Rucio/BigData Express/SENSE (ROBIN)

a Next Generation High Performance Data Service Platform

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Many people’s hard work

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Fermilab STARLIGHT SDX ESnet Energy Sciences Network

Agenda

- Motivation

- ROBIN: a next generation high performance data service platform
  - Architecture
  - Key Mechanisms

- Initial Evaluation
  - An international testbed
  - Experiments

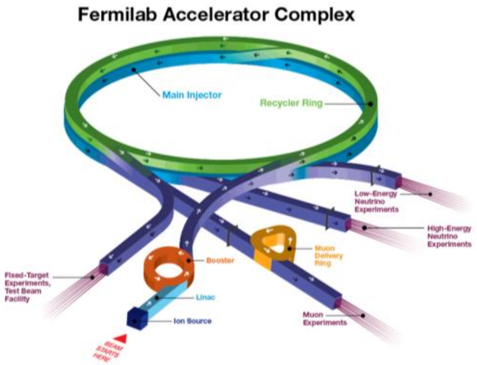
Motivation (I)

- **Big data has emerged as a driving force for scientific discoveries.**

- **Large scientific instruments generates large amount of data.**

- **Science data must be collected, indexed, archived, shared, and analyzed, typically in a widely distributed, highly collaborative manner.**

The LHC Accelerator Complex


Fermilab Accelerator Complex
Main Injector
Recycler Ring
Low-Energy Neutrino Experiments
High-Energy Neutrino Experiments
Muon Delivery Ring
Booster
Fixed-Target Experiments, Test Beam Facility
Linac
Ion Source
Muon Experiments
BEAM STARTS HERE

Fermilab Accelerator Complex

Motivation (II)

Managing and moving extremely large volumes of science data worldwide is a special multidimensional challenges!

Need a comprehensive service solution that incorporates:

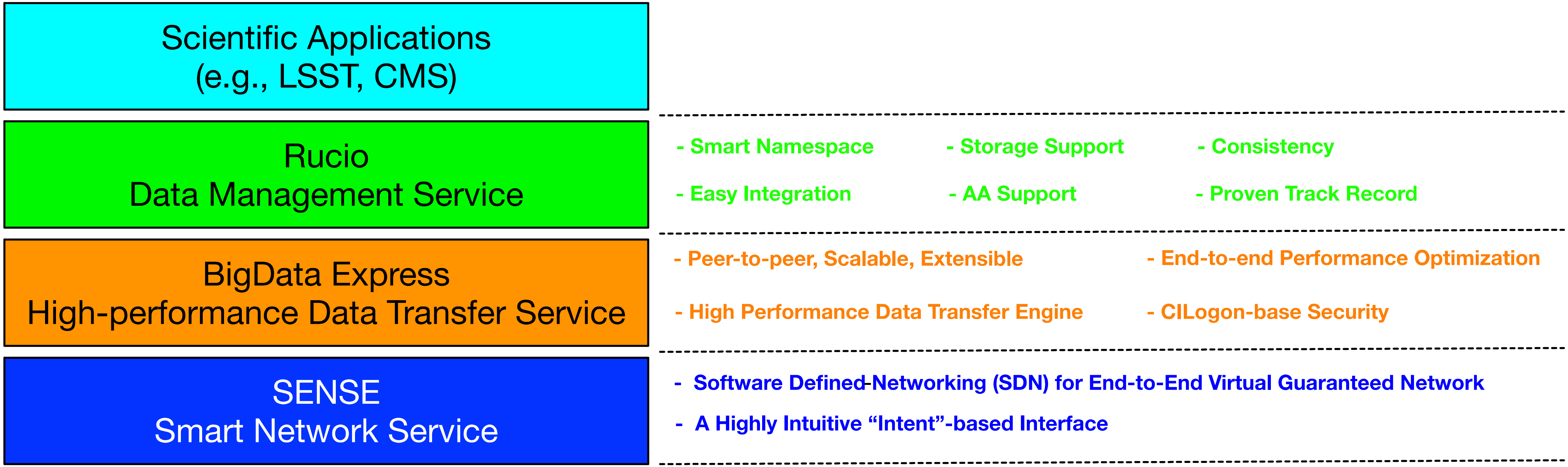
- **Services designed for scientists**
- **Scientific workflows**
- **Data management**
- **Science DMZs**
- **Large volume data transfer services**
- **Orchestration**
- **High-performance networking**

