Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN：1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 01-2023
DOI 10.17605/OSF.IO/36VAH

HYBRID INTER-CYCLE SWITCHING (HICS) FOR SPAN AND NODE FAILURE FOR P-CYCLEBASED WDM NETWORKS

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Abstract

There is an enormous insistence for designing optical transport networks in sucha fashion, so that it has enhanced utilization, reduced spare link capacity, minuscule path length and an escalated level of survivability. Inter-cycle switching (ICS), one of the more recent approaches that is based on idle p-cycles and used to shorten the length of restoration paths in flawed models, is the most promising technique for the survivability of optical transport networks.However, ICS model fails to protect node and span at a time. Using idlep-cycles reduces the inherent span and node failure restorability of failure in thep-cycle design model, whereas ICS releases the most conventional restoration path by only using a small portion of the idle p-cycle, but it had several glitches, which were enhanced by several proposed methods, of which one significantone is Inter-cycle Switching. In the proposed work the authors analyzed the performance of the Inter-cycle Switching and eliminated the snags hindering its performance. Overhear the authors have analyzed Hybrid Inter-cycle Switching (HICS) in various scenarios of span and node failure and have proposed a method for ensuring an effective and efficient restoration process in the event ofspan and node failure as well.

Keywords: Span Failure, Node Failure, P-Cycle.

1. INTRODUCTION

With the proliferation of the Internet, escalating figures of “errand vital” business functions that depend on communication networks, and the advent of rife societal reliance on communications, forge survivability is a vital aspect of communication designing. The network operators must design the network in such a way that the network is able to sustain the impacts in span failures. Amongst link & node failure, node failure is more common i.e. the node failuregenerally occurs due to router crash or due to router restart (due to certain reasons such as software upgrades etc). On the other hand link failure generally occurs due to fiber cut etc [1].

Thus, the most vital aspect for the designers of survivability of WDM networks is to shorten the length of the restored path along with the minimization of sparelink capacity deployment and have survivability against failures. The reduction of the restored path length increases spare link capacity and has better survivability with lower link utilization. Henceforth, the main issues are link spare capacity survivability, link utilization and restored path length. Therefore, there is an extreme demand, for designing a WDM network in such a way, thatit has better utilization, lesser link spare capacity, shorter restored path length and high level of survivability [2]. In the scenario of link/ node failure

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the p-cycle scheme reroutes the traffic on to a backup path along the p-cycles with the aid of local repair actions [3]. P-cycle technology is applicable on IP [4] or MPLS [5] layers, though it was originally invented for providing protection in the optical layer. The P-cycle scheme is extremely popular because of its ring-like speed of protection and mesh-like efficiency [6]. The eminence of p-cycle is evident as it finds application in multitudinous kinds of networks.

Overhear the authors have assumed that unused p-cycles exist that would be extremely assistive in decreasing the real time workload of establishing cross connections amid restoration. The layout of the remaining of the paper is as follows: in section II the authors present a concise backdrop of the associated work. In section III the authors succinctly anatomize three different horizons of network problems and provide an ameliorate solution. In section IV an algorithm for ensuring span and node-failure restoration mechanism has been presented. In section V a numerical analysis has been presented and thereafter the conclusion has been discussed.

2. BACKGROUND AND RELATED WORK

Researchers optimized the restored path for the network's state of span failure using the idle P-cycle, which reduced the additional requirement of spare capacity and avoided the failed span as a result of their earlier discovery that 100% network span and node failure survivability requires a very high amount of additional spare capacity that is too high even for single fault restoration models, but what if span and node got failed together. For reducing the linear measure of the longer restoration paths in the current p-cycle design's optimal spare capacity, the researchers proposed Intercycle Switching (ICS) [7]. In order to decrease the length of the restored path, the authors presented an approach to eliminate the loop backs in [11-14]. A number of research works [8-10], have examined the dual-fault restoration. For instance, in [8] the authors examined three issues Dual Failure Maximum Restorability (DFMR), Dual Failure Minimum Capacity (DFMC) and Multi Restorability Capacity Placement (MRCP).

Therefore, the main objective of Hybrid Inter Cycle Switching Technology (HICS) is to optimize the span and node failure together, by rerouting the working path to bypass the failed node and span together with the help of Idle P-Cycle present on network, so that there is no need to go for the traditional expensive and time taking technique to resolve the node failure state.

