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Selective Switching Strategy using Optical Connectivity for Cloud Databases

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Abstract: With increase in the quantum of data in organisations, new strategies have to be developed to handle data in the cloud. Cloud computing is being used to store data virtually and access is being provided to users based on their requirement. The choice of the cloud also depends on the nature of data. With cloud storage, a large number of Disaster Recovery Sites (DRS) are being designed to handle database crashes. In this condition, the communication between the production database and DRS sites has to be handled efficiently. Optical connectivity is one promising solution to ensure reliable transmission. But again when data volumes are high, new models have to be developed, so that, data loss is minimal. In this research, a probabilistic routing model has been proposed using Weibull distribution. A routing topology based on multistage crossbar topology has also been introduced by utilizing cross points. A cross point is being activated based on the actual requirement. This model ensures optimal and reliable communication. The Reliability Effective Selective Switching strategy (RESS) proposed in this research reduces the average request burst by 22%, compared to the Reconfigurable Optical Add/Drop Multiplexer (ROADM) method currently available. The RESS technique proposed reduces the communication cost by 27%, compared to the conventional ROADM technique.

Key words: ROADM, Weibull method, crossbar topology, cross points, DRS, wavelength selective switching, passive star, ARB, load, erlangs, Markovian Model, bandwidth, RESS

INTRODUCTION

In today's world, the size of the data has increased to a very large extent which has created the need for big databases. Before migration to cloud platforms data should be complete, accurate, reliable and usable. In order to handle such large datasets, many factors like security, storage, performance, communication, etc., have to be considered.

One issue which needs to be addressed is the communication strategy. There are a number of data communication strategies but with the large volume of data and huge distances, attenuation and loss of data may occur.

To combat such conditions in this research optical communication is used where light is used as a communication media. The attenuation in this strategy is far lesser than other media that are traditionally used. Flexibility in the optical system is discussed by Bathula and Vokkarane (2010) and Vicat-Blanc *et al.* (2011).

The different strategies of ROADM architectures have been discussed (Chau *et al.*, 2008; Kachris *et al.*, 2012; Kavitha and Indumathi, 2014; Liggett, 2010; Miller, 2013; Notarnicola *et al.*, 2012; Roy *et al.*, 2013). Data is transferred as photons in an optical system as explained by Simmons (2014), Kachris *et al.* (2012). The scalability of an optical network is explained by Zyskind and Srivatsava (2011).

A wavelength selective switching strategy had been proposed (Kavitha and Indumathi, 2014). But these strategies are optimal but an element of uncertainty in the reliability exists.

In cloud platforms, we may need to map multiple disaster recovery sites to a single production site. Under these circumstances, it may be cumbersome considering the huge data volume transaction associated in backup and recovery. The situation would worsen if multiple disaster recovery sites are mapped to the same production database. Cloud-computing permits data storage using virtualization technique. But despite the storage factor, a communication strategy is required for the same.

Optical based communication is reliable. Here, the communication could be made by using a technique called passive star. A cylindrical block named passive star is used and all other nodes are connected to the passive star which controls the communication. In this communication strategy a number of factors, namely, the signal strength, noise associated, channel capacity, etc., need to be monitored. In this study, a topology which is cross point enabled has been proposed to minimize communications.

MATERIALS AND METHODS

In the previous study, a brief overview of the different challenges associated with our communication strategy was discussed. In this study, we propose a

