Advanced Switch Path First Algorithm for Advanced Lightpath Reservation in Optical Grid

Pratibha Wagaj, Pramod Mane

Abstract—Grid computing is a recently developing technology which involves the simultaneous usage of different resources connected by network links. This characteristic of grid computing mandates that all the resources involved in the execution of a grid application be available at predetermined times. Advance reservation is a technique which ensures that the request get 100% availability of resources. In optical grid networks, an important technology used currently is the advance reservation of lightpaths. It is a key to guaranteeing that enough wavelengths will be available when needed. Generally, a lightpath is defined as a wavelength data channel which links multiple optical segments. In this work, we propose algorithms to solve the routing and wavelength assignment (RWA) problem for advance lightpath reservation request. The Advanced Switch Path First (ASPF) uses the parallel Dijkstra Algorithm for routing between source and destination and SPF scheduling stratergy for selecting a lightpath among all available lightpaths. This algorithm will be helpful to achieve good speedup ratio, minimizes the blocking probability of request.

Index Terms— Advanced Reservation, Dijkstra's Algorithm, Lightpath, optical Grid, speedup.

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1 INTRODUCTION

Optical Grids have emerged around the world to support the bandwidth requirements of many e-Science and e-Business applications. Some examples of such applications include Data Intensive applications such as DynaCode for environmental modeling, Collaborative Remote Data Visualization and High Definition Interactive Video Conferencing that requires high speed transfer of high definition video streams with multicast capabilities.There is also recently seen great progress in the optical networks technology in terms of transmission capacity and dynamic reconfigurability. With Wavelength Division Multiplexing (WDM), a single wavelength can now reach OC-192 (10 Gbps) and hundreds of wavelengths can be supported on each fiber. So the Optical Grids have emerged to interconnect massive compute clusters and large storage resources through multi-gigabit lightpath connections. Although much progress has been made towards developing Grid technologies, the area that is still underdeveloped is the link between Grid applications and underlying network technologies which make Grids truly effective. The abstraction and encapsulation of these optical network resources into manageable and dynamically provisioned Grid entities is necessary in order to meet the complex demand patterns of Grid applications and to optimize the overall network utilization.

Various projects around the world consider the problem of building reconfigurable, dynamic, adaptable Optical Grids. These projects consider the network resources as key Grid resources that can be managed and controlled like any other Grid resource

In an Optical Grid, application requests may be for immediate or for advance reservations. In the immediate reservations case, the application requests resources from the Grid middleware for immediate use. In the advance reservation case, the requests are for a future time, i.e., there is a time period between the request arrival and the time of the resource reservation. In fact, the immediate reservations can be viewed as a special case of the advance reservations, with a zero time period between the request arrival and the time of the resource reservation. We believe that in a shared Optical Grid, advance reservations are a necessity because they guarantee the availability of resources with the required QoS. For the cluster resources, certain schedulers provide some advance scheduling capability. In this paper, focus is of the scheduling of advance reservations of network resources.

The concept of advance reservations in an optical network has attracted some attention in recent years.Advance Reservation (AR) is a process of requesting resources for use at a specific time in the future. Common resources whose usage can be reserved or requested are CPUs, memory, disk space and network bandwidth. AR for a grid resource solves the above problem by allowing users to gain concurrent access to adequate resources for applications to be executed. AR also guarantees the availability of resources to users and applications at the required times. It is a contract between themresources owner and consumer that commits a certain resource for a defined time to the resource consumer. It can ensure the future availability of the Grids heterogeneous resources and help a scheduler to produce better schedules. Some computational grid applications have very large resource requirements and need simultaneous access to resources from more than one parallel computer.

Algorithms are presented for requests having specific start-time and specific duration (STSD), specific start time and unspecified duration (STUD) and Unspecified Start Time and Specified Duration (UTSD). In comparison to the immediate

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reservations, advance reservations generally degrade the resource utilization and the acceptance rate due to resource fragmentation. This can be improved by introducing some flexibility in defining the advance reservations.Advanced reservations (AR) allow users to request resources from scheduling systems at specific times. Advance-reservation is an essential feature of any system in which resources may need to be co-allocated at predetermined times. Advance Reservation engages a distributed, dynamic, fault-tolerant and efficient strategy which reserves resources for future task execution. Advance Reservation proposes a mechanism that receives as input, a set of independent tasks and provides as output a schedule, which consists of mappings of each task on the suitable resource of the Grid for particular period otime; the mappings are called reservations.

