An NDN Testbed for Large-scale Scientific Data

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Motivations on NDN for Large-scale Scientific Application

- As the data volumes and complexity increase, data-intensive science cannot rely on extension in the storage infrastructure.

- It needs to investigate new methods of intelligent processing and data distribution over networks.

- Use of caching technique changes traffic pattern in the network and improves corrupted data rate.

- NDN based large-scale scientific application
  - Climate modeling application as an initial focus
  - Extension of NDN architecture to various data-intensive science application such as HEP and astronomy with hierarchical naming strategies

- Innovative data management lead to traffic pattern change

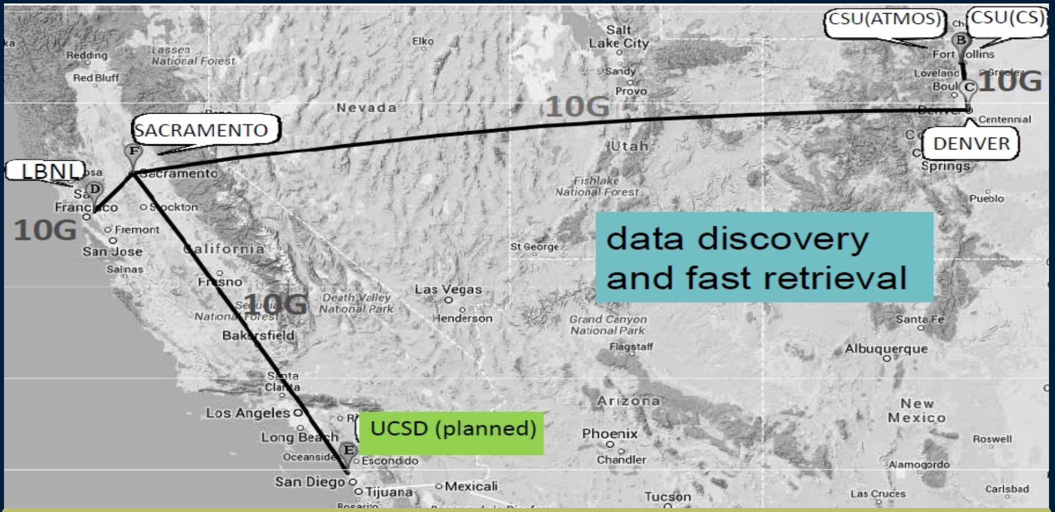
Backgrounds on NDN for Climate Modeling Application

Why climate data transfer using NDN Architecture

- Current CMIP5 data transfer using ESGF, long time latency and corrupted data occur
- To provide innovative transfer, management, and security function for scientific big data using the NDN architecture
- Movement of traffic pattern in data-intensive science and reduction of data explosion on it

R&D on NDN based data-intensive science application

- NDN testbed for climate modeling application (CSU univ.)
- NDN architecture design, development, and deployment for LHC big data transfer (Fermi Lab)
- ESnet for research networks in US