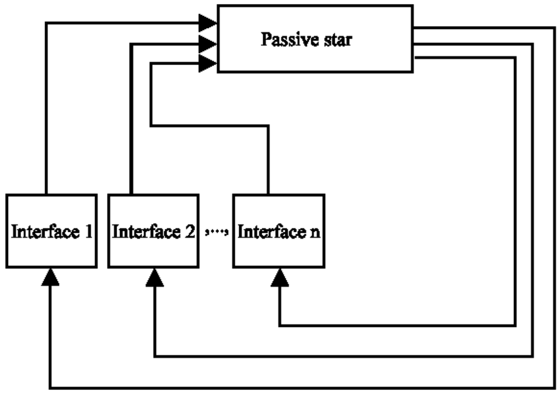

Fig. 1: Passive star arrangement

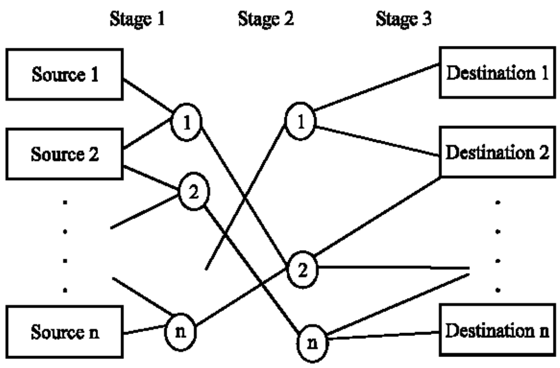

Fig. 2: Crossbar topology

crossbar topology in the passive star arrangement of optical connectivity. A mathematical modelling to ensure reliability based on Weibull distribution has been discussed.

The topology would have a passive star arrangement. In this arrangement a number of interfaces which serve as both sources and destinations are interconnected to a passive star. The passive star is a glass cylinder. This distributes the output light signal which in turn is distributed among the optical fibre as shown in Fig. 1.

The output of the passive star is connected to a crossbar topology. The topology arrangement used in this scenario is 3-stage crossbar. Cross points are provided at each stage. The cross points are activated based on an arbitration logic of the crossbar router as shown in Fig. 2.

The production databases are connected to the passive star arrangement which in turn is connected to the crossbar topology. The crossbar topology at the output end is connected with the Disaster Recovery Sites (DRS). An organization in the model proposed may have multiple production databases which in turn may have multiple DRS. The mapping arrangement could be decided

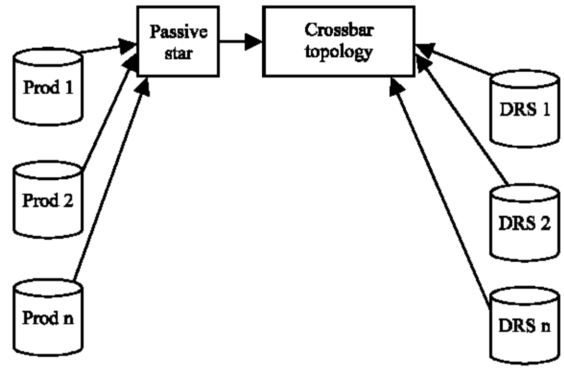

Fig. 3: Schematic diagram showing connectivity topology

based on the crossbar arbitration logic. The blocking possibility could be eliminated by modeling the same using a Weibull distribution which decides on the optimality and reliability. The number of cross points that need to be activated could be decided based on the workload. The factors associated would be:

- Bandwidth
- Data transfer rate of the optical fibre
- DRS memory space requirements
- Production database memory space requirements

The backups need to be scheduled on a periodic basis to prevent blocking in the communication model. Database purging should be carried out periodically to prevent old data being backed up again and again. In this scenario a hot backup or archive log backup would be adequate to be taken on an incremental basis. The cumulative backup may not be necessary as it may result in blocking. The schematic diagram showing the arrangement proposed is illustrated in Fig. 3.

The production databases are interconnected with DRS sites using the passive star arrangement which connects all production and DRS sites. The topology is used to map the production and DRS based on a cross point mapping.

The cross points are activated based on the need. The blocking condition is eliminated by keeping a check on the number of cross points activated at any point of time. The number of cross points needed for m-stages for a P×P network is discussed.

Assuming there are j connections (j<m), the crossbar topology with j = 2m-1 is non-blocking. The total number of cross points required for a 3-stage switch is:

$$\left(\frac{P}{m\times mk}\right)+\left(k\times\left(\frac{p}{m}\right)^{2}\right)+\left(\left(\frac{P}{m}\right)\times mj\right) \quad (1)$$

