

Survey of Optimizing Link Sleeping Reconfigurations in ISP Networks

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Abstract:

The power consumption of the internet accounts has been increased in the bandwidth hungry applications. Several initiatives are being put into place to reduce the power consumption of the Information and Communication Technologies (ICT) sector. Network resource optimization has become one of the most important research areas in the field of ISP networks. Sleeping reconfiguration and rate adaptation has been used for reducing energy consumption when the traffic demands are at their low levels. In this work, an efficient heuristic based Time-driven Link Sleeping (TLS) is proposed for reducing the energy consumption. A robust TLS scheme with Single Link Failure Protection (TLS-SLFP) aims to achieve an optimized trade-off between network robustness and energy efficiency performance.

Key words- Energy consumption, trade-off, traffic engineering, link sleeping, network robustness.

I. INTRODUCTION

The increasing demands for using wireless networks to serve applications that require delay guarantees. Such applications include VoIP, video streaming, real time surveillance, network control etc. one common characteristic of these application is that they have a strict-deadline associated with each packet. Each packet needs to be delivered before its deadline, or it expires and is no longer useful for its application.

Several techniques have been proposed for making the networks more energy efficient. These techniques can be classified into both disruptive and evolutionary solutions. The disruptive is the new features need to be supported by device hardware such as Dynamic voltage Scaling (DVS). The evolutionary, which is an incremental approaches such as link sleeping reconfigurations can be leveraged based on legacy network systems. While disruptive approaches aims at long-term solutions for greening the future Internet, short or mid-term evolutionary schemes are of equal significance, as the environmental issue and the scarcity of energy resources as imminent threats.

Energy-aware Traffic Engineering has been proposed for reducing the energy consumption in the ISP networks. Effectively, ETE paradigms can be further classified into offline and online techniques. Most research works in literature have followed the offline optimization strategy because of its simplicity compared to online energy saving methods. Offline ETE approaches aims to compute a reduced network topology and the online approaches aims to enable adaptive traffic control against changing traffic conditions. In this work, we propose a practical and efficient approach with time-driven network topology reconfigurations called Time-driven Link Sleeping (TLS). The proposed TLS scheme aims to compute a reduced network topology which will produce the optimized combination of the number of sleeping links and the unified duration of their sleeping period. The energy saving is achieved by reducing the topology during the off-peak time from the original full topology. The time window can be used for specifying the activation of the reduced topology reconfiguration and its termination on a daily basis.

Effectively, single link failures can be occur frequently in the operational networks, and it is important to eliminate or minimize when computing the reduced topology for energy saving purpose. The basic TLS scheme is extend and propose an advanced scheme called Time-driven Link Sleeping with Single Link Failure Protection (TLS-SLFP). TLS-SLFP achieves the trade-off between network robustness and energy efficiency performance.

II SURVEY RESULTS

1. 2. Putting into sleep mode:

The network components can be putting into sleep mode during the idle time. This is the normally used approach for reducing the energy consumption on the networks. The sleep states consumed power by putting the sub-components of the overall system to sleep when there is no work to process.[2]

Timer-driven sleeping is one of the methods for putting the network element into sleep mode. This scheme specify the well-defined times for enters and exits the sleep state. The network element specifies the time in future at which it will exit from the sleep before entering into sleep and all packets can be lost while arrive at a sleeping state. The wake-on-arrival (WoA) is another scheme, it senses packet on a line is left powered on even in sleep mode. For reducing the packet lost, the dummy packets can be used for starting the transition. A router is awakened by an incoming (dummy) packet and after forwarding it, return to sleep if no subsequent packet arrives for some period of time. The opportunistic sleep is only possible with the more sophisticated hardware support of wake-on-arrival.

2. Rate-Adaptation:

In this approach, adapts the rate of individual links based on the utilization and queuing delay of the link. Performance states reduce power consumption by lowering the rate at which work is processed. Both the active and idle power consumption depends on the frequency and voltage at which work is processed.[2]

The rate-adaptation solution is one, which reducing the average rate at when the network operates. The device can be operating at lower frequency enable dramatic reductions in energy consumption for two reasons; they are (i) simply operating more slowly, (ii) use of dynamic voltage scaling (DVS) that reduces the operating frequency, DVS is not supported in commercial equipment.

3. Energy-aware Traffic Engineering:

EATe uses a scalable, online technique to spread the load among multiple paths, so as to increase energy saving. The frequent changes in the operating rate of energy proportional networking hardware can result in unnecessary packet delays or losses. [3]

In this scheme, shift links to lower energy regions while being not to move the links on the alternative paths to higher energy regions. EATe quickly moves traffic after link failure. It successfully handles changes in traffic load and quickly restores a low overall energy state, resulting in energy saving of 8%. EATe does not change ingress or egress points of any source-destination pair and it not change the amount of traffic entering and exiting the ISP network. Finally, EATe balances the traffic load and saving the energy on the networks.

4. Adaptive Link Rate:

The Adaptive Link Rate is the one the method for reducing the energy consumption in the network. In this method ALR mechanism and ALR polices are used for reducing the energy consumption on the Ethernet. The ALR mechanism determine how the link data rate is switched and the ALR policy determine when to switch the link data rate.

