Anycast Routing in Optical Burst Switched Grid Networks

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Abstract *To deliver virtually unlimited computing power to residential users, an anycast routed Optical Burst Switched Grid infrastructure is proposed. This architecture is evaluated and compared with traditional shortest path routed systems in Optical Circuit Switched and Burst Switched networks.*

Introduction

Grid computing provides a uniform interface to heterogeneous and geographically distributed resources, all connected over a high speed network. Current Grid implementations are geared toward scientific projects which require large amounts of compute, storage and network resources. These operations remain fairly static over time and as such demand long-lived, photonic network connections. The Optical Circuit Switching (OCS) technique is particularly well suited for this scenario, especially considering the relatively few number of participating sites in these projects.

In contrast, opening Grid technology to the consumer market requires support for a large amount of users with dynamic traffic patterns and short-lived connections. It is well known that when the hold times of network connections decrease, OCS shows reduced efficiency because of its inability to reserve bandwidth below the wavelength scale. Optical Burst Switching (OBS) [1] is an emerging technique capable of addressing bandwidth at the sub-lambda level. Already, a working group in the Global Grid Forum (GGF) is committed to the standardization of OBS in the context of Grid computing [2].

Regardless of the employed switching technique, most networks use fixed shortest path routing between endpoints. The goal is to minimize end-to-end delay, but it can cause overloaded links and thus lead to network congestion. To overcome this problem, deflection routing and multi-path routing can be supported.

In the consumer Grid scenario [3,4], the user is only interested in his job being processed within certain predetermined requirements. In general, there will exist multiple locations where a job can be executed. As such, we can move away from the inflexible unicast routing approach (where the destination is known before transmission), to a much more adaptive anycast [5] routing protocol.

In this paper, we explore the possible gains in using OBS augmented with anycast routing, over traditional unicast routing in OCS or OBS.

Grid over OBS

The basic premise of Grid over OBS is the mapping of one user job into one optical burst. The user starts by creating a request burst containing job code and input data, accompanied by a burst header. This header not only contains the traditional burst-related parameters (most notably the offset between header and burst and the burst length), but also various job-related parameters, such as processing and storage requirements, time deadline, etc. In absence of an explicit destination, the OBS network is responsible for finding an available and capable resource. After successful execution, a response burst which contains the job's results is sent back to the user.

A detailed discussion of possible application scenarios and their associated resource requirements can be found in [3].

Anycast Routing Protocol in OBS

The routing protocol is composed of two parts: the resource state advertisement protocol and the routing and forwarding protocol.

First, each resource (i.e. edge node) periodically sends a status packet, containing the free capacity and distance in hops, to the routers (i.e. core nodes) it is attached to. In turn, these will identify the resource as being locally attached and save the status. Each router then forwards the packet to all neighbouring routers, with an updated free capacity value which is proportional to the available bandwidth between the routers (Fig. 1).

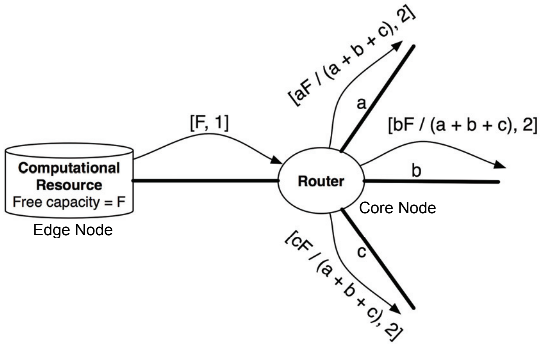

Fig. 1 OBS Resource State Advertisement Algorithm

Observe that adjusting the resource states ensures that advertisements cannot exist forever, since the free capacity value will converge to zero. However, to prevent looping of resource states with extremely large capacities, a status packet is dropped after having travelled a certain number of hops.

The actual routing and forwarding of a burst is then as follows. The burst, preceded by its header, is handed over by the client to the neighbouring router without an explicit destination. Upon reception of the header, a router first verifies if the burst is still able to meet its deadline. Next, the routers checks if it has a resource attached with sufficient free capacity, and delivers the burst accordingly. Otherwise, the router selects the outgoing interface with the largest free capacity available, excluding the original incoming interface to prevent looping and passes the burst optically to the next node without processing it.

When the destination router has been selected, the wavelength reservation mechanism is activated, after which the burst header is forwarded to the destination router. Eventually, each burst will either be dropped along the way, or reach a resource capable of processing the job. Finally, response bursts follow the reverse path from resource to client.

Simulation Scenario

We performed our simulations on two different networks. First, we used a ring topology composed of 50 optical routers, in which clients were attached to all routers. Also, the network contained 5 evenly distributed computational resources, each capable of processing 50 jobs in parallel. A second topology considered is the European core network, containing 13 nodes and 17 bidirectional links. All network links offer 4 wavelengths of 40 Gbps.

We implemented Horizon [6] as wavelength reservation technology. Computational resources are reserved on arrival of the OCS setup packet or the OBS burst header. The blocking policy used is to drop the burst immediately.

Furthermore, we assumed exponential job interarrival times at each client, and generated loads equal to a specific fraction of the total computational capacity. In all simulations, network load remained below 20% of the total capacity.

Simulation Results

Fig. 2 shows the global job blocking rate for different average burst sizes, with the total network and computational load held constant. Clearly, OBS anycast (OBS-A) outperforms both unicast methods (OCS-U and OBS-U). Also, observe in Fig. 3 that both unicast techniques send jobs further away for higher job loads, thus creating additional network load.

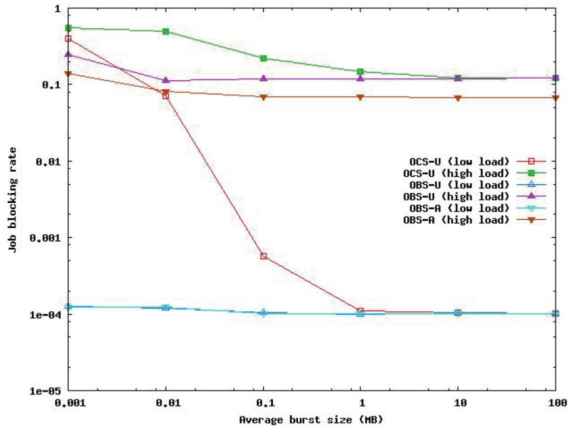

Fig. 2 Influence of burst size on job blocking rates for both low (20%) and high (80%) job loads.

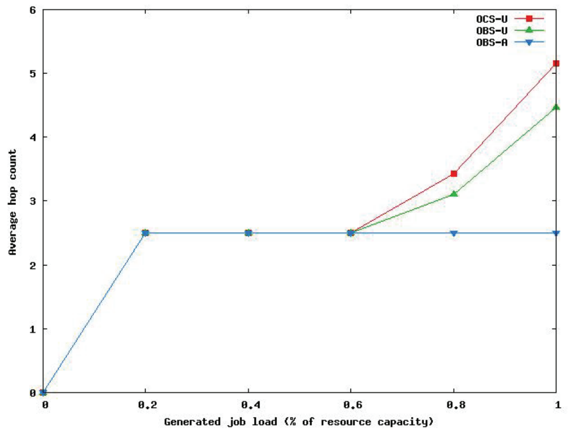

Fig. 3 Influence of job load on average hop count.

Conclusions

The presented architecture promises to offer Grid services to the residential market. We showed the inflexibility of traditional unicast-routed approaches, and explored the gains possible with our OBS based anycast protocol.

References

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