Let us analyze the suggested strategy using the hypothetical network diagram in the figure 2.1 and 2.2.

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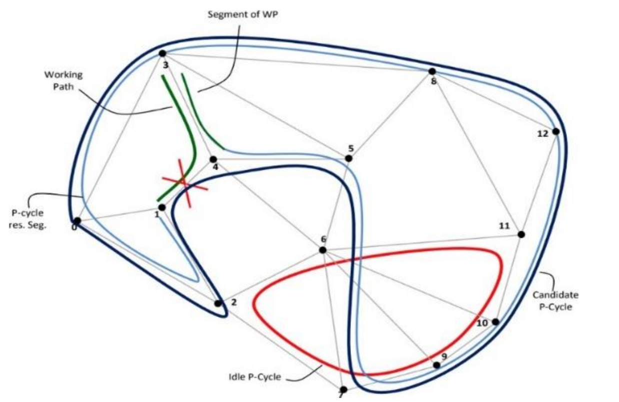

Figure 2.1: Working Concept of P-Cycle and Idle P-Cycle

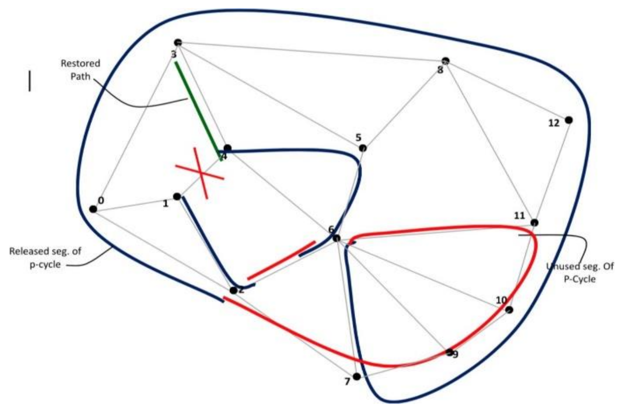

Figure 2.2: Restored Path by Utilization of Idle P-Cycle

Now we will understand two already invented and currently in use technology which are P-Cycle and (ICS) Inter Cycle Switching. In the traditional P-Cycle approach, the working path started at source node 1 and ended at destination node 3, and the first failure event happened on span 1-4, which is shown ingreen in figure 2.1. This traditional restored path is shown in figure 2.2, where the ICS approach identifies two optimal common nodes 2 and 6 between the traditional restored path and the idle p-cycle. It produces a modified restored path (1-2-6-5-4-3) by switching at shared nodes, and figure 2.2 shows that the remaining segment of the traditional restored path (2-0-3-8-12-11-10-9-7-6) is released by ICS. In the traditional P-Cycle approach, the working path originated from source node 1 and destination node 3, and the first failure event occurred on span (1-4), which is traditionally restored by the candidate P-Cycle.It produces a modified restored path (1-2-6-5-4-3), and fig. 1.2 shows that the remaining portion of the conventional restored path (2-0-3-8-12-11-10-9-7-6) is released by ICS.

3. Overview and Contribution

Let us understand node and span failure state together with “**traditional restoration technique**” with hypothetical figure:-

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Here, the working path is <1-2-5-6>, but after span failure between node <2-5> and node failure at 5, there is one traditional way to restore the span and node together identifies 10 nodes to restore the issue between traditional candidate P-Cycle as shown in the figure 3.1, by performing switching at failed nodes 5 with traditional technique it rerouted the working path

<2-3-1-9-10-7-8-6-4-5-6> and restored the working path with the help of traditional restoration restore technology but here is the biggest issue with the traditional restoration system is it takes additional spare capacity for every failure restoration and also it creates loop between restoration cycle.

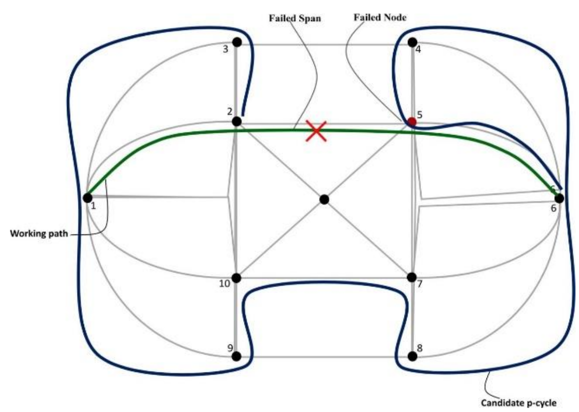

Figure 3.1: Span and Node Failure Scenario

Now the author is expanding the use of HICS technology with different scenarios explained below:-

Scenario A: Node and Span failure together.

