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An Improved Error Control Model in Packet Switched Wide Area Networks

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ABSTRACT

Error is an important problem in communication that occurs in shared networks when a packet fails to arrive at the destination or it arrives at the destination but some of the bits are in error or have been altered. In typical packet switched wide area networks, this can occur quite easily when output links are slower than inputs and multiple traffic sources competing for same output link at the same time. Typical for packet switched WAN, the packet transmit input/output buffer and queue of the network devices in their way towards the destination. Moreover, these networks are characterized by the fact that packets often arrive in "burst". The buffers in the network devices are intended to assimilate these traffic hosts until they can be processed. Nevertheless, the available buffers in the network nodes may fill up rapidly if the network traffic is too high which in turn may lead to discarded packets. The situation cannot be avoided by increasing the size of the buffers, since unreasonable buffer size will lead to excessive end-to-end (e2e) delay. A typical scenario for congestion occurs where multiple incoming link feed into single outgoing link (e.g several Local Area Networks connected to Wide Area Networks). The routers of the networks are highly susceptible for traffic congestion because they are too small for the amount of traffic required to handle.

This paper presented general concepts of Error Control and its mechanisms and its application to packet switched wide area networks An improved model was proposed with reduced error while transmitting packets from one channel to the other.

Simulating the model for reducing error control in packet switched wide area networks increased the number of messages, reduced response time used in transmitting and receiving packets, reduced network utilization.

Keywords: Error , Packet Switched, Wide Area Networks, Throughput, Messages

1 Introduction

Data communications and networking changes the way we transact business and the way we live. Business decisions have been made ever faster, and the decision makers require quick access to accurate information. Today's businesses depend on computer networks and internetworks. But before we ask how quickly we can get hooked up, we need to know which design best fills which set of needs, what type

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of technologies are available and how networks operate. The development of the personal computers achieved huge changes for education, science, business and industry. A similar revolution is occurring in data communications and networking. Technological advances have made it possible for communications links to transmit more and faster signals. As a result, services are developed to allow use of this increased capacity. For example, established telephone services such as voice mail, call waiting, conference calling and caller **ID** have been extended. Research in data communications and networking has resulted in new technologies.

1.1 Network Architecture

Networks are designed according to their topologies or connections. A network is group of networking devices connected by communication links. Most networks use distributed processing which is a task divided among multiple computers.

A network is devices connected through links. A link is a communication pathway that transmits data from one device to another. For exchange of information to occur, two devices must be connected in some way to the same link simultaneously. The types of network connection are point-to-point which provides a direct link between two devices. The entire capacity of the link is reserved for exchange of information between nodes. Most point to point connections use an actual length of wire or cable to connect both ends (source and destination). Point to point networks consists of several connections between individual pair of machines. Going from source to destination, short messages called packets in certain context may have to first visit one or more intermediate machines on a packet made up of point to point links. Often multiple routes of different length are possible. Point to point transmission from sender to receiver is called unicast.

Multipoint network is where more than two specific devices share the same link. In a multipoint environment, the channel capacity is shared temporarily or spatially. If several devices uses the link at the same time is spatially shared connection. If users take turn, it is time shared connection.

2 Error Control

Error control is a mechanism that ensures that packets arrive in proper sequence and accurately. Error Control is both detection and correction of errors. It allows the receiver to acknowledge the sender of lost or damaged frames in transmission and coordinates the retransmission of those frames by the sender. Error control includes detecting corrupt, lost, out of order and duplicate segments. Error control is the handling of errors in data transmission. The data link layer adds reliability to the physical layer by adding a mechanical action to detect and retransmit data of lost packets. Error control also use mechanisms to recognize duplicate frames. Error control is normally achieved through a trailer added to the end of the frame. Error control increases the reliability of systems. The communication point of view will be taken in this case.

Error is an important problem that occurs in shared networks when a frame fails to arrive at the destination or it arrives but some of the bits are in error or have been altered during transmission.

Error control is very important because physical communication circuits are not perfect. Many error-detecting and correcting codes are known but both connection nodes must agree on method(s) being used. In addition, the receiver must have some way of acknowledging the sender which of the messages have been correctly received and which of the messages have been altered while receiving the message.

Not all communication channels preserve the order of messages sent from source. To deal with possible sequencing loss, the protocol must make fully developed provision to allow packets to assemble properly for the receiver.

2.1 Categories of Error Control are

2.1.1 Error Detection

The purpose of this type of Error control is to detect whether a packet has been corrupted. This means that some bits (zeros and ones) describing the data has been flipped compared to their original value. These flipped bits represents an error. To detect this situation, a checksum is calculated depending on the data. The checksum is added to the data and at a point recomputed the checksum and compare it with appended checksum to verify that the data is error free.

2.1.2 Error Correction

The fundamental purpose of this type of error control is to enable reconstruction of an error free data packets given some corrupted data. Typical codes from this category will compute some redundancy bits that describe the original data. Using redundancy a receiver can repair some amount of bit errors. This type of codes are typically used at the lower layer in the networking stack e.g. at the physical/data link layer.

2.1.3 Erasure Coding

Erasure codes are commonly used to increase reliability of unreliable systems. The two main applications of Erasure coding are communication and storage. In this research work the communication point of view will be talked about. Erasure coding can be used in situations where the error correction fails. In case error detection code reports that data has been corrupted and data packets must be discarded. This type of data loss is called erasure. To protect against erasures we can use erasure correcting code which creates redundancy packet that can be injected into the packet in a similar way redundancy is injected into individual packets using and error correcting codes.

3 Model Development

Erasure coding is applied by source node. In this network, the packets are lost on the links joining node 1 to node 2 with probability of p_{12} and on the line joining nodes 2 and node 3 with probability of p_{23} and it continues until it gets to the last node. An erasure code is applied at node I to send messages at an information rate of $(1 – p_{12})(1 –p_{23})$………….$(1 – p_{mn})$ packets per unit time.