Our Solution

ROBIN (Rucio/BigData Express/SENSE):

A Next Generation High-performance Data Service Platform

ROBIN (Rucio/BigData Express/SENSE)
A Next Generation High-performance Data Service Platform



Scientific Applications
(e.g., LSST, CMS)

Rucio
Data Management Service

- Smart Namespace
- Storage Support
- Consistency
- Easy Integration
- AA Support
- Proven Track Record

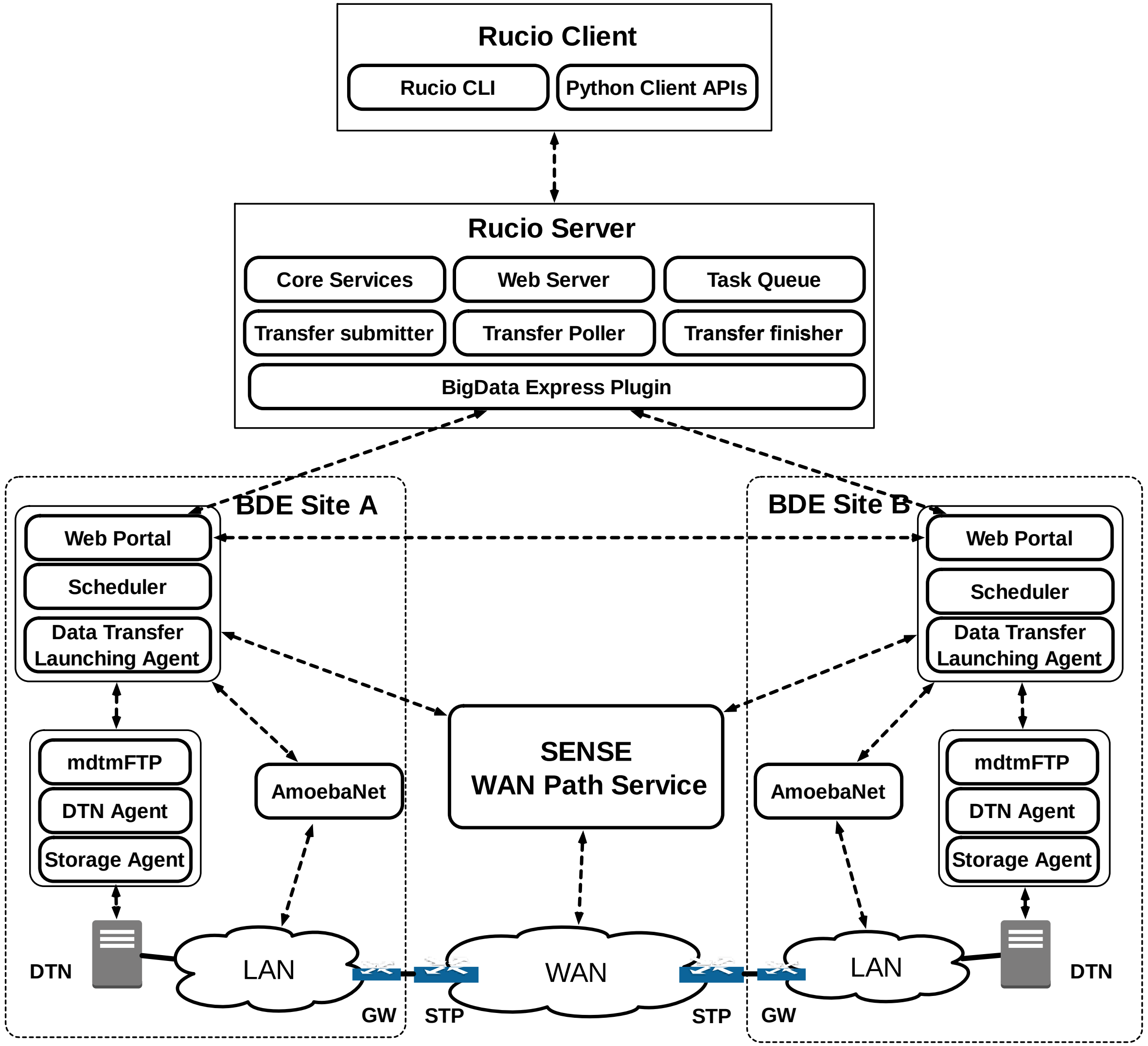
BigData Express
High-performance Data Transfer Service

