ANSE and PhEDEx
SDN Demonstration at FTW

Integrating Network-Awareness and Network-Management into PhEDEx

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Introduction

Overview

- Advanced Network Services for Experiments
- (Short) PhEDEx intro

- Current development efforts w.r.t. circuits and PhEDEx
  - Where/how it can be integrated
  - Previous results (ISGC 2014)

- Circuit awareness PhEDEx
  - Updated FileDownload agent / ResourceManager

- NSI circuits, issues encountered and proposed solution

- Summary and future plans

ANSE

A project funded by NSF CC-NIE program

ANSE - Advanced Network Services for Experiments

Integrate network awareness into the software stacks of experiments

- PhEDEx for CMS
- Panda for ATLAS

Official starting date Jan 2013

- Build on top of existing services (LHCOPN, LHCONE)

PIs:

- Harvey Newman, PI, Caltech
- Shawn McKee, co-PI, University of Michigan
- Paul Sheldon, co-PI, Vanderbilt University
- Kaushik De, co-PI, University of Texas at Arlington

PhEDEx Overview

The data management transfer tool for CMS (since 2004)
Loosely coupled set of agents written in Perl interacting via central DB

- **central agents** (ex. **FileRouter** agent)
- **site agents** running at various T1s and T2s (ex. **FileDownload** agent)
- each agent performs a independent single task

PhEDEx front-end and data-service
Three instances running over the same network

Common workflow:

- Front-end used to request data to sites
- Central agents compute paths of least cost, schedule transfers, etc
- Site agents execute transfer tasks

FileRouter (central) agent builds transfer queue per destination
FileDownload (site) agent examines its queue, processes it & reports back

PhEDEx Overview 2

PhEDEx is:

- not necessarily "near" the storage (i.e. same subnet)
- high level software … only knows about:
    - datasets, blocks, files
    - Hostnames/IPs from URLs
    - Path of files

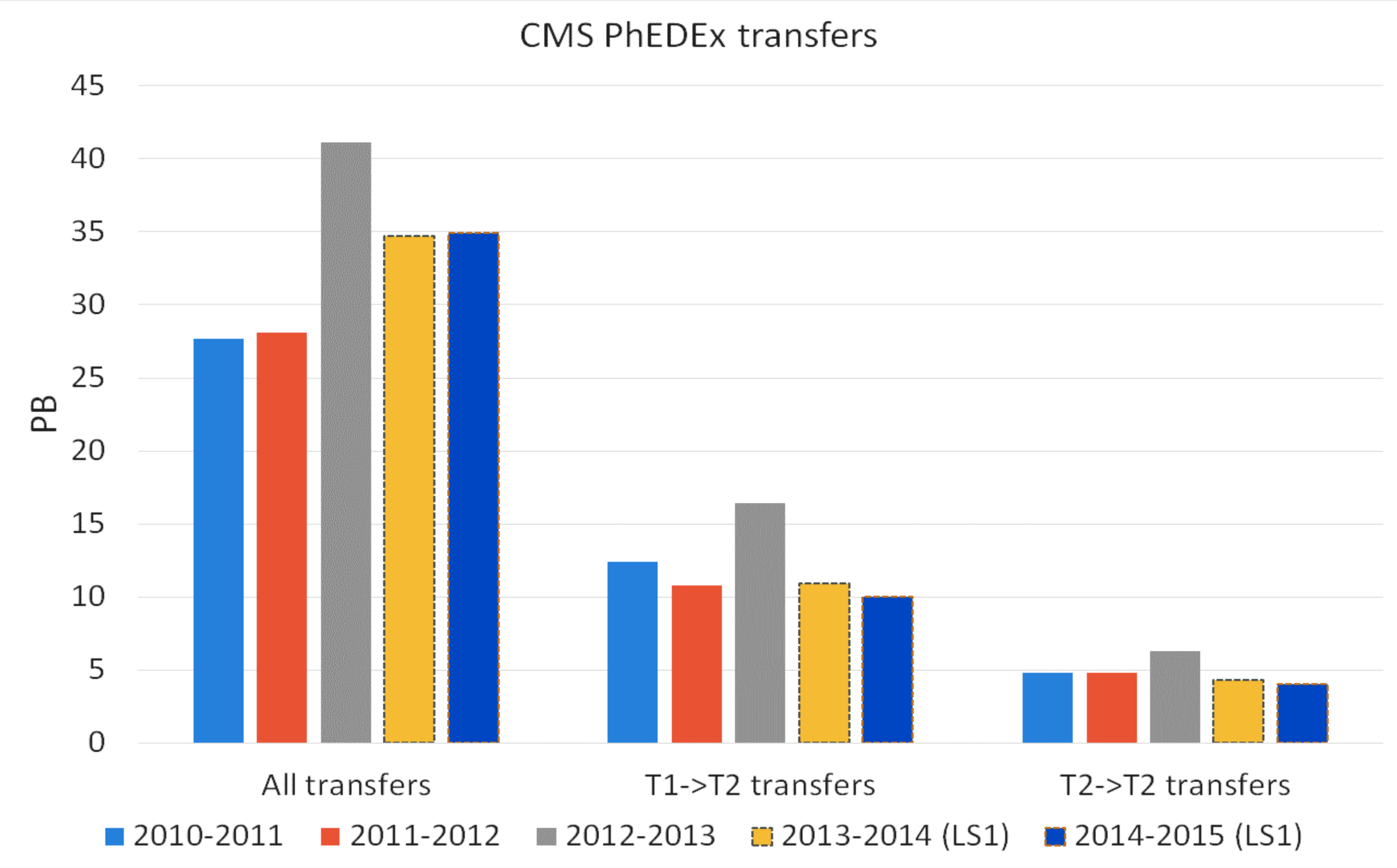
When issuing a transfer request user supplies:

- Dataset/block
- Destination site(s)

Data that PhEDEx can provide

- Datasets, blocks & file names & sizes
- SURL (storage farm hostname, local file path)
- Information about transfer queues
- Limited monitoring information