Essentially erasure channels with erasure probability of $1 – (1 – p_{12})(1 –p_{23})$………….$(1 – p_{mn})$ can be achieved by a suitably design code. The erasure codes is applied over the link joining the nodes from 1 and 2 and another joining 2 and 3 up to nodes joining m and n which makes us use many stages of erasure coding with decoding and recoding at nodes 2 to n. Messages can be between nodes 1 to 2 at $1 – p_{12}$packets and between nodes 2 and 3 at rate of $1 – p_{23}$ up to nodes m and n $(1 – p_{mn})$ packets per unit time. Messages can also be sent between nodes 1 and n at min $(1 – p_{12})(1 –p_{23})$………….$(1 – p_{mn})$ which in general is greater than $1 – p_{12})(1 –p_{23})$………….$(1 – p_{mn})$. Applying extra stages of erasure coding is a special form of error control which is coded a intermediate nodes.

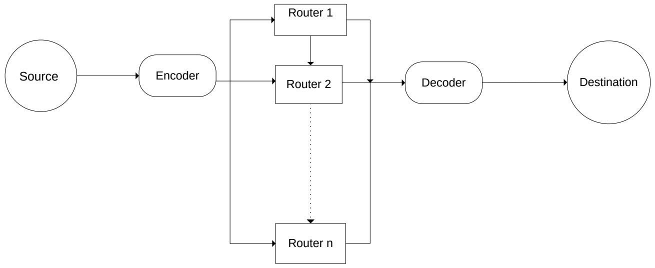

Figure 1: Flow Diagram of the proposed model

3.1 The Proposed Model

Error control mechanism was implemented at the point of each router. When error is detected, the Erasure coding model injects more packets into routers. The encoder turns the messages into codewords while decoder turns the messages back to messages. The encoder and decoder are attached to each router or end of host. For a host to detect erasures, receiver sends information that no, corrupted or garbled messages were received. The erasure coding method corrects the nodes or channels with erasure and the nodes retransmit the packets. The Sender or sources retransmits the packets until the packets gets to the destinations or receiver.

3.2 Solution of the Model

Queuing model is applied to packet switched WAN (www.nationmaster.com). The parameters of the queuing model were modified and solved to reduce error. Following modified parameters:

The queuing model for packet flow in packet switched WAN was analysed

λ = Packet Throughput

μ = Packet Service rate

L_s = Number of messages in the network.

L_q = Number of messages in the queue.

W_q = Waiting time of packets spend in the queue to be transmitted to other networks.

W_s = Waiting time the packets spend in the network

P_n = Probability of routers accepting packets

$\frac{1}{\mu}$ = service time (time packets are acknowledged and transmitted)

$\bar{c}$ = Expected number of servers that reject packets

c = number of servers

ρ = network utilization

$$L_s = \sum_{n=1}^{\infty} np_n. \tag{1}$$

The relationship between W_s and L_s (also W_q and L_q) is known as Little's law which states that the number of packets is directly proportional to the product of average rate of packets and the time taken to deliver the packets.

$$L_s = \lambda_{eff} W_s \tag{2}$$

$$L_q = \boldsymbol{\lambda}_{eff} W_q \tag{3}$$

For multiple server models which is the case of interest, there are c erased channels each serving messages (c>1). The arrival rate is λ and the service rate per server is μ. There is no limit on the number of routers in the network. With Kendall's notation M/M/c is the c server queue with Poisson arrivals and exponentially distributed service time. All queue disciplines are generalised distributions that satisfied all conditions. The parameters considered were throughput (**λ**), service rate (μ), number of servers (c), probability of number of routers not accepting packets (P_o). Throughput remains the same as M/M/1 queues but service rate depends on the number of channels. When the number of channels exceed m, the service rate become μm as shown below.

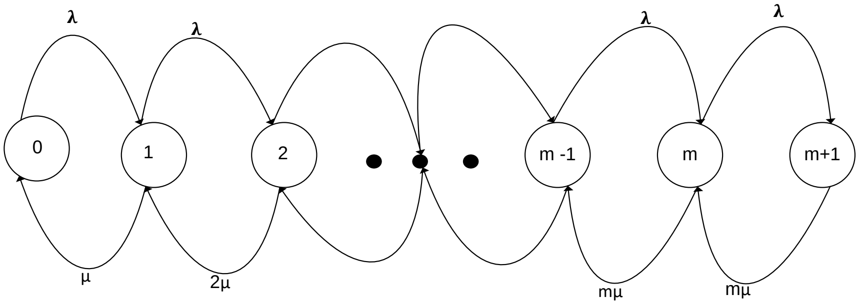

Figure 2: Transition of states in M|M|c Queuing Model

If $\rho = {}^{\lambda}/_{m\mu}$ and assuming ${}^{\rho}/_{m} < 1$, the value gotten from

$$\sum_{k=0}^{\infty} \mathrm{P_k} = 1. \tag{4}$$

N_q was determined in Multiple Input and Multiple Output (MIMO) systems

If $\rho = {}^{\lambda}/_{m\mu}$ (k = 0, 1, 2,….., j+1).

The service rate $\mathrm{m\mu}$ will be

$$\mathrm{m\mu} = \begin{cases} \mathrm{n\mu} & \mathrm{k} < m \text{ for } \mathrm{k} = 1,2,3, \dots \dots \dots \dots, \mathrm{m} \\ \mathrm{m\mu} & \mathrm{k} > m \; for \; k = m, m+1, \dots \dots \mathrm{m} + k \end{cases}$$

Probability of having n messages in the network can be written in a similar way with M/M/1 using revised service rate.

$$\text{Then, } \mathrm{P_k} = \frac{\lambda^k \times P_0}{\mu \times 2\mu \times 3\mu \times ---------- \times k\mu} \tag{5}$$

$$P_k = \frac{\lambda^k}{k!\mu^k} * P_0 \qquad k \leq m \tag{6}$$

$$\mathrm{P_k} = \frac{\lambda^m}{m!m^{k-m}\mu^m} * P_o \qquad n \geq m \tag{7}$$

These are the measurements of performances in a multiple server and multiple queue in a packet switched wide area networks.