Grid computing is an environment that enforces utilization of distributively owned and geographically dispersed resources for supporting various applications with variety of services. In this environment, one of the key considerations is resource management with respect to quality of service (QoS). In general, reservation of the aforementioned resources can be categorized into two: immediate and advance. However, the main difference between these two reservations is the starting time. Immediate reservation acquires the resources to be utilized straight away, whereas advance reservation defers their usage later in the future.

2 PREVIOUS WORK

The author of [5] paper studies the behavior of two algorithms developed for scheduling multiple lightpaths requested by advance reservation. To assess the benefit of each algorithm, they compare the blocking probability introduced by each of them. The blocking probability is obtained by simulating their behavior on different topologies. This simula-tion is based on traces of requests generated by FONTS, our Flexible Optical Network Traffic Simulator, which provides on-demand and advance-reservation requests with different characteristics Naiksatam et al. propose heuristics for STSD fixed window requests requiring multiple wavelengths. They also assume a network under centralized control, fixed sized timeslots, and wavelength continuity constraint. In order to handle multiple wavelength requests, the heuristics proposed either concentrate all required wavelengths on a single path or spread them over multiple paths.

In this study, author of [6] propose an approach to support dynamic lightpath scheduling in optiacal grid networks. To minimize blocking probability in a network that accommodates dynamic scheduled lightpath demands (DSLDs), resource allocation should be optimized in a dynamic manner. These two objectives may be mutually incompatible. Therefore, they propose a two-phase dynamic lightpath scheduling approach to tackle this issue. The first phase is the deterministic lightpath scheduling phase. When a lightpath request arrives, the network control plane schedules a path with guaranteed resources so that the user can get a quick response with the deterministic lightpath schedule. The second phase is the lightpath re-optimization phase, in which the network control plane re-provisions some already scheduled lightpaths. Experimental results show that our proposed two-phase dynamic lightpath scheduling approach can greatly reduce WDM network blocking.

Authors of paper [7] introduce the concept of advance reservation of lightpaths for a certain request charactgorised by some source and multiple destinations and also the time when network resources are demanded. it first present a point to multipoint adaptive routing algorithm that forms the basis of establishing lightpaths. Then the lightpaths are Infixed on the route through a wavelength assignment technique that works along with an AR scheme to ensure conflicts resolution among incoming model to generate results & exemplify the fact that AR outruns on demand reservation as far as blocking probability is concerned

Authors of paper [8] have evaluated and compared several algorithms for dynamic scheduling of lightpaths using a flexible advance reservation model. The main aim is to find the best scheduling policy for a Grid network resource manager that improves network utilization and minimizes blocking. Tanwir et al. consider RWA for specific start time and specific duration (STSD) flexible window requests in networks with full wavelength conversion. In this work it is assumed that the time is slotted into fixed length slots and that the network is under centralized control. In addition to traditional STSD flexible window requests, the authors also analyze the scenario with a non-blocking scheduler. In this case, instead of blocking a request that cannot be scheduled, the re-quest can be moved outside its window until it can be scheduled. Two different routing strategies are proposed, both using k precomputed routes. The routes are computed by first selecting the shortest path route, then checking wavelength availability on each link. If there is any link with no wavelengths available, it is removed and the shortest-path route is recomputed. This is done until a path is found or k links have been deleted. In the first strategy: Slide Window First (SWF), the algorithm tries all possible starting timeslots on one path and then moves to the next path trying all timeslots in order, and so on. The second strategy: Switch Path First (SPF), loops over the start time slots first.

3 PRAPOSED WORK

As said earlier the Routing and wavelength assignment problem is divided into two parts as

Routing: Selecting path from source to destination.

