Combination of Diversity Coded based Protection with Congestion Control Techniques to Enhance QoS in OBS Networks

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by

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Certificate

It is certified that the work contained in this report entitled ”Combination of Diversity Coded based Protection with Congestion Control Techniques to Enhance QoS in OBS Networks” by ”Shivam Srivastava” has been carried out under my supervision and that it has not been submitted elsewhere for a degree.

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Abstract

To protect data from link failure, 1+1 path protection technique has been used in the optical burst switching networks but this techniques wastes the resources by using two paths for the same data, so another protection scheme based on diversity coding is introduced. In this report, We discuss the combination of Diversity Coded Protection with various congestion Control Method already in use like Segmentation and Segmentation with Deflection Routing and develop protocols and we also discussed their shortcomings. Moreover, we also discussed the combination of 1+1 Path Protection scheme and Diversity Coding based scheme and developed a protocol for the merger of two schemes.

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I would extend my sincerest gratitude to my supervisor Professor Y N Singh for giving me the opportunity to do my research on this topic. At the same time, I also want to thank my supervisor for helping me to learn the deep knowledge about this topic. I also want to thank my parents and my friends for always standing by me.

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Abbreviations

OCS	**O**ptical **C**ircuit **S**witching
OPS	**O**ptical **P**acket **S**witching
OBS	**O**ptical **B**urst **S**witching
QoS	**Q**uality **o**f **S**ervice

Chapter 1

Introduction to Diversity Coding in OBS Networks

1.1 Switching in Optical Networks

Switching is a process, which is used to forward data from input to output port in any kind of Network.More precisely switching allows port to port transmission of data between input port and output port. A network contain many such switches which allows data through itself.

In optical networks, data is in form of light signals, so switching in optical domain is done to direct light signals between ports or between input and output ports. There are three kinds of switching techniques present in optical networks

1. Optical Circuit Switching(OCS)
2. Optical Packet Switching(OPS)
3. Optical Bursts Switching(OBS)

1.1.1 Optical Circuit Switching

In non-optical networks, in circuit switching a dedicated path is set from input to output port which is physical in nature but in optical domain in circuit switching, a dedicated wavelength is setup for transmission from input to output port.

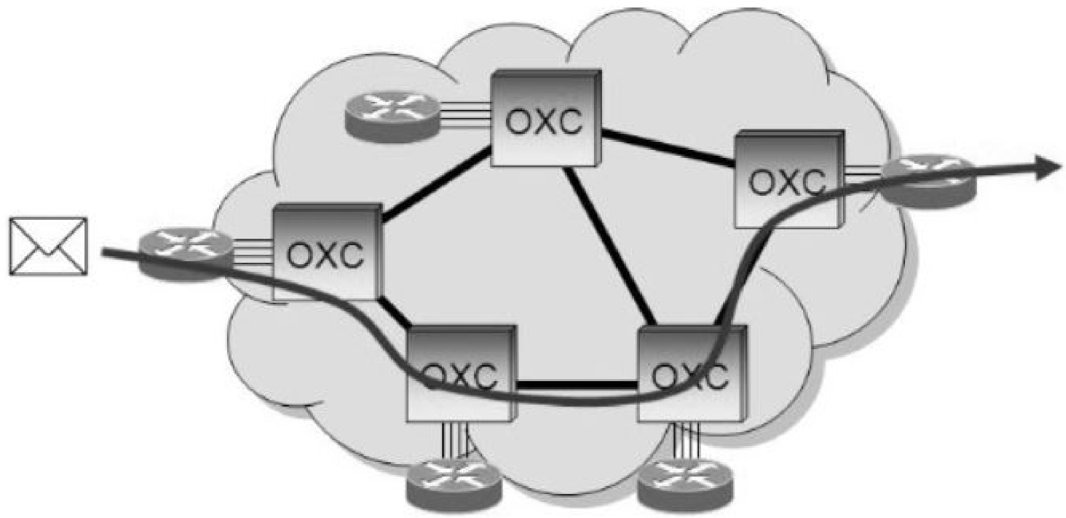


FIGURE 1.1: Basic Architecture of Optical Circuit Switching

1.1.2 Optical Packet Switching

In this technique, data is send in form of packets. Packets contain header and payload. Header contains data regarding length of the packets and various other information about payload and switching is done based on the information about payload.

