SC18 Network Research Exhibition: Demonstration Abstract

BigData Express: A scalable and High-performance Data Transfer Platform

Abstract

Big data has emerged as a driving force for scientific discoveries. To meet data transfer challenges in big data era, DOE's Advanced Scientific Computing Research (ASCR) office has funded the BigData Express project (http://bigdataexpress.fnal.gov). BigData Express is targeted at providing *schedulable, predictable,* and *high-performance* data transfer service for DOE's large-scale science computing facilities and their collaborators.

In this demo, we use BigData Express software to demonstrate bulk data movement over wide area networks. The following features in BigData Express will be demonstrated:

- A peer-to-peer, scalable, and extensible model for data transfer services;
- A visually appealing, easy-to-use web portal;
- A high-performance data transfer engine;
- Orchestrating and scheduling of system (DTN), storage, and network (SDN) resources involved in the file transfers.
- On-Demand provisioning of end-to-end network paths with guaranteed QoS;
- Robust data transfer services provisioning through strong error handling mechanisms;
- Safe and secure data transfer services by using multiple security mechanisms;
- The interoperation between BigData Express and SENSE;

I. Overview

Large scientific instruments (e.g., colliders, light sources, and telescopes) generate exponentially increasing volumes of data. To enable scientific discovery, science data must be collected, indexed, archived, shared, and analyzed, typically in a widely distributed, highly collaborative manner. Data transfer has become an essential function for science discoveries, particularly within big data environments.

The emergence of distributed, extreme-scale science applications has generated significant challenges regarding data transfer. We assert the data transfer challenges of the extreme-scale era are characterized by two relevant dimensions:

(1) High-performance challenges. It is becoming critical to transfer data at the highest possible throughputs because the volumes of science data are growing exponentially. DOE is deploying extreme-scale supercomputer facilities in support of extreme-scale science applications. To fully utilize these expensive computing resources, ultra-high-throughput data transfer capabilities will be required to move data in or out of them.

(2) Time-constraint challenges. Scientific applications typically have explicit or implicit time constraints on data transfer. Providing real-time and deadline-bound data transfer is a challenging task in the extreme-scale era.

The current generation of data transfer tools and services will not be able to successfully meet these data movement challenges, for the following reasons:

- Existing data transfer tools and services lack a data-transfer-centric approach to seamlessly and effectively integrate and orchestrate the various resources in an end-to-end data transfer loop.
- Existing data transfer tools and services lack effective mechanisms to minimize cross-interference between data transfers.
- Existing data transfer tools and services are oblivious to user (or user application) requirements such as deadlines and QoS requirements.
- Inefficiencies arise when existing data transfer tools are run on high performance Data Transfer Nodes (DTNs).

DOE's Office of Science Advanced Scientific Computing Research (ASCR) office has funded the BigData Express Project (http://bigdataexpress.fnal.gov) to address these issues. BigData Express is targeted at providing schedulable, predictable, and high-performance data transfer service for DOE's large-scale science computing facilities and their collaborators.

BigData Express software is currently deployed and being evaluated at multiple research institutions, including UMD, StarLight, FNAL, KISTI, KSTAR, SURFnet, and Ciena. The BigData Express research team is currently collaborating with StarLight to deploy BigData Express on emerging research platforms, including Pacific Research Platform, National Research Platform, and Global Research Platform. We are working toward utilizing BigData Express to build high-performance data transfer federations within big data science.

In this demo, we use BigData Express software to demonstrate bulk data movement over wide area networks. The following features in BigData Express will be demonstrated:

- A peer-to-peer, scalable, and extensible model for data transfer services;
- A visually appealing, easy-to-use web portal;
- A high-performance data transfer engine;
- On-Demand provisioning of end-to-end network paths with guaranteed QoS;
- Robust data transfer services provisioning through strong error handling mechanisms;
- Safe and secure data transfer services by using multiple security mechanisms;
- The interoperation between BigData Express and SENSE;
- Orchestrating and scheduling of system (DTN), storage, and network (SDN) resources involved in file transfer.

II. Innovation

BDE is a high-performance data transfer service for big data. It contains a number of new and innovative features:

- A data-transfer-centric architecture to seamlessly integrate and effectively coordinate computing resources in an end-to-end data transfer loop.
- A time-constraint-based scheduler to schedule data transfer tasks. By allowing user applications to inform the scheduler of their time constraints, the scheduler can prioritize requests from different applications to satisfy as many time constraints as possible.
- An admission control mechanism to provide guaranteed resources for admitted data transfer tasks.
- A distributed peer-to-to model for data transfer services, making it very flexible for the establishment of data transfer federations.
- A scalable software architecture. BigData Express makes use of MQTT as message bus to support communication among its components.
- An extensible plugin framework to support different data transfer protocols, including mdtmFTP, GridFTP, and XrootD.
- An end-to-end data transfer model with fast provisioning of end-to-end network paths for guaranteed QoS. Specifically, the use of an SDN-enabled BigData-Express LANs and SDN-enabled WAN path services to reduce or eliminate network congestion.
- A high-performance data transfer engine. BigData Express adopts mdtmFTP as its default data transfer engine. mdtmFTP is specifically designed for optimization of data transfer performance on multicore systems (DTNs).

