

METHODS FOR DUAL FAILURE RESTORABILITY WITH STATIC OR RECONFIGURABLE P-CYCLE NETWORKS

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ABSTRACT

The methods for achieving high dual failure restorability in p-cycles networks that are specially design to withstand all single failures have minimized the amount of additional capacities for dual failure. In one set we consider static p cycle (once established cannot be rearranged) and proposed strategies enhance dual failure restorability which is based on the concept of failure spreading and limiting maximum number of protection relationships of p-cycle. In this paper we also investigate a p-cycle based protection architecture resembling like UPSR rings, called "UPSR-like p-cycles" used to enable high levels of dual failure restorability.

Key Words: P-Cycle, UPSR

I. INTRODUCTION

There are number of applications of p cycle protection in many networks. In transport networks High capacity-efficiency and fast protection switching times have been achieved for span-protection. p-cycles are ring like structure that has protection capacities preconfigured into the cycles .they provide loop-back type of restoration upon failure of fiber span .Unlike rings-cycles are used to protect working capacity of off cycle spans they have their end points on p-cycle also known as "straddling span". Also, for each straddling span p-cycle provides two protection paths, and, thus, it protects the working capacity twice as on those spans as on the on-cycle.

In most of the network design methods includes survivability considerations, but these considerations are generally limited to single failure events only. We know from basic probability theory that single failure is very common failure scenario in network. The probability of such dual failure can be calculated Somani gave that if $m=9$. Where MTBF is $1/\lambda$ and avg. Repair time is $1/m$, then there is 10% probability of 2nd failure to occur before repairmen of first. It has shown that dual failure scenario has the largest contribution to network outage events.

P-cycle networking design has focused on efficiently providing 100% restorability against single span failure-cycle methods is classified as either static or reconfigurable, with principle difference among them being whether or not initial p-cycle plan changes when any failure occurs on the network.

Restorability is known as fraction of demands that are affected by failure scenario, which survive by recovery mechanism using spare capacity of network. Dual failure work concerned with p -cycle network is more

limited. Generally p-cycle literature tries to design p-cycle network to guarantee full single failure restorability, which is most efficient in terms of capacity redundancy.

There are three regions to trigger dynamic p-cycle reconfiguration:

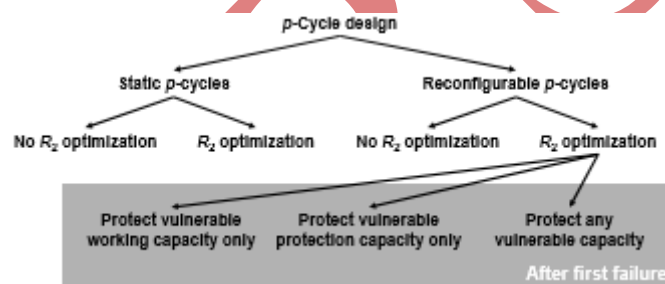
- 1.) Demand changes : newly arrived demands are protected by p-cycle[9][10]
- 2.) Failure (first) occurs: p-cycle reconfiguration maximizes the protection against subsequent failure.
- 3.) Protocol initiation: p-cycles are reoptimized.

In dual failure scenario for simplicity we assume the second failure occurs always after the first failure has been fully responded by p-cycle protection. Static p-cycle explains that dual failure restorability can be improved by:

- (i) Increasing diversity of cycles which are used in design,
- (ii). and by designing to manage the number of protection relationship.

II MOTIVATION

2.1 P-Cycle Design Model for Achieving Dual Failure Restorability



Above figure shows classification of design and operation approaches that can be viewed from a standpoint of R_2 consideration. Some of the options mainly depend on the network operation (e.g. whether reconfiguration is supported or not) and also on design preferences (e.g., designing for single and dual-failure restorability). The Dual-failure optimization i.e. R_2 optimization which is meant for achieving high dual failure restorability all with respect to the average cases.

III LET US NOW DISCUSS DESIGNING TECHNIQUES CORRESPONDING TO THE DIFFERENT OPTIONS IN FIGURE 1.