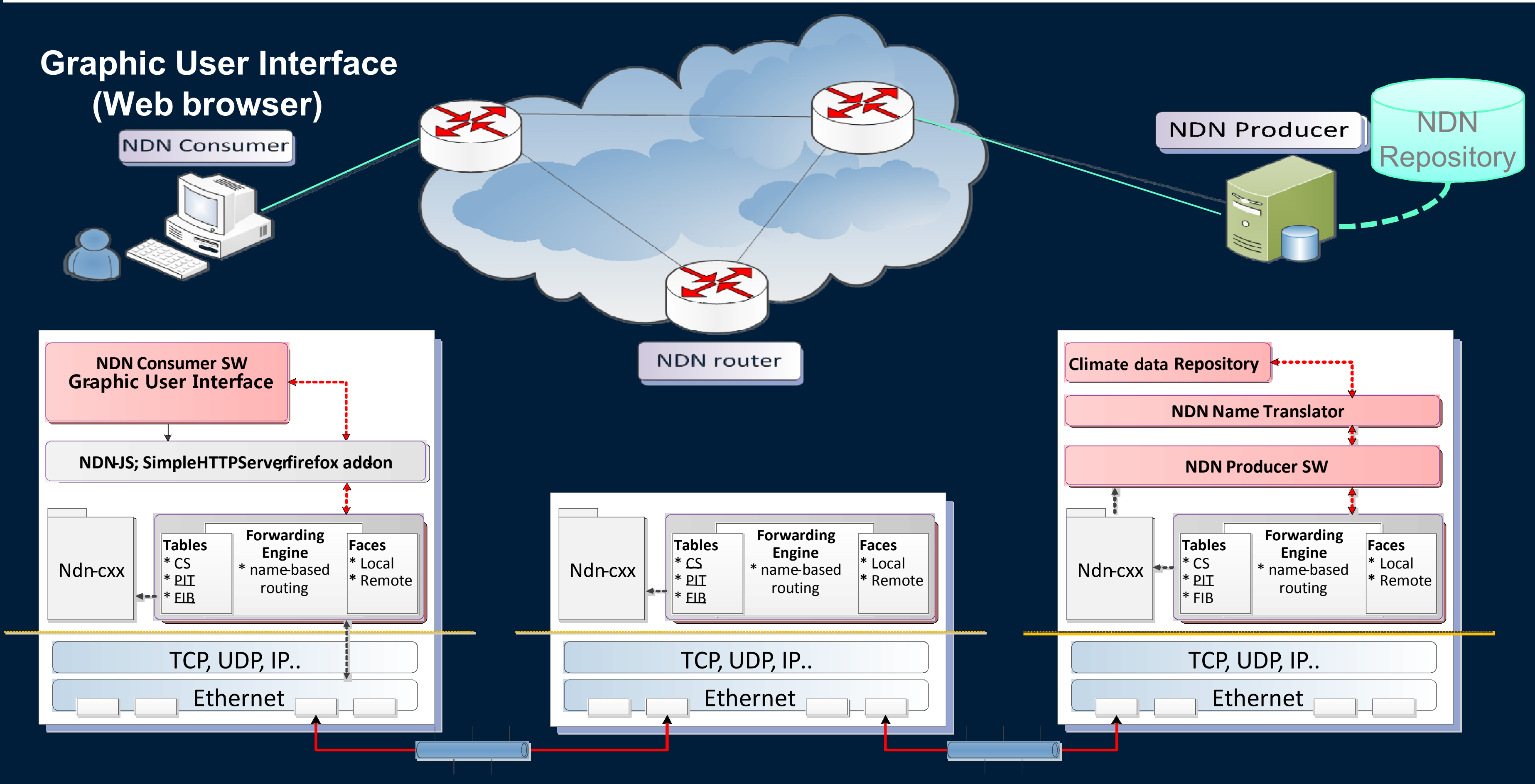


Climate modeling NDN testbed in US

Data-intensive science applications

1. Climate Modeling
2. HEP (LHC, CMS)
3. Astronomy

NDN Testbed for Climate Modeling Application



Graphic User Interface
(Web browser)

NDN Consumer

NDN router

NDN Producer

NDN Repository

NDN Consumer SW
Graphic User Interface

NDN-JS; SimpleHTTPServer, firefox addon

Ndn-cxx

Tables
* CS
* PIT
* FIB

Forwarding Engine
* name-based routing

Faces
* Local
* Remote

TCP, UDP, IP..

Ethernet

Climate data Repository

NDN Name Translator

NDN Producer SW

Functions of front-end system in consumer

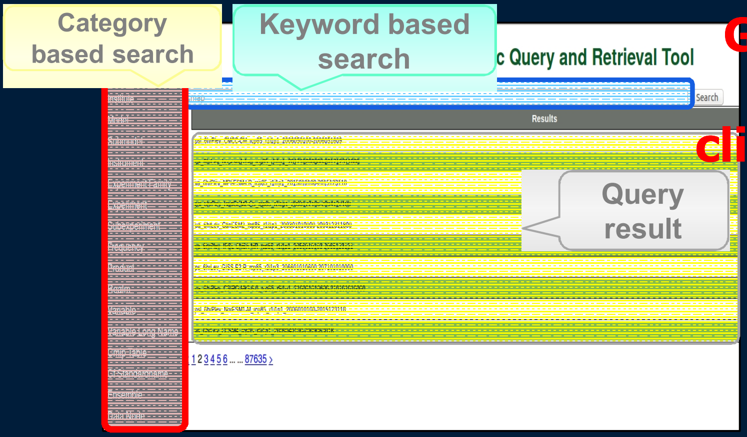
- To provide GUI for climate modeling application based on NDN architecture
- CMIP5 data search using controlled vocabulary
- NDN name based CMIP5 data downloading