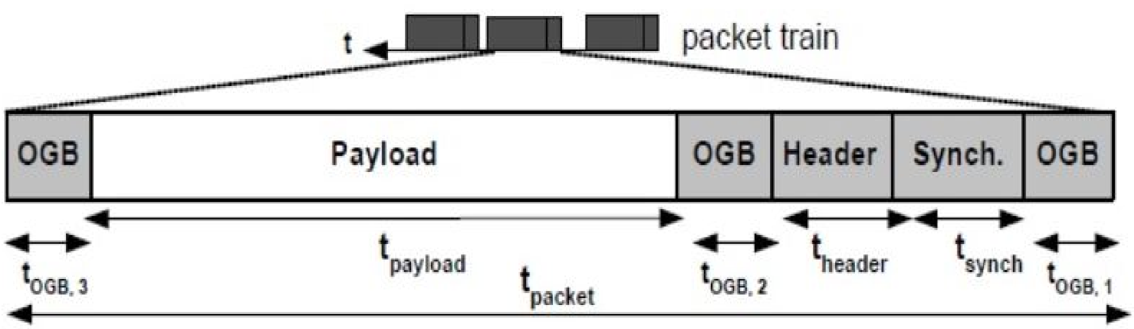


FIGURE 1.2: Basic Architecture of Optical Packet Switching

1.1.3 Optical Burst Switching

In OBS data is accumulated at one end of the network and it is sorted based on destination address and based on destination address it is grouped and these groups are called as bursts and they can be of variable size. A control packet is send to ensure a path for the burst and then after some time the burst is sent into the network. This time difference is called as offset time.

