On Parameter Tuning of Data Transfer Protocol GridFTP for Wide-Area Grid Computing

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Contents

Background

- TCP (Transmission Control Protocol)
  - Has been widely used in the Internet
  - Old protocol designed in the 1970s
  - **Low performance** in fast long-distance networks
- GridFTP
  - Protocol extension to the existing **FTP protocol**
  - Standardized in GGF (Global Grid Forum)
  - Designed to solve **several TCP problems**

GridFTP

- Support the following features
  - Auto-negotiation of **TCP socket buffer size**
  - **Parallel data transfer**
  - Third-party control of data transfer
  - Partial file transfer
  - Security
  - Support for reliable data transfer
- Difficulty in **parameter configuration**
  - Number of parallel TCP connections
  - TCP socket buffer size

Objectives

- Mathematically analyze GridFTP performance
  - Model using a fluid-flow approximation
  - Quantitatively **show GridFTP performance**
- Derive **optimal parameter configuration** of GridFTP
  - Number of parallel TCP connections
  - TCP socket buffer size

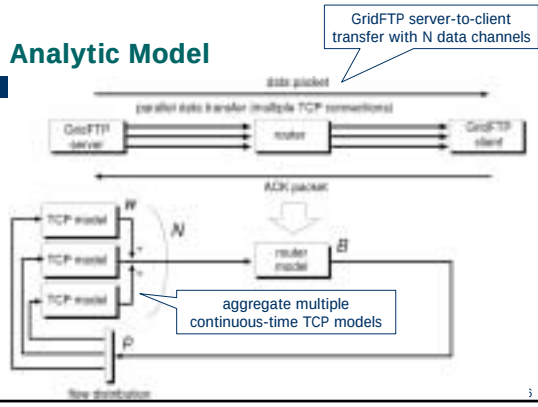
Difficulty in Parameter Configuration

- TCP socket buffer size
  - Should be configured according to **bandwidth-delay product (BDP)**
  - Almost all TCP implementations allocate a fixed size
- Number of parallel TCP connections
  - Should be configured according to **BDP and loss rate**
  - All GridFTP implementations require manual configuration

Analysis Assumptions

- Traffic on a control channel is negligible
  - Model only **traffic on data channels**
- Packet loss is caused only by network congestion
  - Model packet losses only due to **router's buffer overflow**

Analytic Model



Steady State Analysis

- Definition of symbols
  - W: TCP socket buffer size
  - N: number of parallel TCP connections
  - B: bottleneck link bandwidth
  - R: round-trip time
- Focus on relation between W and B*R/N (BDP for a single TCP connection)
  - When W > B*R/N...
    - **Link bandwidth** is the bottleneck
  - Otherwise...
    - **TCP socket buffer** is the bottleneck

Analytic Results

W: TCP socket buffer size
N: number of TCP connections
B: bottleneck link bandwidth
R: round-trip time

- GridFTP goodput

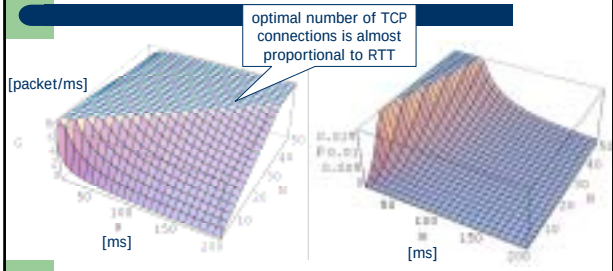
$$\bar{G} \simeq \min\left(\frac{NW}{R}, \frac{N(1-p^*)}{2R}\left(-3+\frac{\sqrt{6+2(1-p^*)}}{\sqrt{p^*}}\right)\right) \quad (12)$$

$$p^* \simeq \left(-2+\frac{2BR}{N}+\frac{2}{3}\left(\frac{BR}{N}\right)^2\right)^{-1} \quad (7)$$

- The optimal number of parallel TCP connections

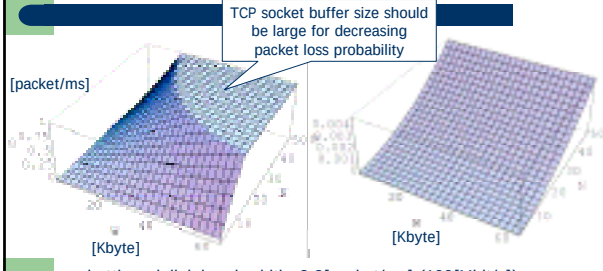
$$N = \left(3BR-3W-\sqrt{3}\sqrt{9B^2R^2-16BRW+7W^2}\right) \times \frac{BR}{9BR-6W} \quad (13)$$

Numerical Examples (Effect of RTT and Parallelism)



bottleneck link bandwidth: 8.3[packet/ms] (100[Mbit/s])
TCP socket buffer size: 64[Kbyte]

Numerical Examples (Effect of Parallelism and Socket Buffer Size)



bottleneck link bandewidth: 8.3[packet/ms] (100[Mbit/s])
round-trip time: 100[ms]

Conclusions

- Analyzed **parallel data transfer** with GridFTP
  - Modeled using a fluid-flow approximation
  - Derived **goodput** and **packet loss probability**
- Derived **optimal parameter configuration** of GridFTP
  - TCP socket buffer size
    - Should be larger than bandwidth-delay product
  - Number of parallel TCP connections
    - Should be configured to maximize Eq. (12) (goodput)

Future Works

- GridFTP analysis in **general network configurations**
  - Existence of background traffic (e.g., non-TCP traffic)
  - Coexistence with different versions of TCP connections
- Design automatic **parameter configuration** mechanism
  - Optimize GridFTP performance based on our analytic results