PhEDEx transfers over the past 5 years



ANSE & PhEDEx

Goals:

- Enhance PhEDEx with circuit awareness capabilities
- Provide a tool which can be used by others

Motivation*:

- More deterministic transfers (schedule jobs with data)
- Data prioritization over other traffic

PhEDEx integration possibilities:

- In the FileDownload agent (site level):
  - + Compromise between desired functionality and complexity
  - - Only has a local view
- In the FileRouter agent (central level):
  - + Has a global view of the whole system
  - - Harder to implement and optimize

* Provided that guaranteed BW is available

Initial prototype

Modified the FileDownload agent to:

- Check its own download queue
- Determine whether a circuit is needed
- Request a circuit (using DYNES)
  - If circuit was established:
    - convert transfer URLs to use the new L3 path
    - start new transfer using the updated URLs
- Manage the lifecycle of the circuit

Prototype:

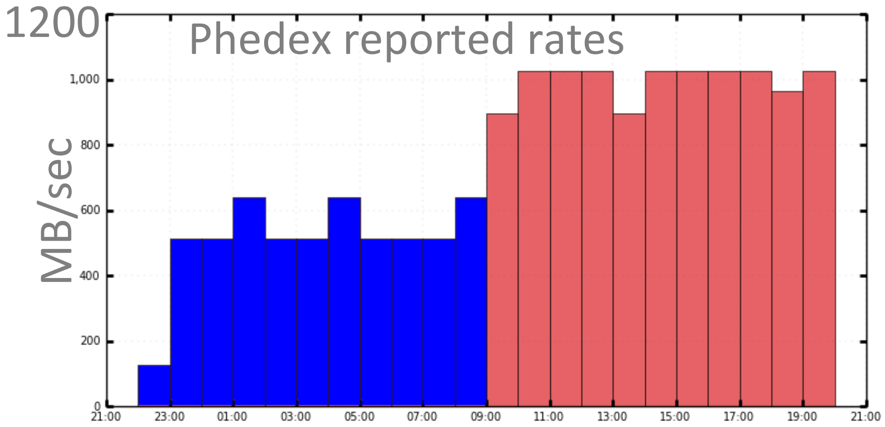
- Required no modifications to PhEDEx DB
- Had all control logic in the FileDownload agent
- Was transparent for all other PhEDEx instances

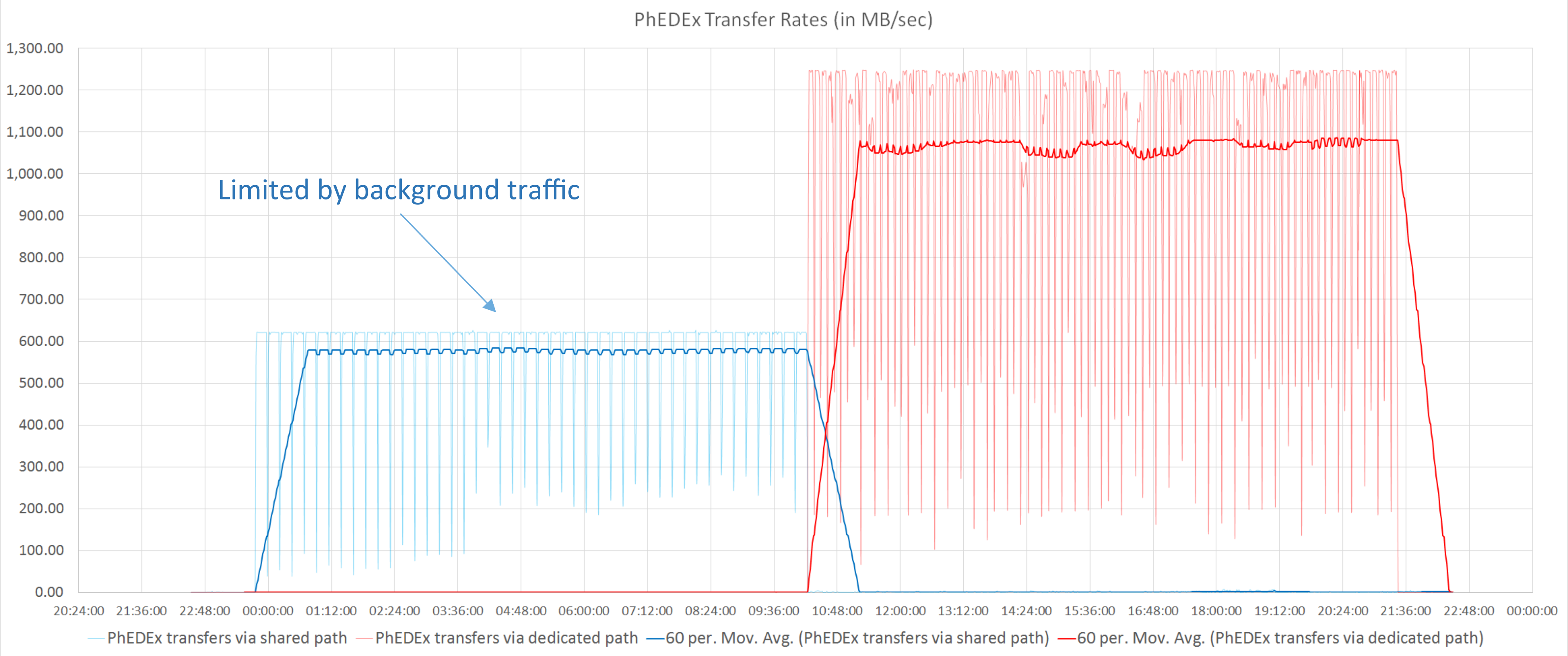
Issues:

- Relied on FDT as a transfer backend
- Could not be used by external apps
- Could not be extended to use other circuit providers

Results using the prototype

- **Seamless path switch**
- Per job link rates with PhEDEx traffic
  - ~620MB/sec -> 1060 to 1250MB/sec
- Average link rates with PhEDEx traffic
  - ~570MB/sec -> ~1050MB/sec