Wavelength Assignment: Assignment of wavelength to the selected path.

This work mainly referred a Dynamic Scheduling of Network Resources with Advance Reservations in Optical Grids.Our focus is to evaluate and compare various algorithms for advance lightpath scheduling which uses different scheduling strategies as maintioned above. The main aim is to find the best scheduling policy for a Grid network resource manager that improves network utilization and minimizes blocking. Authors of [8] have discussed Switch Path First (SPF) and Slide Window First (SWF) algorithms. The results of SWF algorithm as compared to the SPF algorithm are good. But the reservation delay needs to be minimized for the SPF algorithm. Also, the blocking probability needs to be minimized. To overcome these problems, we have proposed Advanced Switch Path First algorithm. Here, focus is to evaluate and compare advanced SPF algorithm for advance lightpath scheduling. The main aim is to find the best scheduling policy for a Grid network resource manager that improves network utilization and minimizes blocking probability by introducing parallel programming in SPF algorithm. This work determines the shortest path from a source to a destination using parallel Dijkstras algorithm.

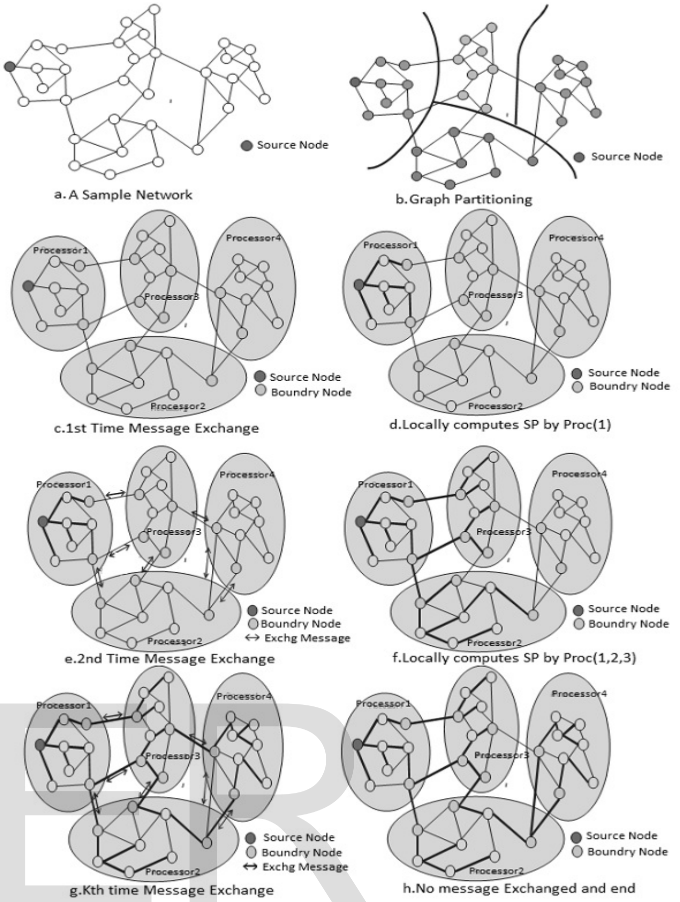
3.1 Parallel Dijkstra Algorithm

The parallel algorithm based on graph-partitioning and iterative correcting [11] which has good speedup ratio and efficiency. Here focus is on satisfying the actual demands of quickly locating the most effective shortest paths over realroad ne works in an intelligent transportation system. Also propose and implement a parallel shortest path algorithm schema based on graph partitioning and iterative correcting. Algorithm iteratively corrects the shortest paths on the whole sequential algorithm. In addition, parallelizing of the Dijkstra algorithm is done. It consists of two phases 1. Graph partitioning 2. Iterative Correcting Phase

1: Graph partitioning: This phase partition the given graph which is a network of a nodes and links connecting to them. The network is partitioned into disjoint subgraphs in the phase, and then each sub-graph is assigned to one of p processors. Each subgraph contains a roughly equal number of nodes and the number of edge-cuts is minimized to balance the load and minimize communications among nodes.