- Peer-to-peer, Scalable, Extensible
- End-to-end Performance Optimization
- High Performance Data Transfer Engine
- CILogon-base Security

SENSE
Smart Network Service

- Software Defined-Networking (SDN) for End-to-End Virtual Guaranteed Network
- A Highly Intuitive “Intent”-based Interface

ROBIN (Rucio/BigData Express/SENSE)
A Next Generation High-performance Data Service Platform



ROBIN Key Mechanisms

- **Site Registration**
- **Rucio/BigData Express (BDE) job launching mechanism**
- **On-demand provisioning of end-to-end network path with guaranteed Qos**
- **Security**

Site Registration

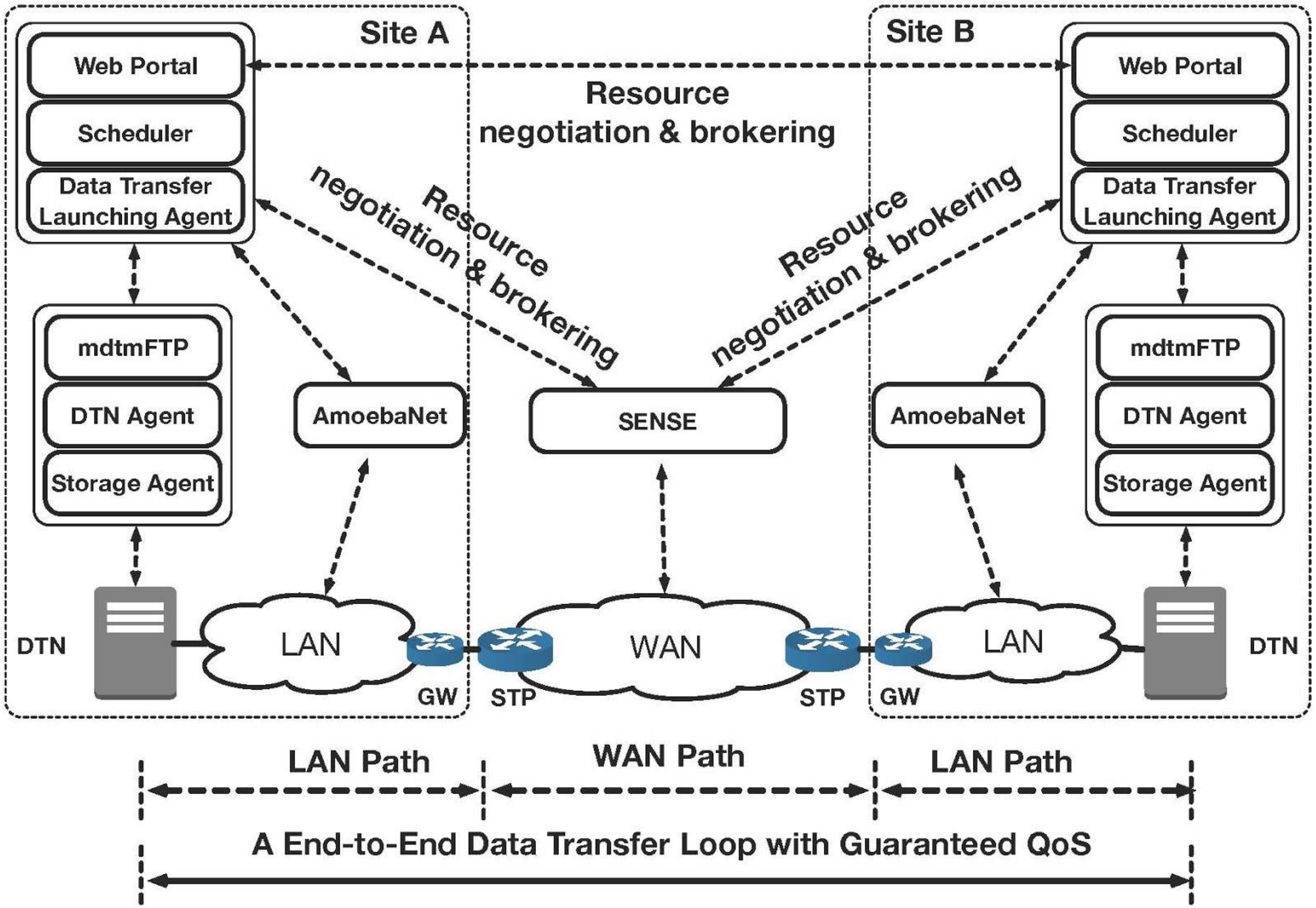
- **Register a BigData Express site as an RSE with the Rucio server**
  - **The RSE name**
  - **The information necessary to access the new RSE**
    - **Hostname, port, protocol, and local file system path**
  - **The distance metric between the new RSE and other RSEs**