Phedex reported rates


PhEDEx Transfer Rates (in MB/sec)

Limited by background traffic

Integrating circuit awareness in PhEDEx – inner workings

Standard FileDownload agent:

- Files from the transfer queue are grouped into transfer jobs
- Jobs are handed to the transfer backend (FDT, FTS, etc…) for execution
- Transfer backend reports back with transfer status
- FileDownload agent reports back to DB

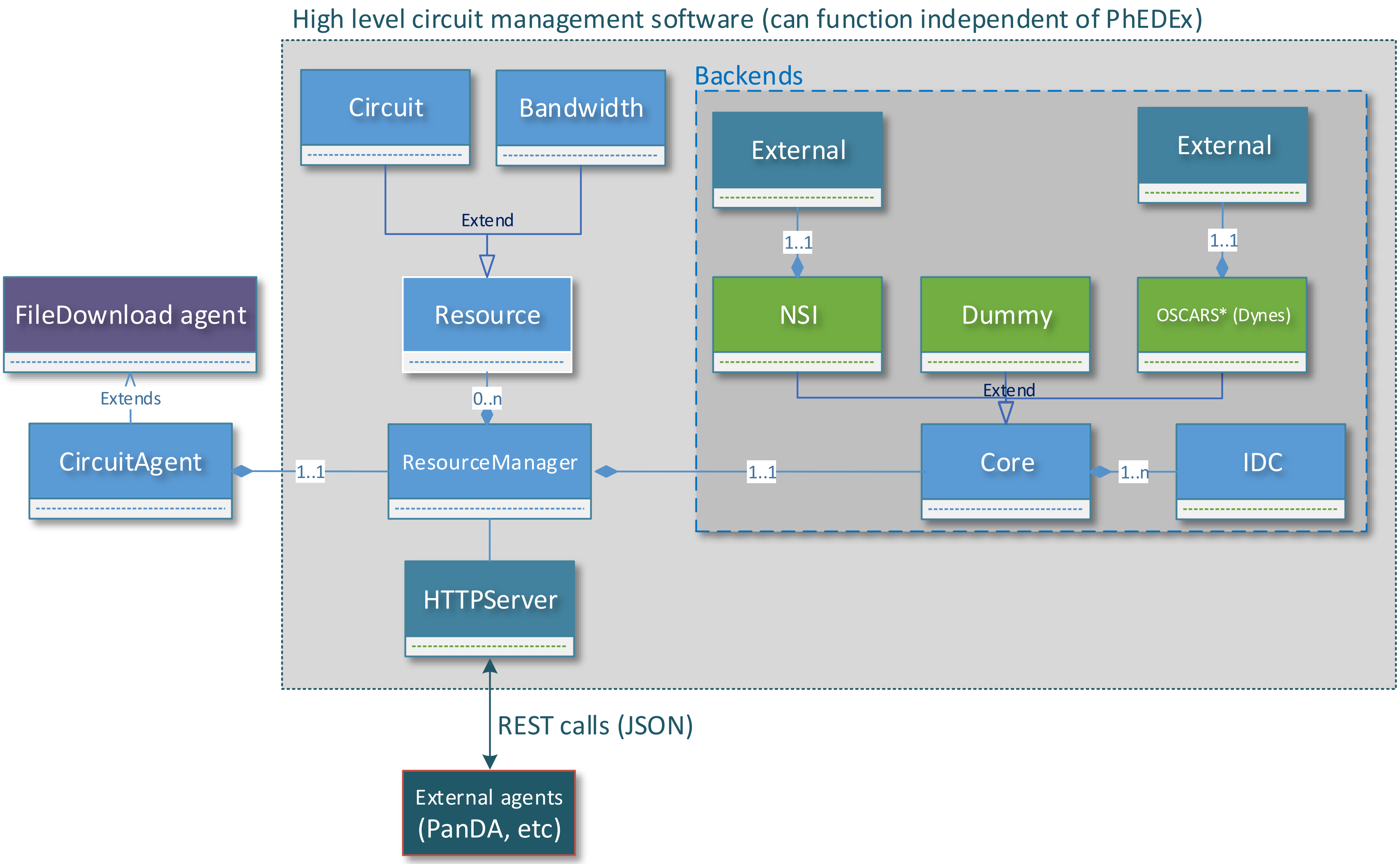
Updated FileDownload agent (CircuitAgent):

- Determines whether a circuit is worthwhile and requests one if it is
- Circuit request goes via the ResourceManager
- When a new transfer job is ready to start
  - Checks if a circuit is available (via ResourceManager)
  - Updates job to use circuit instead of GPN

