance). The unique feature of the present solar cooking system is its robust design and fast thermal response of cooking. The present design of SBC has been found as an adequate clean cooking system for efficient cooking (without pollution), round the globe especially for developing countries and isolated areas.

Conflicts of interest

Author has no conflict of interest.

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Soil Stabilization by Bitumen Emulsion

Prashant Kumar, Mr. Ashish Kumar

Abstract

India is a developing country of the world. The people are migrating from village to city and the capacity of city is limited and some part of city is covered with expansive soil which could not have high strength because soil have low bearing capacity so to increase the strength of soil, soil stabilization process is very necessary. Soil is a sub base material of the earth. The earth is covered by different type of soils and one of such type is expansive soil which does not have high bearing capacity. So, the soil stabilization and compaction are used for increasing the bearing capacity of soil. Soil stabilization process is to stabilize the soil by chemical process by using various materials such as bitumen, bitumen emulsion, lime, cement, fly ash, waste material etc. Bitumen emulsion is a costly material which are used in small areas, pavement etc.

Full Text:

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A Study on Multi Server Queuing Model to Optimize the Performance of a Toll Plaza

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Abstract: In this paper we studied multi server queuing model and analyze the performance of toll plaza which is located at Khalghat, Agra-Bombay road (on NH 3). The results of the analysis showed that average queue length, waiting time of vehicle at toll plaza. In particular, we present the optimal number of toll booths to reduce the queue length and waiting time of vehicles.

Keywords: Toll plaza, queue length, waiting time, Queuing model.

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1. Introduction

Increasing traffic volume causes congestions commonly around the toll gate of highways [1]. When the first road covered with a layer of crushed stone was built in 1792 in Pennsylvania, the boom in road construction began. Over the years, the roads were built all over the country, and because of the decreasing federal support of existing and new freeways toll roads now begin to play an important role in the traffic system. The US transportation trust fund is rapidly shrinking and state departments of transportation around the US are facing budget shortages. In the last two rounds of federal highway program reauthorization, the use of toll roads have expanded and now is becoming more popular. Toll roads, in general, can generate funds for repayment of toll revenue bonds, thus the state can collect enough money to finance the operation, maintenance, improvement and construction of new facilities. By the end of year 2006, there were a total of 4917 miles of toll roads built in the United States, including 223 miles of urban toll roads and 2695 miles of rural (Toll Facilities in the United States). A toll plaza is the essential part of toll roads where the toll is collected. There are three difference basic options for tolling: Manual Toll Collection, which has been the most common approach for collecting tolls. In this option, drivers are required to stop and pay a toll collector sitting or standing in a tollbooth [2]. Toll plaza system increasing traffic volume makes congestion commonly around the tollgates of Highway. So, reform measure of congestion around the tollgates is urgently required. The current system for collecting toll is on the basis of manual transaction. In this each vehicle has to stop at the toll plaza for payment. It causes traffic congestion, increase in pollution, and wasting time of people. The goal is to implement the reliable system that leads to:

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- Saving the time at toll plaza for toll collection.
- Reducing traffic congestion and increases security concerns [3].

National Highway 3 (NH 3) commonly referred to as the Mumbai-Agra Highway is a major Indian National Highway that connects the states of Uttar Pradesh, Rajasthan, Madhya Pradesh and Maharashtra in India. The highway originates in Agra in Uttar Pradesh, generally travels southwest through Dhaulpur in Rajasthan, Morena, Gwalior, Shivpuri, Guna, Biaora, Maksi, Dewas and Indore in Madhya Pradesh, and Dhule, Nashik, Thane and terminates at Mumbai in Maharashtra. NH 3 runs for a distance of 1,190 km. The aim of this paper is to study multi server queuing model and analyze the performance of toll plaza which is located at Khalghat, Agra- Bombay road (on NH 3). The results of the analysis showed that average queue length, waiting time of vehicle at toll plaza. In particular, we present the optimal number of toll booths to reduce the queue length and waiting time of vehicles.