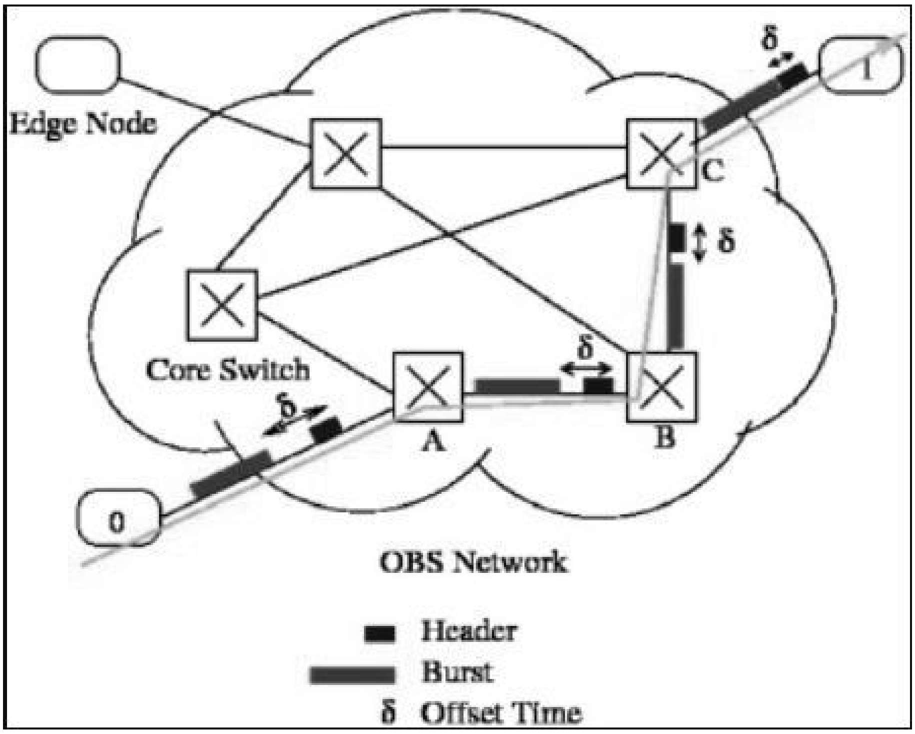


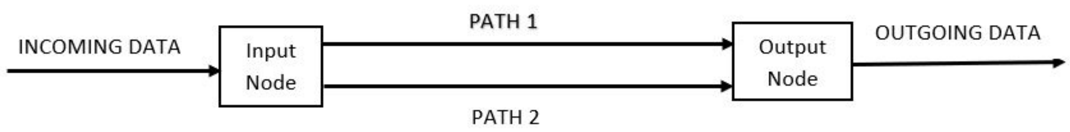
FIGURE 1.3: Basic Architecture of Optical Burst Switching

1.2 Diversity Coding

In conditions, where quality of service (QoS) constraints are very high, we require few techniques which can prevent data loss. One such technique is 1+1 path protection.

1.2.1 1+1 Path Protection

In 1+1 path protection, if there are two disjoint paths from input node to output node, then data can be send in both paths at the same time, so that if one of the path fails, data can still be transmitted and no data is lost.

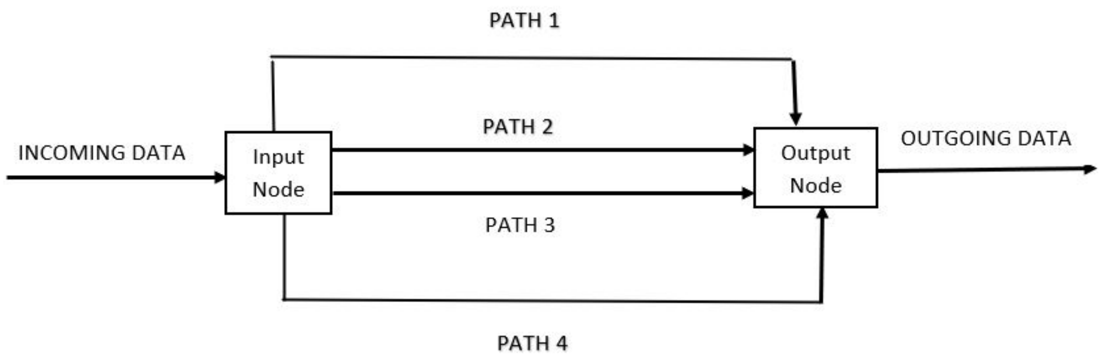


1+1 PATH PROTECTION

1+1 Path protection suffers from disadvantage that network utilisation is low or resources are wasted inside the network.To somewhat control this shortcoming, a new technique is introduced known as Diversity Coding.

1.2.2 Diversity Coding

If there are more than two disjoint path from input to output port then the data stream can be divided and EX-OR of divided streams is carried in a different path, and in case one of the links fail, data can be retrieved back with the help of data on EX-OR link.
For example, let us suppose that there are 4 disjoint path between input and output nodes. So incoming data is divided into 3 different streams and their EX-OR is send through the fourth link. So in case any of the link fails from 1 to 4, the data can be retrieved from the other three links.
In this case network utilisation is better then 1+1 path protection technique as we do not need to regenerate whole data. In Optical Bursts switching networks, Data is in form of burst, so first it is divided into various sub-bursts and then Diversity Coding is applied.



DIVERSITY CODING

1.3 Congestion Control Mechanism in OBS Networks

At high traffic conditions or unreliable condition, data flow may be hindered or slowed down. To avoid such conditions, few techniques are made use of such as
1. Segmentation
2. Deflection Routing

1.3.1 Segmentation

Segmentation is a process in which a burst is segmented in order to avoid congestion at a node. With the help of this process, the overlapping of burst is avoided.

1.3.2 Deflection Routing

In deflection routing, if a node is busy then the incoming bursts may be routed to another output port to avoid contention. In this approach, there is always a risk of looping of burst inside the network or it may never reach the output port.
In the coming chapters we will discuss about the combination of Diversity Coding with these techniques in order to avoid contentions while try to increase QoS.