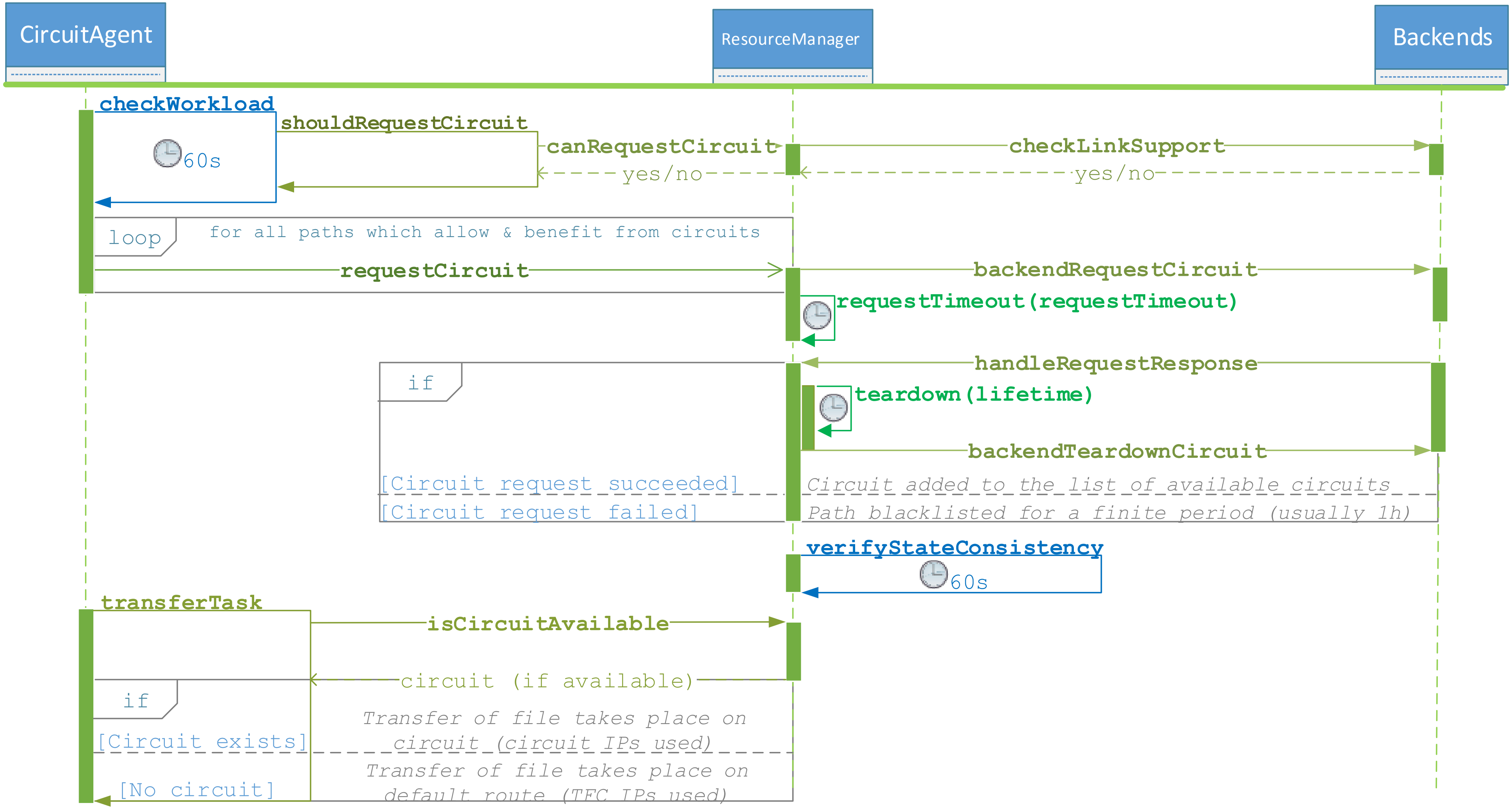
ResourceManager:

- Interacts with PhEDEx via direct calls
- Interacts with external programs via a REST interface
- Handles the lifecycle of the circuit on behalf of those programs
- Can handle different types of circuits (via plug-ins)

Class diagram



Sequence diagram



CircuitAgent

ResourceManager

Backends

checkWorkload

60s

shouldRequestCircuit

canRequestCircuit

yes/no

checkLinkSupport

yes/no

loop

for all paths which allow & benefit from circuits

requestCircuit

backendRequestCircuit

requestTimeout(requestTimeout)

if

handleRequestResponse

teardown(lifetime)

backendTeardownCircuit

[Circuit request succeeded]

Circuit added to the list of available circuits

[Circuit request failed]

Path blacklisted for a finite period (usually 1h)

verifyStateConsistency

60s

transferTask

isCircuitAvailable

circuit (if available)

if

[Circuit exists]

Transfer of file takes place on circuit (circuit IPs used)

[No circuit]

Transfer of file takes place on default route (TFC IPs used)

🟦 Recurrent event

🟩 Countdown timer

🟩 Calls

Using NSI

Network Service Interface

- NSI is an advance-reservation based protocol
- Supports tree and chain model of service chaining

Two phase reservation system

- First phase: availability is checked, if available, resources are held
- Second phase:
  - the requester either commits or aborts a held reservation
  - should the requester fail to do the above, a reservation can expire after a set timeout

NSI reservation properties

- Source, destination endpoints (mandatory)
- Start time, end time, reserved bandwidth (optional)

Limitations

- Only supplies a L2 circuit
- Circuit ends at site border router
- Some providers don’t guarantee BW

Issues in dealing with L2 circuits

Transfer backends can't directly use the NSI L2 circuit

Establishing L3 path to storage requires:

