GDRP: A NOVEL APPROACH FOR POWER OPTIMIZATION IN WIRED CORE NETWORKS

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Abstract

The numbers of applications in the internet are increasing tremendously day by day which results into degrading the network performance because of heavy traffic load on the core routers which causes into more power consumptions in core routers and hence requirement of energy also increases. In order to save the power consumed in the routers an innovative approach is suggested in this paper. Here, one distributed routing protocol is employed which saves power in the core routers without degrading the performance of network adhering to the connectivity of the network. General distributed routing protocol (GDRP) maintains compatibility with any existing distributed routing protocol, which saves power by making some of its core routers into sleep mode called as power saving mode. We highly suggest a novel and distinct approach to resolve this problem that includes making power awareness a primary objective in the design and configuration of networks and routing protocols.

Keywords**:** Green internet; Sleep coordination; Power saving; Distributed routing protocol; GDRP.

1. Introduction

According to the survey made by the united state, it shows that out of nations total power 2 – 8% of the nation’s electrical energy is consumed by the Internet. Internet consume that power in a variety of areas such as home and enterprise IT infrastructures, data centers, and networks. As need of energy is increasing tremendously day by day it may give rise to the more energy requirement. So it is important to minimizing power consumption in the area of ICT (Information and Communication Technologies) is becoming an important threat.

A different number of approaches have been stated about minimizing power consumption, such as dynamic voltage scaling [1] where the voltage used in devices is increased or decreased depending upon situations. One of the most effective methods for power saving is sleep mode. Due to which electronic devices are works in low power mode to save power which provides significant power consumption compared to leaving the device fully power ON and with nothing to do. Nowadays, many electronic devices such as computers, televisions etc can enter into sleep mode automatically when kept idle for a certain interval of time. This autonomic and localized sleep mode cannot be build in routers, however, because they often exchange routing information in the form of non-data packets(i.e. hello packets) with the help of routing protocols, and hence they cannot remain idle even if there is no data traffic. Additionally, if it was not required to process any data packets, a router going into sleep mode will deactivate himself and unresponsive to network data traffic. Unless a network-wide coordination is achieved, it may cause the network topology to virtually disconnect, which could give rise to connection blocking. In [10], the authors discussed the topic of uncoordinated and coordinated sleeping mode in routers of a network. However, the coordination between routers was depends on the previous history of the network traffic, and the setting of network connections was static because of that it cannot adapt to dynamic changes taking place in network traffic. In [3], there is an algorithm to search or identify the largest possible set of network nodes and links to be switched off while still maintaining full connectivity and maximum link utilization. As this approach was centralized and off-line so that some of the network parameters should be previously known like network information, the traffic demand and the structure of the network. However, it was also static and could not adapt to the dynamic changes in the network environment.

To implement autonomic sleep mode in routers, and to save power in wired core networks this paper throws a light on General Distributed Routing Protocol for Power Saving (GDRP-PS). The important aspect of GDRP-PS is to organize routers which go into sleep mode (i.e., sleep coordination) and, at the same time, to maintain the network connectivity as well as quality of service. During peak hours(heavy network traffic), the operation of GDRP-PS is same as that of the present distributed routing protocols so that network performance will not be degraded, while during non-peak hours(low network traffic) one of the core routers can enter sleep mode without affecting the quality of service and badly affects network connectivity. GDRP-PS is designed to be compatible with existent distributed routing protocols and thus making him practical in real execution. Our simulation results show that GDRP-PS can significantly save power and, at the same time, still maintain quality of service and network connectivity during non-peak hours. Additionally, during peak hours, the performance of a network with power-saving routers and GDRP-PS is not degraded. The rest of this paper is structured as follows. Section 2 depicts the operation of power saving routers as well as working of GDRP-PS. Then, a case study and an illustrative example are shown and example is explained in detail. Section 3 presents simulation results of GDRP-PS, and finally, in Section 4 conclusions are discussed.