From equation (3.26) and (3.27) we get the following equations.

$$P_k = \left\{ P_0 \frac{(m\rho)^k}{k!} \quad k \le m \right. \tag{8}$$

$$\left\{ P_0 \frac{m^m(\rho)^k}{k!} \quad k \ge m \right. \tag{9}$$

From equation (3.1)

$$L_s = \sum_{n=1}^{\infty} kp_k$$

$$= P_0 \rho \frac{m^m}{m!}\left(\frac{1}{(1-\rho)^2}\right) \tag{10}$$

Case 1: Number of messages having erased channels.

$$L_q = \frac{m^m}{m!}\,\frac{\lambda}{m\mu - \lambda}$$

When 0 ≤ k ≤ m (The Erased channels are more than the normal working channels)

$$L_s = \frac{m^m}{m!}\,\frac{\lambda}{m\mu - \lambda}$$

When number of running channels is greater than the erased channels

Case 2: Number of messages having erasure channels

$$L_s = \frac{m^m}{m!}\,\frac{\lambda}{m\mu - \lambda} \tag{11}$$

Case 3: Total number of messages with erased channels

$$L_s = \frac{m^k}{k!}\,\frac{\lambda}{m\mu - \lambda} + \frac{m^m}{m!}\,\frac{\lambda}{m\mu - \lambda} \tag{12}$$

Case 4: For dynamic erasure code we differentiate with respect to code utilization ρ to see the effect on the number of messages produced in the network

$$dL_s = \frac{m^k}{k!}\,\frac{m^2\mu^2}{m^2\mu^2 - 2m\mu\lambda + \lambda^2} + \frac{m^m}{m!}\,\frac{m^2\mu^2}{m^2\mu^2 - 2\lambda m\mu + \lambda^2} \tag{13}$$

Probability of messages in queue and all channels busy and forced to wait in queue

$$\sum_{k=m}^{\infty} P_n = \sum_{k=m}^{\infty} \frac{p_0 m^m \rho^n}{m!}$$

$$\sum_{k=m}^{\infty} P_n = \left(\frac{\lambda}{\mu}\right)^m \frac{1}{m!} \tag{14}$$

Average number of customer in queue

$$L_q = \sum_{k=0}^{\infty} k p_{k+m}$$

$$= \left(\frac{\lambda}{\mu}\right)^{m} \frac{1}{m!} \frac{\lambda}{m\mu - \lambda} \tag{15}$$

Expected Number of messages waiting in queue (not in service) = L_q

$L_q = (m - k)P_n$

$$= \frac{(k\rho)^k}{k!} \frac{\rho}{1 - \rho} \tag{16}$$

$$W_q = \frac{\dfrac{\left(\frac{\lambda}{\mu}\right)^{k}}{k!} \dfrac{\lambda}{k\mu - \lambda}}{\lambda}$$

$$W_q = \left(\frac{\lambda}{\mu}\right)^{k} \frac{1}{k!} \frac{1}{k\mu - \lambda} \tag{17}$$

$$W_s = \frac{1}{\mu} + \left(\frac{\lambda}{\mu}\right)^{k} \frac{1}{k!} \frac{1}{k\mu - \lambda} \tag{18}$$

4 Results Produced from the Model

Table 1: Table showing Number of messages produced from throughput at 100 Mb/s

Channel	Higher/Lower Erasures	Total No of messages with Erasures	Dynamic Erasure Coding
2	0.2783	32.914	7274.1
4	2.8062	35.4233	7828.7
6	11.3183	43.8729	9696.1
8	24.4554	56.9137	12578
10	32.8794	65.2754	14426
12	30.1392	62.5556	13825
14	20.0376	52.5282	11609
16	10.1025	42.6658	9429
18	3.9947	36.6031	8089
20	1.272	33.9004	7492