3.1 Basic Models for p-Cycles without R_2 Optimization

This formulation, first given in [9] and employed in [1][2], This serves for R_1 DESIGN as the benchmark (single failure Restorable) which is at lowest spare capacity cost and is the starting point for new models developed. WDM networks is assumed which is having full (or sufficient) wavelength conversion, or networks having equivalent characteristics. Such type of topology is described by the set of spans denoted by S , and indexed by i for failed spans and k denotes for non-failed spans. There is also set of eligible and simple cycles X which is pre-computed, and also including the protection capacity matrix as, $(\square_k^x, \text{ spans } k \in S \text{ each candidate } p\text{-cycle } x$

$\in X$ lies, the working capacity coverage matrix, or matrix of protection relationships, π_i^x that indicates number of working capacity units on span $i \in S$ that can be protected by a single p cycle on which $x \in X$. Solution for design is described by variables n^x for amount of unit copies of p cycles selected on cycle $x \in X$. Cost of 1 unit capacity is denoted by C_k . Solution for designing is described by variables n^x amount of unit Copies of p -cycles selected on cycle $x \in X$, and auxiliary variables s_k for the amount of units of protection Capacity on span k . Assume the working capacities w_k are input parameters.

Minimize: $\sum C_k \cdot S_k$

$$S_k = \sum \pi_i^x \cdot n^x, \forall k \in S \quad (1)$$

$$W_i \leq \rho_i^x \cdot n^x, \forall i \in S \quad (2)$$

$$n^x \in N, \forall x \in X \quad (3)$$

The equation (1) minimizes the total cost weighted protection capacity, and (2) it determines the capacity protection needed during the formation of the p -cycles and (3) ensures that there are enough p -cycles to protect the working capacity.

3.2 Using R2 Optimization Models For Static P-Cycles

3.2.1 Reducing Susceptibility to Dual Failures

By reducing working capacity coverage of cycles low susceptibility is reduced. t^x indicates whether cycle is used in the designing or not. if $n^x > 0$ t^x is 1, or 0

$$(n^x \div N) \leq t^x \leq n^x, x \in X \quad (4)$$

$$t^x \in \{0,1\}, \forall x \in X$$

By reducing ρ_{max} to minimum we can limit the maximum number of unit capacity protection relationship provided by any of the single p -cycle. By this the dual-failure restorability is improved by reducing the propensity for single p -cycle to be simultaneously affected by the two failures. The New results, shows that a different susceptibility measure, simulated to number of protected spans in place of capacity units. This allows better control of dual failure restorability.

$$\text{We define, } \sigma_x^i = (\rho_i^x + \pi_i^x) \div 2 \quad (6)$$

And (5) is replaced by

$$\sigma_{max} \geq \sum \sigma_i^x \cdot t^x, \forall x \in X \quad (7)$$

3.2.2 Failure dispersal

Other principle is designed so as the total protection of working capacity on given span is disperse over multiple p -cycles. The aim is to avoid the situations where a dual failure takes down the overall working demand which is going through a span as they all are protected by the same p -cycle which may be entirely utilized the first failure. If two corresponding cycles each of which covers half working capacity of span then

the second failure for combination A/B causes loss of half of the working capacity while for second failure for combination A/C causes the entire working capacity to be lost. $\sum \sigma_i^x, t^x \geq \mu, \forall i \in s$

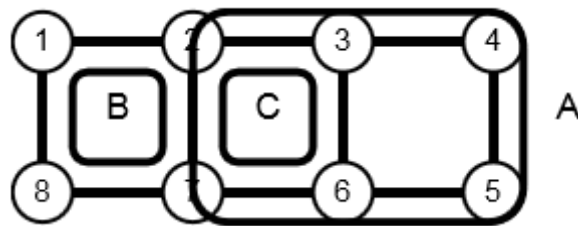


Fig. Fault Sharing

3.3 Reconfigurable P Cycles Model with R2 Optimization

After first failure-cycles which are used for restoration the effected working links are now not available for protection of other working links which were normally protected by them. Also protection paths of p-cycles that are in active restoral state are exposed; second failure should hit them directly. The failure of span 2-7 as shown in figure makes working capacity on the span 2-3-4-5,5-6,6-7,3-6 exposed to second failure if p cycle protects some of the working capacity of these span. The protection path 2-3,3-4,4-5,5-6,and 6-7 is vulnerable.