2. GDRP-PS

This section depicts the operation of power saving routers and also elaborates GDRP-PS algorithm which is presented by flow chart along with some execution topics It also consists of a case study and an illustrative example to demonstrate and describe the operations of GDRP-PS Two types of core routers are present in this network: ordinary routers and power saving routers (PSRs). Ordinary routers works with an existing mostly used distributed routing protocol (e.g., OSPF). Even if there is no packet to process these routers remains always “power on”. PSR’s work with GDRP-PS and they can switch to sleep mode. A PSR has two modes: one is WORKING mode and other is SLEEP mode (Fig.1).

In the WORKING mode, the routing operation of a PSR is the same as a ordinary router, but in the SLEEP

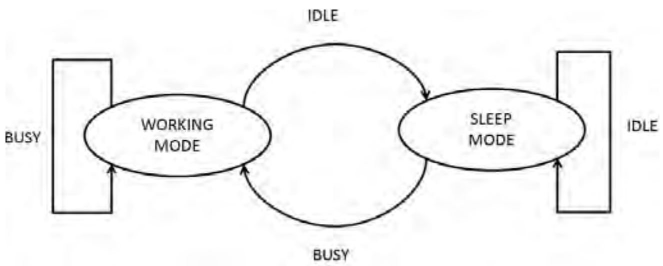

Fig. 1. Two different bahaviours of power saving router

mode the PSR enters into sleep mode so that it will not process any packets until it is switched back to the WORKING mode. Presently there are no PSRs available now because there is no any routing procedure available to ordinate routers entering into sleep state in wired core networks. But truly speaking, sleep mode itself is a very superb technique for saving power consumption and thus it is easy to to have sleep mode for a router.An experimentation in [3] showed that whenever a personal computer enters into sleep mode it consumes approximately 10% of the power drawn in normal mode. Since a PSR works similar to computer, we considered that a PSR if works in sleep mode would also consume approximately 10% of the power drawn in normal mode. The mode of a PSR remains same if the network is processing almost less traffic (i.e., not busy), and it is in the SLEEP mode, or when the network is processing heavy traffic (i.e., busy), and it is in the WORKING mode. If a PSR is in the WORKING mode and the network is not busy (i.e., non-peak hours), GDRP-PS can checks the current status or state of the network nd brings a PSR to switch to the SLEEP mode to save power. Also, when a PSR is in the SLEEP mode and if the network traffic increases i.e., busy (i.e., peak hours), GDRP-PS will switch it into the WORKING mode in order to maintain the network connectivity and quality of service.

2.1. *GDRP-PS working*

At start an election is needed to choose a master out of present PSR’s randomly. The work of the coordinator is to record the position of all PSRs and organize the coordinated operations of GDRP-PS in all the present PSRs. Master coordinator will never go into the SLEEP mode as it has to look and to manage the coordination between PSR,s whether network is busy or not busy. Additionally, there is fair policy to all the PSRs, and since the master coordinator is randomly selected, a new selection will take place after a specific interval of time. The procedure which is needed to switch from the WORKING mode to the SLEEP mode is stated as follows. First of all, a PSR will start this procedure when it detects the network is not busy (i.e., at non-peak hours). In GDRP-PS, a PSR checks the load of the network by measuring the maximum utilization out of all the links connected to itself, which we call Maximum Link Utilization (MLU) and is denoted by LUmax. The value of LUmax can be calculated by real-time measurement inside the PSR. Note that the maximum link utilization of the individual PSR is not same to the total network loading but is more similar to, and hence it is a same idle) problem. We say that the network becomes not busy (i.e., when LUmax is below a threshold (call TH1).

When the network becomes idle, the PSR check for the network connection assuming a network without him or with disconnecting itself. This checking is mandatory because the power saving protocol should not alter the network connectivity and all stations including source and destination can still transmit and receive packets normally when some PSRs go into sleep mode. If the network connectivity can be maintained, without PSR then he will again build the routing table and floods a message to the Master coordinator to get a permission to enter into sleep mode. Here coordination is needful because, for safe purpose, it should not be allowed to have more than one PSR to go to sleep mode at the similar time to avoid a heavy network loading for the rest of routers.