Phase 2: Iterative Correcting Phase This phase is to compute the temporary shortest paths in each sub-graph locally, andkeep correcting the shortest paths during iterations. This phase can be divided into two steps: Computation Step and Commu-nication Step. 1) Computation Step In this step, each process first finds local optimal shortest paths in each subgraph using the sequential shortest path algorithm 2) Communication Step

If the boundary nodes have update information, the algorithm exchanges the boundary information among the adjacent subgraphs else no boundary nodes needed to update shortest path distances and the final optimal shortest paths have been obtained, the algo-rithm ends each process starts to find temporary shortest paths in each sub-graph locally. But in the first iteration, only process 1 actually computes temporary shortest paths (the bold lines) in sub-graph 1 because the other processes do not have the information of the source node. Then, the boundary information is exchanged among the adjacent sub-graphs in Fig. 1(c). Fig. 1(d)-(e) show that with the information exchanging, the number of processes which have got the information of the source node are increasing. After that, the algorithm continues iterating and the temporary shortest paths in each process keep correcting and updating with the boundary information exchanged in Fig. 1(g). The algorithm continues until there are no messages exchanged among the adjacent sub-graphs Fig. 1(h), and then the final shortest path tree is obtained.



a. A Sample Network
b.Graph Partitioning
c.1st Time Message Exchange
d.Locally computes SP by Proc(1)
e.2nd Time Message Exchange
f.Locally computes SP by Proc(1,2,3)
g.Kth time Message Exchange
h.No message Exchanged and end

Fig. 1. Steps in Parallel Dijkstra Algorithm

3.2 Switch Path First

After finding shortest path, next phase is wavelength assignment. Before assigning wavelength to the selected path algorithm checks whether that path is available for specified duration and with specified request or not.There are different scheduling strategies available as described above and we are going to use SPF with parallel Dijkstra Algorithm. The structure of the advanced lightpath reservation request and how they got reserved using ASPF algorithm is discussed. Each request R is defined by the following parameters:

R = [source node, destination node, s, e, d, bandwidth]

Where, d is the reservation duration, and s and e are the starting and ending time of the scheduling window. The time is slotted with a slot size equal to t0. The scheduling window defines the time period within which the requestor would like to make a resource reservation. The scheduling window must be bigger than the reservation duration d. Thus the scheduler must check if a path is available during interval [s+t, s+t+d] where t = 0, 1, 2, ., ., e. In this scheme when a request R arrives, first try to find the shortest available path starting at time s for d slots. This is done by first finding the shortest path, using a delay propagation link cost. Then, we check if all the links on this path have a free wave-length for d slots starting at time s + t, where t=0. If any link is busy along the path, the topology is updated by removing that link and the next shortest path is determined. This step is repeated until either a path is available or a maximum of k different paths have been considered. If a path cannot be determined, repeat the whole process with a start time equal to s + t, where t=1. t is incremented by one slot each time until an available path is found or t = e s d, where upon a request is blocked. The requests for the advance reservation of light paths are as follows and all arrive one by one .

R1[n1,n6,t1,t6,4,1], R2[n1,n9,t1,t6,4,1], R3[n1,n9,t1,t6,4,1],
R4[n1,n6,t2,t6,3,1],R5[n1,n10,t3,t7,4,1], R6[n1,n9,t3,t8,4,1],
R7[n1,n8,t4,t8,3,1], R8[n1,n6,t5,t9,3,1].

These requests are applied on example network as shown in Fig. 2, where more than one path is available for node n6, n10, n9.

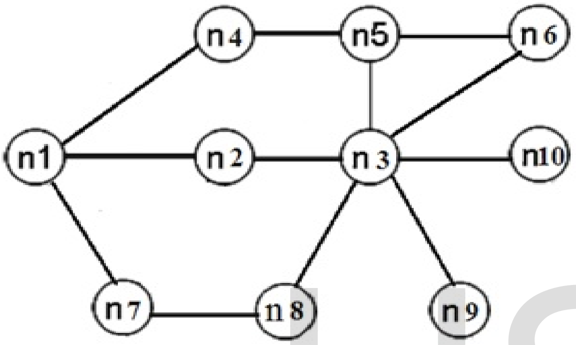


Fig. 2. Example Figure

In our algorithm we are going to make use of the available, unused and extra paths so that the request will not be blocked.Let us consider only one wavelength is available for allocation of request on path or link 1-2-3 and link 1-7-8 whereas two wavelengths are available on link 1-4-5.

