

OSPF-Integration With Energy Saving IP Fast Rerouting Technique

Rajani P. Nagare

PG Student, Department of Computer Engineering
C.A.Y.M.E.T.'S, Siddhant College of Engineering
A/P: Sudumbare, Pune-412109, India.

Prashant B. Kumbharkar

Asst. Prof, Department of Computer Engineering
C.A.Y.M.E.T.'S, Siddhant College of Engineering
A/P: Sudumbare, Pune-412109, India.

Abstract— Energy saving IP-fast rerouting technique with failure recovery procedure is an important challenge in the field of networking. The whole ICT sector is responsible about 9% of worldwide energy power consumption and network accounts is up to 16% of worldwide electricity. In order to satisfy the demand for high availability of energy in case of failure of network the energy saving IP fast rerouting (ESIP-FRR) with failure recovery procedure used. Our proposed solution works on IP backbone network which provides energy saving solution for internet service provider (ISP). The proposed solution known as energy saving IP routing (ESIP-FRR) which integrated with OSPF protocol and allows the selection of link to be switched off so that negative effect of IP topology reconfiguration procedure are avoided. The ESIP-FRR technique is integrated with OFPF protocol which is based on concept of *SPT Exportation and Move*. We prove the basic MSCM problem as Maximum clique problem in graph; Instead the QoS-aware MSCM known as Knapsack problem. The performance evaluation shows that in real network scenario the ESIP-FRR is able to switch up to 40%-60% of network links in daily traffic load to save maximum energy during low traffic hours.

Keywords—energy saving IPFRR; MSCM; OSPF; energy efficient network;

I. INTRODUCTION

Internet is very important communication system in our society and it has specified shares in energy consumption too. As per survey the router power consumption has become an increasing concern for internet service providers (ISP's), data centers, internet exchange points. An ICT sector is responsible for minimum of worldwide electricity consumption but its goes beyond their specified limits. As per network account it estimate about 8% of ICT power consumption [1]. But its actual usage is beyond specified limit.

Our contribution is in field of energy saving by preserving the QoS using the IP fast rerouting with failure recovery procedure. It regards an ESIP-FRR strategy integrated with OSPF protocol. To increase efficiency of network exportation mechanism introduced [2], is the starting point of ESIP-FRR. For this purpose we calculate shortest path tree (SPT) defined as importer router by using Dijkstra algorithm and the modified path tree (MPT) is also calculated using the same links of reference STP associated to different router, defined as exporter router. Finally the performance evaluation is improved introducing new results regarding QoS aware ESIP-FRR and energy saving in real network.

II. RELATED WORK

The related work addressed in this section use to save energy in ISP backbone network. In this paper in which the authors Sherali zeadally, Same Ullah khan they have work on the Energy Efficient Networking: past, present and future. They proposed approaches which explain the fact that our society is highly integrated with ICT sectors that includes the dependence on various ICT sectors e.g. business transportation, education and economy to the point that everyone in our society is almost, completely depends on it. They present some motivations driving the need for energy efficient trends and they identify some challenges that add reused, scalable, cost-effective energy efficient communication in the future [1].

Christopher Lange, Dirk Kosiankowski, Rainer Weidmann, and Andreas Gladisch define energy consumed by telecommunication (TC) network. According survey taken by them, the energy is consumed in fixed and mobile network as well as in data centres and in backbone network is highest. Different methods are recommended and metrics for energy related assessment of networks is compared. They suggested that when we combine different energy reducing methods such as load adaptive networking energy aware system design there can possibility of maximum energy saving. The proposed system based on predicated traffic number and subscriber number [3].

Edoardo Amaldi, Antonio Capone, Luca G. Gianoli and Luca Mascetti proposed an approach which is offline traffic engineering. Aim of this approach is minimize energy consumption and traffic congestion. In this work they defined two heuristic algorithm GA-ES International Journal of Engineering Research & Technology (IJERT) (Greedy Algorithm for Energy Saving) and TA-ES (Two-stage algorithm for Energy Saving) [4].

III. SYSTEM IMPLIMENTATION DETAILS

A. Problem Definition

Depends on the ESIP-FRR strategy integrated with OSPF protocol QoS-aware energy saving using fast rerouting technique is implemented which is useful in case of failure recovery and increase the energy saving capability of network devices. Fast reroute provides redundancy for LSP path. When you enable fast reroute detours are pre-computed and pre-established along LSP. In case of network failure on current LSP path, traffic is quickly routed to one of the detour.