Kisti-ndn-atmos package

Functions of back-end system in producer

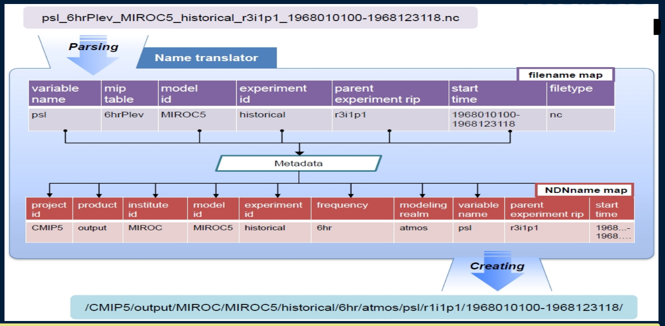
- To translate .nc file names to NDN names
- NDN based repository establishment for CMIP5 data management
- NDN name database establishment, in order to search a CMIP5 data of interest in producer

Key Components in the NDN Testbed



GUI to support NDN based climate modeling application

NDN Name Translator for climate modeling application


psl_6hrPlev_MIROC5_historical_r3i1p1_1968010100-1968123118.nc

variable name	mip table	model id	experiment id	parent experiment rip	start time	filetype
psl	6hrPlev	MIROC5	historical	r3i1p1	1968010100-1968123118	nc

project id	product	institute id	model id	experiment id	frequency	modeling realm	variable name	parent experiment rip	start time
CMIP5	output	MIROC	MIROC5	historical	6hr	atmos	psl	r3i1p1	1968…- 1968….

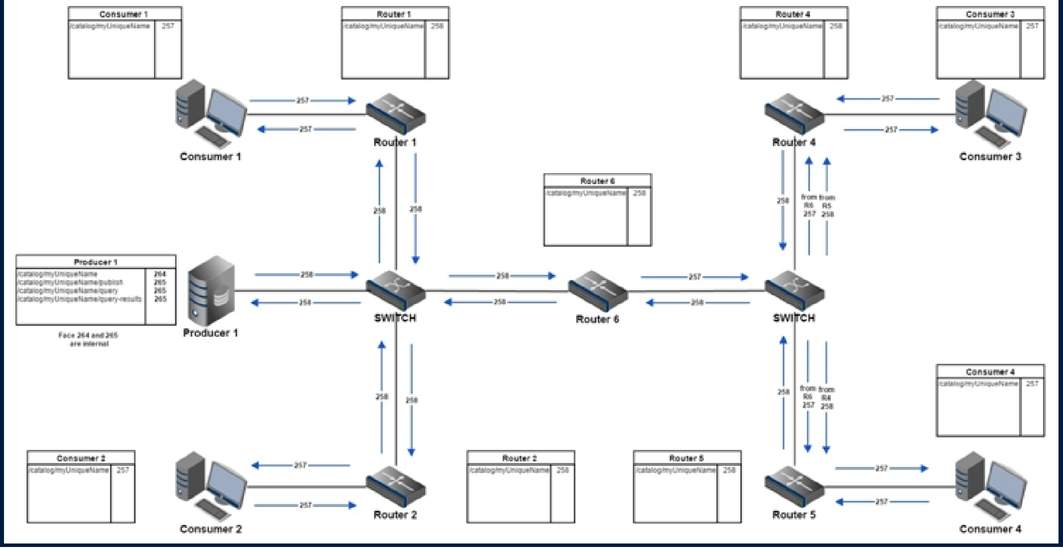
/CMIP5/output/MIROC/MIROC5/historical/6hr/atmos/psl/r1i1p1/1968010100-1968123118/

- Name lists sorting
- To show meta data corresponding to each searched CMIP5 data
- Search results is changed to CMIP5 file name following DRS syntax

