Application-aware Contention Resolution Scheme
for Grid Services over OBS Networks

Byungsang Kim, Ji-Hwan Kim, Min-Gon Kim, Minho Kang
School of Engineering
Information & Communications University
{bskim, jhkim0126, kmg0803, mhkang}@icu.ac.kr

Abstract — In recent, there are many paradigms for supporting convergence both networks and computing. Grid computing offers high levels of computational, storage and network capacity on the wide area environment. Optic based network is a good candidate for supporting the Grid application. In this paper, we will propose the novel contention resolution scheme which is differentiated by specific application and their job type for supporting Grid services in the OBS network.

Keywords — Grid computing, Optical burst switch, OBS network, Contention resolution.

1. Introduction

During the past years it has become evident to the technical community that computational resources cannot keep up with the demands generated by some applications. As an example, particle physics experiments [1] produce more data than can be realistically processed and stored in one location (i.e., several Petabytes/year). In such situations where intensive computation analysis of shared large scale data is needed, one can try to use accessible computing resources distributed in different locations (combined data and computing Grid). Also, AccessGrid is needed real time streaming for multimedia display, presentation, visualization, group to group communication on the multi institutional users. Optical networks and optical burst switching scheme is a good candidate for supporting such Grid enabled networks. However a major concern in OBS is contention, which occurs when multiple bursts contend for the same link. Contention in an OBS networks is particularly aggravated by the highly variable burst sizes and the long burst durations. On the Grid enable network, contention is more critical problems because jobs in users is cooperated and shared by multiple Grid resources and organizations. Thus, it is important issues to guarantee the application specific assembling and forwarding scheme on the OBS networks. In this project, we propose the application-aware contention resolution scheme using completion time of the jobs in Grid services.

2. Related Works

Grid computing is different from common distributed computing by focusing on large-scale resource sharing and cooperating applications among user groups [1]. Because of the heterogeneity and abundance of the resources, it is more and more difficult to increase the efficiency for discovering or allocating the resources and to guarantee the completion time of the service or the synchronization between services. Customizing quality of service (QoS) based on the individual requirement of the services is not easy to brokering as static resource allocation. As a result, dynamic adaptation oriented service rather than computing is more important in order to manage resource and its architecture [2]. There are many architecture for the management of Grid resources. Condor-G system [3] provides the script that advertises the requirement of resources and checkpoint for allocating again. Its mechanism however is limited into controllable domain. Nimrod-G Grid resource broker [4] uses the cost and deadline based on economic foundation. In order to understand why optical networking for Grid, we need also to understand the current limitations of packet switching for Grid and data-intensive applications. The current Internet architecture is limited in its ability to support Grid computing applications and specifically to move very large data sets. Packet switching is a proven efficient technology for transporting burst transmission of short data packets, e.g., for remote login, consumer oriented email and web applications. It has not been sufficiently adaptable to meet the challenge of large-scale data as Grid applications require. Because Grid service requests will be highly unpredictable, a dedicated static infrastructure such as optical circuit switch (OCS) is not the most optimal solution. We need to simplify intelligence in the network as much as possible, as well as use optics wherever appropriate to deal with the huge bandwidth requirements and number of jobs. Many in the networking research community believe that optical burst switching (OBS) can meet the needs of the scientific community in the near term (2-3 years). The fundamental premise of OBS is the separation of the control and data planes, and the segregation of functionality within the appropriate domain (electronic or optical)[5]. This is accomplished by an end-user, an application, or an OBS edge node initiating a set-up message (control message) to an OBS ingress switch. The data burst is launched after a small offset delay. Bursts remain in the optical plane end-to-end, and are typically not buffered as they transit the network core. A burst can be defined as a contiguous set of data bytes or packets. This allows for fine-grain multiplexing of data over a single lambda. Bursts incur negligible additional latency. The bursts’ content, protocol, bit rate, modulation format, encoding
(digital or analog) are completely transparent to the intermediate switches.

For contention resolution, there are many techniques for realizing minimum blocking probability and supporting priority for each burst. Threshold based contention resolution scheme [6] search the optimum burst size on the certain network environment. The threshold specifies the number of packets to be aggregated into a burst. The size of the burst significantly affects the contention of the network resource. In the paper [7], author propose a framework for providing differentiated contention resolution in the photonic packet-switched networks using label-based forwarding scheme for supporting different level service architecture. Recirculation buffering and deflection routing are important control scheme for providing differentiated loss and delay. An OBS architecture would be a good candidate for the future widely available Grid services. When we assume the native mapping between bursts and jobs [4], we can easily describe the advantage of the OBS networks for Grid. A single job will be mapped into one burst. The entire job either gets through, or not at all, which means the transport network can be simplified and reduce the consumption for considering assembly and segmentation. Especially, Grid jobs are distributed services for different domains with same parameter. Optical multicasting is useful functionality for supporting multiple jobs using multiple resources. On those characteristic, we take a new turn for modeling the forwarding algorithm and contention resolution scheme for supporting QoS.

3. Application-aware Contention Resolution Scheme

3.1 Grid Virtual Private Network Architecture for QoS Support

In the Grid networks resource request, discovery and allocation functions have to be performed initially when a processing requirement (i.e. bandwidth demand) arises. When job is released, Grid resource management system should determine the appropriate resources for the job. QoS of an optical transport network will play an important role in the future of high-demand Grid computing. Optical connections in a Grid environment will be initiated on an as needed basis by the Grid applications, and that each connection request will have an associated set of optical transport QoS requirements.