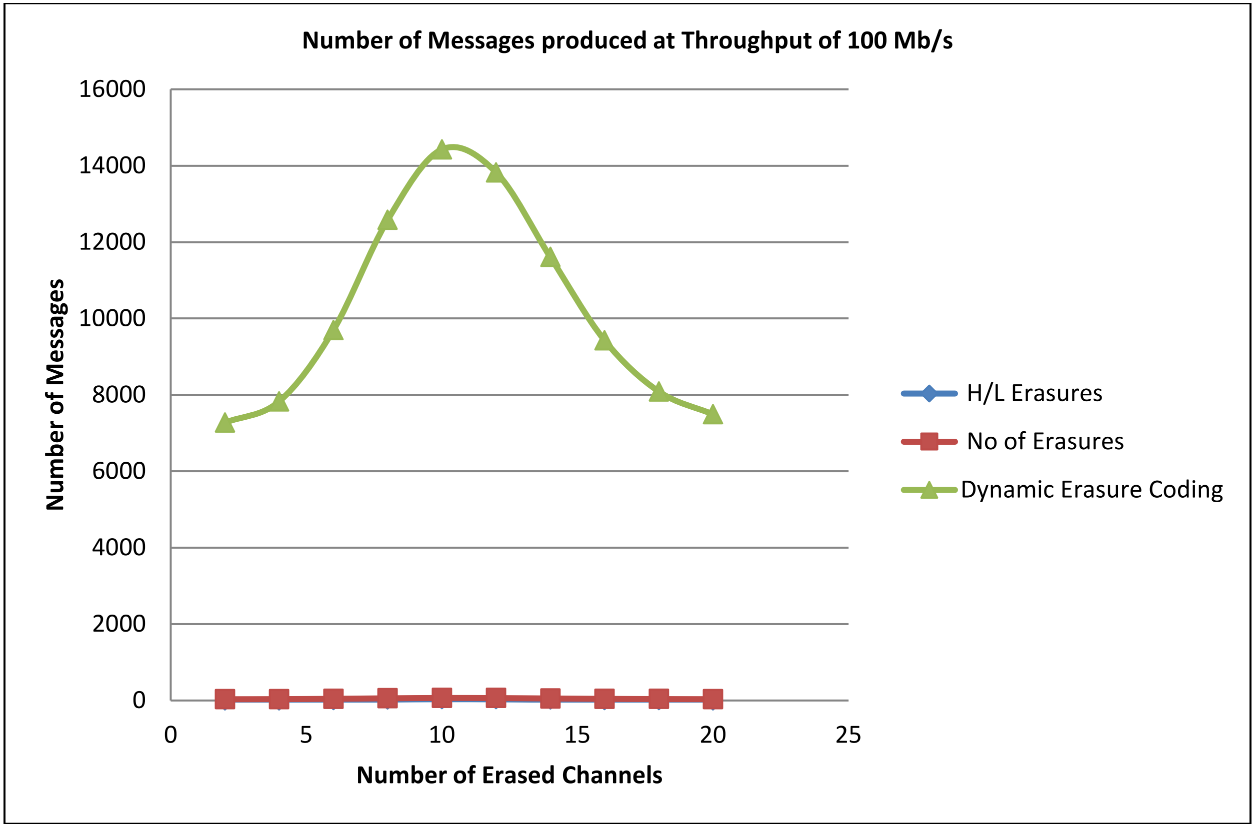

Figure 3: Graph Showing the Number of messages produced at Throughput of 100 Mb/s

The graph shows the number of erased channels producing number of messages. The blue graph shows the result of good or erased number of channels on the number of messages. The graph rose from 0.2783 passing through three points to 33 and sloped down passing through four points to approximately 1. The Wine coloured graph shows the total number of erasures. The graph rose from 32 passing through 3 points to 65 and sloped down through four points to 34. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 7274 passing through three points to 14426, sloped through three points to 7492. The results of the three graphs shows that when the good channel is greater than the erased channel, the number of messages produced increases and when the number of erased channels is greater than the good channels, the number of messages decreases. The closer the good/erased channel, the higher the number of messages. The further the good/erased channel, the lower the number of messages.

Table 2: Table showing Number of messages produced from throughput at 500 Mb/s

Channel	Higher/Lower Number Erasures	Total No of Messages with Erasures	Dynamic Erasure Coding
2	1.4097	167.6316	7547
4	14.2140	180.4116	8123
6	57.3297	223.4456	10060
8	123.8721	289.8628	13051

10	166.5414	332.4493	14968
12	152.6616	318.5972	14344
14	101.4948	267.5273	12045
16	51.1715	217.2980	9784
18	20.2341	186.4203	8393
20	6.4430	172.6559	7774

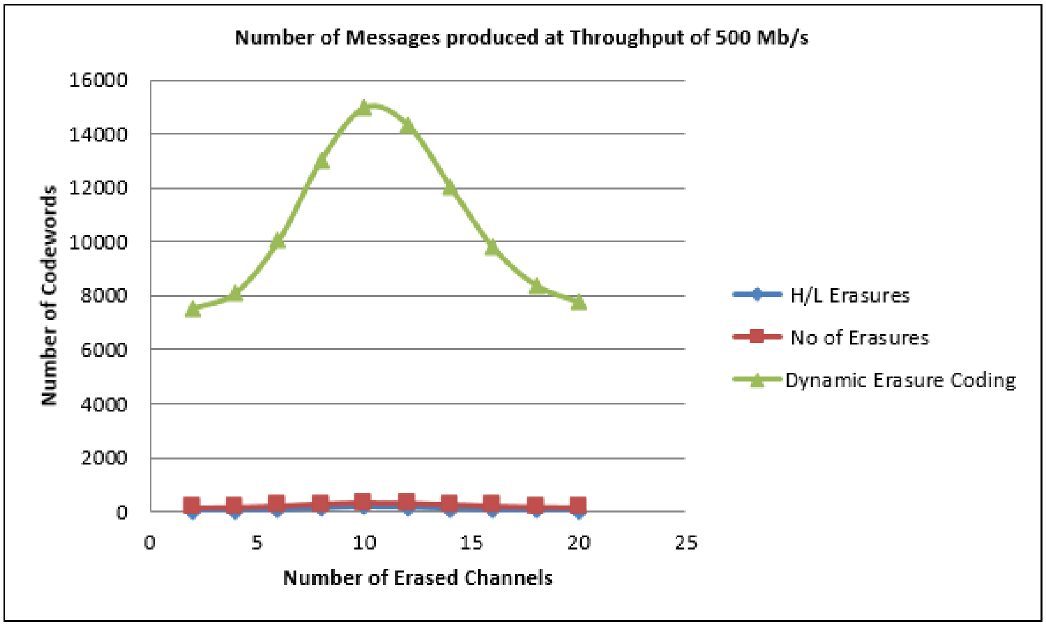

Figure 4: Graph Showing the Number of messages produced at Throughput of 500 Mb/s

The graph shows the number of erased channels producing number of messages. The blue graph shows the result of good/erased number of channels on the number of messages. The graph rose from 1 passing through three points to 167 and sloped down passing through four points to 6. The Wine graph shows the total number of erasures. The graph rose from 167 passing through three points to 332 and sloped down through four points to 172. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 7547 passing through three points to 14968, sloped through three points to 7774. The results of the three graphs shows that when the good channel is greater than the erased channel, the number of messages increases and when the erased channels are greater than the good channels, the number of messages produced decreases. The closer the good/erased channel, the higher the number of messages. The further the good/erased channel, the lower the number of messages.