Equation 1 could be further simplified as:

$$2Pj+j\left(\frac{P}{m}\right)^2 \quad (2)$$

If a represents the probability of using a cross point and b = 1-a the probability of not using the cross point and the blocking probability B is given by. If any cross point is used, the composite blocking probability is equivalent to all cross points being used, given by the Eq. 3:

$$B = \alpha^n \quad (3)$$

When a set of consecutive cross points are used the blocking probability would be given by Eq. 4:

$$B = 1\text{-}b^n \quad (4)$$

This condition could be modeled using Weibull's distribution. The probability distribution function of Weibull's distribution is given by the expression (Eq. 5):

$$f(x) = \left(\frac{\gamma}{\alpha}\right)\times\left(\frac{x-\mu}{\alpha}\right)^{(\gamma\text{-}1)} \exp\text{-}\left(\frac{x\text{-}\mu}{\alpha}\right)^{\gamma} \quad (5)$$

Where:

γ = The shape parameter which defines the shape of the curve

μ = The location parameter which is used to model the application to define the reliability level

RESULTS AND DISCUSSION

The simulations have been carried out by using Weibull ++ Software varying arbitrary loads of traffic in Erlangs (Fig. 4). The simulations have been carried out for 100 runs. The performance of the system is evaluated based on 2 parameters:

- Average Request Blocking (ARB)
- Communication cost

Average Request Blocking (ARB) The ARB is compared for both the techniques (ROADM vs. RESS) is simulated after evaluating the blocking possibility in the network model proposed. It can be observed from Table 1 with increase in traffic the blocking rate is lesser while using the RESS (proposed in this research) as we activate minimal number of cross points based on the traffic burst rate. On average the blocking rate for RESS is 0.32 which is <0.41 obtained in the ROADM method. Thus, there is a reduction of 22.38% in blocking rate for RESS method proposed in this reserach. The maximum blocking rate would be 0.5 while using RESS as compared to the ROADM method for which the blocking rate is 0.65 as shown in Fig. 5-6.

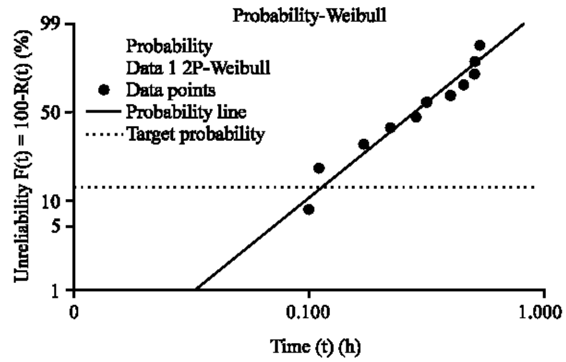

Fig. 4: Reliability modelling using Weibull distrbution; Pradheep Kumar K; BITS Pilani5/02/2018; 9:00:23 PM

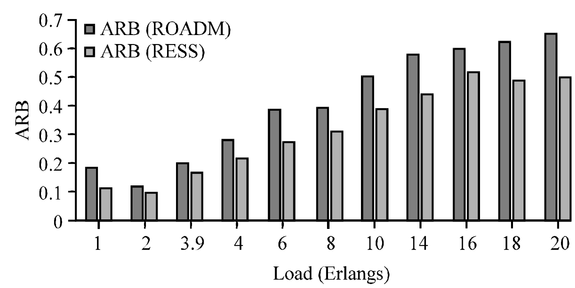

Fig. 5: Comparison of ARB (ROADM vs. RESS)

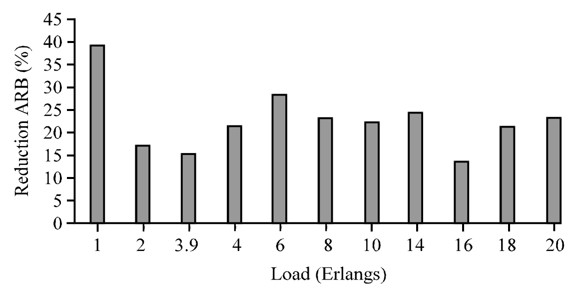

Fig. 6: Reduction of ARB (%)

Table 1: Comparison of ARB time (ROADM vs. RESS)