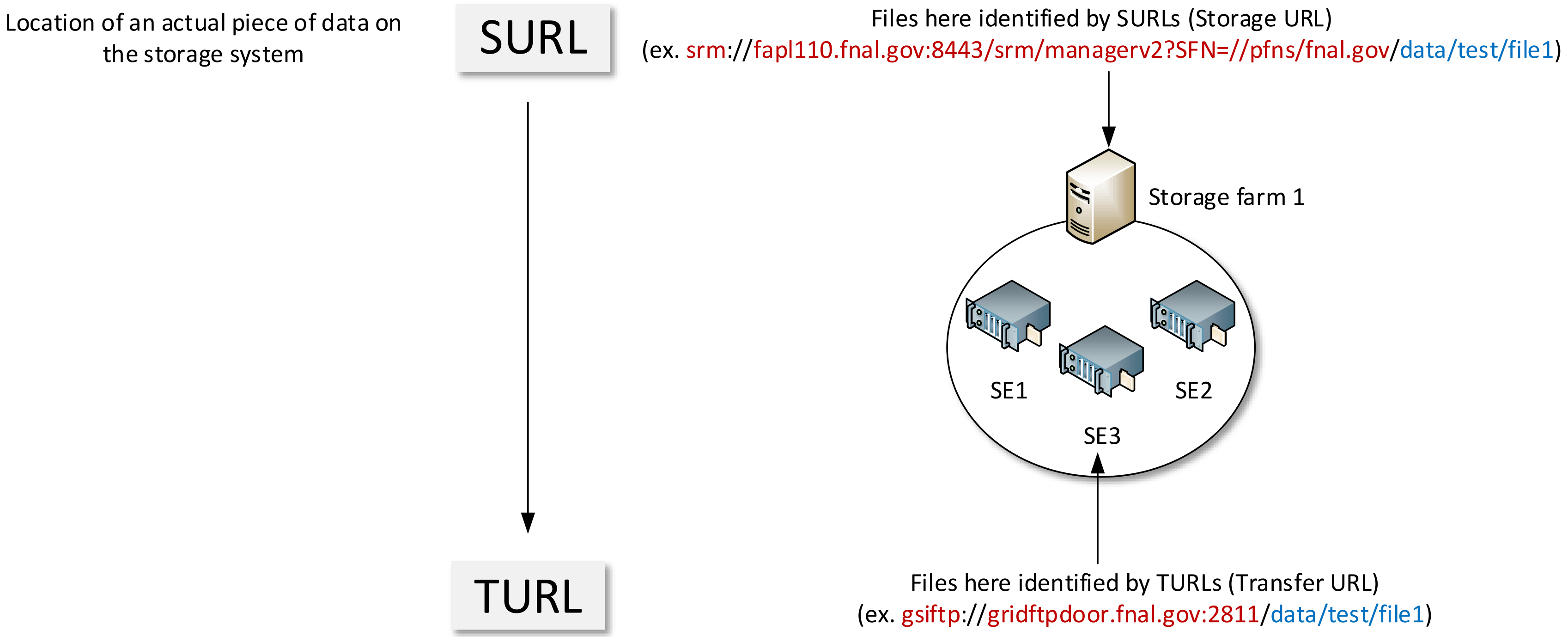
- Some topology knowledge
- Routing information
- Direct access to the site's network equipment

PhEDEx is a very high-level software -> Can only provide

- Datasets, blocks & file names and sizes
- SURL (Storage URL)
  - Storage farm hostname
  - Local file path

=> Establishing L3 paths is non trivial

Issues in dealing with FTS and SRM



Location of an actual piece of data on the storage system

SURL

Files here identified by SURLs (Storage URL)
(ex. srm://fapl110.fnal.gov:8443/srm/managerv2?SFN=//pfns/fnal.gov/data/test/file1)

TURL

Files here identified by TURLs (Transfer URL)
(ex. gsiftp://gridftpdoor.fnal.gov:2811/data/test/file1)

SURLs to TURLs (FTS & SRM)

- Get source TURL (call srmPrepareToGet)
- Get destination TURL (call srmPrepareToPut)
- Assuming that the TURL-s are gridftp endpoints, start gridftp copy
- Monitor transfer progress
- Release TURLs

Initial discussions

Technical constraints:

- Only a L2 circuit
- L2 circuit ends in the site's border router
- Limited feedback in case of errors
- NSI adoption in production is still limited

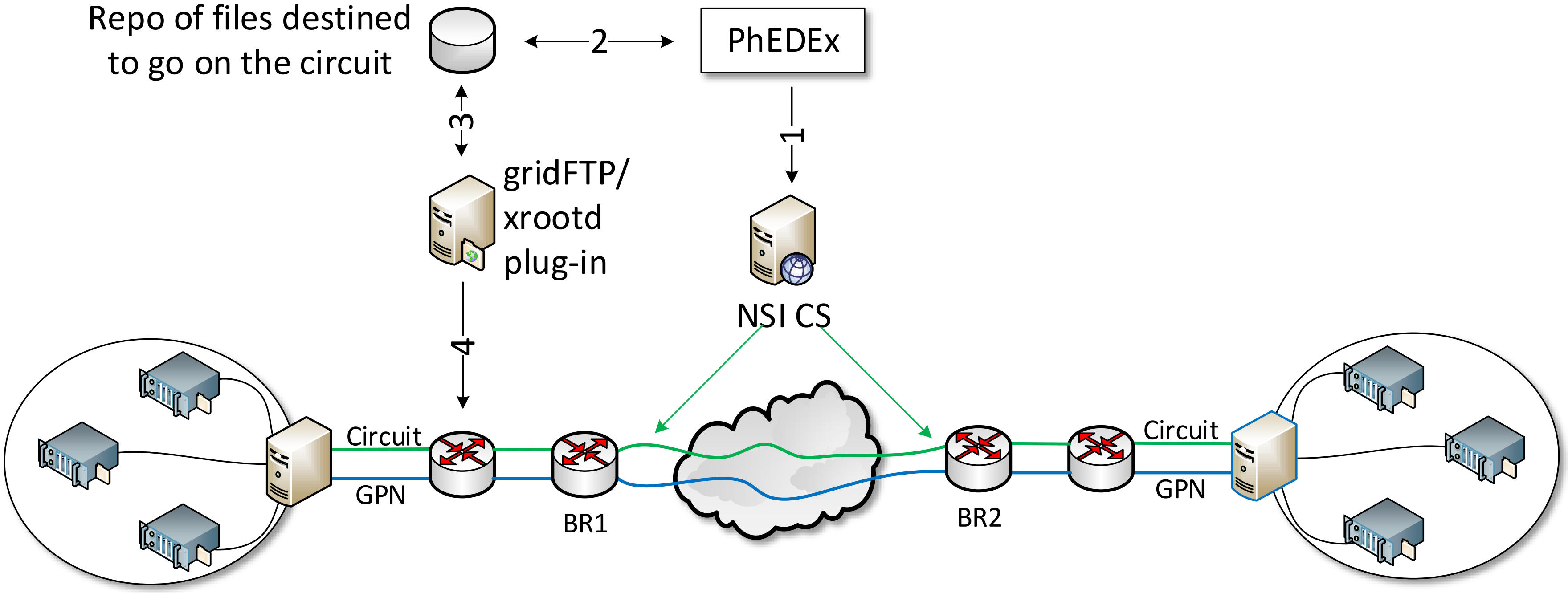
All solutions of creating a L3 path rely either on

- privileged access on site's servers/routers
- specialised hardware in place (OF capable)

Our solution must:

