On Modeling GridFTP using Fluid-Flow Approximation for High Speed Grid Networking

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Extended Abstract

Currently, in the Internet, TCP (Transmission Control Protocol) has been widely used as its transport-layer communication protocol. GridFTP has been designed on the assumption that TCP is used as a transport-layer communication protocol. However, TCP is an old communication protocol designed in the 1970s. So, several problems on TCP itself have been pointed out by many researchers.

For instance, the current deployed version of TCP (TCP version Reno) cannot detect congestion in a network until a packet loss occurs, so that a lot of packets will be discarded. As either the network bandwidth or the buffer size of the router in a network increases, the amount of lost packets becomes large, leading the significantly degraded TCP throughput.

In order to solve the problems of the existing TCP, GridFTP has mechanisms such as establishing multiple TCP sessions in parallel, and negotiating for the maximum TCP window size between source and destination hosts. However, investigation on the effectiveness of these mechanisms has not been sufficiently performed, and just a couple problems of TCP can be solved by these mechanisms.

In this paper, we therefore quantitatively evaluate the performance of GridFTP operating on the existing TCP by using a mathematical analytic approach. GridFTP has the following mechanisms for solving the problems of the existing TCP. First, for accelerating the start-up in the slow start phase of TCP, multiple TCP sessions can be established in parallel. Second, according to the bandwidth delay product of a network, the maximum window size of TCP can be adjusted between source and destination hosts. However, in the literature, sufficient investigation has been performed neither on the optimal number of TCP sessions, nor the optimal configuration of the maximum window size. Therefore, in this paper, by focusing on the number of TCP sessions and the maximum window size, we investigate the optimal parameter configuration and quantitatively show the performance limitation of GridFTP.

First, the continuous-time model of GridFTP is derived by multiplexing the continuous-time model of TCP. Furthermore, the performance of GridFTP in steady state and transient state is investigated by a mathematical analytic approach. TCP is a sort of feedback-based controls, which dynamically changes its window size according to the packet loss probability in a network. Therefore, we model multiple TCP sessions as independent continuous-time systems, and model the bottleneck router in a network as another single continuous-time system. We then obtain the analytic model for GridFTP by combining these continuous-time systems. Using our analytic model for GridFTP, we quantitatively show the performance limitation of GridFTP while investigating the optimal parameter configuration of GridFTP, in particular, in terms of the number of TCP sessions and the maximum window size of TCP.