Chapter 2

Combination of Diversity Coding with Segmentation and Deflection

We have discussed about various contention resolution techniques in the introductory chapter. In this chapter combination of segmentation and deflection routing is studied in combination with Diversity Coding.

2.1 Combination of Segmentation and Deflection Routing

There are various ways in which these two techniques can be combined and which of the original and contending bursts is going to be segmented or deflected or both.

2.1.1 First Segment and then Deflect

The original burst is segmented, and the tail segments of the original burst may be deflected if an alternate port is available, otherwise the tail segments of the original burst are dropped.In this way, the data loss happens with the original burst and contending burst is transmitted completely

2.1.2 Deflect First and Drop

The contending burst isdeflected to an alternate port if an alternate port is available. If no alternate port is available, then the contending burst is dropped.Overall this method does not effect the transmission of original burst.

2.1.3 First Deflect, Segment and Drop

If there is an alternate port available then the contending burst is deflected to that port. If no alternate port is available, then the original burst is segmented and the tail segments of the original burst are dropped, while the contending burst is routed to the original output port. This method can effect both types of bursts.

2.1.4 Segment and Drop

The original burst is segmented and the tail segments of the original burst are dropped.The contending burst is unaffected and has upper hand in this method.

2.1.5 Only Drop

In this method, whole contending burst is dropped and the original burst is transmitted without any change. This is the only process in which no deflection is involved

2.2 Combination with Diversity Coding

Diversity Coding requires a burst to be divided into various sub-bursts. Number of sub-bursts should be one less than number of end to end path available.
This whole process of segmentation with Deflection routing can be combined with Diversity Coding in two ways.

2.2.1 First contention resolution Schemes then Diversity coding

In this approach Diversity coding is applied after contention is avoided and the path for various sub-bursts will be decided afterwards.There should be more than 2 paths starting at the same node and ending at same node inside the network.

2.2.2 First Diversity Coding then Segmentation and deflection

In this approach, first burst is divided and coded and then various contention resolution schemes are applied in the network.
The disadvantage of this approach is data loss may happen and various sub-bursts may be out of sync at the end of network due to deflection.

2.3 Shortcomings

2.3.1 Potential Looping

One very major disadvantage of these methods is that all of them involves deflection to an alternate port. In deflection, one burst or sub-burst may never come out of the loop and be continuously deflected inside the network.

2.3.2 Violation of Offset time

In OBS networks, there is always a time difference between header and data burst called as Offset time which is fixed and burst is expected to travel according this offset time but when deflection occurs, the burst may not reach the output node inside this offset time. So this way, the burst may become out of synchronization.

We saw that main reason for shortcomings is Deflection routing. With Deflection it is difficult to follow time constraint as well as it can cause potential looping of one or more of the sub-bursts. So we remove this deflection process and try to go ahead with segmentation only.

Chapter 3

Combination of Segmentation and Diversity Coding

3.1 Segmentation

As discussed in previous chapters, segmentation is a process in which a burst is segmented in order to avoid contention.When a burst is segmented, one of the segment may have to be dropped which results in data loss.

Based on time of arrival, burst can be broadly classified into 2 categories.

3.1.1 Original Burst

The burst which reaches first at the input node is termed as original burst.

3.1.2 Contending Burst

The burst which reaches after the original burst is termed as contending burst.
Based on above definition a burst can be of both types as it can be after a burst as well as another burst can be after it.