When the master coordinator gets a request message to enter in sleep mode from the PSR, it checks whether more than one PSR is requesting to enter into sleep mode at the same time. If there is only lone PSR, the master coordinator sends back a positive reply in response to its request to the PSR; otherwise, the master coordinator replies the to PSR which had requested first and there is no response message for remaining PSRs. If the PSR gets a positive response from the coordinator, then it floods the requited routing table and then enter into the SLEEP mode within a fixed perticular period (call sleep period); otherwise, it remains in the WORKING mode, waits for a particular fixed period (say wait period) and checks its own maximum link utilization (LUmax) one more time to see whether the network is not busy or idle.On another end the steps needed to change from the SLEEP mode to the WORKING mode is stated as follows.

When a PSR enters into sleep mode, it will wake up after the sleep period finishes. It gets attached to the network once again by using the existing distributed routing protocol procedure, and all other routers will again build the new routing table. The master coordinator knows that PSR wake up time. It will check its own maximum link utilization (say U'max) to find out the loading of the network. If U'max>Threshold 2, we claim that the load on the network is high (i.e., peak hours). It is also a same problem. If the load on the network is high, it will send a wake-up message to the PSR who is in sleep mode, otherwise no message. On the another side, if the PSR receives a wake-up message from the master coordinator within a given period (say confirm period), it will switch in the WORKING mode (i.e., does not go back to the SLEEP mode); otherwise, it will switch back to the SLEEP mode and one more time enter into another sleep mode. Some execution points are listed out here.

(1) The routing protocol stated above is dedicatedly designed to be distributed in order to support autonomic and localized decision making about going to sleep. Centralized routing protocol need a manager for the network in order to manage the sleep coordination, and hence reliability of the protocol is strictly dependent on the manager of the network and because of this network manager handles a lot of traffic. As GDRP-PS is distributed, reliability of the protocol is high and the traffic load of control packets are evenly distributed throughout the network. GDRP-PS is simple to execute in a real network or it upgrade an existent network because only PSRs need to install GDRPPS and all existing ordinary routers will remain unchanged.

(2) GDRP-PS is compatible with pre existing intra-domain routing protocol so that ordinary routers can work easily with these new routers properly. Thus, it is possible in terms of practically to implement. One method to implement this protocol is to update the existent routers by simply installing this protocol as software application.

(3) The load on the network is calculated by measuring theindividual maximum link utilization of core router. Since the maximum link utilization is nothing but local information, the calculation can be considered as one problem. We do not directly measure the load of the whole network because it involves all routers in the network and it spends a lot of network resources (e.g., processing power of routers and the transmission of many control packets). There are some other problems to be taken into account to measure the network loading indirectly (e.g., packet processing rate of a router).

(4) The length of time-out periods in GDRP-PS (i.e., wait period, confirm period, and sleep period) are mostly dependent on the pre-existing routing protocol. The wait period should be two to three times greater than the maximum duration that a router disconnects from a network. The confirm period should be the similar as the time-out period of a general data packet. The sleep period of a PSR should be large enough so that a router may not wake up too frequently to determine the condition of the network i.e whether busy or not busy.[8]

2.2. GDRP-PS behavior along with OSPF

To show the robustness and reliability of the proposed protocol, we demonstrates how GDRP-PS compatible with a de facto intra-domain routing protocol OSPF (Open Shortest Path First) which is commonly used famous protocol used in large or big enterprise networks. In Fig. 1 above, to switch from working mode to sleep mode we require the disconnection procedure. To apply GDRP-PS into a network with routing protocol OSPF, we have used the disconnection procedure which is used by OSPF. To act as a keep-alive mechanism, OSPF uses hello protocol [4]. Typically, OSPF routers floods hello packets into the network to find out their neighbors. If a PSR wants to starts the disconnection procedure, it will not give response to any packets including the hello packets. When its neighbors could not get any response to any packet including hello packet from the PSR for 4 to 5 times of re-try, they will consider that this PSR has been disconnected from the network. The neighbors then gives rise to new link state advertisements (LSAs) to spread this notice that this is an unreachable node and which can be treated as network failure and advertise these LSAs throughout the network via flooding.

