Optical Switching and Networking 6 (2009) 20–28

Contents lists available at ScienceDirect

Optical Switching and Networking

journal homepage: www.elsevier.com/locate/osn

# Admission control in Flow-Aware Networking (FAN) architectures under GridFTP traffic☆

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ARTICLE INFO

*Article history:*
Received 9 April 2008
Accepted 17 May 2008
Available online 17 June 2008

*Keywords:*
Quality of service
Flow-Aware networking
Grid services

ABSTRACT

Computing and networking resources virtualization is the main objective of Grid services. Such a concept is already used in the context of Web-services on the Internet. In the next few years, a large number of applications belonging to various domains (biotechnology, banking, finance, car and aircraft manufacturing, nuclear energy etc.) will also benefit from Grid services. Admission control is a key functionality for Quality of Service (QoS) provision in IP networks, and more specifically for Grid services provision. Service differentiation (DS) is a widely deployed technique on the Internet. It operates at the packet level on a best-effort mode. Flow-Aware Networking (FAN) that operates at the scale of the IP flows relies on implicit flow differentiation through priority fair queuing (PFQ). It may be seen as an alternative to DS. A Grid session may be seen as a succession of parallel TCP/IP flows characterized by data transfers with much larger volume than usual TCP/IP flows. In this paper, we propose an extension of FAN for the Grid environment called Grid over FAN (GoFAN). We compare, by means of computer simulations, the efficiency of Grid over DS (GoDS) and GoFAN. Two variants of GoFAN architectures based on different fair queuing algorithms are considered. As a first step, we provide two short surveys on QoS for Grid environment and on QoS in IP networks respectively.



## 1. Introduction

Grid networks consist of large-scale distributed systems that share heterogeneous resources (computing, storage, network components and equipment, sensors, etc.), and make possible the creation of virtual organizations (utility-computing, utility-storage, virtual laboratories, etc.) [1]. Furthermore, these capabilities enable powerful, flexible, pervasive and cost-effective services to the users. The term *Grid* has been adopted as an analogy to the power Grid. Since the widespread of the Internet, the growth of users and the increasing demand for high-demanding applications, Grid services will be progressively deployed in Internet networks (e.g. GoIP) in the years to come. However, the large installed base of Internet services, equipment and providers slows down network development and makes the introduction of disruptive technology difficult. To solve this problem, overlay network technologies, like Grid networks, appear to be very promising [2].

Quality of Service (QoS) is a key issue for Grid services provisioning [4], and admission control mechanisms are very important to achieve this [3]. Most current Grid

☆ A short summarized version of this paper was presented at the First Symposium on Advanced Networks and Telecom Systems (ANTS) 2007 in Mumbai, India, in December 2007. The authors would like to thank the support from CONACYT, SEP and Monterrey Tech Querétaro Campus, Mexico, the European Union VI Framework Programme e-Photon/ONe+ Network of Excellence (FP6-IST-027497) and the BONE-project ("Building the Future Optical Network in Europe"), a Network of Excellence funded by the European Commission through the 7th ICT-Framework Programme.

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doi:10.1016/j.osn.2008.05.003

services are provided over best-effort (BE) networks. Thus, QoS architectures originally developed for IP such as DiffServ (DS) have been adapted to Grid environments: GARA [6], NRSE [7], G-QoSM [8], GNRB [9] and [10–17]. Nevertheless, none of those proposals has been widely adopted yet. Therefore, QoS provisioning for GoIP still remains a challenge.

Flow-Aware Networking (FAN) architectures were proposed in [18–20] as a potential alternative for QoS provisioning in Internet networks. FAN overcomes the difficulties of DS and IntServ (IS). To this end, FAN employs per-flow admission control and implicit flow differentiation through priority fair queuing (no packet marking and explicit classification as in DS, no resource reservation as in IS).