Here, the working path is <1-2-5-6>, but after span failure between node <2-5> and node failure at 5, there is one traditional way to restore the span and node together which needs additional spare capacity, so the author is using HICS technology to protect and restore the Node and Span together. The HICS approach identifies two nodes between the traditional candidate P-Cycle and the idle p-cycles as shown in the figure 3.2, switching is carried out at designated nodes with the help of HICS technology it yields modified restore path <1-3-4-6>, and restored the working path with the help of HICS by rerouting identified nodes and utilization two Idle Cycles.

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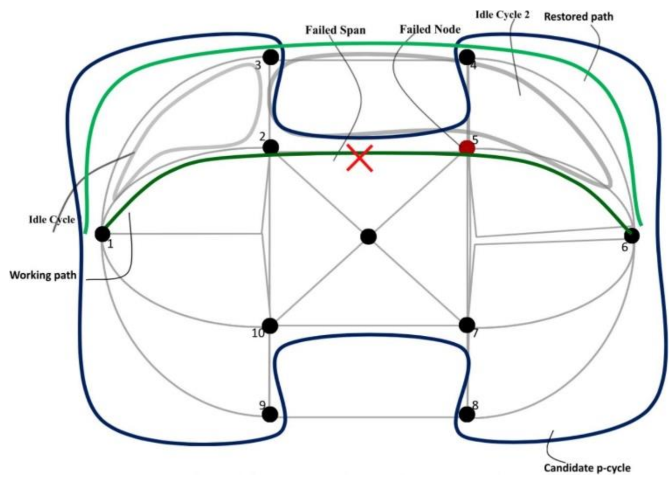

Figure 3.2: Node and Span failure Restoration

Scenario B: UP Node and Span Failure together.

Here the working path is originated from node 1 and ends with node 6 (1-2-5-7-6), but after span failure between node < 2 - 5 > and node failure at 2 as illustrated in the Figure 3.3, which were the Up Node and Span of the working path <1-2-5-7-6>, Therefore the author is using HICS technology to protect and restore the failed node and span together. The HICS approach identifies two common nodes <10-5> between the traditional candidate P-Cycle and idle cycle 1 and 2 as illustrated in the Figure 3.3, thereafter new route needsto be established to reach the destination, so with implementation of HICS technology and by switching at designated common nodes, it produces modified the working path <1-2-5-7-6> and rerouted to an new restored working path <1-10-11-5-6>.

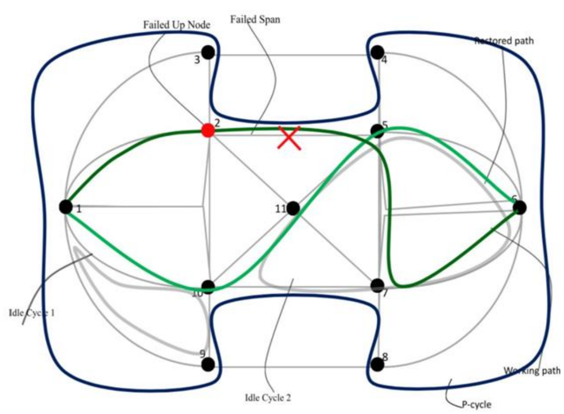

Figure 3.3: Up Node and Span Failure Restoration

Scenario C: Intermediate Node and Span Failure.

Here, the working path is originated from node 1 and ends with node 6but after span failure between nodes <2-5> and node failure at 7 which is also called Intermediate Node

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and Span of working path <1-2-5-7-6> as illustratedin the Figure 3.4, so the author is implementing the technology of HICS to protect and restore the failed intermediate node and span together. When comparing the conventional candidate p-cycle and the idle cycle 1, the HICS

Method reveals two shared nodes (10, 5) and idle cycle 2 as illustrated in the Figure 3.4. Now new route needs to be established to protect the node and span failure and to reach the destination node, therefore by implementation of HICS technology and by performing switching at identified nodes it yields modified the working path <1-2-5-7-6> and restored will be <1-10-11-5-6>, so the new working path to flow of data traffic with lightning speed is <1-10-11-5-6>.