When receiving these LSAs, all other routers including the master coordinator in the network will build new routing table.GDRP-PS initiates the connection procedure by using hello packet procedure of OSPF to its neighbors or near by routers. And after that neighbors will advertise a new LSA to spread this message that new connection has been arrived in the network and hence should update their routing tables.

2.3. Illustrative Example

To illustrate GDRP-PS which is mentioned above, consider an 8-node network which consist of 13 bi-directional links as shown in Fig.2. In this network, SRC1 and SRC2 are considered as source routers that generate traffic, whereas DST1 and DST2 are considered as destination routers that sink traffic. The remaining nodes (CR1 to CR4) are core routers through which traffic travels. OSPF is used as routing protocol for this network and each link is given an OSPF value called OSPF weight. With this set of given link weights,shortest path from each source router to individual destination router is shown by different arrows in the example. CR2 is set as a ordinary router while CR1, CR3 and CR4 are PSRs, CR1 is the choosen as master coordinator. We consider that all the links have an equal data transmission capacity of 100 units. The traffic in the network is generated such that the maximum link utilization during busy was 40% and during non-busy hours 14% .

In above example, we considered that the power utilization of a ordinary router and a PSR were the similar during busy hours and we used such values to calculate the power consumed in the network. Additionally, the thresholds *v1* and *v2* were set as 10% and 30% respectively, which meant that a PSR will enter sleep state if the LUmax <10%, and the master coordinator will wake up all routers from sleep state when its LUmax > 30%.

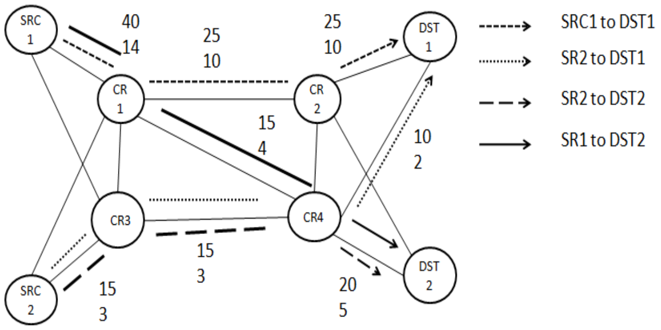

Fig. 2. An eight-node network topology

Assume that CR3, wants to enter the SLEEP state during non-busy hours because its LUmax is 3% only.which is<*v1*. Then it is disconnected from the network, and the routing table of all other routers is changes. The new routing table is shown in Fig. 3

From example it is observed that the quality of service is not changed yet and the network is not disconnected. Thus, CR3 can enter into the SLEEP state without affecting the quality of service and without altering the network connectivity. Note that when the network traffic is changed from non-busy hours to busy hours, the master coordinator CR1 will find that its maximum link utilization LU'max is>= 40%. This value is greater than the threshold *v2* and thus it will wake CR3 to maintain the quality of service.

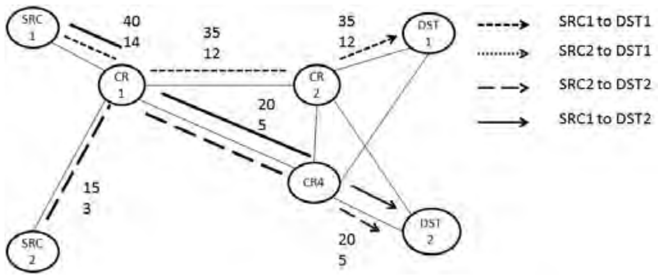

Fig. 3. A core router 3(CR3) goes into sleep state during non-peak hours

3. Simulation results

This section mainly deals with the simulation results obtained with the designed network in the PC environment