A new protocol “bde” is defined to support BDE-based data transfer.

Rucio/BDE Job Launching Mechanism

1. **A Rucio client uses Rucio CLI to request replication on a destination RSE.**
2. **The client sends the replication request to the Rucio server.**
3. **The Rucio server creates a replication rule for the request and generates the data transfer tasks. The tasks are temporarily kept in a *task queue*.**
4. **The Rucio server regularly pulls tasks from the queue. It ranks the sources for each task, selects the protocol "*bde*" for src/dst RSEs, submits the tasks in groups to BDE.**
5. **BDE schedules and assigns resources (DTNs, network) to execute the data transfer tasks.**
    - **BDE calls SENSE to provision WAN paths with guaranteed QoS between sites.**
6. **After the DTNs and the paths have been successfully reserved, BDE launches the data transfer tasks, monitors the progress of the tasks, retries in case of errors, and notifies the Rucio server upon completion.**
7. **The Rucio server closely monitors the status of the transfers. A failed data transfer will be resubmitted in the *task queue* for retries until the maximum retry limit is reached.**
8. **The Rucio server updates the internal states and notifies the client upon completion**

On-demand Provisioning of End-to-end Path with Guaranteed Qos


Site A
Site B
Web Portal
Scheduler
Data Transfer Launching Agent
Resource negotiation & brokering
Resource negotiation & brokering
Resource negotiation & brokering
Web Portal
Scheduler
Data Transfer Launching Agent
mdtmFTP
DTN Agent
Storage Agent
AmoebaNet
SENSE
AmoebaNet
mdtmFTP
DTN Agent
Storage Agent
DTN
LAN
GW
STP
WAN
STP
GW
LAN
DTN
LAN Path
WAN Path
LAN Path
A End-to-End Data Transfer Loop with Guaranteed QoS