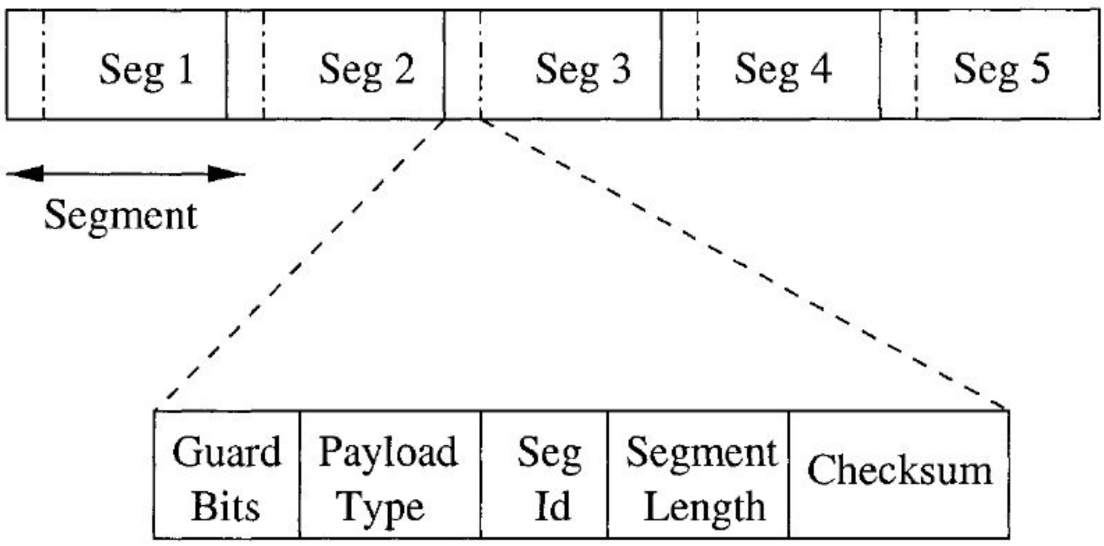


FIGURE 3.1: Basic Architecture of Segmentation

3.2 Operations Based on Classification of Bursts

Based on classification, there are various operations which can be performed on segmented sections of bursts.

3.2.1 Head Dropping

In head dropping, the starting segments of contending bursts are dropped and whole original burst and tail segments of contending burst are transmitted one after another once the contention is avoided.

3.2.2 Tail Dropping

In tail dropping, the tail segments of original bursts are dropped and whole contending burst and head segments of original burst are transmitted one after another once the contention is avoided.

In both, the above procedures data loss is going to happen as a segment is going to be dropped anyway.