Table 3: Table showing Number of messages produced from throughput at 1000 Mb/s

Channel	Higher/Lower Number Erasures	Total No of Messages with Erasures	Dynamic Erasure Coding
2	2.8798	343.2457	7910
4	29.0380	369.4143	8514
6	117.1198	457.5314	10545
8	253.0606	593.5285	13679
10	340.2305	680.7294	15689

12	311.8752	652.3657	15035
14	207.3456	547.7939	12625
16	104.5391	444.9436	10255
18	41.3366	381.7178	8798
20	13.1624	353.5324	8148

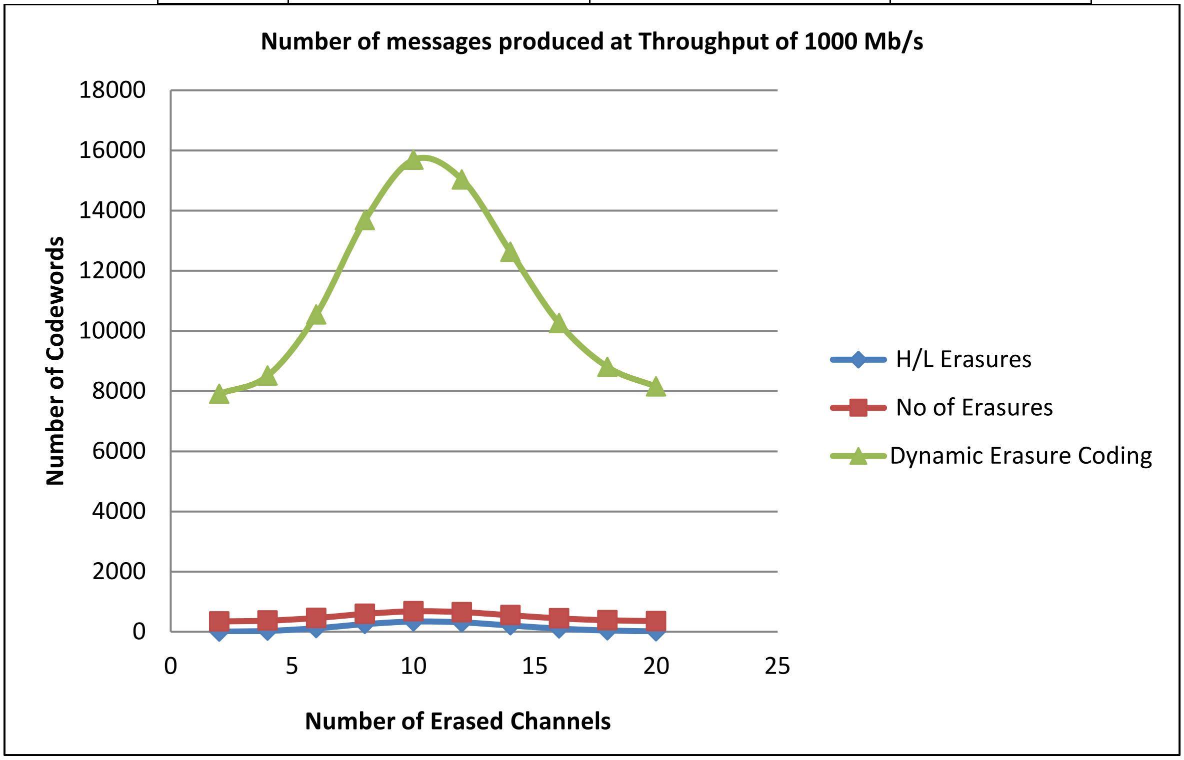

Figure 5: Number of messages produced at throughput of 1000 Mb/s

The graph shows the number of erased channels producing number of messages. The blue graph shows the effect of good/erased number of channels on the number of messages. The graph rose from 3 passing through three points to 340 and sloped down passing through four points to 13. The Wine graph shows the total number of erasures. The graph rose from 343 passing through three points to 681 and sloped down through four points to 354. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 7910 passing through three points to 15689, sloped through three points to 7774. The results of the three graphs shows that when the good channel is greater than the erased channel, the number of messages increases and when the number of erased channels is higher than the good channels, the number of messages produced decreases. The closer the good/erased channel, the higher the number of messages. The further the good/erased channel, the lower the number of messages.

Table 4: Table showing Number of messages produced from throughput at 2000 Mb/s

Channel	Higher/Lower Number Erasures	Total No of Messages with Erasures	Dynamic Erasure Coding
2	6.05	720.8159	8722
4	61.0042	775.7701	9387
6	246.05	960.8160	11626

8	531.64	1264	15082
10	714.77	1429.5	17297
12	655.2	1370	16577
14	435.6	1150.4	13919
16	219.62	934.3816	11306
18	86.8415	801.6074	9649
20	27.6522	742.4181	8983