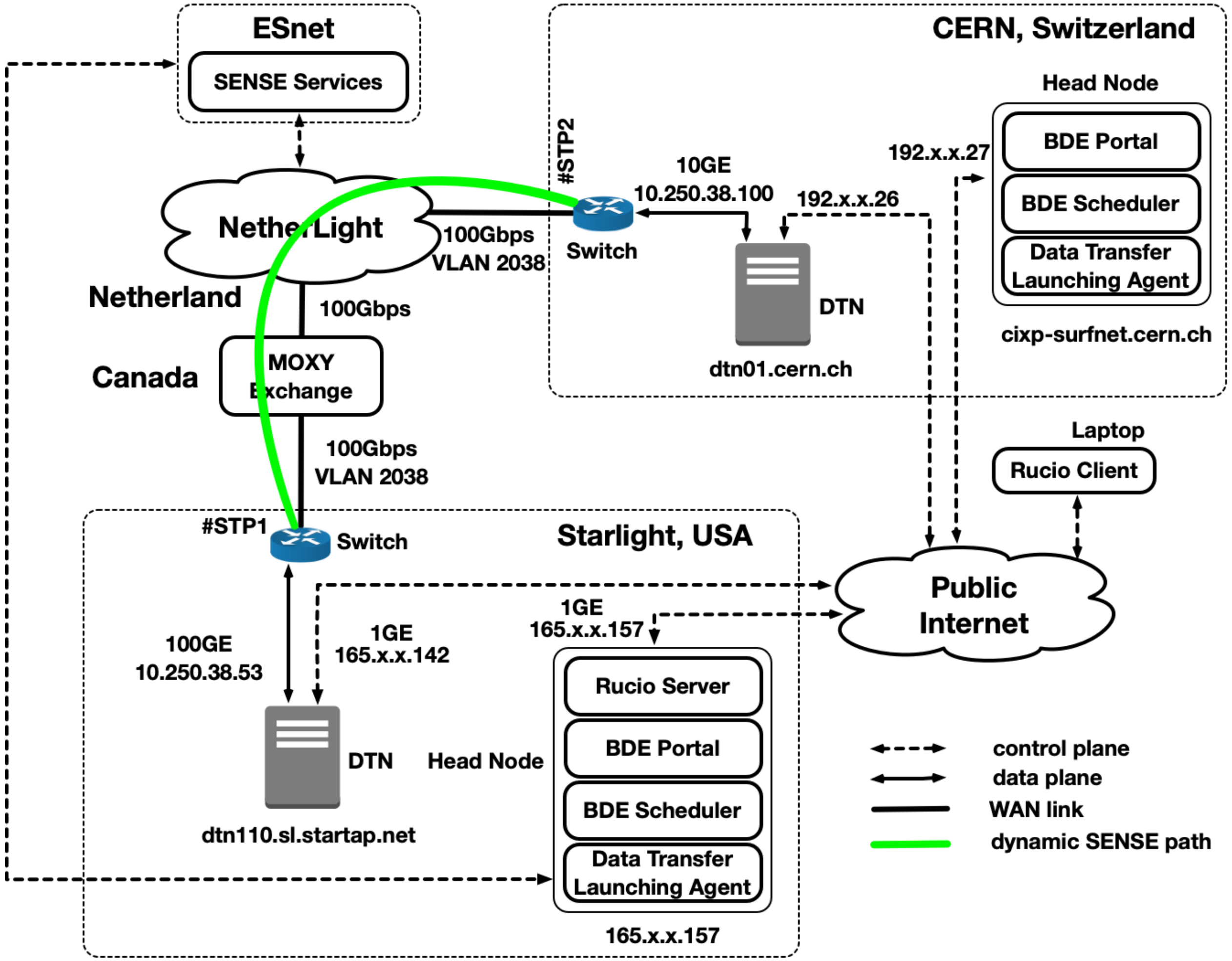
Security

- **Keep each system's security intact**

- **Execute a logic mapping between them to enforce security at all levels**
  - **Direct mapping between Rucio and BDE accounts with X509 certificate delegation**
  - **Each BDE site, acting as a SENSE client, with pre-configured client credential.**

Systems	Authentication/Authorization methods
Rucio	Username/password, X509 certificates, Kerberos tickets, SSH-RSA public key
BigData Express	Username/password, X509 certificates
SENSE	Username/password, OIDC

ROBIN Cross-Atlantic Testbed



StarLight site:

- DTN: *dtn110.sl.startap.net*, with several Intel NVMe drives for data storage, a 100GE Mellanox NIC for data transfer, and a 1G NIC for control.
- Head node: *165.x.x.157,* with a 1G NIC for control.