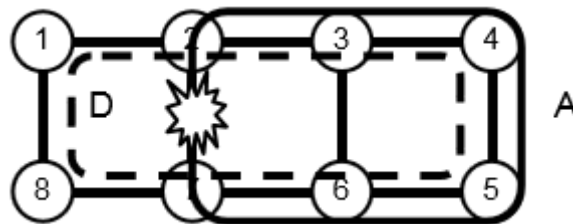


Fig. p-cycle reconfiguration

3.3.1 After First Failure Complete Cycle Reconfiguration

Complete reconfiguration means that for single failure state any network we have predetermined optimized collection of alternative p-cycles to switch; so as to maximize protection against subsequent failure. In case of no failure state has particular configuration of p cycle which is used for 100% restorability to any first failure. In practice reconfiguration can be done using cross connect nodes with preplanned information. Once the failure span identity is propagated network wide. Each and every cross connects nodes increments local set of spare capacity connections which effects the next mandatory p-cycle network wide independently. The p-cycle configuration is preplanned, its estimation can be done offline.

$$n_i^x \in N \forall x \in X. \quad \Pi_i^x = 0 \quad (8).$$

3.3.2 After First Failure Incremental Configuration

Other approach is to increment the existing configuration in each and every single failure state. After first failure we want p-cycles, that are initially found and are partially active in regaining the first failure. We use additional p-cycles and assign more protection to the existing p-cycle to protect against second failure.

After modification of this model additional p cycles are found and initial p cycles remain untouched in terms of their configuration. However, to protect against secondary failure we can also exploit the initial set of p cycle. These extra variables shows how many extra cycles are used in reconfigured state after span failure i ;

$$\Delta n_i^x \in N, \forall x \in X, \forall i \in S;$$

$$\Pi_i^x = 0$$

3.3.3 Actions for Minimizing Reconfiguration

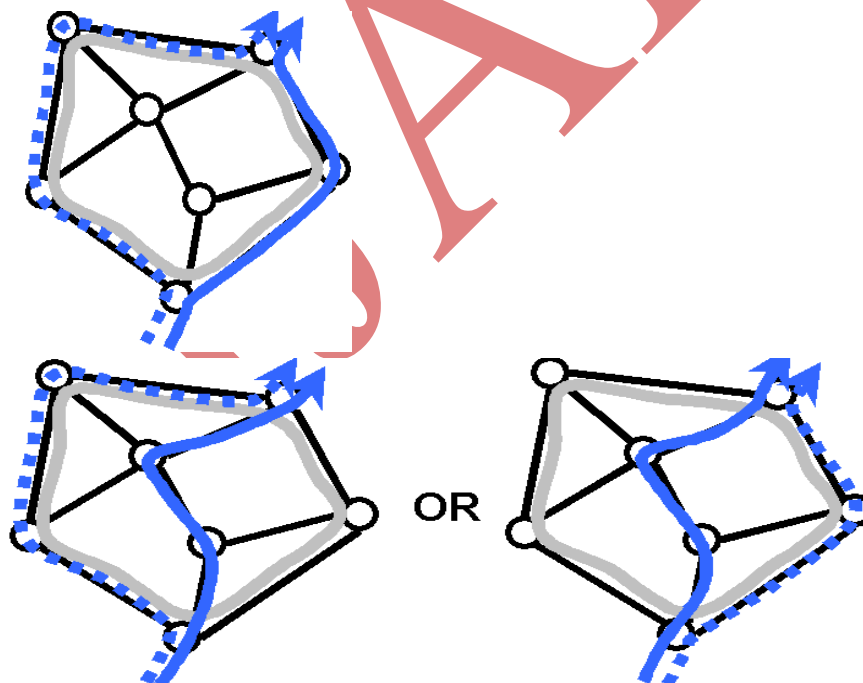
Reconfiguration is effected by the number of cross section that could be concerned. Complete modification of protection configuration is needed. Reconfiguration is taken over to occur after the first failure is shielded and before occurring of second failure. It can be comparatively a slow process and very short comparatively to the first failure .If nodes are able to do corresponding operations those are not of any importance.