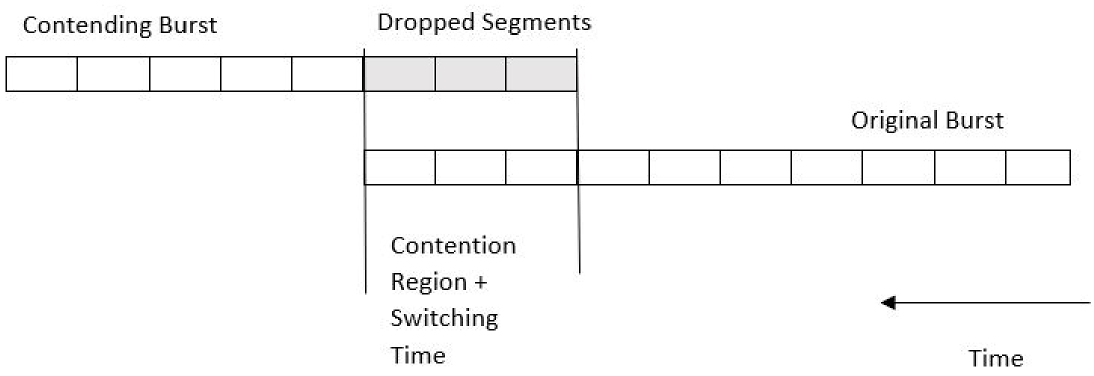


FIGURE 3.2: Head Dropping

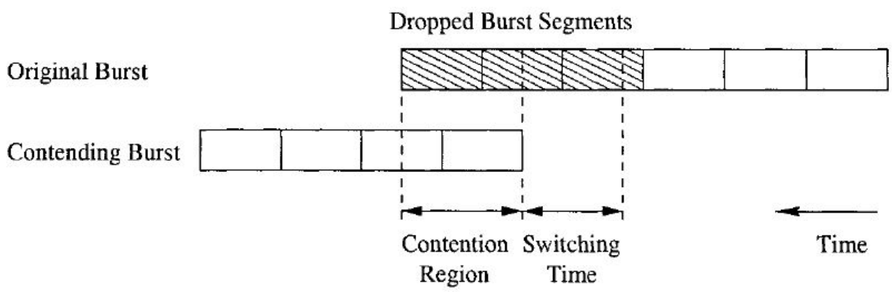


FIGURE 3.3: Tail Dropping

3.3 Combination with Diversity Coding

In high traffic conditions, the segmentation process can be combined with Diversity Coding to increase QoS.
Diversity Coding can be applied with segmentation using two procedures.

3.3.1 First diversity coding then Segmentation

In this approach, if Diversity Coding is applied before segmentation, then while segmentation, data loss may happen when a sub-bursts gets curtailed and if two sub-bursts of same bursts get segmented, then we can not recreate the whole burst at the output node and whole point of Diversity coding is lost.

For example, after diversity coding is applied there are two sub bursts and a third sub-burst as EX-OR of them. Now at high traffic condition, while performing segmentation

any of the burst can segmented. As long as only one of them is lost partially, we can recreate it but if more than one sub-bursts gets curtailed then the data lost can not be retrieved back, and this is from the failure of segmentation. We are not taking link failures into account and these link failures will also affect this approach.
So this method is not very profitable.

3.3.2 First Segmentation then Diversity Coding

In the second approach, if Diversity Coding is applied after segmentation then sub-bursts will be formed after a burst is segmented. After segmentation, normal Diversity Coding may be applied. So, in this case data loss may happen but it will not affect Diversity Coding process.

For example, Take two burst of length 10 bits each with 5 bits in each of the bursts in contention.Let us have tail dropping, so the 5 bits of tail segments of original bursts are dropped and as a result we have a 15 bit burst. Now, suppose we have 4 different paths from input to output nodes, then we can divide this 15 bit burst into three 5-bit sub-bursts and have the EX-OR of these three sub-bursts travel in remaining one path.In this way, this second approach can work better than the first approach.

3.4 Shortcomings

3.4.1 Data Loss

In any case of segmentation, be it head dropping or tail dropping, there is loss of data involved. So even after applying Diversity Coding, this data loss is always going to happen.

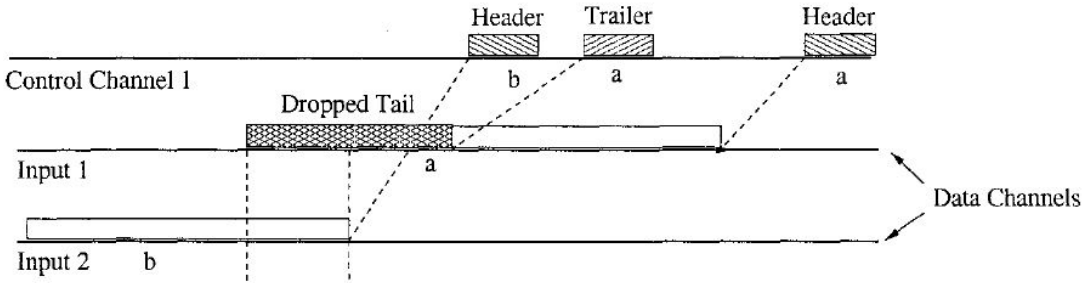


FIGURE 3.4: Trailer Generation

3.4.2 Trailer Generation

When applying segmentation, the length of a burst or a sub-burst is going to change when the segments are going to be dropped. So the length which the header knows is going to change and then we have to send a trailer to upcoming ports stating about change in length and reserve the resources accordingly. This modification is required without applying Diversity Coding.

