THREDDS in ESGF

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with
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netCDF C library, OPeNDAP
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Problems with THREDDS in ESGF v1

1. ESGF using version 3.x
    - 4-5 years old
    - many improvements, including security
2. Catalog code large and unoptimized
    - circa Java 1.0
    - earliest THREDDS code we wrote
3. TDS keeping all catalogs in memory
    - convoluted with state management
    - expect max ~100 catalogs / server, actual 5-50K
    - 10s of gigabytes of memory, very slow startup
4. Mutual lack of attention

Example set of ESGF catalogs

B:/esgf/badc/data1/esgcet/

- **catalogs** = 37,634
- **datasets** = 3,920,375
- **restrict** =3,882,732
- **ncml**=642,572 **ncmlOneFile**=471,270 (73%)
- **serviceType** (4)
  - GridFTPServer: count = 2,584,875
  - HTTPServer: count = 2,584,875
  - OpenDAPFiles: count = 2,584,875
  - gridded : count = 642,572

```
NcML
numberOfFiles  numberOfDatasets
            1: count = 471,270
            2: count = 50,200
            3: count = 29,213
            4: count = 14,616
            5: count = 2,527
            6: count = 8,458
            7: count = 13,305
            8: count = 2,061
            9: count = 843
              ...
          315: count = 4
          330: count = 5
          360: count = 64
          374: count = 82
          380: count = 8
          475: count = 8
          501: count = 10
          670: count = 10
          672: count = 23
         1000: count = 11
         1140: count = 58
         1956: count = 4
```

Improvements in TDS 5.0

- Complete rewrite of server catalog handling and state management
- Eliminate storing catalogs in memory
  - User-settable LRU cache for serving catalogs
- Refactor state management
- Persistent key/value store for state info
  - ChronicleMap creates a shared memory-mapped file
  - High performance, embedded, pure java
- Reinit / update TDS without shutdown

➔ eliminate obscene memory use by catalogs

➔ eliminate long startup times (15-20 min ESGF)

Catalog Configuration for ESGF

{tomcat}/content/thredds/threddsConfig.xml

```
<ConfigCatalog>
  <keepInMemory>100</keepInMemory>
  <reread>check</reread>
  <dir>/tomcat_home/content/thredds/cache/catalog/</dir>
  <maxDatasets>1000000</maxDatasets>
</ConfigCatalog>
```

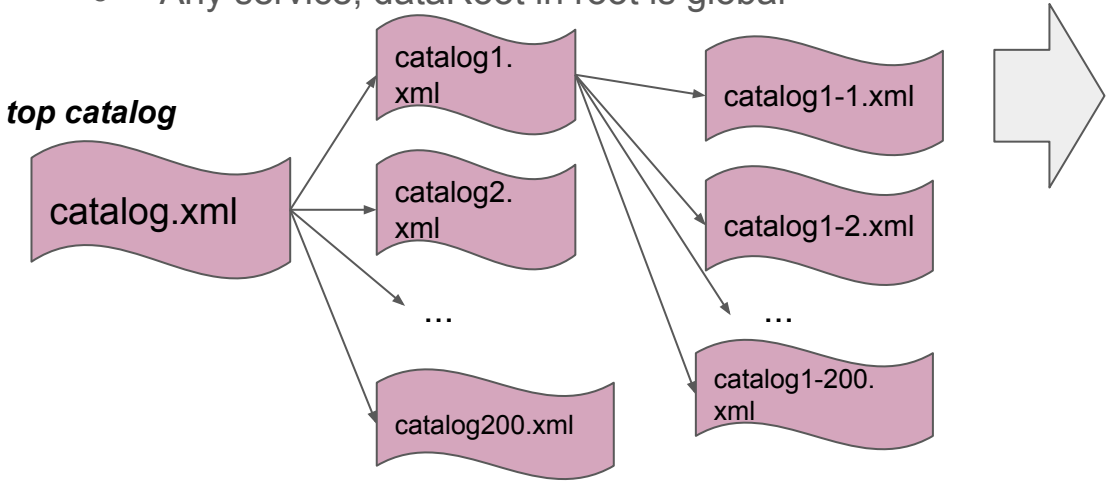
Catalog reread options

- ***always*** read all catalogs at startup
- ***check*** reac only changed catalogs
- ***trigger*** manual trigger of rewrite