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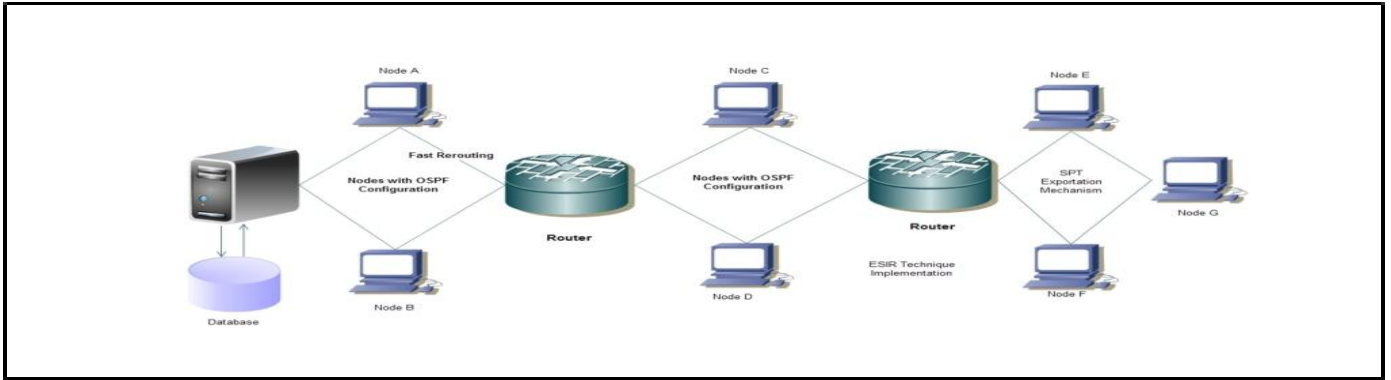


Fig. 1. Architecture of OSPF Using Fast Rerouting

Fig. 1 shows architecture of OSPF using FRR. We are finding the optimal paths for packet transmission, in which various network, are binds as node's those are shown as workstation computers. These nodes bind the overall energy together into the part of good and efficient communication periodic wake up. The whole interfaces allowing the exchange of OSPF hello packet rerouting protocol to support low power mode is needed to maintain the IP routing protocol. In particular the OSPF rerouting protocol analyzed the received importer message and executes the path computation algorithm (Dijkstra) inserting the information about the export node.

B. Energy Saving ESIP-FRR Strategy(Mathematical Model)

We consider an IP network, modeled as a weighted directed Graph $G(V, E)$, where V is the set of nodes (i.e. IP routers) and E is the set of directed edges (i.e. IP links). Let N and be the cardinalities of V ($N = ||V||$) and E ($L = ||E||$), respectively. For each directed link, $l \in E$, $s(l)$, $e(l)$ and $w(l)$ denote the source node, the end node and the weight associated to the link, respectively. We consider OSPF as link-state routing protocol. Each router $v \in V$ computes its own Shortest Path Tree, $SPT(v)$, composed of the links belonging to at least one shortest path having v as source node. The set E of active links is defined as the set of links belonging to at least one SPT:

$$E_A = \cup_{v \in V} SPT(v) \tag{1}$$

Considering that each move is able to remove some links from E_A , the MSCM problem consisting of deleting the set of moves. Let V_i be the set of importers, we have that the network paths are exclusively determined by the nodes of the set $V_p = V - V_i$. Therefore, the set E^*A of links still active for routing is given by,

$$E^*A = \cup_{v \in V_p} SPT(v) \tag{2}$$

The compatibility relationship can be defined as follows:

$$m_2(i_2, e_2) \propto m_1(i_1, e_1) \text{ if } \begin{cases} e_2 \notin bn(m_1) \\ e_1 \notin bn(m_2) \end{cases} \tag{3}$$

1) The MSCM Problem

It is investigated in two steps: Basic MSCM Problem here the QoS requirement; in second steps, QoS-aware MSCM problem the full solution of problem considered.

a) Basic MSCM Problem

Given graph $G(V, E)$, where C is compatibility matrix Where c_{ij} represents the compatibility relationship between moves m_i and m_j

$$C = \{c_{ij}, 1 \leq i \leq L \quad 1 \leq j \leq L\}. \tag{4}$$

Where c_{ij} represents the compatibility relationship between moves m_i and m_j :

$$C_{ij} = \begin{cases} 0 & \text{if } m_i \not\propto m_j \\ 1 & \text{if } m_i \propto m_j \end{cases} \tag{5}$$

Therefore, the basic MSCM problem can be formulated as Follows:

$$\max \sum_{i=1}^L w_i x_i \tag{6}$$

$$x_j \leq 1 \quad \forall (i, j) \in (F) \tag{7}$$

$$X_i \in \{0, 1\} \quad \forall i \in M \tag{8}$$

b) The QoS-aware MSCM problem

From the previous considerations, the QoS-aware MSCM problem can be formulated starting from the basic one by introducing a constraint on the maximum link load. In particular, the following condition has to be added to (6), (7) and (8):

$$r_k + \sum_{i \in m} x_i \Delta t_{ik} \leq p_k, \max C_k \forall k \in E \tag{9}$$

Where C_k is the capacity of link k and p_k is the maximum link load on link k .