Chapter 4

Diversity Coding with 1+1 Path Protection

We have discussed Segmentation and Segmentation with Deflection in the previous chapters and the possibilities and limitations arising after their combination with Diversity Coding.
Diversity Coding can also be combined with 1+1 path protection depending on the traffic condition to get an increase in QoS.

4.1 1+1 Path Protection

In services where the requirement of QoS is very high, additional techniques are required to ensure it. One such techniques is 1+1 Path Protection.
In this technique, two disjoint paths are required to send same data at the same time but this process wastes resources of network.This process creates 100 per cent overhead of Data.

4.2 1+1 Path Protection against Protection based on Diversity Coding

4.2.1 Low traffic

At low traffic intensity, the overall number of burst is low per unit of time, so number of sub-bursts is also low. In such conditions, the probability of loss of a sub-burst is quite low. So overall probability of data loss is low and if 1+1 path protection is used in such condition then it wastes the resources of the network.

4.2.2 High traffic

At high traffic, the overall number of bursts and subsequently number of sub-bursts are very high. So if Diversity coding based protection is used then the overall probability of loss of sub burst is high. In this case, having 2 simultaneous path for data transmission is more safe and 1+1 Path Protection outperforms Diversity Coding based protection.

4.3 Combination of Diversity Coded Protection and 1+1 Path Protection

We have seen the comparison of performances of both these techniques at high traffic and low traffic condition.Now we can develop a system in which, at low traffic condition Diversity Coding based protection is used and at high traffic condition 1+1 Path Protection can be used to enhance the overall QoS of network.

4.3.1 Basic Idea

This technique can be applied only when the network has more than two disjoint paths from input to output node.In any other case, Diversity Coded protection can not be applied.
First we need to set a threshold value of traffic intensity, above which the 1+1 Path Protection is applied and below which Diversity Coded protection is applied. Above

threshold, we need to select two shortest paths from input to output node and send the same data and below threshold, we need to select at least three shortest paths and then send sub bursts and EX-OR of them in those paths.
This technique does not involve any of the congestion control mechanism and therefore limits any modification required due to them.