Works to support NDN based Climate Modeling Application

- To translate CMIP5 data files stored in NDN repository to NDN names and to store them in DB
- NDN name translation following DRS structure

NDN network for climate modeling in Korea

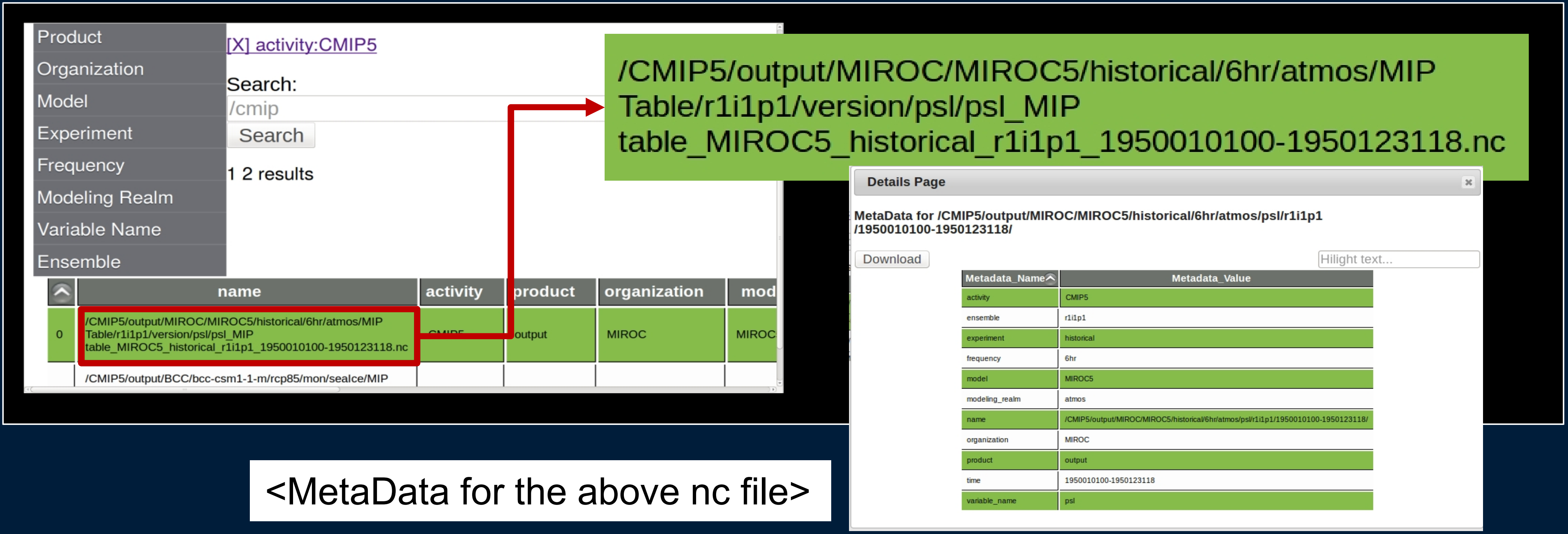


Producer 1	
/catalog/myUniqueName	264
/catalog/myUniqueName/publish	265
/catalog/myUniqueName/query	265
/catalog/myUniqueName/query-results	265

- Forwarding and caching of interest/data packets
- Synchrinized FIB table management in the NDN testbed
- NDN platform (ver 0.3.4)
  - NDN-cxx, NFD
  - NDN-js (one of NDN-ccl)
  - NDNfs-port

Features of GUI (1)

- **Reflection of the ESGF system workflow**
- **CMIP5 climate data searching following climate DRS structure**
  - To show original CMIP5 nc file names changed from NDN names, together with meta data sets corresponding to .nc file names
  - Key word based CMIP5 data search and user-friendly sorting for search results



1 2 results

	name	activity	product	organization	mod
0	/CMIP5/output/MIROC/MIROC5/historical/6hr/atmos/MIP Table/r1i1p1/version/psl/psl_MIP table_MIROC5_historical_r1i1p1_1950010100-1950123118.nc	CMIP5	output	MIROC	MIROC
	/CMIP5/output/BCC/bcc-csm1-1-m/rcp85/mon/sealce/MIP				