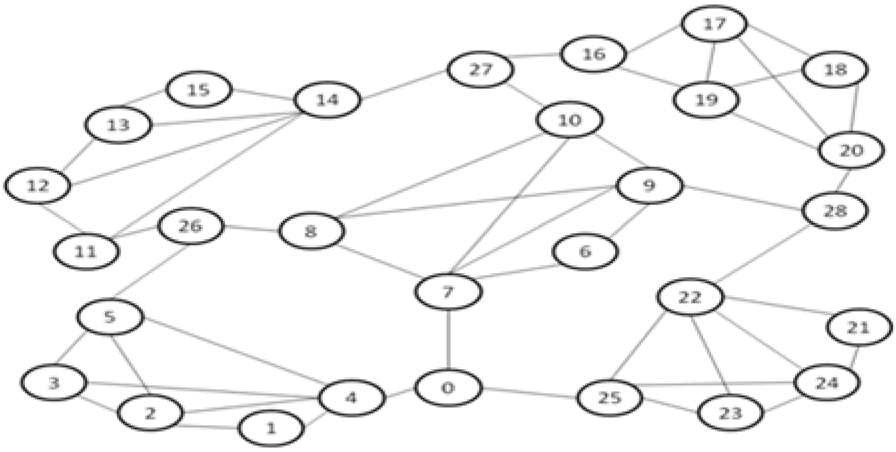

Fig.4.A 25-node network topology

supporting the NS-2. Network is designed with 4 edge routers and 25 core routers. The network designed is shown in the Fig. 4

The selection of the routers gives the following results which supports the optimum response of the designed protocol. Fig. 5 gives the response of the network indicating the packet delivery ratio versus the simulation time. It is mathematically expressed as,

$$PDR = \frac{Number\ of\ packets\ received}{Number\ of\ transmitted} \quad (1)$$

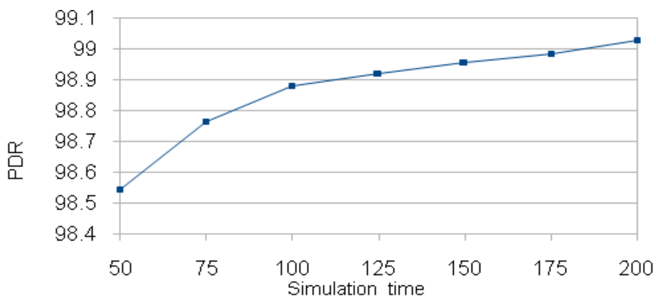

Fig.5. Packet Delivery Ratio vs. simulation time

The percentage of the overall power saving was calculated as shown below:

$$\%Power\ saving = \frac{P - P_{GDRP-PS}}{P}. \quad (2)$$

Where,

P = overall power utilized by the network without GDRP-PS.

$P_{GDRP-PS}$ = overall power utilized by the network with GDRP-PS.

From result it is seen that percentage of power saving is zero at zero threshold while it achieves constant value

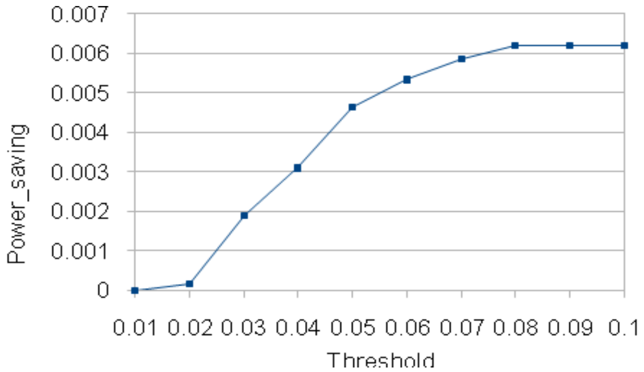

Fig.3.The % of power saving at various thresholds

after 0.08 threshold because number of routers satisfying this threshold condition are less and if more routers goes into sleep mode then it will degrade performance of network.

4. Conclusion

Recently power utilization in the network is increased and sleep mode is one of the most suitable techniques to save power. The simulation results shows the performance parameter of GDRP-PS. Around 99% Packet delivery ratio is obtained which shows the better performance of GDRP. The power saving increases with increase in threshold and remains constant after 0.08 threshold value. General Distributed Routing Protocol for Power Saving (GDRP-PS) which coordinates the process of entering into sleep mode for power saving. GDRP-PS is a distributed protocol showing compatibility with existing core networks.

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