Size of shared memory mapped file ~ 200 * maxDatasets

Other Catalog Improvements of interest

- Catalog Scans
  - read all catalogs in a directory
- Global Services, data roots
  - Any service, dataRoot in root is global



<dataRoot>
<dataRoot>
<service>
<service>
<dataset>
<dataset>
…
<dataset>

Example top catalog

```
<?xml version='1.0' encoding='UTF-8'?>
<catalog name="ESGF Master Catalog" version="1.2">

 <datasetRoot location="/esg/data" path="esg_testroot"/>
 <datasetRoot location="/esg/arc/data/" path="esg_obs4MIPs"/>
 <datasetRoot location="/esg/cordex/data/" path="esg_cordex"/>
 <datasetRoot location="/esg/specs/data/" path="esg_specs"/>

 <service base="/thredds/dodsC/" desc="OpenDAP" name="gridded" serviceType="OpenDAP">
  <property name="requires_authorization" value="false"/>
  <property name="application" value="Web Browser"/>
 </service>

 <service base="" name="fileservice" serviceType="Compound">
  <service base="/thredds/fileServer/" desc="HTTPServer" name="HTTPServer" serviceType="HTTPServer"/>
  <service base="gsiftp://cmip-bdm1.badc.rl.ac.uk/" desc="GridFTP" name="GridFTPServer" serviceType="
GridFTP" />
  <service base="/thredds/dodsC/" desc="OpenDAP" name="OpenDAPFiles" serviceType="OpenDAP" />
 </service>

 <catalogScan name="ESGF catalogs" path="esgcet" location="esgcet" />

</catalog>
```

TDS Data Services Review

- Bulk File download
- DAP-2 missing some features of netCDF extended model
  - signed bytes, 64-bit ints,
  - Groups
  - shared dimensions (but workable)
- DAP-4: full extended model, but not production ready yet
  - Hyrax server (alpha)
  - TDS server and NetCF-Java client (alpha)
  - No C client library (!)

Other TDS Data Services of interest

- Netcdf Subset Service
  - subset in coordinate space (like WMS, WCS)
  - return netcdf3 or netcdf4 (regardless of original format)
  - REST API
  - example
  - beta / close to production ready
- cdmremote web service
  - index and coordinate space access
  - full CDM extended data model
  - targeted to give python clients full access to CDM stack
  - alpha / APIs still being tweaked
- WMS, WCS Servers

New Features in NetCDF-Java library 5.0

- Major version ← → API changes
- Complete rewrite of client catalog handling
  - simplification of the catalog specification
- Explicit DataType for unsigned byte, short, int, long
- Variable Length (vlen) Dimensions and Variables clarified and implemented
  - use in nested structures
- Extensive reworking to use Java 7 features
  - try-with-resources (AutoCloseable)
  - for-each (Iterable)
- Continued evolution of GRIB Collection handling
- Complete reworking of Grid FeatureType
  - handle very large collections
  - subsetting in coordinate, not index space

TDS 5.0 Summary

- Catalog rewrite is stable for 6 months
  - Fixed some problems in latest release
- File Serving, OPeNDAP mostly unchanged for many years
  - ESGF use limited to these
- WMS is being upgraded to ncWMS 2.0
  - not ready yet, turned off in current version
- GRIB, Grid Feature rewritten for scalability and performance
  - NCSS, WMS, WCS, all depend on this
- APIs are (mostly) frozen now
- 5.0 release candidate this winter
- 5.x stable release by spring

TDS Software Engineering

- Github workflow: open source collaborative development
- Test-driven development
  - Travis Continuous Integration (CI)
  - Jenkins Unit testing running on Amazon cloud
  - Coverage
- Coverity defect tracking : static defect analysis tool
  - 4500 defects fixed
- automated build system / dependency management
  - make -> ant -> maven -> gradle
  - nexus for maven artifacts
- Active development
  - Unidata/NSF support 3 FTE

```
> git clone git://github.com/Unidata/thredds.git thredds
> cd thredds
> git checkout master
> ./gradlew assemble
```