/CMIP5/output/MIROC/MIROC5/historical/6hr/atmos/MIP Table/r1i1p1/version/psl/psl_MIP table_MIROC5_historical_r1i1p1_1950010100-1950123118.nc

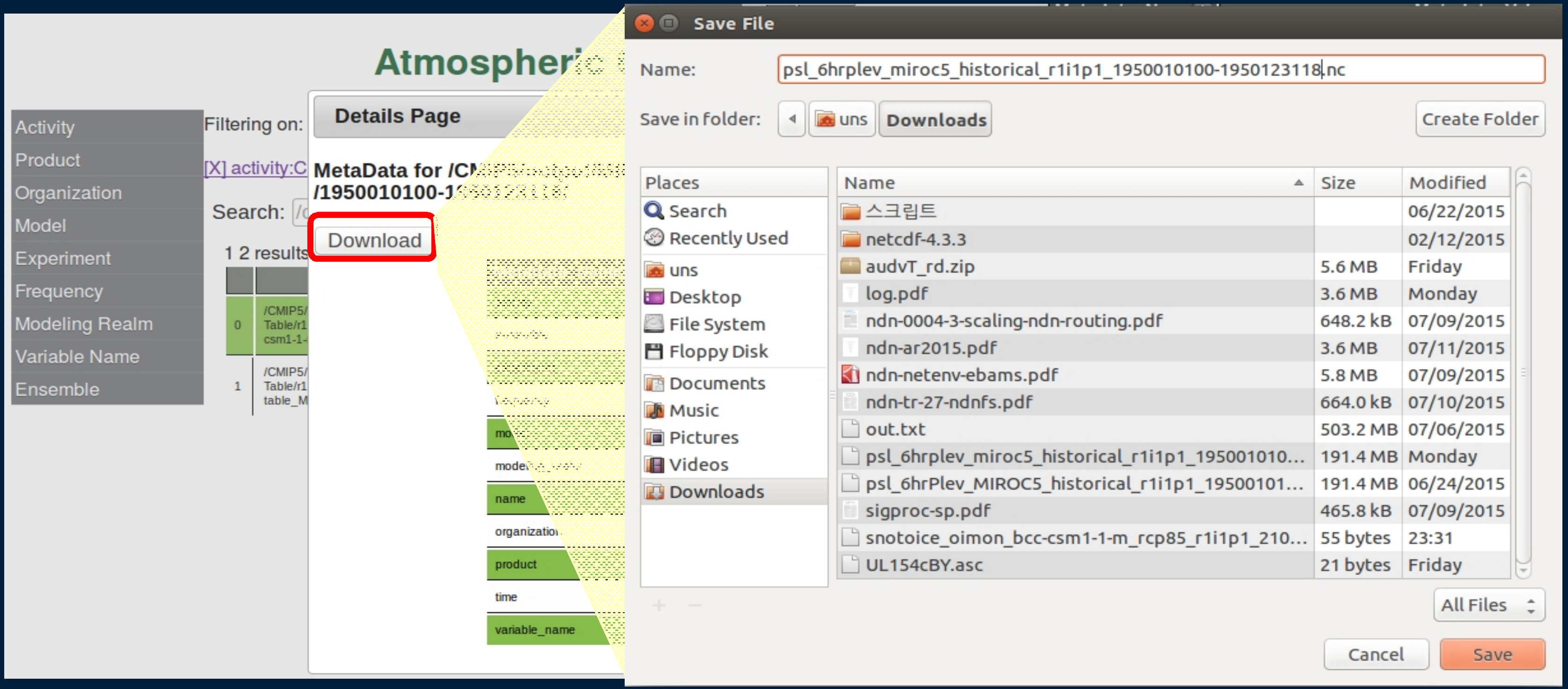
MetaData for /CMIP5/output/MIROC/MIROC5/historical/6hr/atmos/psl/r1i1p1 /1950010100-1950123118/

Metadata_Name	Metadata_Value
activity	CMIP5
ensemble	r1i1p1
experiment	historical
frequency	6hr
model	MIROC5
modeling_realm	atmos
name	/CMIP5/output/MIROC/MIROC5/historical/6hr/atmos/psl/r1i1p1/1950010100-1950123118/
organization	MIROC
product	output
time	1950010100-1950123118
variable_name	psl

