SC26 Network Research Exhibition: Demonstration Publishable Abstract

[UDTS-Integrated SRCNet Data Control System]

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Abstract

The SKA Observatory (SKAO) is an international organization responsible for constructing and operating the Square Kilometre Array (SKA), one of the world's largest radio astronomy projects. The SKA telescopes will generate unprecedented volumes of observational data that must be reliably transferred between SKA Regional Centres (SRCs) distributed around the world. Within the SKA Regional Centre Network (SRCNet), high-throughput and stable data transfer capabilities are essential for efficient data management and scientific research.

NEC's Ultra-high-speed Data Transfer System (UDTS) has demonstrated high-speed disk-to-disk transfer performance over 100 Gbps-class networks. Through a proof-of-concept (PoC) study, we are evaluating the integration of UDTS with the existing SRCNet software stack, consisting of SKA IAM, Rucio, FTS, and XRootD, to accelerate inter-site data transfers while preserving the existing data management and transfer control workflows.

At SC26, we conduct a live demonstration of an SRCNet-compatible data transfer system connecting three sites in Japan and the United States. The demonstration verifies end-to-end interoperability between the SRCNet software stack and UDTS and evaluates UDTS's transfer performance over a 100 Gbps-class network using datasets of varying file sizes and file counts, including Science Data Challenge (SDC) datasets.

Introduction

SKA is one of the world's largest radio telescope projects, currently under construction in Australia and South Africa. It is expected to generate and accumulate approximately 700 PB of data annually, and SRCNet is being developed as a globally distributed research data infrastructure connecting SRCs around the world. In addition to high-speed data transfer performance, SRCNet requires interoperability with its existing software stack for authentication and authorization, data management, and transfer job orchestration. In particular, a key technical challenge is to achieve high-speed inter-site data transfers while maintaining the data lifecycle management processes, including replication, placement, and deletion of observational data.

To address this challenge, the National Astronomical Observatory of Japan (NAOJ) and NEC Corporation have been conducting a PoC study to evaluate the applicability of UDTS to SRCNet.

UDTS is a solution developed based on research outcomes from the collaboration between NEC and The University of Osaka. At SC24 NRE, NEC and The University of Osaka demonstrated disk-to-disk data transfer performance exceeding 90 Gbps between Japan and the United States using the core technology of UDTS [SC24-NRE-037].

Subsequently, we demonstrated high-speed and stable data transfers over a round-the-world network path from Japan through Europe and North America via SINET's international network links.

Building on these results, we integrate UDTS with an environment that emulates the SRCNet software stack to evaluate its interoperability with existing data transfer workflows and its high-speed transfer performance across multiple internationally distributed sites.

Proposal : UDTS-Integrated SKA Data Control System

The proposed system places SKA IAM, Rucio, and FTS at a central site for data management and transfer orchestration, while XRootD and UDTS are deployed at each SRC for data transfer.

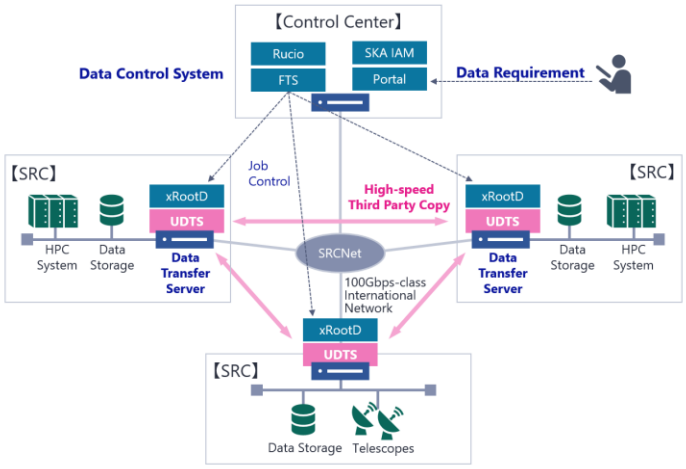


Figure. 1. UDTS-integrated SKA Data Control System

The main roles of these components are as follows:

- **SKA IAM:** Token-based authentication and authorization using OpenID Connect.
- **Rucio**: Policy-based data placement and replication management.
- **FTS**: Data transfer job management and orchestration.
- **XRootD**: Gateway for data access and transfer requests.
- **UDTS**: High-speed data transfer engine.