2. Queuing System and Mathematical Model Analysis

2.1. The basic indexes of the queuing systems

n = Number of customers in the system

λ = Mean arrival rate

μ = Mean service rate per busy server

ρ = Expected fraction of time for which server is busy

P_n = Steady state probability of exactly n customers in the system

L_q = Expected number of customers waiting in the queue (i.e. queue length)

L_s = Expected number of customers in the system (waiting + being served)

w_q = Expected waiting time for a customer in the queue

W_s = Expected waiting time for a customer in the system (waiting + being served)

2.2. $M/M/S$ Model (Multi server queuing system)

For this queuing system, it is assumed that arrivals follow a Poisson probability distribution at an average rate of λ customers per unit of time and are served on a first come first served basis by any of the servers. The service times are distributed exponentially with an average of μ customers per unit of time. It is further assumed that only one queue is formed. If there are n customers in the queuing system at any point in time, then following two cases may arise:

(1). If n < s (number of customers in the system is less than the number of servers), then there will be no queue. However, $(s-n)$ numbers of servers are not busy. The combined service rate will then be: $\mu_n = n\mu$; $n < s$.

(2). If $n \geq s$ (number of customers in the system is more than or equal to the number of servers) then all servers will be busy and the maximum number of customers in the queue will be $(n-s)$. The combined service rate will be $\mu_n = s\mu$; $n \geq s$.

Thus to derive the result for this model, we have

$$\lambda_n = \lambda \quad forall \quad n \geq 0$$

$$\mu_n = \begin{cases} n\mu; & n < s \\ \mu_n = s\mu; & n \geq s \end{cases}$$

The probability of$n$ customers in the queuing system is given by

$$P_n = \begin{cases} \frac{\rho^n}{n!} P_0; & n \leq s \\ \frac{\rho^n}{s! s^{(n-s)}} P_0; & n > s \end{cases}$$

$$P_0 = \left[\sum_{n=0}^{s-1} \frac{1}{n!} \left(\lambda/\mu \right)^n + \frac{1}{s!} \left(\lambda/\mu \right)^s \left(\frac{s\mu}{s\mu - \lambda} \right) \right]^{-1}$$

Expected number of customers waiting in the queue (i.e. queue length)

$$L_q = \left[\frac{1}{(s-1)!} \left(\lambda/\mu \right)^s \left(\frac{\lambda\mu}{(s\mu - \lambda)^2} \right) \right] P_0$$

Expected number of customers in the system

$$L_s = L_q + \frac{\lambda}{\mu}$$

Expected waiting time of a customer in the queue

$$W_q = \frac{L_q}{\lambda}$$

Expected waiting time that a customer spends in the system

$$W_s = W_q + \frac{1}{\mu}$$

3. Analysis of Data

The data were obtained from Khalghat toll plaza, A. B road (on NH 3) Khalghat, M.P., India through Personal Observation on toll plaza. We use TORA software to compute the performance measures of the multi- server queuing model system at Khalghat toll plaza using data

Indore to Bombay Saturday										
Time	Server 1		Server 2		Server 3		Server 4		Server 5	
	Arrival rate	Service rate	Arrival rate	Service rate	Arrival rate	Service rate	Arrival rate	Service rate	Arrival rate	Service rate
9-10 AM	62	40	78	52	50	42	38	26	82	72
10-11 AM	58	40	70	54	60	41	44	28	86	79
11-12 Noon	58	40	70	44	48	40	34	26	66	56
12-1 PM	64	40	66	44	58	40	46	26	62	50
1-2 PM	96	56	90	59	78	40	64	34	44	40
2-3 PM	142	92	132	99	110	71	130	109	98	80
	480	308	506	352	404	274	356	249	438	377

Table 1. **Summary of the data server 1 to server 5**

Total number of vehicles arrived in six hours is 1746 (291 per hour)

Total number of vehicles served in six hours is 1560 (260 per hour)