<MetaData for the above nc file>

Features of GUI (2)

- **CMIP5 data downloading in metadata window**
  - **Download button have the address corresponding to an NDN name of interest in producer side**
    - Address: NDN name based URI
    - “ndn:/catalog/myUniqueName/*<CMOR fiflename.nc>*”
      - ex) ndn:/catalog/myUniqueName/*psl_amip_MIROC5_historical_r1i1p1_1950010100-xx.nc*



Name: psl_6hrplev_miroc5_historical_r1i1p1_1950010100-1950123118.nc

Save in folder: uns Downloads

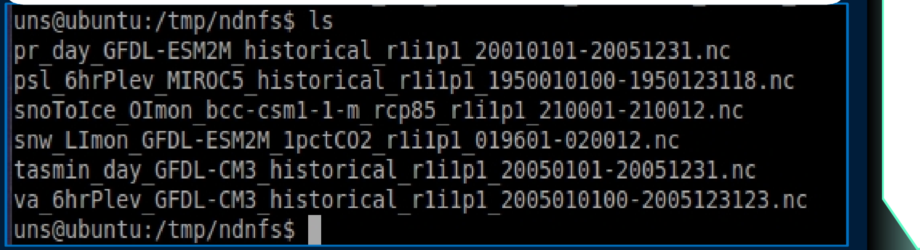
Name	Size	Modified
스크립트		06/22/2015
netcdf-4.3.3		02/12/2015
audvT_rd.zip	5.6 MB	Friday
log.pdf	3.6 MB	Monday
ndn-0004-3-scaling-ndn-routing.pdf	648.2 kB	07/09/2015
ndn-ar2015.pdf	3.6 MB	07/11/2015
ndn-netenv-ebams.pdf	5.8 MB	07/09/2015
ndn-tr-27-ndnfs.pdf	664.0 kB	07/10/2015
out.txt	503.2 MB	07/06/2015
psl_6hrplev_miroc5_historical_r1i1p1_195001010...	191.4 MB	Monday
psl_6hrPlev_MIROC5_historical_r1i1p1_19500101...	191.4 MB	06/24/2015
sigproc-sp.pdf	465.8 kB	07/09/2015
snotoice_oimon_bcc-csm1-1-m_rcp85_r1i1p1_210...	55 bytes	23:31
UL154cBY.asc	21 bytes	Friday

<Downloading of CMIP5 climate data>

Features of Name Translator

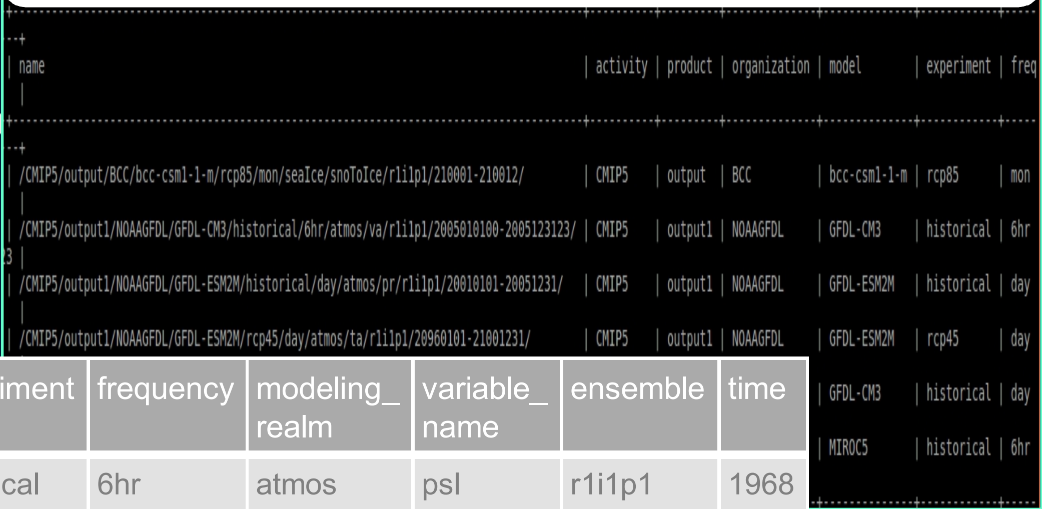
- **To translate all nc file names stored in repository to NDN names**
  - **Parsing of each name component**
  - **To check time variable in an nc file has the same value in metadata**
    - Sometimes, time in metadata is slightly different from one in real data.
    - For allowable error range, name translation for an nc file name.
    - If they are outside from it, no translation for that one.