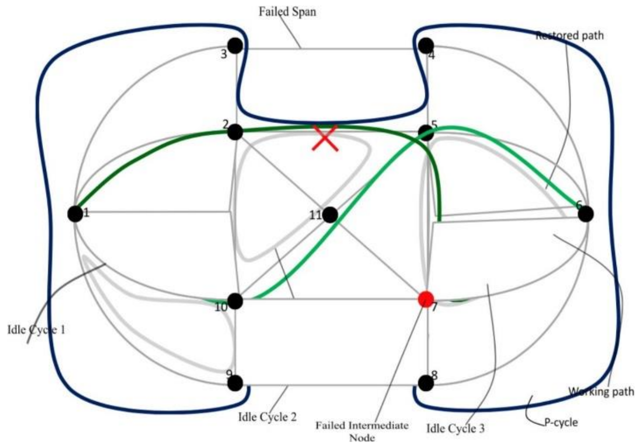

Figure 3.4: Intermediate Node and Span Restoration

4. Algorithm

X-distance (XOP)Y-distance (YAP) cycle no 1

While** (cycle_no<3)**Do

Identify index P and Q in XOP and XAP, respectively, in such a way, so thatboth portions XOP(1 X) and YAP (2 Y)

Are identicalL2

***While** (L>=0)**Do**1 nodeYAP[P]*

Examine the left section of the XOP starting from the index R to identify theindex M such that XOP[M]

=1node.

If** XOP[M]=1node, **then

***Copy** Segment XAP[1 Y] into cycle [cycle No]*

***Append** Segment XOP[m--------------- 0+1] into cycle [cycle No]*

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Set *nm and Y1* ***Increment*** *cycle No****Else***

Decrement 1Endwhile Endwhile

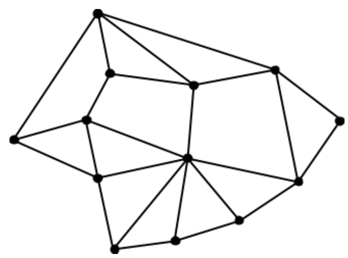
Return *new cycle [1] and cycle [2]*

5. Simulation and Results

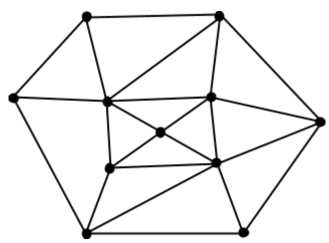
Network Topology For Test Bed

Figure 5.1. a. Test Network-1 b. Test Network-2 c. Test Network-3

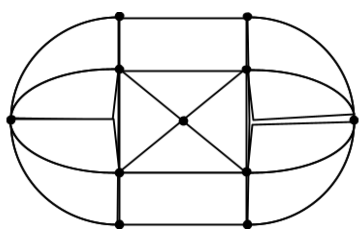
(a)



(b)



(c)



This segment evaluates the performance of the proposed mechanism and it is evident from our illustration in section III that the HICS can solve the issue of Node and Span failure state at the same time and can also lessen the distance between the end to end of the restored path. The performance of the proposed HICS assessed with the aid of three test networks as illustrated in Figure 5.1a, figure 5.1.b and figure 5.1.c the test network 1 shown in the figure consists of13 nodes, 23 links, and an average node degree of 3.5, while the test network 2 consists of 10 nodes 22 links and an average node degree of 4.4 and the rest network 3 consists of 11 nodes, 22 links and an average node degree

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of 3.2. Over-here 100% span and it is possible to fix a node that has failed, as long as there is enough spare capacity.