III. HPC and Science Relevance

Our demo is closely related to the HPC communities and large-scale science. BigData Express is particularly designed and developed for extreme-scale data movement, which is one of the major challenges faced in the HPC communities and data-intensive science.

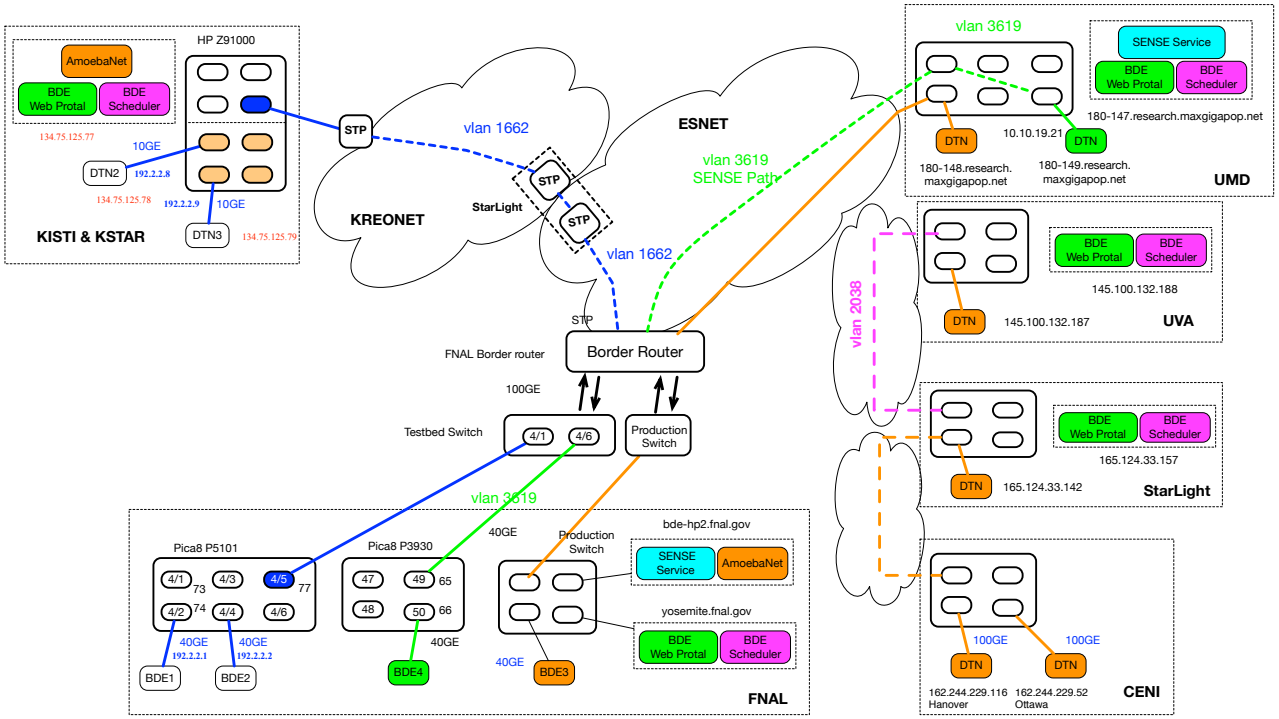

Figure 1 BigData Express SC'18 Demo

IV. SCinet and R&E Requirements

BigData Express software is currently deployed and evaluated at multiple sites, including FNAL, StarLight, UMD, KISTI, KSTAR, and SURFnet. We are working with involved parties to implement high-bandwidth layer-2 circuits between these sites for our demonstrations. The planned network topology is illustrated in Figure 1.

V. Involved Parties

- Qiming Lu, Fermilab, qlu@fnal.gov
- Liang Zhang, Fermilab, liangz@fnal.gov
- Sajith Sasidharan, Fermilab, sajith@fnal.gov
- Wenji Wu, Fermilab, wenji@fnal.gov
- Phil DeMar, Fermilab, demar@fnal.gov
- Jim Chen, iCAIR, jim-chen@northwestern.edu
- Joe Mambretti, iCAIR, j-mambretti@northwestern.edu
- Chin Guok, ESnet, chin@es.net
- Inder Monga, ESnet, imonga@es.net
- Tom Lehman, UMD, tlehman@umd.edu
- Xi Yang, UMD, maxyang@umd.edu
- Jin Kim, KISTI, jkim@kisti.re.kr
- Seo-Young Noh, KISTI, rsyoung@kisti.re.kr
- Jaesic Hong, KSTAR, hjaesic@nfri.re.kr
- Jinseop Park, KSTAR, linupark@nfri.re.kr
- Nagy Rao, ORNL, raons@ornl.gov
- Gary Liu, NJIT, qing.liu@njit.edu
- Buseung Cho, KREONET, bscho@kisti.re.kr