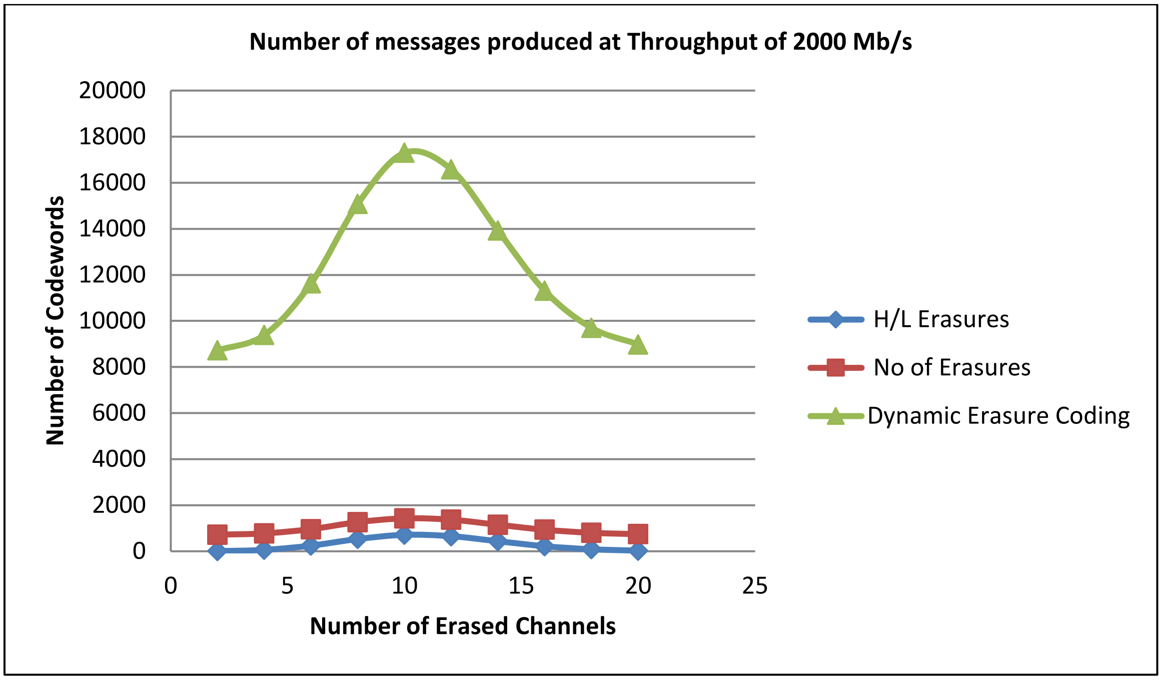

Figure 6: Number of messages produced at throughput of 2000 Mb/s

The graph shows the number of erased channels producing number of messages. The blue graph shows the result of good/erased number of channels on the number of messages. The graph rose from 6 passing through three points to 714 and sloped down passing through four points to 28. The Wine graph shows the total number of erasures. The graph rose from 721 passing through three points to 1430 and sloped down through four points to 742. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 8722 passing through three points to 17297, sloped through three points to 8983. The results of the three graphs shows that when the good channel is greater than the erased channel, the number of message increases and when the erased channels are greater than the good channels, the number of messages produced decreases. The closer the good/erased channel, the higher the number of messages. The further the good/erased channel, the lower the number of messages.

Table 5: Table showing Response time produced from throughput at 100 Mb/s

Channel	Higher/Lower Number Erasures	Total No of Messages with Erasures	Dynamic Erasure Coding
2	0.0028	0.3291	72.7410
4	0.0281	0.3542	78.2870
6	0.1132	0.4387	96.9610
8	0.2446	0.5691	125.7800
10	0.3288	0.6528	144.2600
12	0.3032	0.6256	138.2500
14	0.2004	0.5253	116.0900
16	0.1010	0.4267	94.2900
18	0.0399	0.3660	80.8900
20	0.0127	0.3390	74.9200

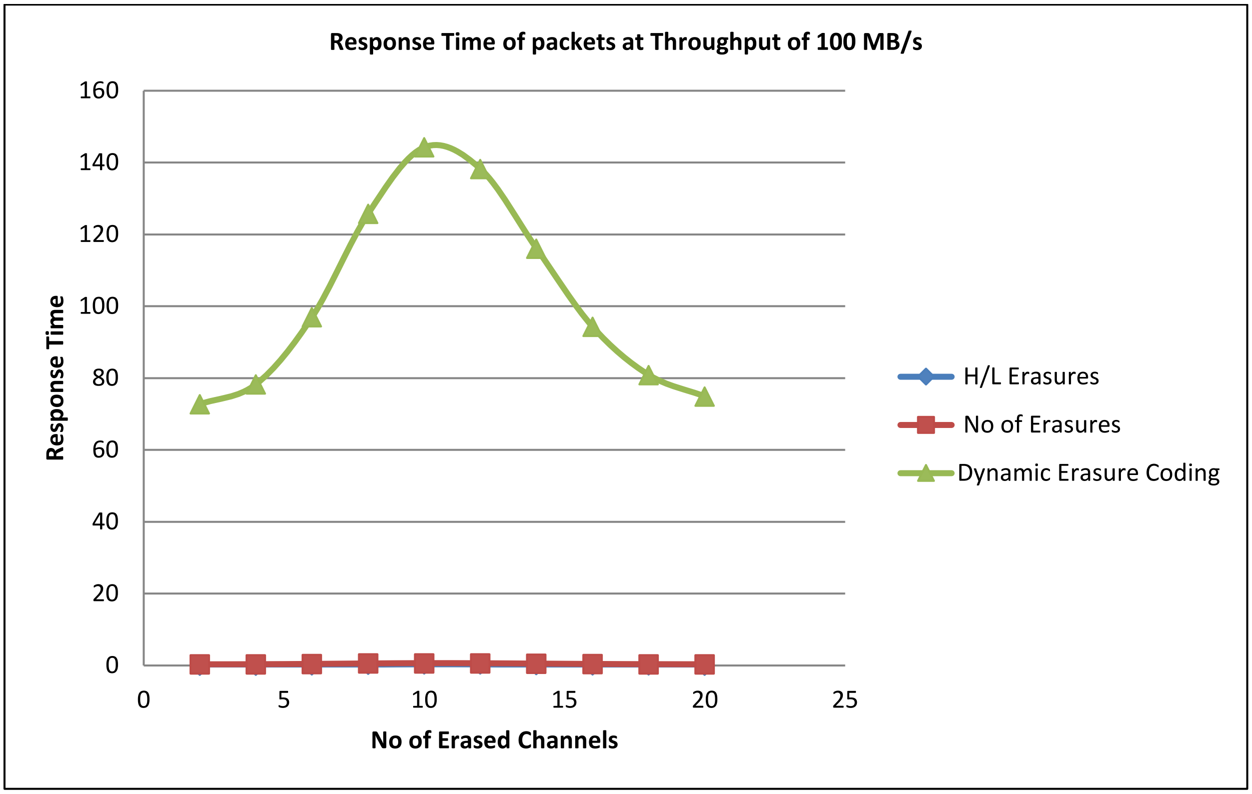

Figure 7: Graph Showing Response time of packets at Throughput of 100 MB/s

The graph shows how the number of erased channels affects the response time. The blue graph shows the effect of good/erased number of channels on response time messages are produced. The graph rose from 0.0028 seconds passing through three points to 0.3288 seconds and sloped down passing through four points to 0.0127 seconds. The Wine graph shows the total number of erasures. The graph rose from 0.3291 seconds passing through three points to 0.6528 seconds and sloped down through four points to 0.3390 seconds. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 73 seconds passing through three points to 144 seconds and sloped through three points to 75 seconds. The results of the three graphs show that when the good channel is higher than the erased channel, the response time increases and when the erased channels are greater than the good channels, the response time decreases. The closer the good/erased channel, the higher the response time and the lower the number of messages produced. The further the good/erased channel, the lower the response time, the higher the number of messages produced.