CERN site:

- DTN: *dtn01.cern.ch*, with a rotational disk for data storage, a 10GE Mellanox NIC for data transfer, and 1G NIC for control.
- Head node: *cixp-urfnet.cern.ch,* with a 1G NIC for control.

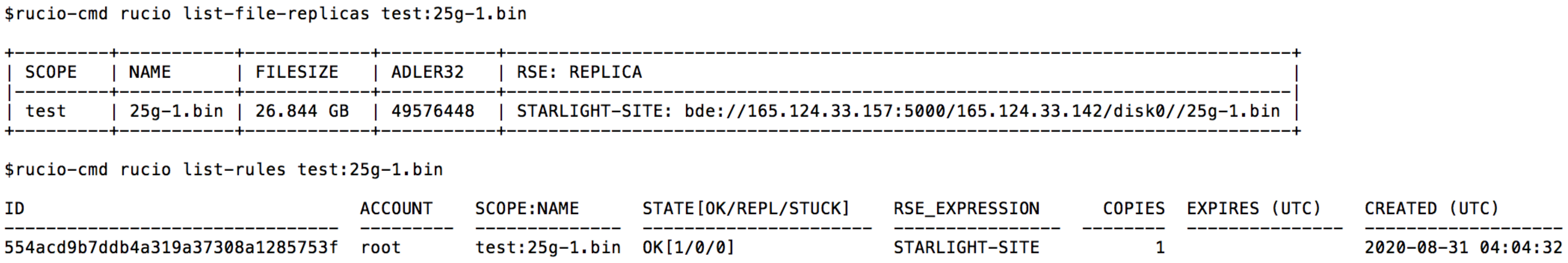
Experiments

1. **Register each BDE site in the testbed as an RSE with the Rucio server**

2. **Create an experiment file named *25g-1.bin* and register the file with the Rucio server**

3. **Use the Rucio client to submit a request to the Rucio server to replicate the registered file from *StarLight* to *CERN***

Results (I) – Rucio Rules



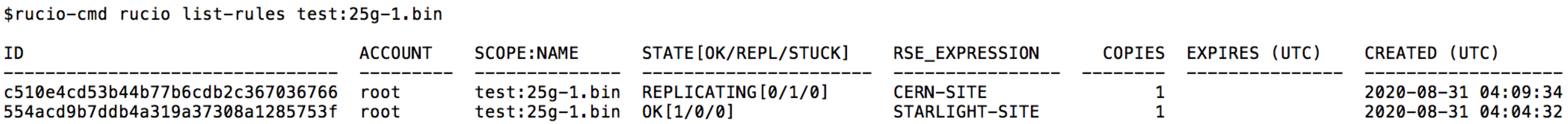
```
$rucio-cmd rucio list-file-replicas test:25g-1.bin

+---------+-----------+------------+-----------+------------------------------------------------------------------------------+
| SCOPE   | NAME      | FILESIZE   | ADLER32   | RSE: REPLICA                                                                 |
|---------+-----------+------------+-----------+------------------------------------------------------------------------------|
| test    | 25g-1.bin | 26.844 GB  | 49576448  | STARLIGHT-SITE: bde://165.124.33.157:5000/165.124.33.142/disk0//25g-1.bin |
+---------+-----------+------------+-----------+------------------------------------------------------------------------------+

$rucio-cmd rucio list-rules test:25g-1.bin

ID                                ACCOUNT    SCOPE:NAME      STATE[OK/REPL/STUCK]    RSE_EXPRESSION      COPIES  EXPIRES (UTC)    CREATED (UTC)
--------------------------------  ---------  --------------  ----------------------  ----------------  --------  ---------------  -------------------
554acd9b7ddb4a319a37308a1285753f  root       test:25g-1.bin  OK[1/0/0]               STARLIGHT-SITE           1                   2020-08-31 04:04:32
```