The ALR method focuses only on the Ethernet. It don't put the network component to sleep and it did not focus on more than one data rates and higher layer protocol. Hence it reduce the energy consumption on the Ethernet only . [4]

III PROPOSED METHODS

1. Time-driven Link Sleeping (TLS)

TLS scheme is now proposed for reducing the energy consumption on the ISP backbone networks. In TLS the reduced network topology is used instead of full topology during the off-peak time. The synthetic traffic matrix is used for computing the future off-peak configurations. The main heuristic steps involved in the process are (1) computing the synthetic traffic matrix and the starting point for off-peak window size expansion, (2) greedy link removal for the provisional reduced topology and (3) the joint expansion of the off-peak window size and the finalization of the reduced topology to be applied during the off-peak period.

a) *Stage 1*, computing the synthetic traffic matrix and the starting point for off-peak window size expansion: The traffic matrix information is used for computing future off-peak network configurations. The synthetic off-peak TM is computed by multiple sampled TMs from different days in the considered period based on which sleeping links are initially identified in the reduced network topology. Multiple TMs are used instead of single one for robustness reasons.

b) *Stage2*, greedy link removal for the provisional reduced topology: The computation of the reduced topology is achieved by the iterative greedy removal of the links from the full network topology. If link l^* cannot be removed means, then it is put into the Link Removal Failure List so that it will not be further considered. Stage2 has been used for finding the alternative shortest paths for all the source-destination pairs of the graph and route all the traffic demands of the synthetic traffic matrix.

c) *Stage3*, determination of combined off-peak time window size and the final reduced topology: The final stage of TLs is to compute the actual off-peak window size jointly with the fine-tuning of the number of sleeping links. The expansion of the off-peak window starts from the stage1 expansion points. From this point the expansion is performed in both directions sequentially and independently. The termination condition for the iterative consideration of restoring sleeping links depends on the best value of the objective function. The objective function is formed by multiplying the number of sleeping links with the number of consecutive off-peak traffic matrix intervals.

For each restoration of the sleeping link, stage3 has to find the new shortest path of all the source-destination pairs of the graph and route all the traffic demands of all the traffic matrices until violation of the MLU constraint.

2. TLS with Single Link Failure Protection:

During the off-peak time, the unexpected link failure caused because of a decrease in the connectivity options and the capacity of the network. The proposed TLS scheme does not consider the single link failure on the reduced topology. Time-driven Link Sleeping with Single Link Failure Protection aims to optimize the reduced network topology so that it always remains fully connected and also it protect any failure of single link during off-peak time.

Algorithm extension from TLS:

TLS-SLFP has four stages, which are described below

a) *Stage 1*, Computing the synthetic TM and the starting point for off-peak window size expansion: this stage is same as Stage 1 for TLS

b) *Stage 2* Greedy link removal with full network connectivity check for single link failure scenarios: Stage 2 of the TLS has been extended for taking the new constraints on post-failure connectivity of the reduced topology when determining sleeping links. The connectivity check is based on L-2 single link failure with the removal of l^* , where L is the total number of links in the network topology. The removal of any link in the modified stage 2, an additional connectivity check is needed for each remaining active links when they are projected to fail.

c) *Stage 3* Determination of combined off-peak time window size and the final reduced topology: this stage is same as Stage 3 for TLS.

d) *Newly added Stage 4*, Optimizing sleeping link selection to avoid traffic congestion during single link failures: The first step of this stage calculate the number of single link failure scenarios that cannot be supported by the reduced topology produced at the end of stage 3. After identifying the total number of unsupported single link failure scenarios, TLS- SLFP identifies what impact each sleeping link in reduced topology will have on this number if the sleeping link were to be restored back to the topology again. After each sleeping link is considered for restoration, the number of unsupported single link failure is re-calculated and the next link in the list is tested. This procedure is applied to ensure that the minimum number of sleeping link needs to be restored back to the working topology, and conserve the energy savings achieved in stage 3 as much as possible. The next major step of stage 4 is to calculate the remaining unsupported single link failures after each sleeping link restoration.

IV. CONCLUSIONS

The traffic pattern of many equipped ISP networks are generally regular and conventional on a daily basis, such a characteristic can be exploited by applying simple time-driven energy-aware network reconfigurations with low operational complexity. In this work, an algorithm called Time-driven Link Sleeping (TLS) was proposed which jointly optimizes the reduced network topology and the period of off-peak operation during which this reduced topology can be used. The novelty of TLS is that it performs optimization with respect to a period of traffic behavioral dynamics (represented by multiple traffic matrices) compared to only one instance of traffic matrix, as is the case in the vast majority of existing works. The proposed scheme enables a simple and practical energy management paradigm that eases the complexity of ISP operations for energy conservation. TLS has been evaluated based on the GEANT network and its real historical traffic traces, and the results show that the proposed scheme is able to achieve up to 28.3% energy saving effects during daily operations. We have also taken into account the network robustness requirement against single link failures while formative sleeping links for off-peak time operation. The rationale behind is to avoid potential broken topology or traffic congestion due to unexpected single link failures that might occur to the reduced topology during the off-peak time. Towards this end, TLS has been further extended to cater for any single link failure scenario, which is known as Time-driven Link Sleeping with Single Link Failure Protection (TLS-SLFP).

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