6 nc files in NDN file system (repository)



```
uns@ubuntu:/tmp/ndnfs$ ls
pr_day_GFDL-ESM2M_historical_r1i1p1_20010101-20051231.nc
psl_6hrPlev_MIROC5_historical_r1i1p1_1950010100-1950123118.nc
snoToIce_OImon_bcc-csm1-1-m_rcp85_r1i1p1_210001-210012.nc
snw_LImon_GFDL-ESM2M_1pctCO2_r1i1p1_019601-020012.nc
tasmin_day_GFDL-CM3_historical_r1i1p1_20050101-20051231.nc
va_6hrPlev_GFDL-CM3_historical_r1i1p1_2005010100-2005123123.nc
uns@ubuntu:/tmp/ndnfs$
```

6 CMIP5 NDN names translated in Mysql DB repository



```
+-------------------------------------------------------------------------+----------+---------+--------------+-------------+------------+-----
--+
| name                                                                     | activity | product | organization | model       | experiment | freq
  |
+-------------------------------------------------------------------------+----------+---------+--------------+-------------+------------+-----
--+
| /CMIP5/output/BCC/bcc-csm1-1-m/rcp85/mon/seaIce/snoToIce/r1i1p1/210001-210012/          | CMIP5    | output  | BCC          | bcc-csm1-1-m | rcp85      | mon
  |
| /CMIP5/output1/NOAAGFDL/GFDL-CM3/historical/6hr/atmos/va/r1i1p1/2005010100-2005123123/ | CMIP5    | output1 | NOAAGFDL     | GFDL-CM3     | historical | 6hr
3 |
| /CMIP5/output1/NOAAGFDL/GFDL-ESM2M/historical/day/atmos/pr/r1i1p1/20010101-20051231/   | CMIP5    | output1 | NOAAGFDL     | GFDL-ESM2M   | historical | day
  |
| /CMIP5/output1/NOAAGFDL/GFDL-ESM2M/rcp45/day/atmos/ta/r1i1p1/20960101-21001231/        | CMIP5    | output1 | NOAAGFDL     | GFDL-ESM2M   | rcp45      | day
                                                                                                                            | GFDL-CM3     | historical | day
                                                                                                                            | MIROC5       | historical | 6hr
                                                                                                                          -+-------------+------------+-----
```

name	sha256	activity	product	organization	model	experiment	frequency	modeling_ realm	variable_ name	ensemble	time
Full name	Hash value	CMIP5	output	MIROC	MIROC5	historical	6hr	atmos	psl	r1i1p1	1968 …..

Database schema => http://redmine.named-data.net/projects/ndn-atmos/wiki/Schema

Summary of kisti-ndn-atmos SW Package

Summary of kisti-ndn-atmos SW package

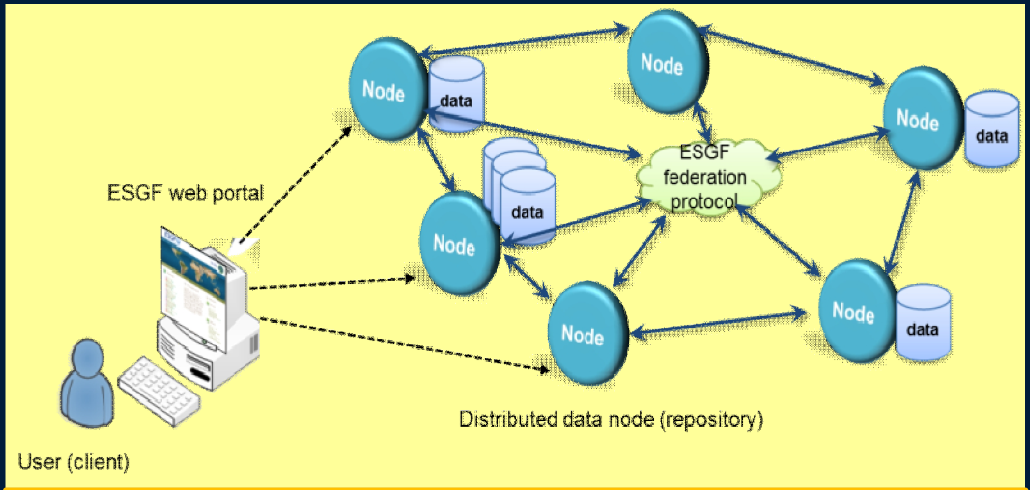
Key function		kisti-ndn-atmos
User Interface	Data search	To show .nc file name lists following DRS structure
	Metadata	Supported
	File downloading	Supported
	User-friendly functions	Sorting and key word based searching
Name translator		NDN name translation for valid climate data
Repository for NDN		To provide a repository using ndnfs-port