Table 5.1 Span and Node Failure Restorability

Unit of Restoration Capacity (at all second failure candidate spans)								
First Failed Span	ICS Based Dynamic Reconfiguration of p-cycle				HICS Based Dynamic Reconfiguration of p-cycle			
	Required for spare channels	Available	Remaining Demand	% additional unit of protection obtained	Required for spare channels	Available	Remaining Demand	% additional unit protection obtained
0	3	65	88	9.28	3	66	82	9.38
1	34	55	129	19.38	32	55	124	20.10
2	25	84	91	26.02	23	86	82	27.5
3	38	34	154	7. 78	37	37	151	7.90
4	45	55	140	11.39	43	59	139	12.52
5	14	37	127	3.79	12	39	124	4.39
6	14	57	107	10.83	11	61	101	11.41
7	37	60	127	16.99	34	66	124	17.79
8	62	30	182	14.55	59	32	178	15.53
9	54	40	164	9.39	52	47	151	10.10
10	40	50	140	14.11	39	55	137	14.92
11	29	60	119	8.46	25	66	110	8.92
12	26	50	126	15.44	25	55	120	16.94
13	45	60	135	14.56	43	68	131	15.51
14	64	45	169	10.11	61	47	163	10.91
15	29	25	154	9.41	25	29	151	9.91
16	26	50	126	5.97	25	52	120	6.23
17	79	25	204	7.69	75	28	191	7.99
18	73	27	196	8.41	68	29	187	9.43
19	55	49	156	17.02	50	52	151	17.92
20	81	28	213	3.62	75	30	194	4.61
21	25	73	102	7.27	23	77	100	7.57

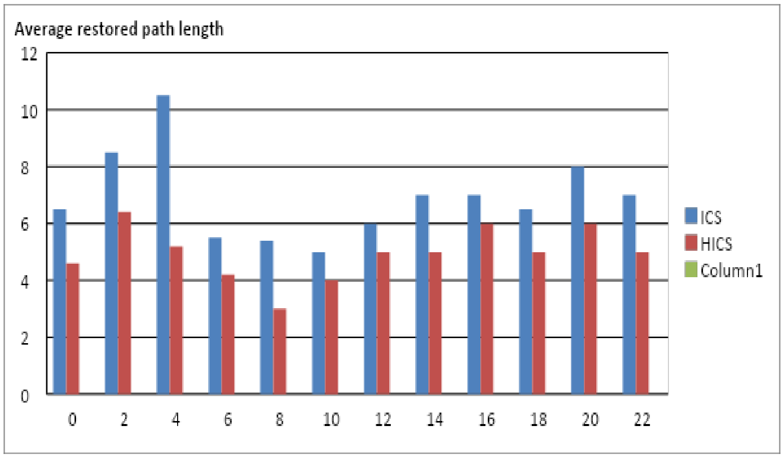

Figure 5.2:- Length of the Restored paths with ICS and HICS for test network

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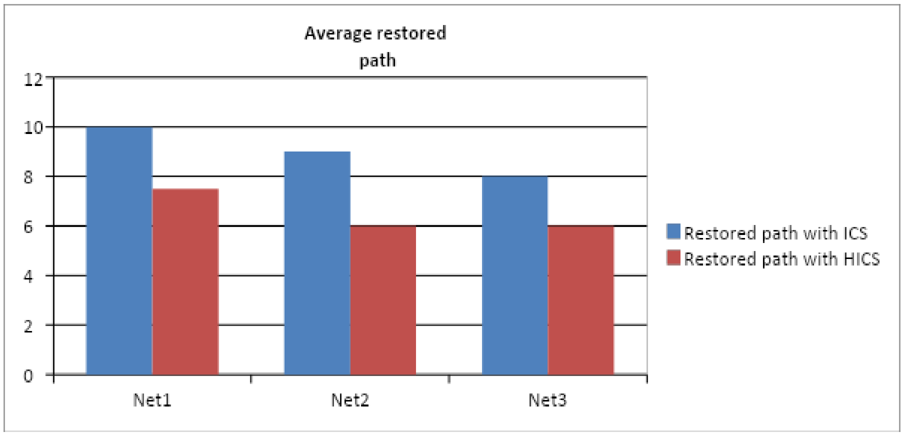

Figure 5.3:- Effect on restored path lengths with ICS and HICS

The test network 1, test network 2 and test network 3 has been simulated with the aid of the Network Simulator NS-2. Overhear the demand of every single pair of nodes is presumed to be one and the requested routing is attained in conformity to Dijkstra's Shortest Path Algorithm (DSPA) and for a single fault model, the requisite candidate p-cycle are discovered with the aid of the Distributed Cycle Pre-Configured (DCPC) protocol [1].