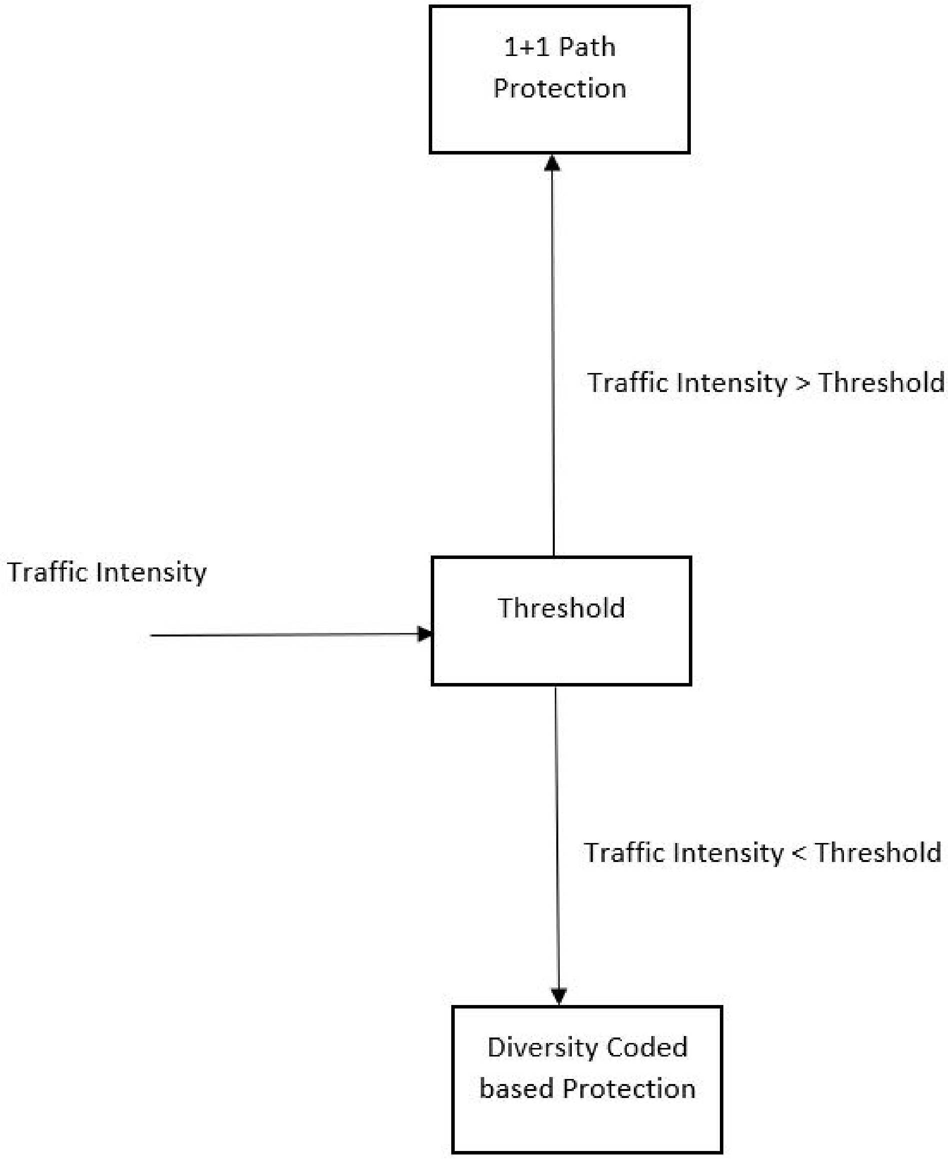


FIGURE 4.1: 1+1 Path Protection with Diversity Coded Protection

4.4 Further Modifications Required

4.4.1 Threshold value

We need to find the optimum threshold value for the transition between the two protection mechanisms for best QoS.

4.4.2 Offset Value Modification

Based on threshold value, the offset time will also be altered to serve to both mechanisms as the length of the paths selected for transmission will also change based on which protection mechanism is being used.

Chapter 5

Conclusion and Future Scope

We have discussed about various techniques combining Diversity Coded Protection with congestion control mechanisms and they all have various shortcomings and then we have one mechanism in which congestion control is not used

5.1 Conclusion about each Technique

Let us draw a comparison between all of the discussed hypothesis

5.1.1 Deflection and segmentation with Diversity Coding Protection

When we try to combine protection technique based on diversity coding with combination of deflection routing with segmentation, the modification required were far too significant to be ignored and at the same time this technique also has a potential risk of looping of sub-bursts inside the network. In that case, it is very difficult to set an offset time.
So, this technique does not hold much ground.

5.1.2 Segmentation with Diversity Coding Protection

After previous technique's failure due to deflection routing, only segmentation is tried to combine with Diversity Coding Protection in which shortcomings of deflection like looping and inability to set an offset time were not present on paper but segmentation also involves generation of a trailer packet when a burst is curtailed at the incoming node. After the burst is curtailed, then it is a normal process of Diversity Coded protection.

5.1.3 Combination of 1+1 Path Protection and Diversity Coded Protection

After combining with congestion control protocols, a hypothesis was developed to combine 1+1 Path Protection and Diversity Coded Protection as they both outperform each other depending on the traffic as discussed in chapter 4 but this also involves a knowledge of a threshold of traffic intensity which is still unknown. Further we will require a mechanism for modification of offset value on the either side of threshold value.

5.2 Further Scope for Research

We have discussed combination of Diversity Coded Protection with two congestion control mechanisms and try to develop protocols for them. In case of Deflection Routing research is required to contain number of deflection to avoid risk of looping inside the network and accordingly try to get an approximate of offset value. In case of only segmentation research is needed to develop a mechanism for formation of trailer packet before applying Diversity coding Protection. In case of combination with 1+1 path protection, further research is required to find a threshold value which delivers best QoS. At the same time, there is need to find the mechanism to set offset value according to technique being used based on threshold value.

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