In our previous work [23,24] we compared DS against one of the second generation FAN architectures under Grid traffic (Go2GFAN); the scheduling algorithm was based on Priority Fair Queuing (PFQ) [19]. The metrics were average GridFTP session delay and average GridFTP goodput. Our results showed that FAN approach can also be considered as a promising solution for QoS provisioning in a Grid environment. In another work [25], we make an extensive comparison of the two FAN architectures under GridFTP traffic. The work presented here complements our previous results [23]. First, we give a short overview of QoS architectures for a Grid environment, then we compare the other 2GFAN (PDRR or Priority Deficit Round Robin) architecture against DS, and finally we compare 2GFAN (PFQ) against 2GFAN (PDRR) when admission control is applied to Grid sessions.

This work is organized as follows. In Section 2, we survey current QoS architectures for the Grid environment. Then, in Section 3 we recall the main standards for QoS in IP networks before going to Section 4 where we describe the FAN architectures. Our main previous results and related work are discussed in Section 5. In Section 6 we describe our experiments. Then, in Section 7 we discuss the results of our computer simulations. The last section concludes this work.

## 2. Quality of service architectures for grid environment

Currently, almost all Grid services are being supported by undifferentiated, nondeterministic, best effort IP services. Grid networks must support many large-scale data-intensive applications requiring high volume and high performance data communications. Grid network performance is measured by the support for high-volume data flows and by the capacity of the network to control fine-grained applications [4]. Some efforts to provide QoS in Grid networks are: GARA [6], NRSE [7], G-QoSM [8], and GNRB [9]. Which are describe as follows.

**General-purpose Architecture for Reservation and Allocation** (GARA) [6] (a.k.a. Pre-GRAM) is a prototype intended to integrate Grid environments and networks services. GARA provides a uniform QoS for different types of Grid resources, it allows advance and online reservation of such resources. Some functionalities of GARA are part of the Globus Tool Kit (GTK).[1] Through Application Programming Interfaces (APIs), GARA links Grid services to Layer 3 services and allows the DS-based router interfaces to ensure application requirements are fulfilled by network resources and controlled by Grid services. GARA signaling and per-flow state overhead cause scalability problems.

**Network Resource Scheduling Entity** (NRSE) [7] tries to overcome the difficulties of GARA by storing per-flow/per-application states only at the end-host involved in the communication. Service demands can also be online or in advance. A drawback of NRSE is that the API is not clearly defined.

**Grid Quality of Service Management** (G-QoSM) [8] is a framework to support QoS management under the Open Grid Service Architecture (OGSA). G-QoSM supports many types of resources.

**Grid Network-aware Resource Broker** (GNRB) [9] is a centralized and enhanced per-domain Grid Resource Broker with the capabilities provided by a Network Resource Manager. GNRB allows requests of the network status and can reserve network resources. A problem may arise when the number of administrative domains rises since the GNRB may become a bottleneck. Also, the administrative domain is very sensitive to GNRB failure.

A new concept for QoS provisioning in Grid networks based on a Virtual Machine approach is in development [26]. It provides very fine grain reservations of CPU time, disk and network bandwidth. The main idea is to reserve the resources and to run the jobs on top of them. Other advanced QoS concepts and architectures have been tested in experimental platforms: Equivalent Differentiated Services (EDS) [14], programmable networks [15], active networks [16], DiffServ-IntServ [17].

## 3. Quality of service in IP networks

Native IP technology is connectionless and only offers Best Effort (BE) services. Two paradigms have been proposed to improve QoS in IP networks: IntServ (IS) and DiffServ (DS). IntServ (IS) is based on the concept of flow defined as a packet stream that requires a specified QoS level and it is identified by the quintuple "IP source address, IP destination address, Protocol, TCP/UDP source port, TCP/UDP destination port". QoS is reached by the appropriate tuning of different mechanisms: resource reservation, admission control, packet scheduling and buffer management. Both packet scheduling and buffer management act on per-flow basis. The state of the flows must be maintained in the routers and periodically updated by means of a resource reservation signaling system. Since it needs to detect each single flow, the cost and complexity increase with the number of flows, therefore, IS lacks scalability.

DiffServ has been proposed to solve the scalability problems of IntServ. DS classify an aggregation of the traffic in 64 different classes by means of a label in the DS Code Point (DSCP) field of the IPv4 packet header. Identification is performed at edge nodes. The DSCP

[1] http://www.globus.org/.