There have been significant code sharing between KISTI and CSU project, in order to develop each ndn-atmos SW package for climate application

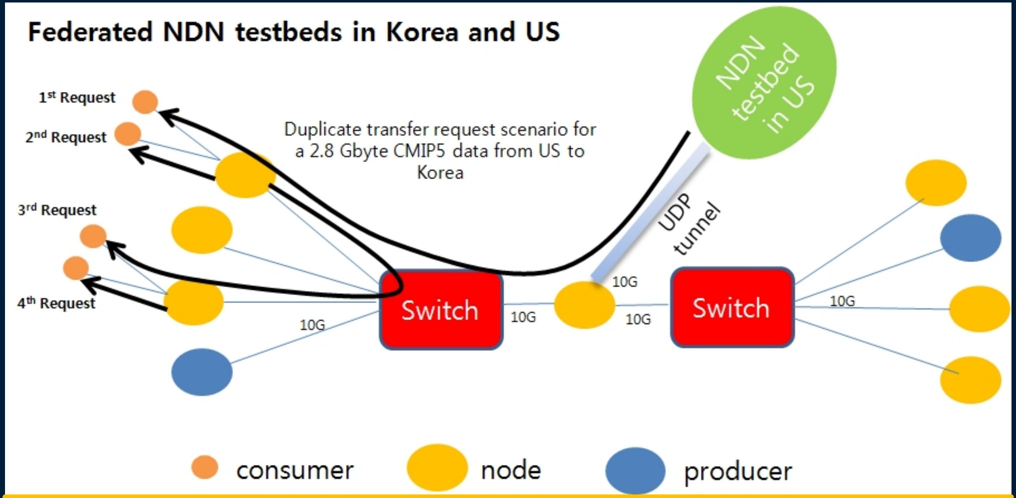
Climate Data Transfer by Federated NDN Testbed in Korea and US

- **Transfer by the Earth System Grid Federation (ESGF) infrastructure**
  - **ESGF: Distributed CMIP5 data management protocol in current IP based networks**
  - **Data explosion for duplicate big data requests results in BW waste**

- **Transfer by federated NDN testbeds**
  - **Smart transfer for duplicate big data requests**
  - **Change of traffic pattern results in traffic reduction in networks**
  - **Prevention of data explosion in networks**



ESGF architecture based CMIP5 delivery



NDN based CMIP5 delivery

- **Current works on federated NDN Testbed in Korea and US**
  - Interoperability for front and back-end systems in each doman
  - To create synchronized FIB tables to search for all CMIP5 data sets at each producer using NLSR
  - Caching scheme for large scale scientific data

Summary and Future Works

- Current climate data transfer by ESGF results in long time latency and high corrupted data rate.

- To provide large-scale scientific data with innovative transfer and management.

- To change traffic pattern in data-intensive science and to prevent data explosion in networks.

- NDN testbed with kisti-ndn-atmos package for climate application
  - Front-end system in consumer and back-end system in producer
  - To show original climate .nc file names following DRS and corresponding metadata sets
  - Key word based climate data search and downloading
  - To translate all .nc file names stored in the NDN repository to NDN names
  - Forwarding and caching of interest/data packets on climate modeling application

- Future works
  - Federated NDN testbed in Korea and US for climate modeling application
  - Performance analysis for ESGF and NDN based transfer
  - Caching and mobility to consider characteristics of large-scale scientific data