- deal with sites serving multiple VOs
- potentially deal with privileged and non privileged files transferred from the same server
- work with the FTS/SRM/gridFTP
- be as un-intrusive into sites operations as possible

Initial discussions (2)

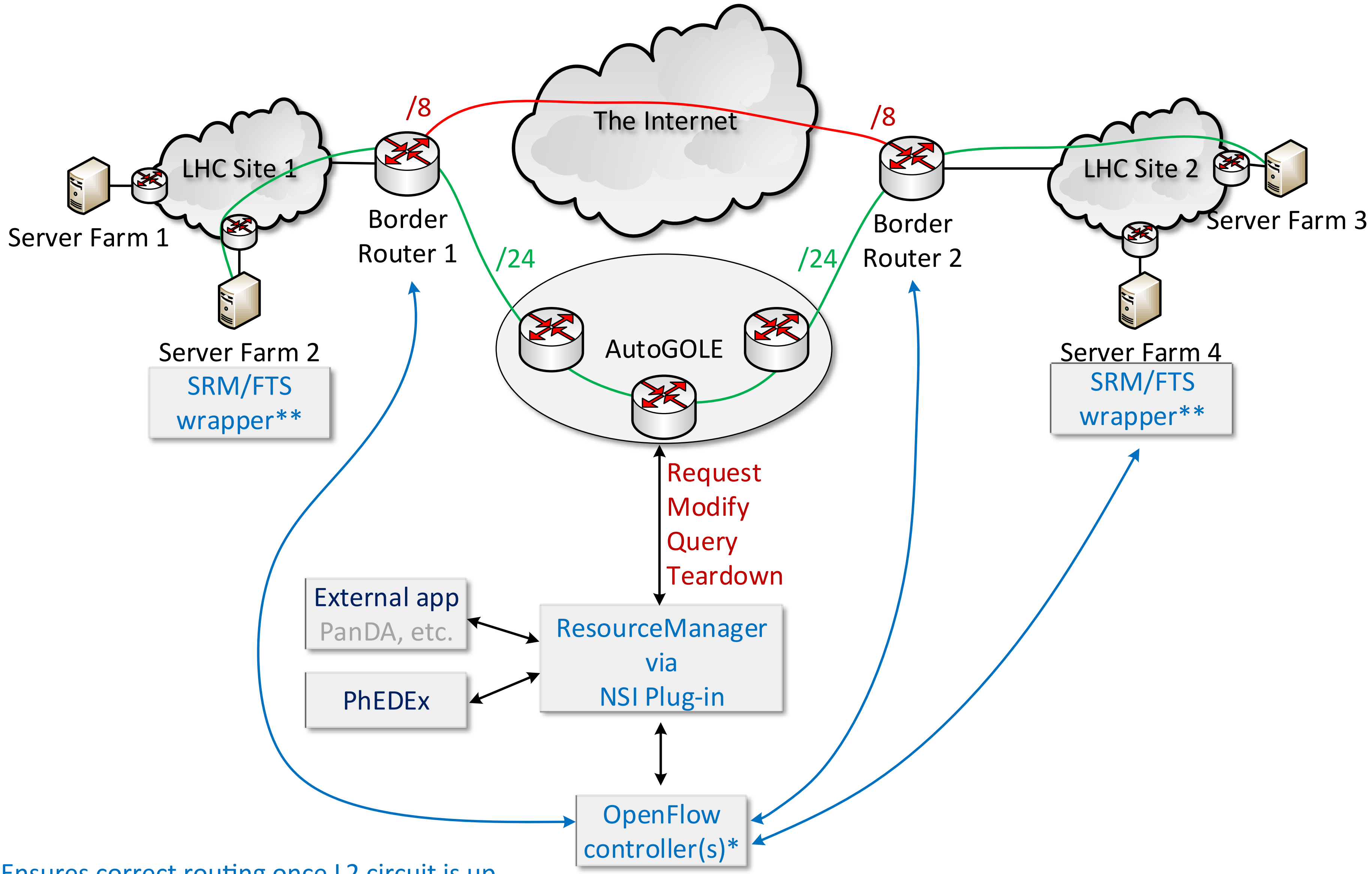


1. Request circuit between site A and site B
2. PhEDEx specifies, list of files to be transferred
3. Before transfer, gridFTP checks if the file(s) should go on the circuit
4. If that's the case set up a TC rule: mark packets of files to go on the circuit
5. Set up a PBR (or use OF) to do the routing of those files afterwards

Issues:

- Relies on modifying or developing plug-ins for the transfer tools
- Relies on having privileged access on servers (for packet marking)

