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Green Computing: A Step Ahead for Energy Conservation with Energy Aware Routing Strategy

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Abstract: *Green computing is used to denote efficient use of resources which minimize the use of power consumption and increases the energy savings proportionally so to save energy consumption in richly-connected networks .Energy Aware Routing strategy is fully compatible with OSPF and based on shortest path tree (SPT) exportation mechanisms which share the SPT among couples of router by using Dijiksta algorithm by introducing the concept of importer and exporter routers. Its main purpose is to minimize the active links in which all links belongs to one SPT of a network. These active links are those numbers of links which are to be used to route traffic from source to destination. Such an algorithm saves about 65% of network links with a negligible increase of network path lengths and link loads.*

Keywords: *Energy aware routing, Exporter router, importer router energy saving, IP network, Dijkstra algorithm*

1. Introduction

In an IP network energy saving mechanisms can be implemented by the modified version of link state routing protocol i.e. OSPF; it's a contribution or a new step towards a green OSPF for today IP network. According to OSPF protocol each router computes its own shortest path tree (SPT) by using classical Dijkstra algorithm ,by this process network links which route the traffic belongs to at least one SPT. Basic strategy that is used for this is called as EAR (Energy aware routing) strategy .EAR strategy based on two sets:

1.1 Exporters Routers

1. Such a router calculate their own SPTs by using classical Dijkstra algorithm
2. Using these SPTs the routing of packets is fixed and a shortest path is calculated to carry forward the traffic.

1.2 Importers Routers

1. It takes a reference of SPT from one of the exporter router.
2. Then it modifies their own SPTs and calculates Modified Path tree (MPT) from them
3. After this it determines the links to be switched off which are base on MPT

The general objective of this paper is to maximize energy saving in an IP network which is based on link state routing protocol i.e. OSPF which is compliant to LSA database and get implemented by using classical Dijkstra algorithm to calculate shortest path tree. Such a paper is divided into three section in Section I specifies about energy aware routing algorithm strategy and Section II elaborates the calculation of shortest path using Dijkstara algorithm and Section III brief the performance of algorithm in terms of energy savings.

2. Idea of EAR

It induce a correlation between the routing decisions taken by the network router it means the number of active links could be reduced by using SPT which are calculated by selected routers which are known as exporters router [1,2] , to influence these evaluation of routing path importers router are used. Importers routers utilized the information from the exporter router to modify the SPT such a tree is called as MPT (Modified Path tree).Exporters use the Dijkstra algorithm to calculate SPTs. Importers use the links of SPT which are already evaluated by exporters and construct its own MPT and fix up those links which are to be switched off.

2.1 Assumption for EAR

It is implemented by link state routing algorithm because of coincidence between the LSA databases where each router can execute Dijkstra algorithm.

Assumption I $L_{min} \le L_e \le L_D \le L$

Where,

1. L_e is the number of links used to route traffic when EAR is performed
2. L_{min} is the links in which router has the same SPT.
3. L_D is number of active links consist of at least one SPT.
4. L is the total number of edges in a network graph.

Assumption II $\eta e = (L_D - L_e) / (L_D - L_{min})$

Where,

1. ηe is the performance index of EAR algorithm.
2. (L_D-Le) is the number of links to be powered of when implementing EAR.
3. (L_D-L_{min}) it means maximum number of links to be powered off.

Hence EAR said to be as a improved version of OSPF protocol.

2.2 Energy Aware Routing Algorithm

Its main purpose is to minimize the active links (L_D) in which all links belongs to one SPT of a network. These active links are those numbers of links which are to be used to route traffic from source to destination. For this purpose network routers are divided into three subsets:

1. Exporter Router (ER): It is associated to a number of IR's
2. Importer Router (IR): It is associated to a single ER.
3. Neural Router (NR) : It works as a classical OSPF routing protocol

EAR algorithm is divided into three phases these are as below:

2.2.1 Phase-I: ER Selection

The role of ERs is a key concept of EAR algorithm. The ERs compute their SPT via the classical Dijkstra algorithm, the neighbours routers of an ER will use its SPT to modify their routing paths and to identify the links to be switched off. The number of ERs is denoted as Re , such a number is chosen very carefully as to avoid the overloading of active links by using LSA database which implement the concept of OSPF protocol from this we get the information of Re. From LSA database each router select a Re router, which has the highest degree value in network graph [4]. Then such a router is get inserted into list of Re as being a exporter but when this router is considered as ER its neighbour are not taken into the list they can be ER, it means that if a router has highest degree value means it has higher number of neighbour and it can export its SPT to a large number of IRs so that high number of links to be powered off. Basically this strategy is based on the node degree of a network graph.

2.2.2 Phase-II: MPT Evaluation

Such an evaluation is computed by every IR and determines those links which are to be switched off [5]. Numbers of steps for this evaluation are as follows:

Step1: Main goal of this phase is to identify set of links to be switched off.
Step2: For this purpose IRs have to modify the SPTs and determine their own MPT.
Step3: For the computation of path routing table is constructed which get influenced by router role in network.