$$\beta.n_i^x \leq n_i^x, \forall x \in X, \forall i \in S(9).$$

$$\pi_i^x = 0.$$

IV NEW APPROACH FOR DUAL FAILURE PROTECTION

Many approaches were made to improve dual failure restorability of p cycles. Now we are going to give brief discussion regarding UPSR RINGS. Which are used for enabling high level of dual failure restorability UPSR TECHNIQUE uses mesh network topology to have protection.



UPSR P CYCLES

Recently it was realized that resilience to dual failures can be done in a p-cycle architecture by combination of principle of path protection p cycles the protection approach of UPSR rings. In a UPSR ring, the working signal is rotated in both directions around the cycle from source to destination, so that a single failure on every side of the ring will leave the other path intact. A UPSR-like p-cycle would incorporate this type of circulation principle with mesh like routing of working paths in traditional p-cycles. By This method we can handle at most one path failure at a time, and susceptible to dual failures because network coding is required.

In contrast, enhanced R2 I is provided by UPSR-like p-cycles. If a working path is routed as a straddle, around both side of the cycles there are two possible protection paths.

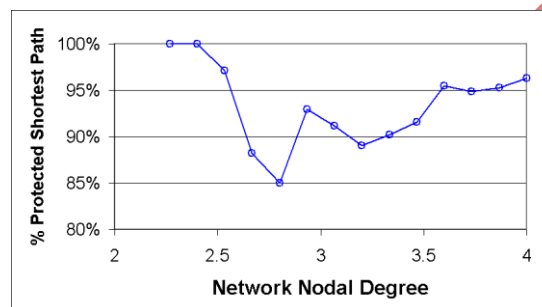


Fig:2 Straddlers in upsr design for frequency of shortest path.

Default protection path fail in addition to working path, a high-priority demand might preempt traffic on the other side of the cycle and use some of that capacity to create a second protection path. See in Fig1 above for difference between UPSR-like p-cycles and UPSR. This routing flexibility in addition not only introduces possibility of saving cost over UPSR by working routes lengths be reduced, but continues to open the further possibility of optimization of structure capacity by making choices for protection routing within the structure itself. By using advantage of routing options in a mesh networking, we can do combination of UPSR protection benefits with some of well-known p-cycles efficiency

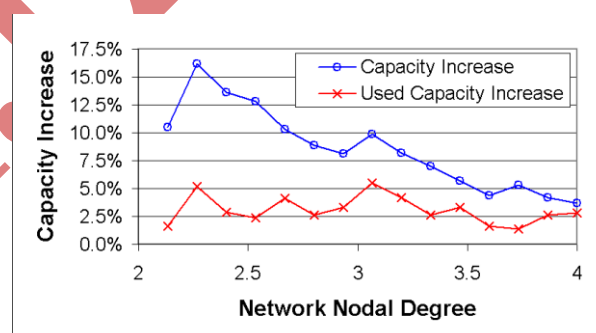


FIG 3: For UPSR-like p-Cycle designs spare capacity increases as compared to 1+1 APS lower bound

By using method discussed above, UPSR-like p-cycles on comparison with other dedicated protection architecture, especially where primary concern is high R2 . In general, beyond the shortest path used by 1=1

APS UPSR-like p-cycle designs didn't detour protection paths significantly, and the under both schemes amount of used spare capacity was comparable over a large range of network's degree.

V CONCLUSION

In this paper we presented capacity design methods for improved or the complete dual failure restorability using static p-cycles or p-cycles reorganized after the event of first failure. Reconfigurable p cycles one allows to offer a dual failure guaranteed at a low capacity cost, this cost is higher than the cost of design for single failure restorability .Another approach for p-cycle network is designed for protection against single failure.

In this paper we have also discussed new approach of p-cycles based protection which are UPSR-like p-cycles, a fast and efficient technique for designing restorable network. We found that UPSR-like p cycles provide dedicated protection as compared to others.

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