To integrate UDTS with the existing SRCNet software stack, we utilize XRootD's Third-Party Copy (TPC) functionality, which enables data transfers between SRCs to be initiated by an external control system. The XRootD ofs.tpc plugin invokes UDTS as an external transfer program, allowing UDTS to perform the actual data transfers while the existing SRCNet software stack manages data and orchestrates transfers.

Demonstration Environment

We conduct a live demonstration of data transfers over a wide-area network connecting the booth of the National Institute of Informatics (NII) at the SC26 venue with two sites in Japan.

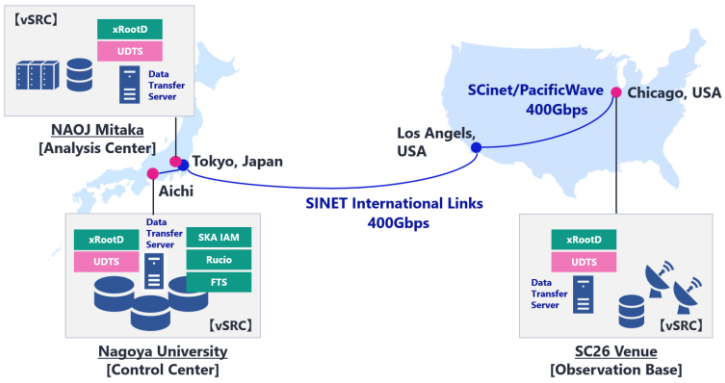


Figure. 2. Virtual SRCNet Demonstration Configuration

Three virtual SRCs , as shown in Table 1, are established at geographically distributed sites in Japan and the United States, interconnected via an L2VPN using SCinet and SINET's international networks. Two VLANs are configured over the L2VPN, one for data transfer and the other for control traffic. A 100 Gbps-class network is used for data transfers.

Table 1. Summary of Virtual SRCs

Location	Role	Max. Bandwidth
SC26 Venue, Chicago, USA	Observation Base	100 Gbps
Nagoya University, Aichi, Japan	Control Center	80 Gbps
NAOJ Mitaka, Tokyo, Japan	Analysis Center	70 Gbps

At Nagoya University, which serves as the control center, an SRCNet-compatible data management and transfer control system consisting of an SKA IAM-compatible authentication and authorization system, Rucio, and FTS are deployed. Each virtual SRC is also equipped with a data transfer server running XRootD and UDTS.

The data transfer servers are equipped with 100 GbE NICs and multiple NVMe SSDs to support 100 Gbps-class disk-to-disk data transfers. One of the data transfer servers is showcased in a live hardware demonstration at the NII booth.

Demonstration Scenario

The demonstration executes end-to-end data transfer workflows between virtual SRCs over the international network, with data management and transfer requests issued through Rucio. Operations such as data registration, relocation, transfer requests, and deletion are controlled by Rucio rules.

To evaluate the impact of file sizes and counts on transfer performance, we use synthetic datasets consisting of a single large file (2.5 TB), medium-sized files (10 GB × 250), and small files (1 GB × 2,500). SDC datasets are also used to evaluate performance under conditions representative of actual scientific data.

For each transfer, we measure elapsed time, network throughput, cumulative data volume, transfer status, and errors. A visualization system at the NII booth displays inter-site data transfers in real time.

Involved Parties

- Atsuko Takefusa NII
- Takuya Akahori, NAOJ
- Kazuyoshi Yamashita, NAOJ
- Jesus Salgado, SKAO
- Jeremy Coles, University of Cambridge (ukSRC)
- Kiyotomo Ichiki, Nagoya University
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