Average arrival rate $\lambda = 291$ per hour

Average service rate $\mu = 260/5 = 52$ per hour

$$\rho < 1 \quad i.e., \quad \frac{\lambda}{S\mu} < 1, \quad \frac{291}{S(52)} < 1, \quad S > 5.59 \cong 6$$

Here the minimum no. of toll booths are required more than five ($S > 5$)

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Tuesday, April 07, 2015 11:16

QUEUEING OUTPUT ANALYSIS

Title: hgg
Comparative Analysis

Scenario	c	Lambda	Mu	L'da eff	p0	Ls	Lq	Ws	Wq
1	6	291.00000	52.00000	291.00000	0.00130	16.97459	11.37843	0.05833	0.03910
2	7	291.00000	52.00000	291.00000	0.00285	7.52865	1.93250	0.02587	0.00664
3	8	291.00000	52.00000	291.00000	0.00340	6.22434	0.62819	0.02139	0.00216

Table 2. **Summary of the performance measures of queuing model**

Bombay to Indore Saturday										
Time	Server 6		Server 7		Server 8		Server 9		Server 10	
	Arrival rate	Service rate	Arrival rate	Service rate	Arrival rate	Service rate	Arrival rate	Service rate	Arrival rate	Service rate
9-10 AM	106	96	62	58	72	62	106	90	76	62
10-11 AM	98	90	64	60	76	66	120	102	70	58
11-12 Noon	84	76	68	64	76	64	98	82	72	58
12-1 PM	78	72	76	68	84	78	102	90	82	70
1-2 PM	58	56	52	28	68	40	88	60	102	76
2-3 PM	78	70	92	76	124	106	92	76	120	106
	502	460	414	354	500	416	606	500	522	430

Table 3. **Summary of the data server 6 to server 10**

The average waiting time of the vehicle in the system is 0.05833 hrs (3.5 min.) and the average waiting time of the vehicle in the queue is 0.0391 hrs (2.34 min.) when six tool booths are available.

Total number of vehicles arrived in six hours is 2544 (424 per hour).

Total number of vehicles served in six hours is 2160 (360 per hour).

Average arrival rate $\lambda = 424$ per hour.

Average service rate $\mu = 360/5 = 72$ per hour.

$$\rho < 1 \quad i.e., \quad \frac{\lambda}{S\mu} < 1, \quad \frac{424}{S(72)} < 1, \quad S > 5.88 \cong 6$$

Here the minimum no. of toll booths are required more than five ($S > 5$).

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QUEUEING OUTPUT ANALYSIS

Title: Bombay to Indore
Comparative Analysis

Scenario	c	Lambda	Mu	L'da eff	p0	Ls	Lq	Ws	Wq
1	6	424.00000	72.00000	424.00000	0.00030	56.19666	50.30778	0.13254	0.11865
2	7	424.00000	72.00000	424.00000	0.00188	8.94553	3.05665	0.02110	0.00721
3	8	424.00000	72.00000	424.00000	0.00244	6.81376	0.92487	0.01607	0.00218

Table 4. **Summary of the performance measures of queuing model**

The average waiting time of the vehicle in the system is 0.13254 hrs (7.9 min.) and the average waiting time of the vehicle in the queue is 0.11865 hrs (7.12 min.) when six tool booths are available.

4. Conclusion

From the Table 2 the average waiting time of the vehicle in the system is 0.05833 hrs (3.5 min.) and the average waiting time of the vehicle in the queue is 0.0391 hrs (2.34 min.) when six tool booths are available. From the table 4 the average waiting time of the vehicle in the system is 0.13254 hrs (7.9 min.) and the average waiting time of the vehicle in the queue is 0.11865 hrs (7.12 min.) when six tool booths are available. After studying and analyzing the data the average waiting time of the vehicle in system is exceeds three minutes this is leads to inconvenience and dissatisfaction to the customers. This paper strongly recommends that to increase the number of toll booths instead of five to at least six on the both sides to avoid inconvenience and dissatisfaction to the customers.

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