3.2 Grid Applications and QoS Assurance

In the Grid environment, Resource means the entities that participate in the Grid in order to serve the applications. It can be a fabric such as node for computation, network for transmission or other special purpose instruments for cooperating. Resource surely can be data in the storage, library for run-time binding. Service Level Agreements (SLA) in the resource management is contracted by negotiation between provider of the resources and demander of the resources. SLA has established when satisfying both provider and demander. Each resource whether it is node or network has the current status of the performance. Performance will be represented by the capacity or workload of the resource. Usually, variable resource performance represent as a current resource status. All resources are distinguished from others and ranked as a group in terms of resource performance.

In terms of application, resource performance are correspondent to the resource requirement of the users i.e. QoS. Thus, element that represent the resource performance directly is compared to the element that represent the resource requirement of the application. We denote those kind of performance enumeration as a QoS vector \( \Theta \).

\[
\Theta = (\theta_1, \theta_2, \theta_3, ..., \theta_m)
\]

QoS vector is a row vector of which element \( \theta \) represents the application QoS parameter on the resource demander and resource performance parameter on the resource provider. As a QoS element in the application, we select completion time \( C \). We denote computation time for a job \( i \) as \( E_i \). A
computation time means actual time that is consumed by executing the job and completion time means the relative time that user can be afford to get back the result for the job. When current time is $T$, toleration time for a job $i$ is defined by
\[ \varepsilon_i = C_i - (T + E_i) \] (2)
where $C_i$ is a completion time for a job $i$ which is given by user when contracting SLA. The completion time is important issue for guaranteeing QoS of each Grid service. Grid network needs to consider the toleration time for a given job in the network level. The $\varepsilon$ will be an important factor for resolving the contention in the nodes.

3.3 Completion Time-based Contention Resolution Scheme

The primary protocols in the OBS core focus on contention resolution in order to support differentiated service between the Grid jobs in the OBS networks. We should consider the flexible contention resolution method for adapting the characteristic of applications.

**Figure 2 Completion Time and Relative Tolerate Time**

Figure 2 shows the completion time and their violation of the QoS requirement in the networks. When burst is blocked and retransmitted, tolerate time $\varepsilon_i$ will be decrease when time is elapsed.

When burst is assembled in the edge router, control packet has the QoS vector which includes the QoS parameters for determining the dropping policy. In this paper, we compare general contention resolution policy to our proposed one such as:

- **Latest Arrival Drop Policy (LDP):** The simplest soft contention resolution policy is the latest arrival will be discarded.
- **Shortest Size Drop Policy (SDP):** In SDP, the algorithm searches for an available unscheduled channel, and if no such channel is found, the shortest size data burst will be discarded.
- **Deadline based Drop Policy (DDP):** In DDP, the algorithm searches for an available unscheduled channel, and if no such channel is found, they determine which one will be dropped and retransmitted using each tolerate time ($\varepsilon_i$). Tolerate time is a relative priority which represent the service level.

4. Simulation Results

In order to evaluate the performance of the contention resolution scheme, we will show a simulation model for examining blocking probability. The following have been assumed to obtain the results:
- Core routers do not have the function for contention resolution schemes such as deflection routing and fiber delay lines (FDL).
- Packet will be dropped and retransmitted when blocked.
- Packet arrivals to the network are Poisson with rate.

Figure 4 shows the simulation result for blocking probability about three different policies when existing deadline in each burst. Figure 4 shows the total blocking probability about three different kinds of contention resolution policies with arbitrary completion time. LDP is slightly higher than SDP and DDP. But Fig. 4 can not verify the blocking probability according to the deadline $\varepsilon$.

**Figure 3 Contention Resolution Policies Using LDB (a), SDP (b) and DDP (c)**

![Image](image-url)

**Figure 4 Total Blocking Probability for each policy (LDP, SDP, DDP)**

![Image](image-url)
We evaluate three different classes of the priority based on the deadline \((\epsilon)\). Figure 5(a), 4(b) and 4(c) compare between LDP and DDP with different deadline limitation.

![Blocking Probability vs Load](image)

(a) Comparison LDP to DDP when Deadline \((\epsilon) < 3\) ms

![Blocking Probability vs Load](image)

(b) Comparison LDP to DDP when Deadline \((\epsilon) < 6\) ms

![Blocking Probability vs Load](image)

(c) Comparison LDP to DDP when Deadline \((\epsilon) < 9\) ms

Figure 5 Blocking Probability with Relative Deadline

Simply we set the three levels such as less than 3ms, 6ms and 9ms respectively. As we can see, the blocking probability of the Figure 4(a) is rapidly decreased compared to total blocking probability. Figure 5(b) and 4(c) show that the blocking probability of the DDP compared to LDP. It is adaptively increased when network is enough to support the deadline. It means that flexible contention resolution is possible to support the QoS using the relative deadline for each burst.

5 Conclusion

In this paper, we proposed a Grid enabled OBS networks and their contention resolution scheme. Grid networks and their jobs are characterized by the strict QoS requirement of the completion time as well as the resource QoS requirement. An application-aware contention resolution scheme is more flexible and enables to differentiate according to the Grid jobs and their QoS requirement. Deadline based contention resolution can adapt the end to end delay based on the relative completion time. Simulation results show that our proposed scheme can support differentiated Grid service over OBS networks.

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References