COMMON: Coordinated Multi-layer Multi-domain Optical Network Framework for Large-scale Science Applications

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Addendum - Updated list of Project Tasks and Deliverables

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) multi-layer multi-domain path survivability, 2) multi-layer multi-domain quality of service (QoS), and 3) anycast/multicast/manycast request provisioning. We will investigate these three in the context of multi-layer and multi-domain networks. The task details are outlined in the following sections.

We plan to extend the OSCARS reservation system with the following proposed features. OSCARS supports on-demand and in-advance reservation of layer 2 and layer 3 virtual circuits (VCs). OSPF-TE, MPLS-TE, and RSVP-TE are used to to maintain MPLS-LSPs for the VCs. OSCARS is used as a domain controller for ESnet to both manage internal resources as well as communicate with other domains [1].

1 Multi-Layer Multi-Domain Path Survivability

In this project, we consider the problem of survivability for immediate and advance reservation of optical circuits. In advance reservation, the setup time and tear-down time of a connection are either fixed or flexible. The advance reservation with flexible setup and tear-down times provides more flexibility in provisioning working and backup resources in a time-disjoint manner so that resource sharing in the time domain can be maximized. Provisioning backup resources in a time-shifted manner subject to the deadline constraint of a request can further improve the network resource utilization. However, if the backup is time-shifted from the working reservation, then when a failure occurs, the application needs to be informed of the backup reservation time. If a failure occurs, there is also the question of how many circuit requests (calls) must be re-routed. Assuming the failure will be fixed, not all future calls that have booked-ahead would need to be re-routed.

We will also investigate multi-layer (IP, Ethernet, and Wavelength) survivability. The OSCARS system will have knowledge about what circuits at which layers are used over the network. For example, a user may submit a request for a Layer 3 virtual circuit that does not require survivability. This may then be routed over an optical path that does not provide any survivability guarantees. We can partition the network into physical-layer paths providing survivable or non-survivable service, then route higher-layer requests over these paths depending on their requirements. It may also been beneficial to route higher-layer circuits that have similar survivability requirements together. We will investigate both path protection and restoration based survivability techniques.

As an extension to this work, we will investigate schemes to ensure that survivability can be accomplished across multiple domains. This includes proposing new topology abstractions that incorporate temporal information.

We have investigated multi-layer survivability for IP and optical networks in the past [2] and we will incorporate some of this in the proposed work.

Summary of Tasks:

- Investigate providing multi-layer path survivability for immediate reservation requests.
- Investigate the unique requirements for provisioning survivability for advance reservation requests and develop a set of protection strategies to satisfy different reliability requirements.
- Investigate handling different failure scenarios (single link, multiple link, and shared risk link group) for multi-layer immediate reservation requests.

- Investigate handling different failure scenarios for multi-layer advance reservation requests.

Deliverables: All the deliverables are expected to be deployed on OSCARS (or a DOE test-bed) in collaboration with the ESnet group at LBNL. The PI has included travel support for himself and a student to travel to LBNL annually to facilitate the smooth implementation of the project deliverables.

1.1: Develop algorithms for coordinated multi-layer survivability and deploy on OSCARS.

1.2: Extend multi-layer survivability techniques to work in multi-domain networks and deploy on OSCARS.

2 Multi-Layer Multi-Domain Quality of Service (QoS)

In this project we introduce different priority levels to ensure QoS for high priority calls (circuit requests). Our algorithms will ensure that high priority calls will get the required bandwidth, possibly at the expense of lower priority calls. For example, we may incorporate preemption of lower priority calls by higher priority calls in order to satisfy the QoS requirements of the high priority traffic.

We will investigate the use of non-continuous transmission rates to improve the quality of service (QoS) of other low priority traffic in the network. If we find that a request cannot be scheduled, we may be able adjust the transmission rate of certain requests in order to accommodate the other requests, as long as we do not violate deadline or other QoS constraints. This may require coordination between the OSCARS system scheduler and the user.

We will also investigate multi-layer QoS. Each layer may have its own QoS requirements based on well-known existing metrics. We will use these metrics to guarantee QoS across multiple layers.

We will also incorporate QoS across multiple domains. While different domains may provide different services, we will develop methods to ensure that some minimum level of service is provided to calls across multiple domains if available.

We have investigated several QoS models for optical networks in the past [3, 4] and we will incorporate some of this in the proposed work.

Summary of Tasks:

- Investigate providing multi-layer QoS to immediate reservation calls.
- Investigate providing multi-layer QoS to advance reservation calls.
- Investigate incorporating QoS into multi-layer multi-domain path setup.
- Develop a general framework to negotiate QoS levels across multiple domains.

Deliverables:

2.1: Implement request preemption on OSCARS to support multiple classes of traffic.

2.2: Implement multi-layer QoS on OSCARS.

3 Anycast/Multicast/Manycast Request Provisioning

We will introduce algorithms for provisioning anycast, multicast, and manycast calls. We will support both immediate and advance reservation. We will investigate supporting these communication paradigms at multiple layers. Anycast can be supported directly at the optical-layer without need for special hardware or at the higher layers as a virtual circuit service.

Multicast and manycast would require multicast-capable optical cross-connects (MC-OXCs) to implement at the optical-layer. Because ESnet does not currently have these devices, multicast and manycast will be implemented as overlays. We will use anycast and unicast at the optical-layer to support multicast and manycast at higher layers. Our algorithms will have to minimize Layer 1 resources when the point-to-multipoint paradigms are implemented as network overlays.

We will also investigate multi-domain provisioning of these types of calls. This may require setting up multiple inter-domain links for the case of point-to-multipoint paradigms.

We have investigated manycast in the past [4, 5] and we will incorporate some of this in the proposed work.

Summary of Tasks:

- Investigate anycast, multicast, and manycast immediate reservation algorithms.
- Investigate anycast, multicast, and manycast advance reservation algorithms.
- Investigate techniques such as path switching to reduce blocking probability and increase utilization.
- Investigate batch versions of our algorithms. With batch scheduling problems we can let our algorithms run longer to find more optimal results.
- Investigate batch scheduling across multiple domains.

Deliverables:

3.1: Deploy anycast, multicast, and manycast immediate reservation algorithms on OSCARS.

3.2: Deploy anycast, multicast, and manycast advance reservation algorithms on OSCARS.

4 Project Timeline

We summarize the deliverables in Fig. 1. The deliverable numbers in the figure refer to the deliverables at the end of each of the previous sections. The timeline for each of the tasks is based on the number of students working on the project, which will be two graduate research assistants and one post-doc working simultaneously.

We will have Deliverable 3.1 completed in the first year, Deliverables 1.1 and 3.2 completed by the second year, and the remaining completed by year three.

ID	Deliverable Name	Start	Finish
1	Deliverable 1.1	7/1/2011	10/1/2012
2	Deliverable 1.2	4/2/2012	9/30/2013
3	Deliverable 2.1	10/3/2011	12/28/2012
4	Deliverable 2.2	10/1/2012	9/30/2013
5	Deliverable 3.1	10/1/2010	9/30/2011
6	Deliverable 3.2	1/3/2011	3/30/2012

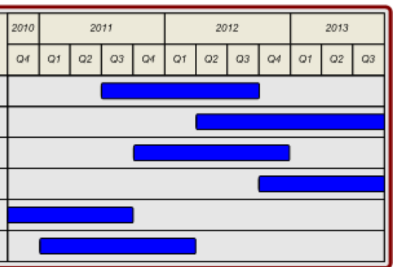

Figure 1: Project Timetable.

References

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