C. Dijkstra Algorithm (Shortest Path Tree)

Instead of using all the SPTs, one for each router, our strategy imposes a subset of routers, defined as importer routers, to modify their SPTs. In particular, each importer router computes a Modified Path Tree (MPT) using the same links of a reference STP associated to a different router, defined as:

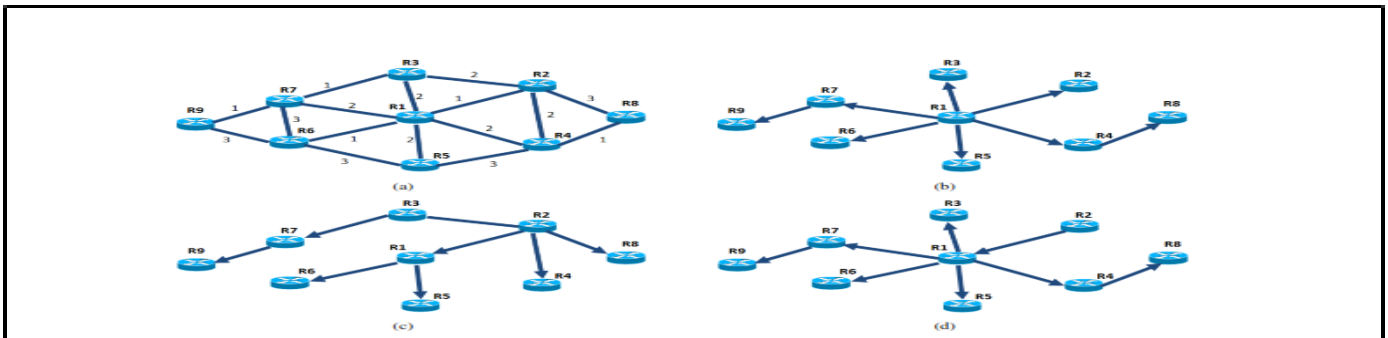


Fig. 2. a) Example of an IP network. b) SPT computed by R1, SPT(R1). c) SPT computed by R2, SPT(R2).d)TheMPT of R2, MPT(R2), is the result of an exportation having R2 as importer and R1 as exporter.

exporter router. An importer can easily compute the SPT of its exporter by assuming the exporter itself as the root node when performing Dijkstra algorithm.

Steps given As follows:

- 1) Function Dijkstra(Graph, source):
- 2) For each vertex v in Graph: // Initializations
- 3) $\text{dist}[v] := \text{infinity}$
- 4) Previous [v] := undefined // Prev. node in optimal path
- 5) End for
- 6) $\text{dist}[\text{source}] := 0$;
- 7) $Q :=$ the set of all nodes in Graph
- 8) While Q is not empty: // The main loop
- 9) $u :=$ vertex in Q with smallest distance in $\text{dist}[]$;
// Source node in first case remove u from Q
- 10) If $\text{dist}[u] = \text{infinity}$:
- 11) Break
- 12) For each neighbor v of u : // where v has not yet been
// removed from Q .
- 13) $\text{alt} := \text{dist}[u] + \text{dist_between}(u, v)$;
- 14) if $\text{alt} < \text{dist}[v]$: // Relax (u, v, a)
- 15) $\text{dist}[v] := \text{alt}$;
- 16) previous [v] := u ;
- 17) decrease-key v in Q ; // Reorder v in the Queue
- 18) End if
- 19) End for
- 20) End while
- 21) Return $\text{dist}[], \text{previous}[]$;
- 22) End function

Fig 2 shows an example of exportation. In Fig 2a the reference IP network is drawn; for the sake of simplicity the same OSPF weight is associated to both directions of each IP link. In Fig 2b and 2c the SPTs of nodes R1 and R2, SPT (R1)

and SPT (R2), are shown, respectively. In Figure 1d the exportation having the node R2 as importer and the node R1 as exporter is performed and the MPT of node R2 i.e., SPT (R2), is computed. It is to be observed that, the MPT (R2) uses the same three links of SPT (R1) and, with respect to SPT (R2), allows three network interfaces of R2 to be passed in a standby state, precisely those towards nodes R3, R4 and R8.