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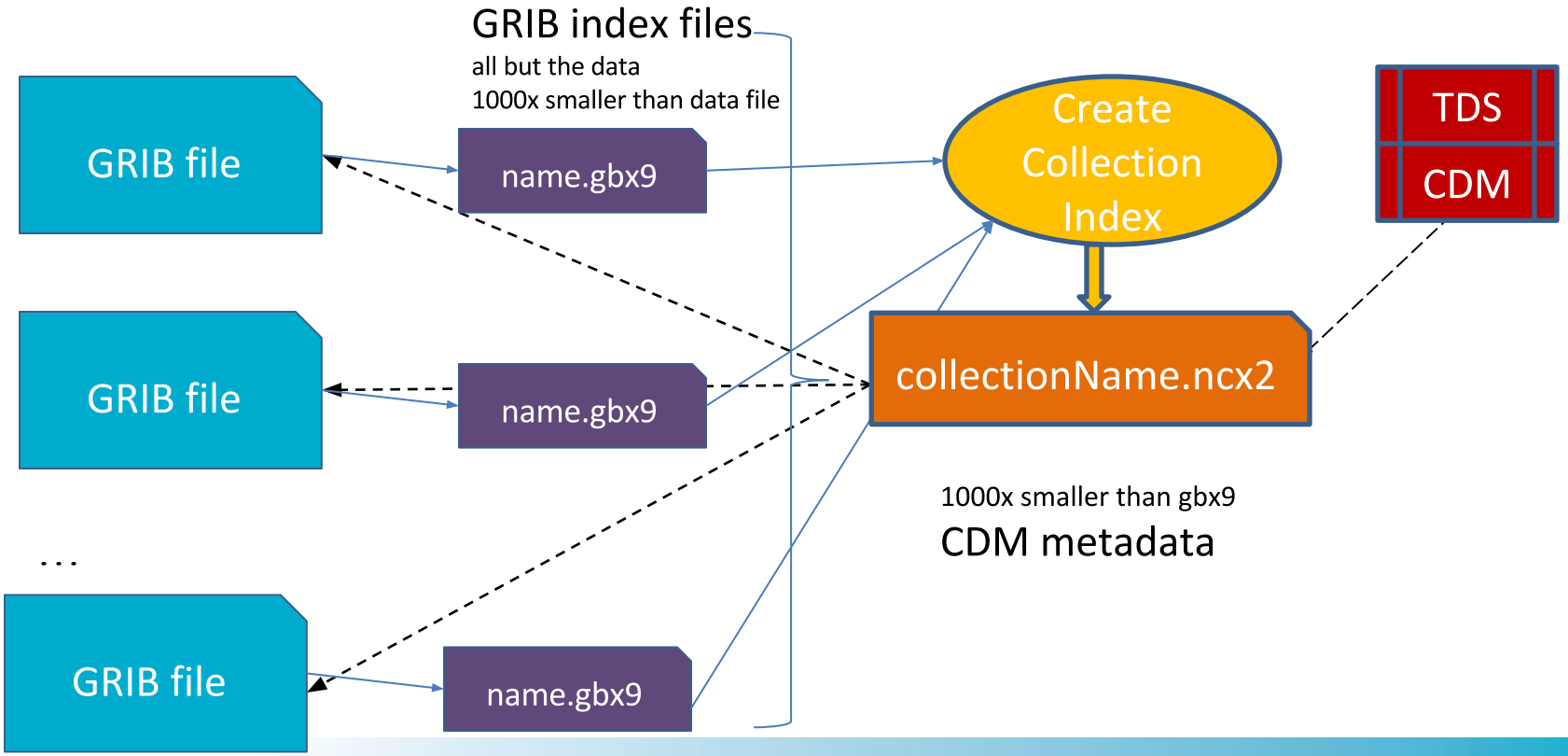
Aggregations → Feature Collections

- DatasetScan in Catalog
  - serve individual files, but minimize config burden
- NcML Aggregations
  - create logical datasets on-the-fly
- Feature Collections
  - server side, performant
- GRIB
  - NCDC, NCAR RDA
  - millions of files in a single logical datasets
- GRID (TBD)
  - generalize FMRC (Forecast Model Run Collections)
  - GridDataset → CoverageDataset