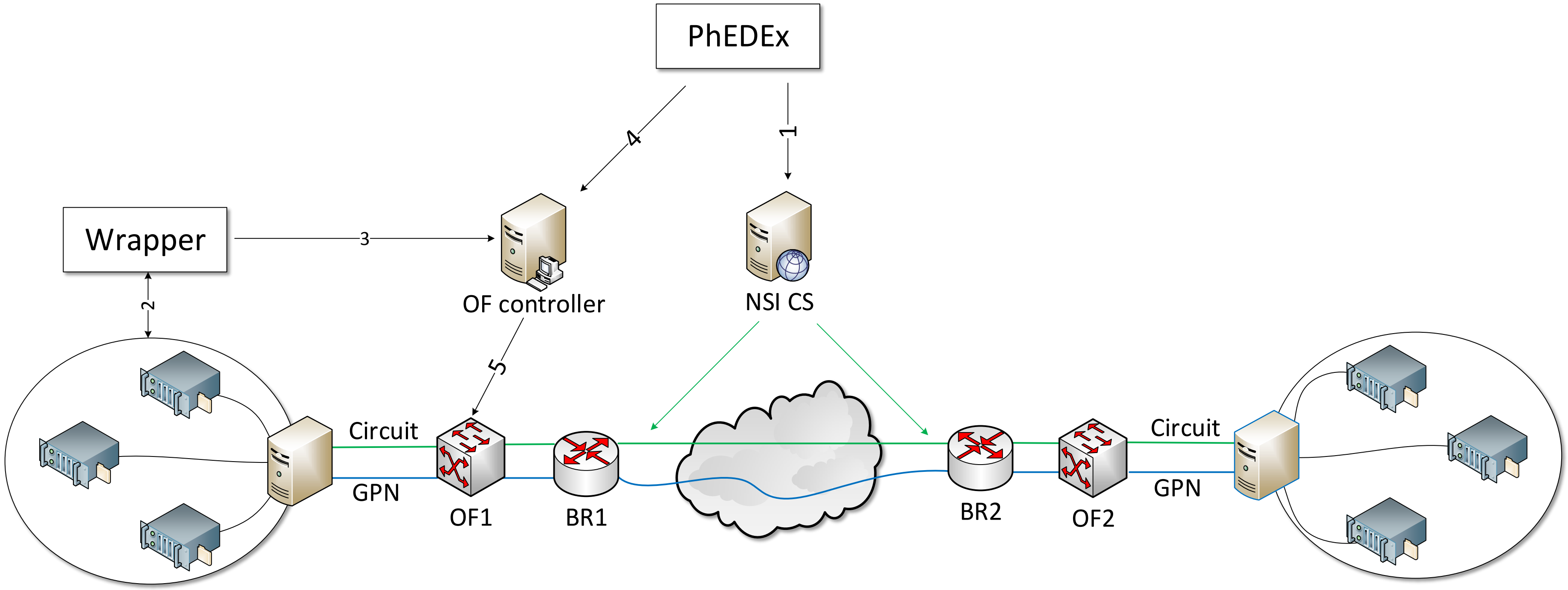
Proposed solution diagram



* Ensures correct routing once L2 circuit is up

** Retrieves the IPs of gridFTP servers involved in transfer

Proposed solution diagram



1. Request circuit between site A and site B
2. Wrapper gets IPs of all servers involved in the transfer
3. Wrapper passes this information to the OF controller
4. PhEDEx informs the OF controller that a circuit has been established between the two sites
5. OF controller adds routing info in the OF switches that direct all traffic on the subnet to the circuit

Summary & future plans

PhEDEx is set to use circuits when they are available

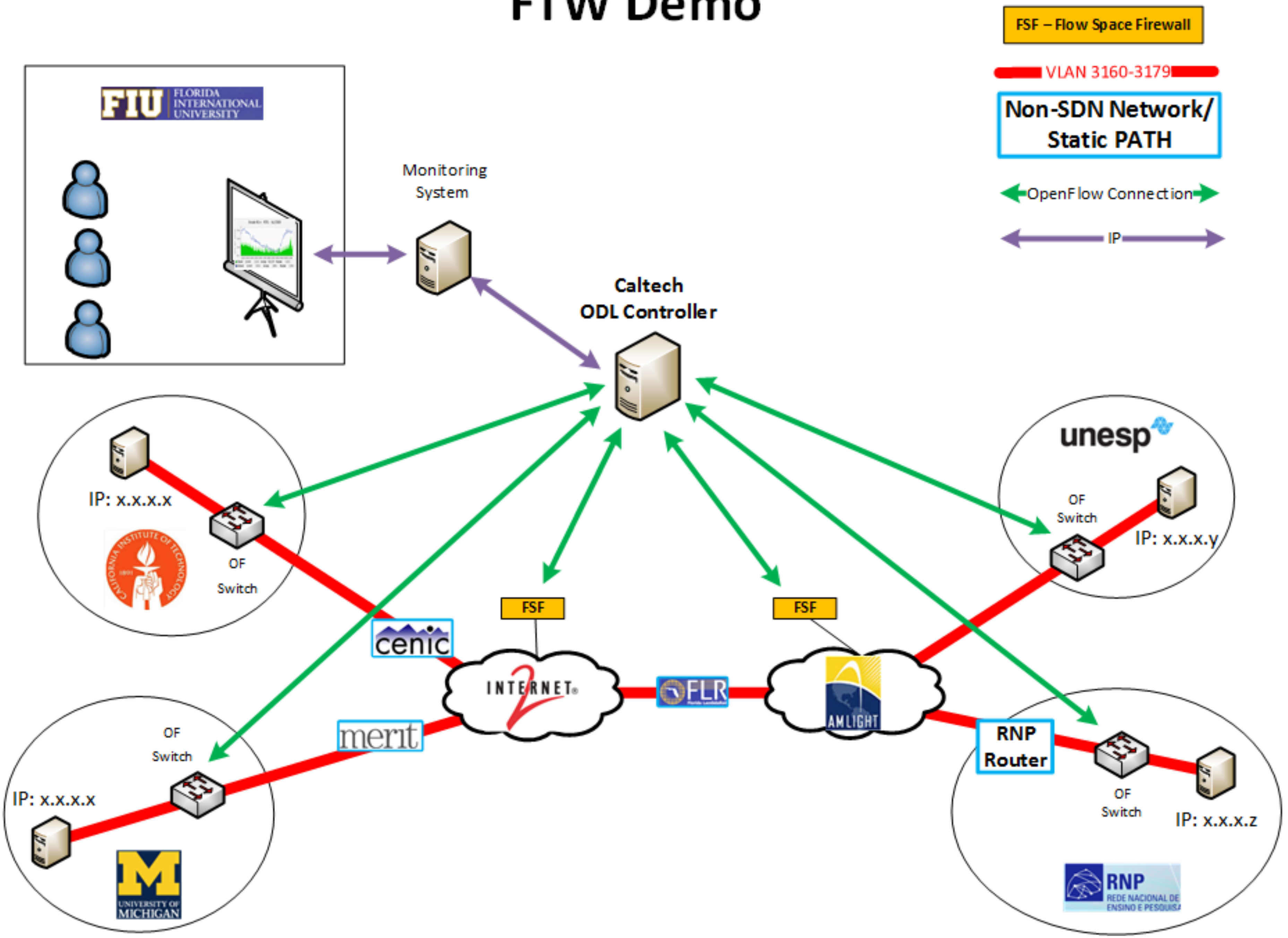
- No modifications done to PhEDEx DB
- Control logic is in the FileDownload agent
- Lifecycle handled by the ResourceManager
- Transparent for all other PhEDEx instances