IV. RESULTS AND DISCUSSIONS

The performance of ESIR is evaluated here. In the first section the part of MSCM is fixed to analyse upper bound of energy saving capabilities of ESIR solution. In the second part QoS-aware MSCM problem and its impact on QoS is evaluated.

In Table I, We can consider a pair of Importer and Exporter (i.e. Move) by satisfying the following three conditions:

- Importer can be neighbour of exporter.
- Importer must be object of single exportation.
- A move cannot form a loop by exportation.

These results are tentative results. We are going to assume the values. First we calculate SPT of router and find number of neighbours of routers then secondly by doing MPT (modified path tree), we can call it as Move Exportation Concept. Here we calculate the neighbour of Importers. Then we get number of switch off links by performing a move by subtracting number of neighbours in MPT the larger number of switch off links by performing a move is our feasible solution of Basic MSCM problem. Indirectly we are decreasing the cardinality of graph. As shown in Table I the Max Compatibility heuristic provides results really very close to the expected optimal ones: moreover founded maximum cliques differs at most of two nodes and the obtained difference between them is in terms of standby links is less than 5%.

TABLE I. THE BASIC MSCM OUTPUT

BASIC MSCM PROBLEM OUTPUT		
IMPORTER	EXPORTER	NO OF SWITCH OF LINKS
R6	R1	3
R8	R4	3
R3	R1	3
R2	R1	2
R9	R7	2
R5	R1	1

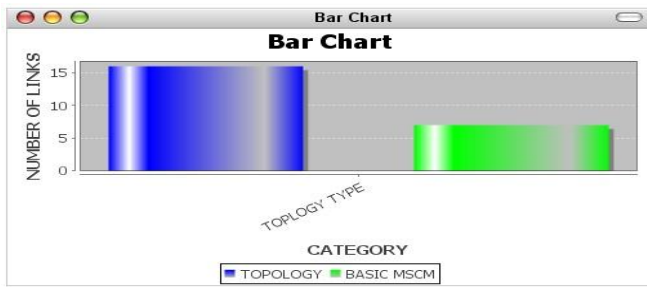


Fig. 3. Cardinality Comparison

In Fig. 3 Which shows the bar chart which shows that the cardinality of graph is calculated by number of unique links by performing SPT of all routers. For storing unique links by removing duplicate we use set (collection framework class) which allows only unique element if we add duplicate elements those duplicate elements are ignored. Single elements stored only once. The cardinality of set means number of elements present in set after performing MPT. We store links in a collection framework class i.e. Set and in a graph we compare before MPT and after MPT.

In Table II we see that QoS aware MSCM problem is taken in consideration. For each link we assign a traffic load for each link while sending packet/data the traffic load varies by some amount when traffic load reaches to maximum traffic the packet should be delivered by SPT path.

According to Fig. 4 comparisons between numbers of sleep links and number of moves shown. The Expected Result is ESIR will be integrated with OSPF protocol and allows the selection of the links based on the SPT algorithm & QoS aware MSCM problem to be switched off the links. So the negative effects of the IP topology can be reduced.

V. CONCLUSION

The proposed system addresses the strategy of energy saving in IP network called as ESIR during the low traffic hours. SPT is calculated using Dijkstra algorithm and also find MPT of same active links. ESIR strategy is implemented integrating the OSPF with ESIR. The concept is based on sequence of "Moves" (Exportation Concept) which has aim to determine the best way to put low Power mode maximum number of links as set and also fast rerouting path crossing them increase the energy saving capability of network topology. The solution obtained is very close to optimal solution. These results are tentative. The further work is still going on for final results.

Further studies are now carried out on definition of OSPF protocol enhancement and its integration with ESIR using fast rerouting technique.

TABLE II QoS-AWARE MSCM PROBLEM OUTPUT

MOVE NUMBER	IMPORTER	EXPORTER	Destination	LINK LOAD Rk	TRAFFIC VARIATION ...
M1	R9	R7	R5	10.0	11.5

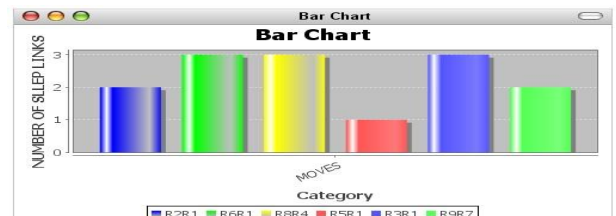


Fig. 4. Number of sleep links comparisons

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