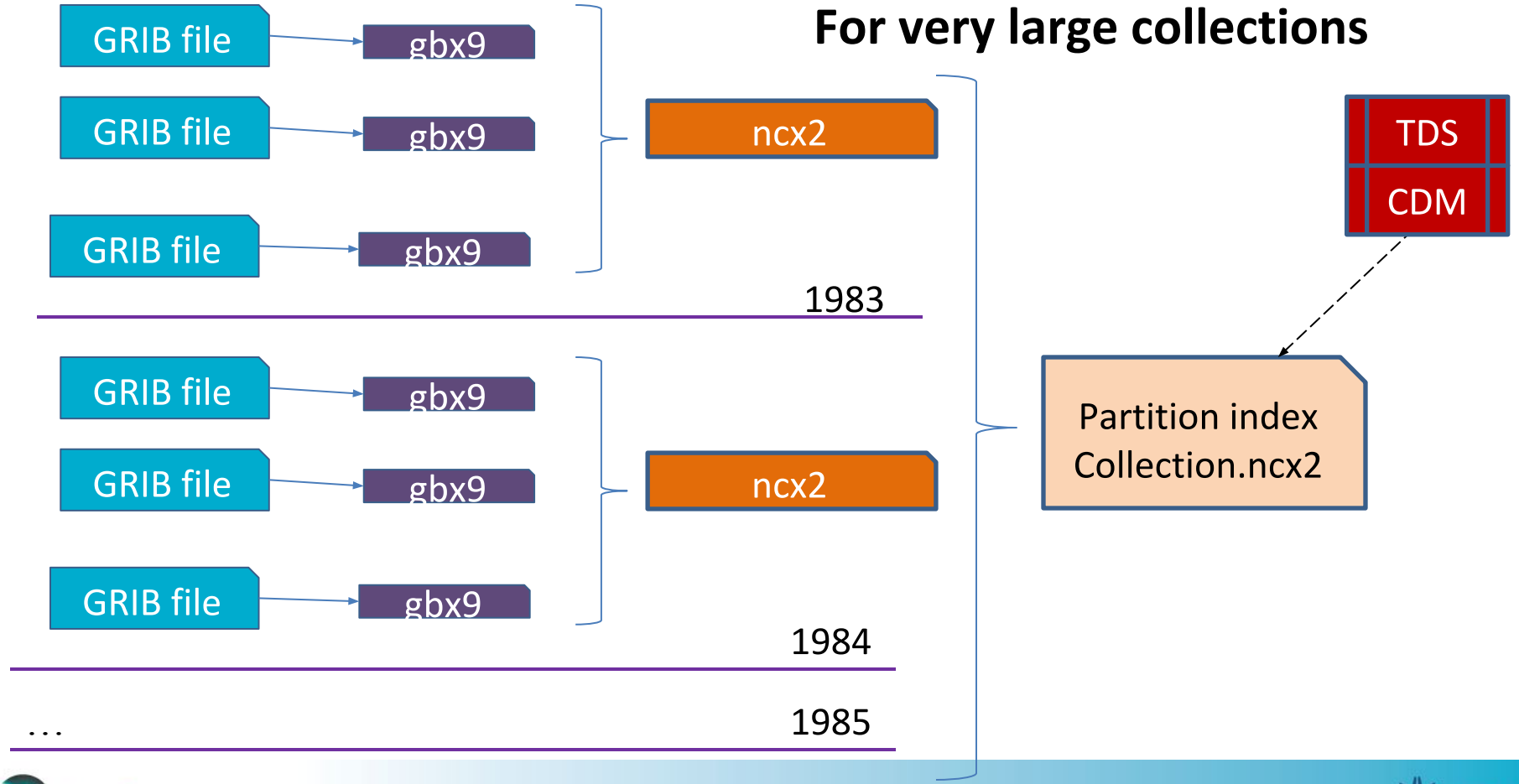
GRIB Feature Type catalog configuration

```
1)<featureCollection featureType="GRIB1" name="rdavm partition none" path="gribCollection/none">
2)  <metadata inherited="true">
3)    <dataFormat>GRIB-2</dataFormat>  <!--not used -->
      <serviceName>all</serviceName>
      <dataType>Grid</dataType>
    </metadata>

4)  <collection name="ds083.2-none"
5)          spec="Q:/cdmUnitTest/gribCollections/rdavm/ds083.2/PofP/**/.*grib1"
6)          timePartition="none"/>

7)    <update startup="never" trigger="allow"/>
8)    <tdm rewrite="test" rescan="0 0/15 * * * ? *" trigger="allow"/>
9)    <gribConfig datasetTypes="TwoD Latest Best" />
</featureCollection>
```

GRIB collection indexing



GRIB time partitioning (nested heirarchies)
For very large collections



Summary

- TDS / Netcdf-Java is alive and well
  - Personell, software engineering
- TDS 5.0 is ready for ESGF
  - Memory problem is fixed
  - Scales to any number of catalogs
- Other services interesting to ESGF
  - Netcdf subset service
- Ongoing innovations
  - make CDM features avail in python