Table 6: Table showing Response time produced from throughput at 500 Mb/s

Channel	Higher/Lower Number Erasures	Total No of Messages with Erasures	Dynamic Erasure Coding
2	0.0028	0.3353	15.094
4	0.0284	0.3608	16.246
6	0.1147	0.4469	20.120
8	0.2477	0.5797	26.102
10	0.3331	0.6649	29.936
12	0.3053	0.6372	28.688
14	0.2053	0.5351	24.090
16	0.1023	0.4346	19.568
18	0.0405	0.3728	16.786
20	0.0129	0.3453	15.548

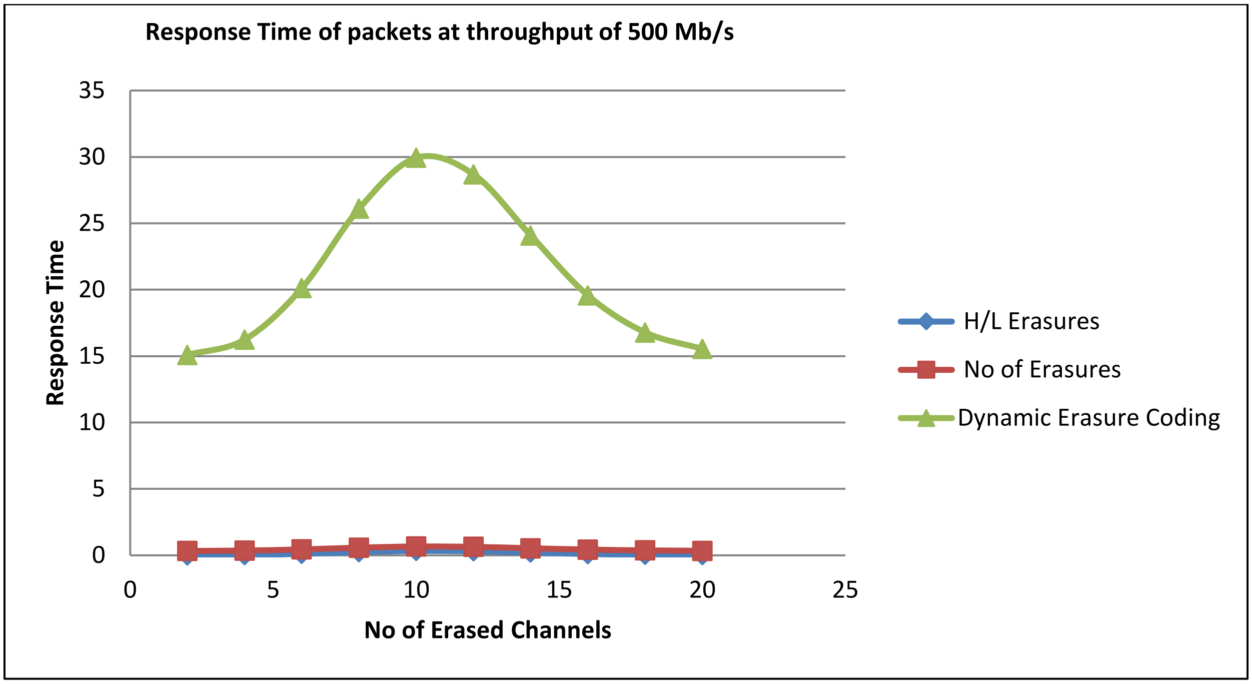

Figure 8: Graph Showing Response time of packets at Throughput of 500 MB/s

The graph shows how the number of erased channels affects the response time. The blue graph shows the effect of good/erased number of channels on response time messages are produced. The graph rose from 0.0028 seconds passing through three points to 0.3331 seconds and sloped down passing through four points to 0.0129 seconds. The Wine graph shows the total number of erasures. The graph rose from

0.3353 seconds passing through three points to 0.6649 seconds and sloped down through four points to 0.3453 seconds. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 15 seconds passing through three points to 30 seconds and sloped through three points to 16 seconds. The results of the three graphs show that when the good channel is greater than the erased channel, the response time increases and when the number of erased channels is higher than the good channels, the response time decreases. The closer the good/erased channel, the higher the response time and the lower the number of messages produced. The further the good/erased channel, the lower the response time, the higher the number of messages produced.

Table 7: Table showing Response time produced from throughput at 1000 Mb/s

Channel	Higher/Lower Number Erasures	Total No of Messages with Erasures	Dynamic Erasure Coding
2	0.0029	0.3432	7.9100
4	0.0290	0.3694	8.5140
6	0.1171	0.4575	10.5450
8	0.2531	0.5935	13.6790
10	0.3402	0.6807	15.6890
12	0.3119	0.6524	15.0350
14	0.2073	0.5478	12.6250
16	0.1045	0.4449	10.2550
18	0.0413	0.3817	8.7980
20	0.0132	0.3535	8.1480