The replica and the replication rule for *25g-1.bin*

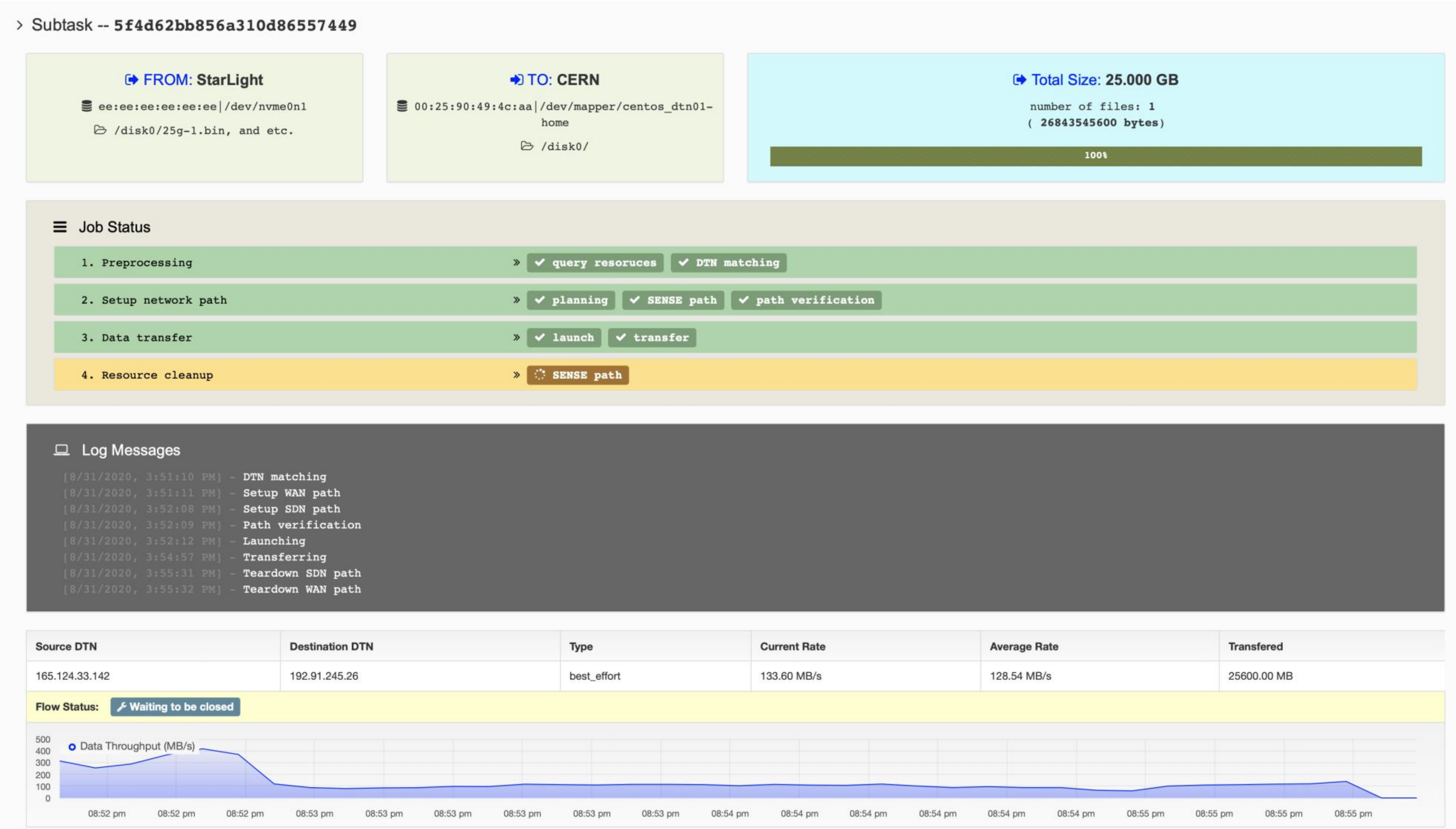


```
$rucio-cmd rucio list-rules test:25g-1.bin

ID                                ACCOUNT    SCOPE:NAME      STATE[OK/REPL/STUCK]    RSE_EXPRESSION      COPIES  EXPIRES (UTC)    CREATED (UTC)
--------------------------------  ---------  --------------  ----------------------  ----------------  --------  ---------------  -------------------
c510e4cd53b44b77b6cdb2c367036766  root       test:25g-1.bin  REPLICATING[0/1/0]      CERN-SITE                1                   2020-08-31 04:09:34
554acd9b7ddb4a319a37308a1285753f  root       test:25g-1.bin  OK[1/0/0]               STARLIGHT-SITE           1                   2020-08-31 04:04:32
```

