Data Transfers in the Grid: Workload Analysis of Globus GridFTP

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Objective 1: Quantify volume of transfers
- What is the transfer size distribution?
- What is the volume of activity for the most active hosts?

Objective 2: Understand how tuning capabilities are used
- What are the buffer sizes used during the transfers?
- What is the average bandwidth?
- What is the utilization of functionalities like streams and stripes?

Objective 3: Quantify user base and predict usage trends
- How does the user base evolve over time?
- What are the geographical characteristics of the GridFTP data transfers?
Outline

- Metrics dataset
- Surprises and …
- … zoom in (TeraGrid)
- Lessons and discussions
## GridFTP Metrics Dataset

<table>
<thead>
<tr>
<th>Field</th>
<th>Range of Values</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source hostname/host IP</td>
<td>String/IPnet</td>
<td>Anonymized</td>
</tr>
<tr>
<td>Start time of the transfer</td>
<td>Timestamp</td>
<td>Accuracy: ms</td>
</tr>
<tr>
<td>End time of the transfer</td>
<td>Timestamp</td>
<td>Accuracy: ms</td>
</tr>
<tr>
<td>TCP Buffer Size</td>
<td>Integer (Bytes)</td>
<td>≥0</td>
</tr>
<tr>
<td>Total Number of Bytes</td>
<td>Integer (Bytes)</td>
<td>≥0</td>
</tr>
<tr>
<td>Number of Streams</td>
<td>Integer</td>
<td>≥1</td>
</tr>
<tr>
<td>Number of Stripes</td>
<td>Integer</td>
<td>≥1</td>
</tr>
<tr>
<td>Store or Retrieve</td>
<td>Integer (0, 1,2)</td>
<td>STOR, RETR, LIST</td>
</tr>
</tbody>
</table>
Metrics Dataset

- Started with ~137.5 million records (Jul’05 - Mar’07)
- Cleaning:
  - transfer size ≤0: ~22.8 million records
  - buffer size <0: ~1000 records
  - directory listings: ~3.9 million records
  - invalid hostnames (e.g., /[B@89712e]: ~4,600 records
  - ANL-TeraGrid testing: ~11.4 million records
  - duplicate reports: ~16.8 million records
  - self transfers (source=destination): ~5.75 million records
- Clean database: ~77.2 million records (~56.2%)
Surprise #1: Transfer Size Distribution

Objective 1: Quantify volume of transfers
Zoom-in: TeraGrid

Are these results representative for production grids?
- GridFTP testing for deployment and learning

Identify transfers from TeraGRID and analyze dataset.
Transfer Size Distribution (TG)

Objective 1: Quantify volume of transfers
<table>
<thead>
<tr>
<th>Transfer Size</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bytes</td>
<td>KB</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
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<tr>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>32</td>
<td>64</td>
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<tr>
<td>64</td>
<td>128</td>
</tr>
<tr>
<td>128</td>
<td>256</td>
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<tr>
<td>256</td>
<td>512</td>
</tr>
<tr>
<td>512</td>
<td>1</td>
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<td>1024</td>
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<td>2048</td>
<td>4</td>
</tr>
<tr>
<td>4096</td>
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<tr>
<td>8192</td>
<td>16</td>
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<tr>
<td>16384</td>
<td>32</td>
</tr>
<tr>
<td>32768</td>
<td>64</td>
</tr>
<tr>
<td>65536</td>
<td>128</td>
</tr>
<tr>
<td>131072</td>
<td>256</td>
</tr>
<tr>
<td>262144</td>
<td>512</td>
</tr>
<tr>
<td>All</td>
<td>All</td>
</tr>
</tbody>
</table>

Graphs showing distribution of transfer sizes across different units (Bytes, KB, MB).
Why So Small Transfers?

- There are still many old versions (i.e., before v3.9.5) of GridFTP in use. These versions do not include trace reporting capabilities.
- Other data transfer protocols and implementations are used.
- Users have turned off the reporting capability.
- Some of the logs are inevitably lost due to the UDP-based reporting mechanism.
- The low transfer volumes could suggest a shift towards data-aware job scheduling (?)
Server to Server Transfers

- High reporting of Self Transfers (more than 1/3)

**Objective 1: Quantify volume of transfers**
Top 6 Active Hosts (all)

Top 6 hosts traffic adds up to ~28% of total volume
Next 48 hosts (IPs) transferred 10s of TB

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Daily Workload (TG)

- Average volume transferred per day: ~ 0.6TB
- GridFTP doesn’t get weekends free!

Objective 1: Quantify volume of transfers
Monthly Workload (TG)

- ~50,000 transfers per day
- ~1TB per day of total volume
- Lowest around 0.5TB per day
- Peaks due to particular days

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Surprise #2: Usage of Streams and Stripes

- Unreliably reported (from Globus team).
- Reliable observations:
  - At least ~20% of the transfers used 4 streams (suggested number by ANL’s website)
  - At least ~10% of the transfers used a different value, larger than one.
  - Maximum number of streams reported: 1010 (!!)

Objective 2: Understand how tuning capabilities are used
Buffer Size Distribution

- 60% from the original table: OS-controlled (0 bytes)
- Most commonly used: 16–128KB
- Largest buffer size: 1-2GB (92 records)

Objective 2: Understand how tuning capabilities are used
Average Bandwidth Distribution

- Peak: 128-256Mbps, ~7.7 million records
- Most common (58%): 4Mbps—1Gbps
Average Bandwidth Distribution (TG)

Compared to the total dataset:

=> The region of 4Mbps to 1Gbps includes more than 85% of the transfers (58% for the whole dataset)
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Surprise #3: Geographic Distribution

- USA: 78.4% or ~50.8 million transfers and 82.9% or ~1.7 PB
- Canada+Taiwan+Japan+Spain: ~14M transfers and 346TB
- 49 different countries and 446 different cities (178 cities from USA)

Objective 3: Quantify user base and predict usage trends
User and Domain Evolution (all)

- Continuing increase of user and organization population
- Forecasts: 67 new IPs and 14 new domains per month

Objective 3: Quantify user base and predict usage trends
Summary of Results

- Many transfers in the range of KBs to 10s MB (peak in 16MB-32MB).
  - relevant for setting up realistic simulations.
  - previous work assume different, larger file sizes.
- Bandwidth measured in previous work is confirmed by our workload analysis.

Tuning parameters:
- Users tend not to set the buffer size explicitly (60%), leaving it to the OS
- The unexpectedly small transfers do not justify tuning GridFTP parameters (stripes and streams)

- The usage of Globus GridFTP is growing over time in terms of IPs (users), domains (organizations), and volume transferred.
- Missing some of the big players