The request allocation to particular link in ASPF is shown in Fig. 3.The first request R1 arrives and it get allocated on link 1-2-3 because the link is available for requested time duration. Next R2 arrive which want the same path as for R1 but it already get reserved by R1 hence we apply the switch path first strategy and search other parallel path for request R2. Link 1-4-5 is available and gets reserved by R2. After that R3 arrives which require path 1-2-3 which already reserved by R1 so it apply the SPF and select the second available path i.e. 1-4-5 where two wavelengths are available for reservation. Hence R3 is reserved on link 1-4-5.similarly request R4 is reserved on link 1-7-8 by considering SPF. When request R5 and R6 arrive all links are already reserved so both are included in Waiting list. For request R7 link 1-2-3 is not currently available so SPF allows R7 to be allocated on link 1-4-5 and request R8 get allocated on available link 1-2-3 at that time.

Algorithm: Advanced SPF algorithm

```
function FindPath using Parallel Dijikstra
Algo(Request r, topology t)
    i = 1
    start time = s
    end time = s + d
    while (end time < = e) do
        while (i < =k) do
            find shortest path with parallel Dijkstras algorithm
            with propagation delay
            link cost
            if a path is found then
                if wavelengths are available on all links during
                start time and end time then
                    assign wavelengths, update all tables
                    return
                else
                    delete busy link from the topology
                    i ++
                end if
            end if
        end while
        start time = start time + t0
        end time = start time + d
    end while
end function
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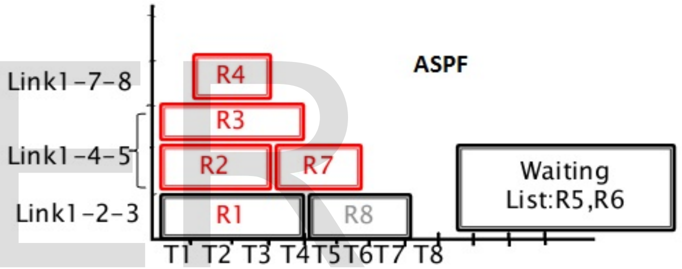

Fig. 3. ASPF

6.5 Experimental Environment

A simulation model is developed to check the performance of ASPF on Grid Network. To evaluate the performance of proposed algorithm,

GridSim 5.2 beta (released on Nov. 25, 2010)[12] with Advance Reservation is used.

National Science Foundation (NSF) network topology is used wherein 5 core and 9 edge routers are connected with 21 bidirectional links

Each node have one Grid Resource or one Grid User, that means 7 Grid user and 7 Grid Resources are considered.

Users have priority from 1 to 5. Grid User submit Gridlets to ARScheduler.

ARScheduler is also connected to one node and act as global scheduler

Gridlet demands 3 PE and size of Gridlet is 200000 MI, but they have different duration and different priority.

Gridlet have StartTime, EndTime, Duration, UserID, UserName etc.

Duration range is 600 to 1800 Seconds.