Flowchart for this evaluation is below:

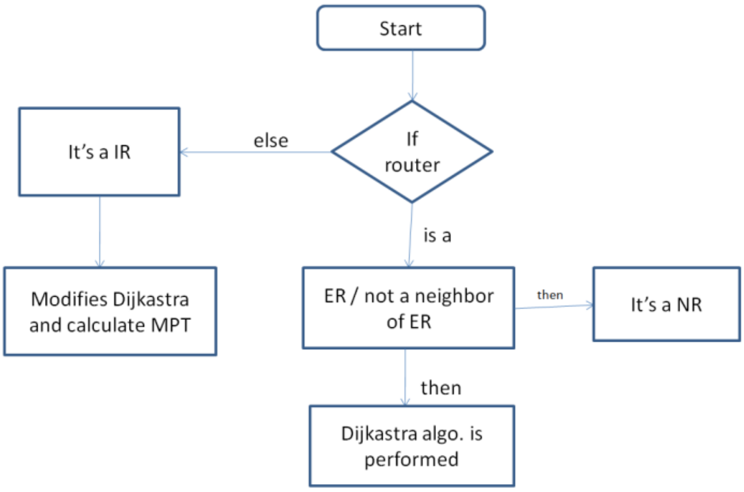

Figure 1. *Working of ER and IR router*

2.2.3 Phase III: Routing Path Optimization

1. At the end of phase 2 each IR has identified the set of links that has to be switched off.
2. These links are removed from the network topology to determine the actual routing path and update routing table.
3. This updating is also being done in LSA database by giving LSA messages (means topology update database).
4. After this updating network router again recomputed the network paths using Dijkstra algorithm as a reference to the residual network topology which guarantees that each router computes the minimum cost path on the reference topology.

Hence the conclusion from this algorithm is that it provides a solution based on coordination among routers, to save energy during low traffic periods i.e. night hours. As this algorithm does not consider any traffic load in day hours and does not guarantee for any QoS parameters [6-7]. So a new algorithm is developed which is an advanced version of EAR algorithm strategy that increases network performance and also guarantee for QoS parameters.

PATH COMPUTATION

Step1: A network graph with OSPF weights, shown in below figure:

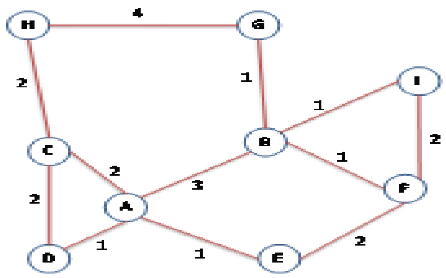

Figure 2. *Network graph with OSPF weights*

Step 2: SPT computed by a, SPT (a) where a is treated as a exporter router, shown in below figure:

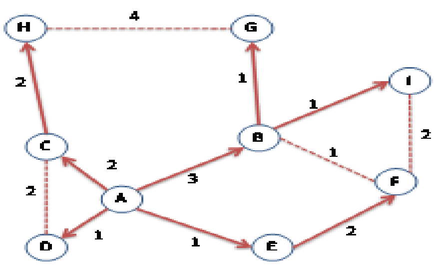

Figure 3. *SPT computed by a, SPT (a)*

Step 3: SPT computed by b, SPT (b) where b is treated as exporter router, shown in below figure:

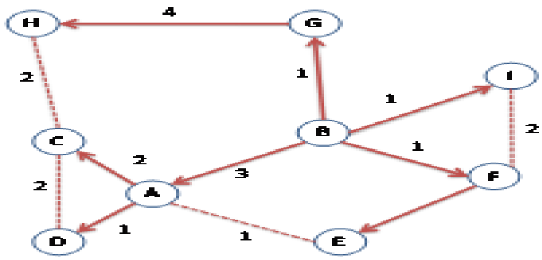

Figure 4: *SPT computed by b, SPT (b)*

Step 4: EAR algorithm performed by b treated as importer router if a is the exporter router, MPT (b, a).In this step the node b has to perform MPT evaluation phase. It first computes SPT (a) and then modifies it “inserting “itself as root node, the result is MPT (b, a), shown in below figure:

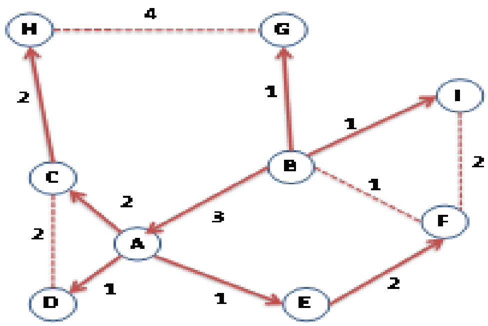

Figure 5: *MPT (b, a), computed by b*

3. PERFORMANCE

The performance index we have considered to evaluate the EAR algorithm is ηe, the percentage of links that EAR algorithm allows to power off, i.e. ($L_D - L_e$), with respect to the maximum number of links that could be powered off, i.e.($L_D - L_{min}$).

Consider the above Figure 4 and 5

1. L_D is number of active links consist of at least one SPT(a)=4 ,
2. L_e is the number of links used to route traffic when EAR is performed MPT(b,a) =3
3. L_{min} is the links in which router has the same SPT =1
4. $\eta e = (L_D - L_e) / (L_D - L_{min})$

Therefore ηe % = (4-3) / (4-1) = 66%

EAR performance are really promising it potentially allows to power off more than the 60% of the network links.

4. CONCLUSION

By analyzing the problem of energy efficiency in real IP network, novel network energy is proposed to save energy during low traffic periods i.e. night hours and a purposed algorithm is EAR that is fully OSPF compliant. The idea of this algorithm is that only subset of routers evaluate their SPT and while other utilize these SPTs to determine their routing paths and it’s the way to deflect the packet traffic and power off some network links.EAR algorithm is fully compatible with OSPF and its also based on the concept of sequence of moves to determine best mode to switch off a set of links and reroute the paths crossing them.EAR is able to modulate the network performance and allows a QoS strategy to be implement. Such an algorithm is implemented by determining by using two heuristics. Such an algorithm saves up to 60% of energy in IP network

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