The replication rule created for the Rucio data replication request

Results (II) – BigData Data Transfer Process



› Subtask -- **5f4d62bb856a310d86557449**

FROM: StarLight

ee:ee:ee:ee:ee:ee|/dev/nvme0n1

/disk0/25g-1.bin, and etc.

TO: CERN

00:25:90:49:4c:aa|/dev/mapper/centos_dtn01-home

/disk0/

Total Size: 25.000 GB

number of files: **1**

(**26843545600 bytes**)

100%

Job Status

1. Preprocessing » ✓ query resoruces ✓ DTN matching
2. Setup network path » ✓ planning ✓ SENSE path ✓ path verification
3. Data transfer » ✓ launch ✓ transfer
4. Resource cleanup » SENSE path

Log Messages

```
[8/31/2020, 3:51:10 PM] - DTN matching
[8/31/2020, 3:51:11 PM] - Setup WAN path
[8/31/2020, 3:52:08 PM] - Setup SDN path
[8/31/2020, 3:52:09 PM] - Path verification
[8/31/2020, 3:52:12 PM] - Launching
[8/31/2020, 3:54:57 PM] - Transferring
[8/31/2020, 3:55:31 PM] - Teardown SDN path
[8/31/2020, 3:55:32 PM] - Teardown WAN path
```

Source DTN	Destination DTN	Type	Current Rate	Average Rate	Transfered
165.124.33.142	192.91.245.26	best_effort	133.60 MB/s	128.54 MB/s	25600.00 MB

Flow Status: Waiting to be closed

Results (III) – BDE/SENSE Interactions

BDE Control Event	Transaction Time	SENSE Control Event	Transaction Time
Service Negotiation	5s	Compute Service Intent (initial)	3s
		Re-Compute Service (negotiate)	2s
Service Reservation	9s	Reserve with RMs	7s
Service Allocation	94s	Commit with RMs	34s
		Verify Service Model	51s
Service Deallocation	60s	Release with RMs	4s
		Commit with RMs	33s
		Verify Service Model	12s

Future Plans (Work in Progress)

- **Continue to evaluate/test ROBIN**
  - **100Gbps international WAN paths**
  - **High-end DTNs**
  - **Multiple site deployment**
  - **Increased automation**
  - **Enhanced parameter analytics**

- **Compare ROBIN with Rucio/FTS**

- **SC’20**

Conclusion

- **ROBIN (Rucio/BigData Express/SENSE)**
  A Next Generation High-performance Data Service Platform

- **A unique comprehensive set of integrated services designed specifically for managing and moving extremely large amounts of data over long distances**

Questions?

Additional Information

[1] Rucio: https://rucio.cern.ch/
[2] BigData Express: http://bigdataexpress.fnal.gov
[3] SENSE: http://sense.es.net