Every span in the test network is taken one at a time, treating it as having failed,and its available restorable paths (RPs), number of working paths passing over it, and available idle p-cycles are all calculated. It is evident that there are enough idle p-cycles at each span to allow the HICS approaches to avoid the span and node failure state and shorten longer restored paths. The graph in Figure 5.2 shows the average hop counts needed to restore working paths passing over a failed span against the span's number, the node with the restored path using ICS, and the suggested methods HICS. via Fig. In Figure 5.2, it is seen that the average length of the end-to-end restored optical path with HICS isbetween 3 and 6 hops, compared to the ICS's initial range of 4 to 11 hops. By using the HICS method, this average length was further decreased to an average of 4 hops. Additionally, three different test networks—Net-1 (13 nodes, 23 spans, 3.5 A.N.D.), Net-2 (10 nodes, 23 spans, 4.4 A.N.D.), and Net3—have been used to simulate the proposed approaches (11 nodes, 22 spans, 3.2 A.N.D.). Figure 5.3 displays the average restored path length at each network level as calculated using various methods. It is evident from the figure that for all three networks, the average restored path length significantly decreases and is restorable using the HICS approach for both span and node failure states. Therefore, we can state that the suggested methods are applicable to all topological network types.

In Table 5.1, column numbers 2 and 6 show the required unit of restoration in order to ensure the protection of the spare capacity with the aid of the traditionalICS based p-cycle approach and the proposed approach (HICS) respectively. The statistics of Table 5.1 can be better understood with the aid of the followingexample: During the recursive analysis of the proposed technique (HICS), it has been observed that with the aid of the proposed technique the requisite of a restoration unit at each span is significantly lesser as

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compared to the traditionalapproach of ICS based p-cycle. Accessibility of the restoration unit during idle ICS p-cycles and during dynamic reconfiguration (HICS) has been delineated with the aid of column 3, and column 7, hence it has been substantially observed that in the traditional approach of span and node failure survivability the proposed technique (HICS) facilitates enhanced protection as compared to idle ICS based p-cycles. The depletion in the exigency of the restoration unit has been substantiated with the aid of column no. 4 and column no. 8 (Table 5.1), which is due to the aforementioned fruitful aspects. The percentage of the additional unit of protection obtained with the aid of the proposed technique as compared to the traditional approach has been depicted by column no. 9 (Table 5.1). It's evident that the proposed technique (HICS) provides enhanced span and node failure survivability as compared to the traditional ICS p-cycle based approach as substantiated by Table No. 5.1.

Table 5.2 displays the results of a detailed analysis of the performance of different

Table 5.2

Average Lengths of Restored Path with Percentage of Released Spare Capacity

		Average Restored Path		Spare Capacity		
Network	Working Path	ICS	HICS	Deployed	Released	% of Released
Net1	4.62	8.1	6.21	832	310	37.25
Net2	4.23	6.33	5.12	201	79	39.30
Net3	4.09	5.25	4.33	85	22	25.88

survivability approaches, and it is clear that the HICS approach significantly increases the effectiveness in comparison with ICS. The average length of the restored path obtained using HICS is also close to the average length of the working path, demonstrating reliability on par with the average working path. It was determined that HICS released 37.25 percent of spare capacity in Net-1, 39.5 percent in Net-2, and 25.6 percent in Net-3. This demonstrates another key aspect of the new method proposed, namely, that it frees up a sizable amount of unused capacity.

CONCLUSION

We have investigated and resolved issues related to shorter end-to-end restored paths in p-cycle based survivability network design in the event of span and node failure. Over here it has been established that in the event of failure, the proposed technique i.e. HICS, provides equivalent magnitude of trustworthiness and Quality of Service as its counterparts, along with this it also diminishes the restored path by utilizing the idle p-cycle. The simulation results also validate that the HICS enhances span and node failure survivability as shown in the table5.2, where test net1 shows the restored path of ICS is 8.1 and HICS is 6.21, in test net2 the restored path of ICS is 6.33 and HICS is 5.12 and in test net3 ICSis 5.25 and HICS is 4.33. Here the difference between ICS and HICS restored path. The restored path of HICS is shorter than ICS restored path.

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