Progress Report

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Introduction

We intend to implement a Coordinated Multi-layer Multi-domain Optical Network (COMMON) Framework for Large-scale Science Applications. In the COMMON project, specific problems to be addressed include 1) anycast/multicast/manycast request provisioning , 2) multi-layer multi-domain quality of service (QoS), and 3) multi-layer multi-domain path survivability. In what follows, we outline the progress in this quarter for catogories 1) and 2) (Year 1 deliverables).

Activities

We has some discussions with the ESnet team on the best approach to integrate the anycast services into OSCARS 0.6.

Progress/Accomplishments

In this section we describe the progress and accomplishments in each of the tasks (labeled T1, T2) as outlined in the project proposal:

- T1: Anycast/Multicast/Manycast Request Provisioning

  Work Performed:

  With the increasing number of high-bandwidth applications, energy consumption of networks has become an important issue that needs to be addressed. Manycasting is a communication paradigm that finds applications in such high-bandwidth environments. To support manycasting functionality in an optical network that is muticast incapable (MI) we propose two overlay approaches: Manycasting with Drop at Member Node (MA-DAMN) and Manycasting with Drop at Any Node (MA-DAAN). In these solutions, we achieve manycasting by creating a set of lightpath routes (possibly multiple hops) in the overlay layer.

  We consider a static traffic model and present integer linear programs (ILPs) to solve these problems with a goal of minimizing the total number of wavelengths required to service the request set. Note that the reduction in the number of wavelengths will lower the networks energy consumption. We also present an efficient heuristic and compare its performance to the ILP for a small network, and run simulations over real world, large-scale networks. We compare our proposed approach to a baseline unicast approach, i.e., by creating unicast (single hop) lightpaths.

  Moreover, we have also performed extensive simulations on three real-worl large scale networks for the above mentioned heuristics by also considering a dynamic traffic scenario, wherein multicast request arrive to the network following some stochastic process.

  Findings:

  Our results show that MA-DAMN and MA-DAAN achieve $25-45\%$ improvement (reduction in the number of wavelengths) compared to the baseline unicast approach. We further weigh our manycast approaches against comparable multicast approaches, and observe that manycasting achieves a $27-44\%$ improvement in terms of reduction in the number of wavelengths. The work on manycasting is submitted to two conference papers [1, 2], which are currently under peer-review.

  We have also investigated the problem of provisioning dynamic anycast holding-time-aware (HTA) lightpath in all-optical wavelength division multiplexed (WDM) networks. We employ a technique called lightpath switching (LPS) wherein the data transmission may begin on one lightpath and switch to a different lightpath at a later time. Lightpath switches are transparent to the user and are managed by the network. Allowing LPS creates a number of segments that can use independent lightpaths. We propose two heuristics to solve the anycast routing and wavelength assignment (RWA) problem: anycast lightpath switching (ALPS) and anycast continuous segment (ACS). In ALPS, we allow a request to switch lightpaths to the closest anycast destination. If we cannot accommodate the data transmission request to the selected destination with lightpath switching we try other candidate destinations, thereby increasing the probability of the users request being provisioned. In ACS, we do not allow a connection request to switch lightpaths. We find a lightpath using traditional RWA to each anycast destination and select the one that best utilizes network resources.

Findings:

We compare the performance of ALPS to that of ACS. Our results suggest that ALPS achieves better blocking performance compared to ACS. Furthermore, we also compare the performance of these two anycast RWA algorithms to the traditional unicast RWA algorithms. We observe that the anycast RWA algorithms significantly outperform the traditional unicast RWA algorithms. This work has resulted in a conference paper in the upcoming conference *IEEE International Conference on High Performance Routing and Switching-2011* [3].

- T2: Multi-Layer Multi-Domain Quality of Service (QoS)

  In this task we examine the multi-layer quality of service in optical WDM networks. The purpose is to deliver a QoS framework to map input connection requests to a certain number of classes, wherein each of these classes gets a different treatment in the network.

  Work Performed:

  Following with the findings from the previous quarter (Q2), during this quarter we proposed to extend the framework by providing a partition-based QoS. The idea is to set different network resources partitions to different classes. In order to provide some extra flexibility, we have initiated some work on defining some policies over these partitions. Instead of setting a fixed partition, our aim is to make this partition flexible in the way that connection requests mapped to one class may use also resources from another class, as long as its re-mapped at a lower priority. To this end, two different policies are expected to be evaluated: one based on switching connection requests to other class resources partitions before preempting resources within its original class; and another that performs first the preemption of resources, and if these are not available, try to use resources from another partition.

  During this quarter we also proposed a mathematical model for hybrid immediate and advance reservation. The purpose is to compute, in advance, the blocking probability into the system, depending on whether the input call is for immediate or advance reservation. We tested our model on a simple link scenario.

  Findings:

  The main results obtained during this quarter come from the mathematical model. As introduced, we proposed a simple link model for hybrid IR/AR. The results show its good fitting in comparison with the simulations for an scenario with 3 different traffic classes, one IR and two AR. We also tested the model under different traffic percentage distributions among the three classes, and in almost all of them, the results fitted quite well those obtained from simulation. The results were submitted as a conference paper to GLOBECOM 2011 [4] and it is currently under revision. We plan to extend the model to a network-wide model in the coming months.

NOTE: All the above work which has resulted in conference proceedings have acknowledged the DOE-COMMON project.

Cost Status & Unexpected Funds

See attached document.

Next Quarter Deliverables

- Plan to integrate our algorithms into a OSCARS module
- Evaluate the OSCARS architecture to implement a new QoS module.

References

[1] A. Gadkar, J. Plante, and V. Vokkarane, "Manycasting: Energy-Efficient Multicasting in WDM Optical Unicast Networks," in *Proc. of GLOBECOM 2011*, Houston, TX, USA, Dec. 2011, under review.

[2] J. Plante, A. Gadkar, and V. Vokkarane, "Dynamic Manycasting in Optical WDM Networks for High-Bandwidth Applications," in *Proc. European Conference on Optical Communication (ECOC) 2011*, Geneve, Switzerland, Sep. 2011, under review.

[3] B. Ramaprasad, A. Gadkar, and V. Vokkarane, "Dynamic anycasting over wavelength routed networks with lightpath switching," in *Proc. IEEE Conf. on High Performance Switching and Routing*, June. 2011.

[4] J. Triay, C. Cervelló-Pastor, and V. M. Vokkarane, "Analytical Model for Hybrid Immediate and Advance Reservation in Optical WDM Networks," in *Proc. of GLOBECOM 2011*, Houston, TX, USA, Dec. 2011, under review.