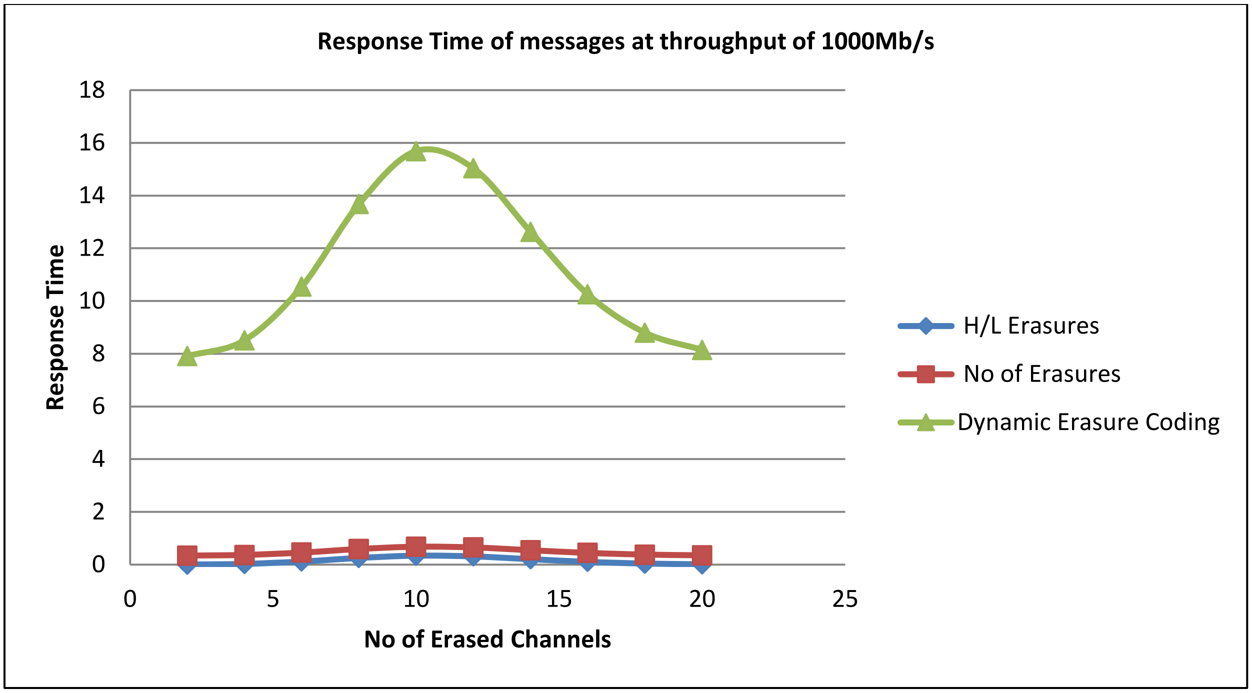

Figure 9: Graph Showing Response time of packets at Throughput of 1000 MB/s

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The graph shows how the number of erased channels affects the response time. The blue graph shows the effect of good/erased number of channels on response time messages are produced. The graph rose from 0.0029 seconds passing through three points to 0.3402 seconds and sloped down passing through four points to 0.0132 seconds. The Wine graph shows the total number of erasures. The graph rose from 0.3432 seconds passing through three points to 0.6807 seconds and sloped down through four points to 0.3535 seconds. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 8 seconds passing through three points to 16 seconds and sloped through three points to 8 seconds. The results of the three graphs show that when the good channel is higher than the erased channel, the response time increases and when the erased channels are greater than the good channels, the response time decreases. The closer the good/erased channel, the higher the response time and the lower the number of messages produced. The further the good/erased channel, the lower the response time, the higher the number of messages produced.

Table 8: Table showing Response time produced from throughput at 2000 Mb/s

Channel	Higher/Lower Number Erasures	Total No of Messages with Erasures	Dynamic Erasure Coding
2	0.0003	0.3604	4.3610
4	0.0305	0.3879	4.6935
6	0.1230	0.4804	5.8130
8	0.2658	0.6320	7.5410
10	0.3574	0.7148	8.6485
12	0.3276	0.6850	8.2885
14	0.2178	0.5752	6.9595
16	0.1098	0.4672	5.6530
18	0.0434	0.4008	4.8495
20	0.0138	0.3712	4.4915

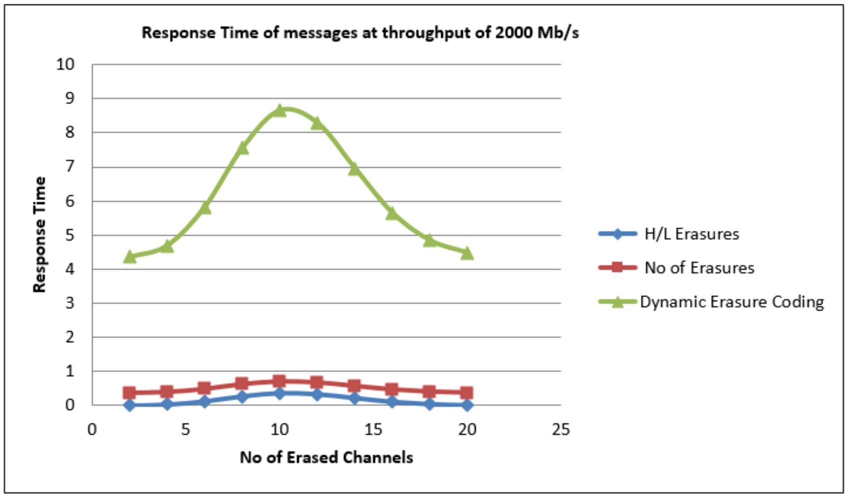

Figure 10: Graph Showing Response time of packets at Throughput of 2000 MB/s

The graph shows how the number of erased channels affects the response time. The blue graph shows the effect of good/erased number of channels on response time messages are produced. The graph rose from 0.003 seconds passing through three points to 0.3574 seconds and sloped down passing through four points to 0.0138 seconds. The Wine graph shows the total number of erasures. The graph rose from

0.3604 seconds passing through three points to 0.7148 seconds and sloped down through four points to 0.3712 seconds. The green graph shows the proposed method (Dynamic Erasure coding) method. The graph rose from 4.3 seconds passing through three points to 8.6 seconds and sloped through three points to 4.5 seconds. The results of the three graphs show that when the good channel is higher than the erased channel, the response time increases and when the erased channels is higher than the good channels, the response time decreases. The closer the good/erased channel, the higher the response time and the lower the number of messages produced. The further the good/erased channel, the lower the response time, the higher the number of messages produced.

5 Conclusion

In this chapter we showed how Dynamic erasure coding and network coding techniques can be used for reducing error in Packet Switched Wide area Networks. The main conclusion is that Dynamic Erasure Coding Method reduced throughput, increased number of messages and reduce response time which happens to be one of the constraints in packet switched wide area networks.

While some of these challenges have been addressed in the surveyed literature, numerous open problems remain. For example, the questions of combining the erasure encoding with multiresolution and distributed compression architectures, as well as faster encoding and decoding algorithms are among the issues that need to be addressed in future work. Distributed and scalable algorithms naturally fit with the randomized linear network coding theory and we believe that such ideas will be useful for practical applications.

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