ResourceManager can be used as a 3rd party tool

Future plans:

- Solve the issue of how to route data once a circuit is active
- Demonstrate circuit management capabilities between select sites
- Demonstrate improvement while using circuits

FTW Demo



FSF – Flow Space Firewall

VLAN 3160-3179

Non-SDN Network/
Static PATH

OpenFlow Connection

IP

FIU FLORIDA INTERNATIONAL UNIVERSITY

Monitoring
System

Caltech
ODL Controller

IP: x.x.x.x

OF
Switch

unesp

OF
Switch

IP: x.x.x.y

FSF

FSF

cenic

INTERNET2

FLR

AMLIGHT

merit

OF
Switch

IP: x.x.x.x

UNIVERSITY OF MICHIGAN

RNP
Router

OF
Switch

IP: x.x.x.z

RNP
REDE NACIONAL DE ENSINO E PESQUISA

FTW Demo

FSF – Flow Space Firewall

VLAN 3160-3179

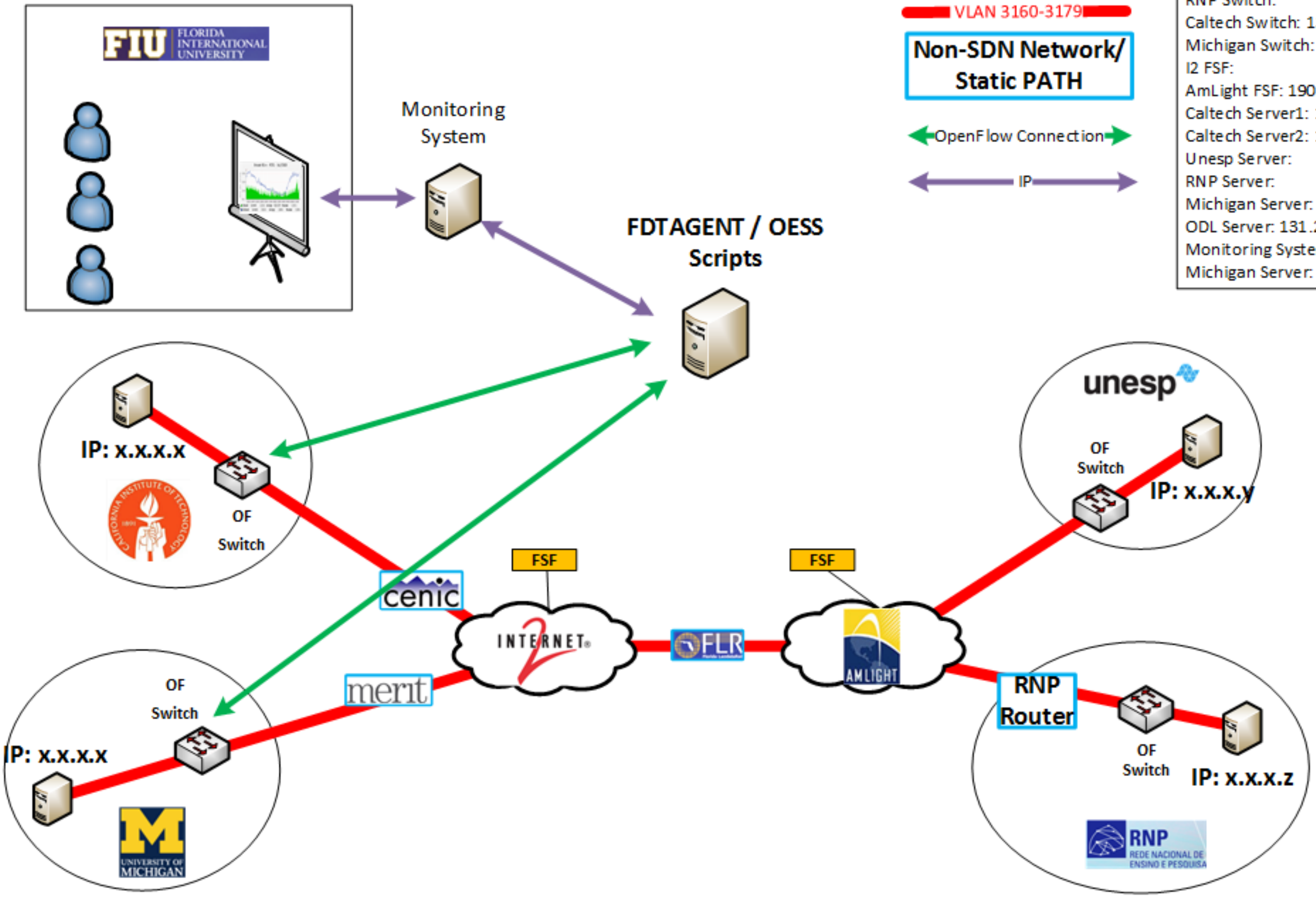
Non-SDN Network/ Static PATH

OpenFlow Connection

IP

IP Addresses:

Unesp Switch:
RNP Switch:
Caltech Switch: 131.215.207.30
Michigan Switch:
I2 FSF:
AmLight FSF: 190.103.184.134
Caltech Server1: 131.215.207.24
Caltech Server2: 131.215.207.25
Unesp Server:
RNP Server:
Michigan Server:
ODL Server: 131.215.207.57
Monitoring System:
Michigan Server:



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Monitoring System

FDTAGENT / OESS Scripts

IP: x.x.x.x

OF Switch

cenic

FSF

INTERNET2

FLR

AMLIGHT

merit

OF Switch

IP: x.x.x.x

unesp

OF Switch

IP: x.x.x.y

RNP Router

OF Switch

IP: x.x.x.z

RNP REDE NACIONAL DE ENSINO E PESQUISA

Thank you!