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DTN based Management Framework for Green On/Off Networks

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***Abstract*—The increasing cost of powering high performance networking infrastructure has led to the proposal of various energy saving schemes. The On/Off technique, being the most common energy saving scheme, consists of powering down partially or entirely a network infrastructure for energy saving purposes. Despite their capability to achieve great energy savings, On/Off networks experience high packet-loss rates due to the absence of reliability on packet delivery. Moreover, they cannot guarantee any response time to user applications. This paper presents the design and implementation of MFO2N; Experimental results show a correlation between offered quality of service and overall network power consumption, revealing that a trade-off should be made[1].**

***Index Terms*—energy efficient networks; on/off networks; proactive switch on/off; DTN; quality of service;**

I. Introduction

Initiatives conducted by research laboratories call for introduction of Green On/Off networks capable of switching off links (either redundant or not) or nodes for power saving purposes. On/Off networks can be divided into two categories: (1) Unplanned On/Off networks whose communication opportunities are completely or partially unknown. (2) Planned On/Off networks whose communication opportunities are planned and well known.

Our work focuses on bulk data transport dedicated networks with advance bandwidth reservation features. The network is designed to switch off links and nodes not in use by any data transfer to achieve power saving. In this context, to avoid affecting the utilisation of the network as well as degrading network performance, users should be able to send bandwidth reservation requests irrespective of the state of the network. In addition, users should be able to receive a response within a reasonable time. This paper introduces the Management Framework for On/Off Network (MFO^{2}N); a framework providing energy-efficient management of information transfer with quality of service in planned On/Off networks. The goal is to minimise the total power consumption of a dedicated network infrastructure by switching off unused nodes and links while making network unavailability transparent to users. For this purpose, we combined the DTN Store and Forward message switching with a **proactive switch On/Off** mechanism to service users request which may either (1) arrive at a network node where the link to the next hop towards its destination is down (or the next hop itself) or (2) timed out in a DTN router's forwarding queue. We present preliminary results that permit us to estimate the power cost of providing a Green On/Off network with management tools. This paper is organized as follows. Section II presents the network management model description. Section III describes the Management Framework for ON/OFF networks. Section IV analyzes evaluation results. Finally section V concludes this paper and proposes some future works.

[1]This work is supported by the Hemera INRIA Large Wingspan project. Experiments of this paper were performed on the Grid'5000 platform, an initiative from the French Ministry of Research through the ACI GRID incentive action, INRIA, CNRS and RENATER and other contributing partners (http://www.grid5000.fr)

II. Network Management Model Description

The management model we propose associate each network node and link with an on/off agenda [1]. The On/Off agenda, local to each node, is actually a chronologically ordered list of On/Off events describing the future network usage. Thus, given a network node N, N maintains an agenda whose elements are of the form (t_i, N, *ACTION*), and (t_i,l, *ACTION*) where:

- t_i is the time when the action *ACTION* starts.
- l designate a network link connected to N.
- There are two types of actions: *On* for switch on, and *Off* for switch off.

We also associate each management request with a lifespan or time to live (TTL) fixed by the users and representing the maximum number of seconds after which the user expects to receive a response to its requests. We then leverage the DTN Store and Forward message switching paradigm to guarantee the delivery of users requests. To guarantee on demand delivery time, we combined the DTN Store and Forward message switching with the proactive switch-on mechanism which consists of making links and/or nodes available to service management information information transport.

III. Management Framework for On/Off Networks (MFO^{2}N)

We present in this section the Management Framework for On/Off Networks (MFO^{2}N) an implementation of the network management model described in Section II. The main objective of the proposed framework is to minimise the extra energy cost

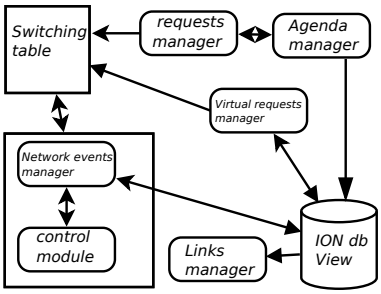

Figure 1: MFO^{2}N architectural model.

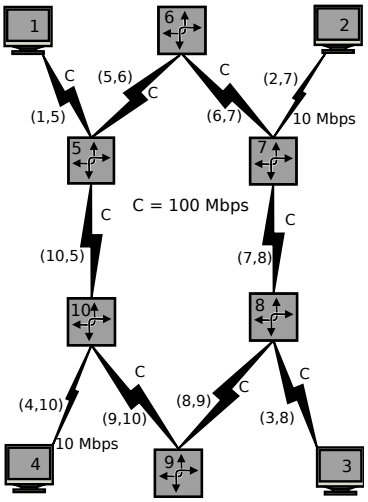

Figure 2: Network topology.

of bandwidth reservation requests transport while guaranteeing on-demand response times to users as well as reliable transport of requests. MFO^{2}N lays on the Interplanetary Overlay Networking (ION) [2] software, an implementation of the DTN architecture to which we have brought substantial changes. MFO^{2}N consists of several functional elements (see Figure 1) whose description is not given in this paper due to lack of space.

IV. Evaluation

The evaluation of MFO^{2}N is performed on a 10 node network topology (see Figure 2) deployed on the large scale experimental platform Grid5000 [3] via ION.

We consider several agenda scenarios of a few minutes each in which end nodes, i.e, nodes 1, 2, 3 and 4, send and/or receive bandwidth reservation requests. We then inject in the network after every 10 seconds one bandwidth reservation request whose source and destination nodes are chosen randomly.

We investigate the impact of the offered quality of service expressed essentially in terms of requests response time on the overall network power consumption. Figure 3 depicts the cumulative on time per network link for the various on-demand requests response times denoted as TTL in that figure. As expected, requests with short response delay are more power consuming. Figure 3 also show the ability of MFO^{2}N to

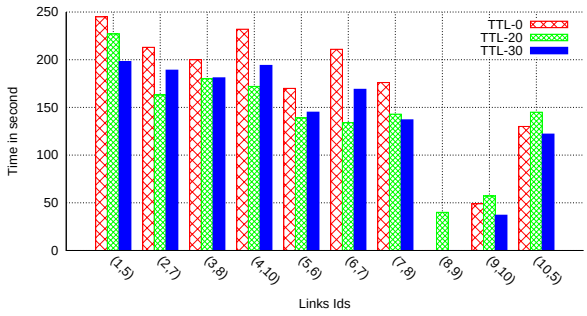

Figure 3: On time variation with respect to requests response times (TTL).

successfully deliver user data, mainly bandwidth reservation requests on a network which is down while guaranteeing reasonable response times.

V. Conclusion

The paper introduced the design of MFO^{2}N. We run MFO^{2}N Grid5000 platform and showed through many requests scenarios that the designed framework can ensure the transport of management information in Green On/Off networks. We then provided estimates of the extra energy cost of the proposed framework. Collected results exhibit a correlation between the overall network power consumption and the offered quality of service revealing that a trade-off should be made. This work is ongoing, and obtained results may depend on the DTN under-layer communication software. Future work envisage more complex network topologies and the implementation of a Web based management platform.

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