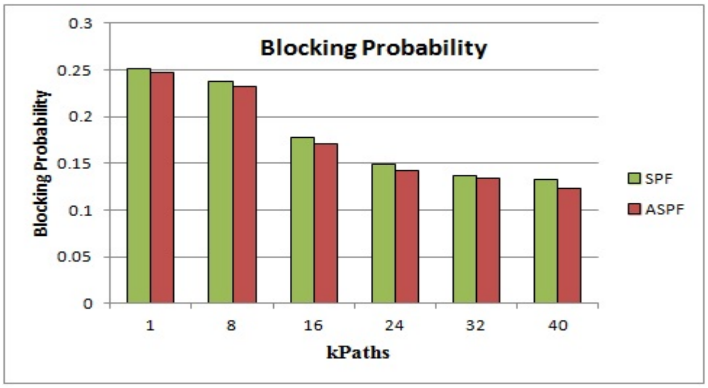

FIG. 4 BLOCKING PROBABILITY VS ARRIVAL RATE

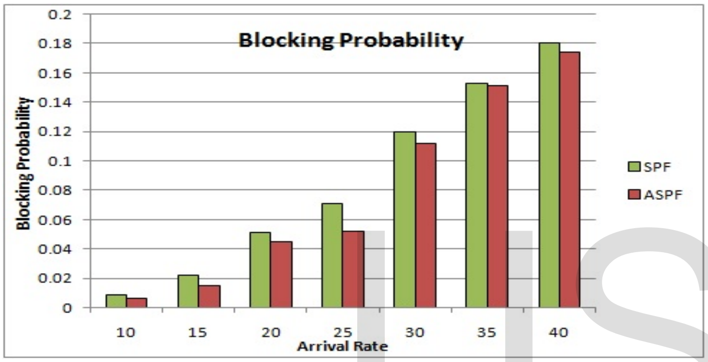

FIG. 5 BLOCKING PROBABILITY VS. PATHS

7 PERFORMANCE EVALUATION

The Figure 4 shows the effect of the arrival rate on the blocking probability. The rate is expressed in terms of number of requests/link. From the graphs, we can see that ASPF performs slightly better than SPF because it tends to schedule the connections on alternate paths speedily than SPF due to use of parallel dijkstra algorithm.

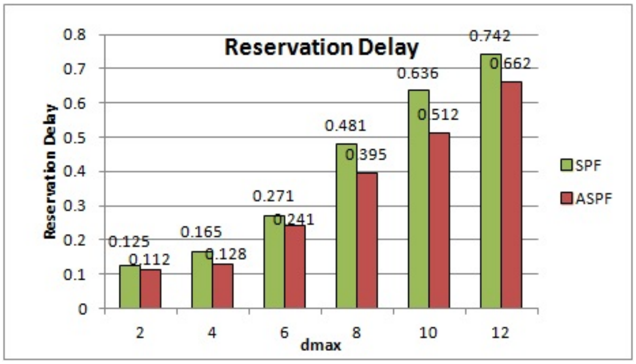

Fig. 6. Reservation Delay vs dmax

Algorithm considers k alternate paths before block-ing a request. The results are shown in Fig. 5 The blocking probability and k paths have inverse relation i.e. the blocking probability decreases as the value of k paths increases.The blocking probability of ASPF is lower than SPF due to fast calculation of path from source to destination. Fig. 6 show the reservation delay, i.e., the time elapsed from the requested start time s to the time s + t where the reservation was actually made, as a function of dmax for both ASPF and SPF. ASPF always tries to schedule as close to the start time s of the scheduling window as possible and it is faster than SPF due to parallel Dijkstra algorithm.

7 CONCLUSION AND FUTURE WORK

Advance reservation is an efficient technique to support co-allocation and end-to-end QoS. But advance reser-vation has many negative effects on resource sharing and task scheduling in the grid systems. This work has evaluated Fig. 6 Reservation Delay vs dmax various algorithms for advance scheduling of lightpaths that can be implemented in a Grid resource request scheduler. The scheduling of lightpaths involve both routing and wavelength assignment. The simulation results show that searching for k alternate paths within the scheduling window significantly improves the performance. ASPF finds the shortest path from source to destination earlier than SPF due to parallel dijkshtra algorithm, which provides speed up of 30% than SPF. Due to searching of K alternate paths in ASPF, request is not blocked which helps in minimizing the blocking of requests also rejection rate is significantly reduced. Here only network resources like channels and routers are simulate in Optical Grid. Algorithm may work for stor-age as well as computational resources. When user reserves bandwidth and channel in advance for job execution, there is need to take care about the availability of other resources like computational resources. So in future work there is need.
To develop single algorithm for both compute and network resources reservations.

To co-allocate all types of resources from different sites.

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