Load (Erlang)	ROADM Average Request Blocking (ARB)	RESS Average Request Blocking (ARB)	Reduction = ((ARB (ROADM)-ARB (RESS))/ARB (ROADM)×100
1	0.18	0.11	38.89
2	0.12	0.10	16.67
3.9	0.20	0.17	15.00
4	0.28	0.22	21.43
6	0.39	0.28	28.21
8	0.40	0.31	22.50
10	0.50	0.39	22.00
14	0.58	0.44	24.14
16	0.60	0.52	13.33
18	0.62	0.49	20.97
20	0.65	0.50	23.08
Average	0.41	0.32	22.38

Table 2: Reduction in logic gates and communication cost (ROADM vs. RESS)

		ROADM	RESS				
No. of production databases	No. of DRS	No. of logic gates used in decoders/multiplexers (ROADM) (%)	Stages	Cross points/stage	Total No. of cross points = No. of stages cross points/stage	No. of logic gates required (RESS)	Reduction in logic gates and communication cost (%)
2	5	8	1	2	2	4	50.00
4	10	16	2	1	2	8	50.00
8	17	32	3	1	3	25	21.88
16	33	64	3	2	6	53	17.19
32	67	128	3	4	12	106	17.19
64	132	256	3	8	24	212	17.19
128	257	512	3	16	48	424	17.19
Avearge							
36	74	145	3	5	14	119	27.00

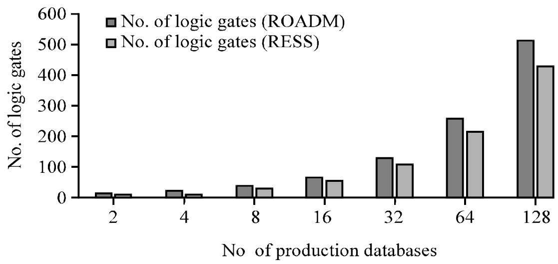

Fig. 7: Comparison of logic gates (ROADM vs. RESS)

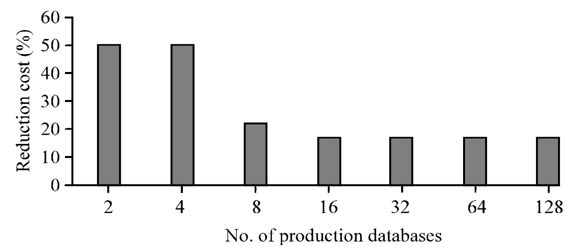

Fig. 8: Reduction of communication cost

Communication cost: The communication cost involved in the network topology model has been evaluated. It would be possible that production databases may be connected to many Disaster Recovery Sites (DRS). This would be possible also when the backups are split based on the DRS. The cross point activation would be carried out based on the feasibility.

Ideally a cross point of first stage requires 4 NAND gates which would be similar to 2:1 MUX. Similarly for a cross point of second stage resembling a 4:1 MUX would require 7 NAND gates. A cross point of the third stage resembling an 8:1 MUX could be constructed from two 4:1 MUX and so on.

The advantage of using a cross point would minimize the number of MUX and decoders being added manually in the ROADM technique which would complicate the circuit and network topology.

From Table 2, it may be inferred that the number of logic gates and hence the communication cost is reduced in the RESS technique as compared to the ROADM technique. The communication cost reduces by 27% on using the RESS technique, compared to the ROADM technique. On an average 36 production databases can be interconnected to 74 DRS using 14 cross points which involves 119 logic gates.

The RESS technique provides reduction in the communication cost, compared to ROADM technique (Fig. 7). The reduction in communication cost is maximum when the number of production databases are smaller (Fig. 8).

CONCLUSION

The RESS method of modelling explained in this research provides better reduction in blocking rate. It improves the reliability of the transmission and minimizes the data loss. Further, the crossbar topology eliminates the blocking rate and also tends to optimize the traffic involved in communication depending on the bandwidth and transfer rate. The arbitration logic incorporated in this research provides efficient load balancing among the optical fibres. When production databases are mapped on to multiple DRS, the RESS method decides which DRS would provide a quick and reliable backup in different situations.

SUGGESTIONS

The research could be extended by incorporating a security feature coupled with the reliable transmission as used in network communication. The communication would be more reliable and secured thereby preventing unauthorized access to data. By incorporating this feature, performance could be improved without compromising security in a cost-effective manner.

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