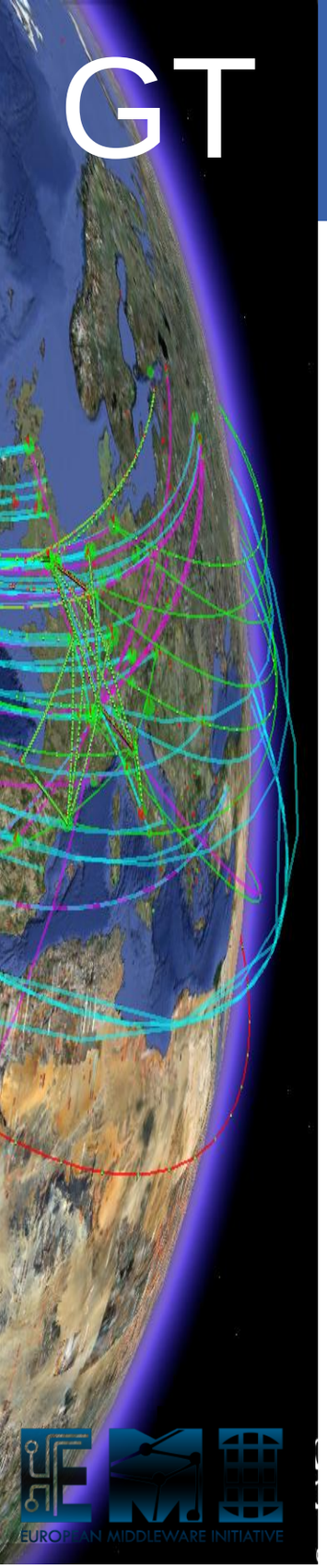

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Dynamic Federations

Seamless aggregation of open-protocol-based storage endpoints

Fabrizio Furano (presenter)
Patrick Fuhrmann
Paul Millar
Daniel Becker
Adrien Devresse
Oliver Keeble
Ricardo Brito da Rocha
Alejandro Alvarez

Credits to ShuTing Liao (ASGC)

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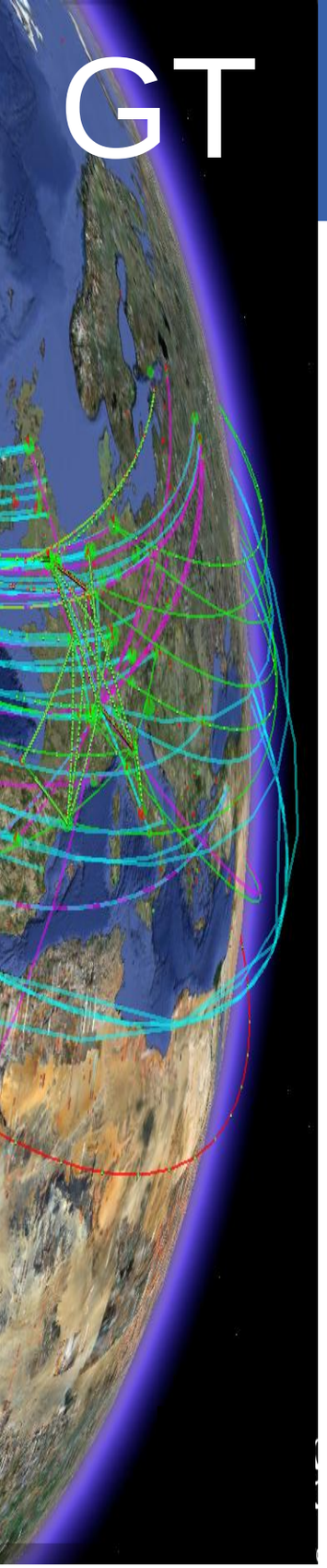

Dynamic Federations

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- Federating storage means giving seamless access with thin, standard clients
  - without the need of switching communication protocol
- We know several use cases
  - Easy, direct job/user data access, WAN friendly
  - Failover is part of the concept
  - Friend sites can share storage and bandwidth
  - Easy access to shared things like conditions
  - Automatically detect if the endpoint is working
  - Federate un-indexed fast changing things, like SQUID caches
  - Federate third party outsourced HTTP/DAV servers (also clouds)
  - Federate the information of one or more experiment's DBs (e.g. two LFCs), also considering what's in the SQUID caches worldwide
    - Transparent, direct access to the official replicas AND the cached ones as well
  - Support for advanced site choices, e.g. self healing
- We like HTTP and DAV
- We want to take the concept to the next level

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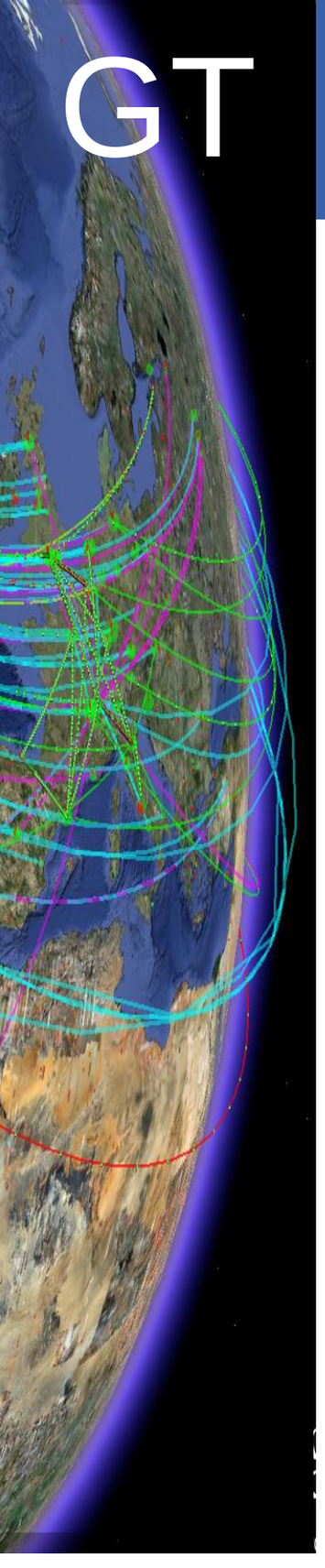

Dynamic Federations

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- Technically “loosely coupled storage systems”
- Idea: a single entry point for a federation of endpoints
  - “lonely”, un-indexed storage clusters (e.g. dCache, DPM, plain HTTP servers)
    - Caches fall in this category
  - site/VO catalogues (e.g. LFCs) indexing their storage elements
- Idea: **make it dynamic**
  - The task of federating is done ***on the fly***, just communicating with the endpoints
- This entry point knows its endpoints, can redirect clients to them, it can merge and present their metadata to browsing clients

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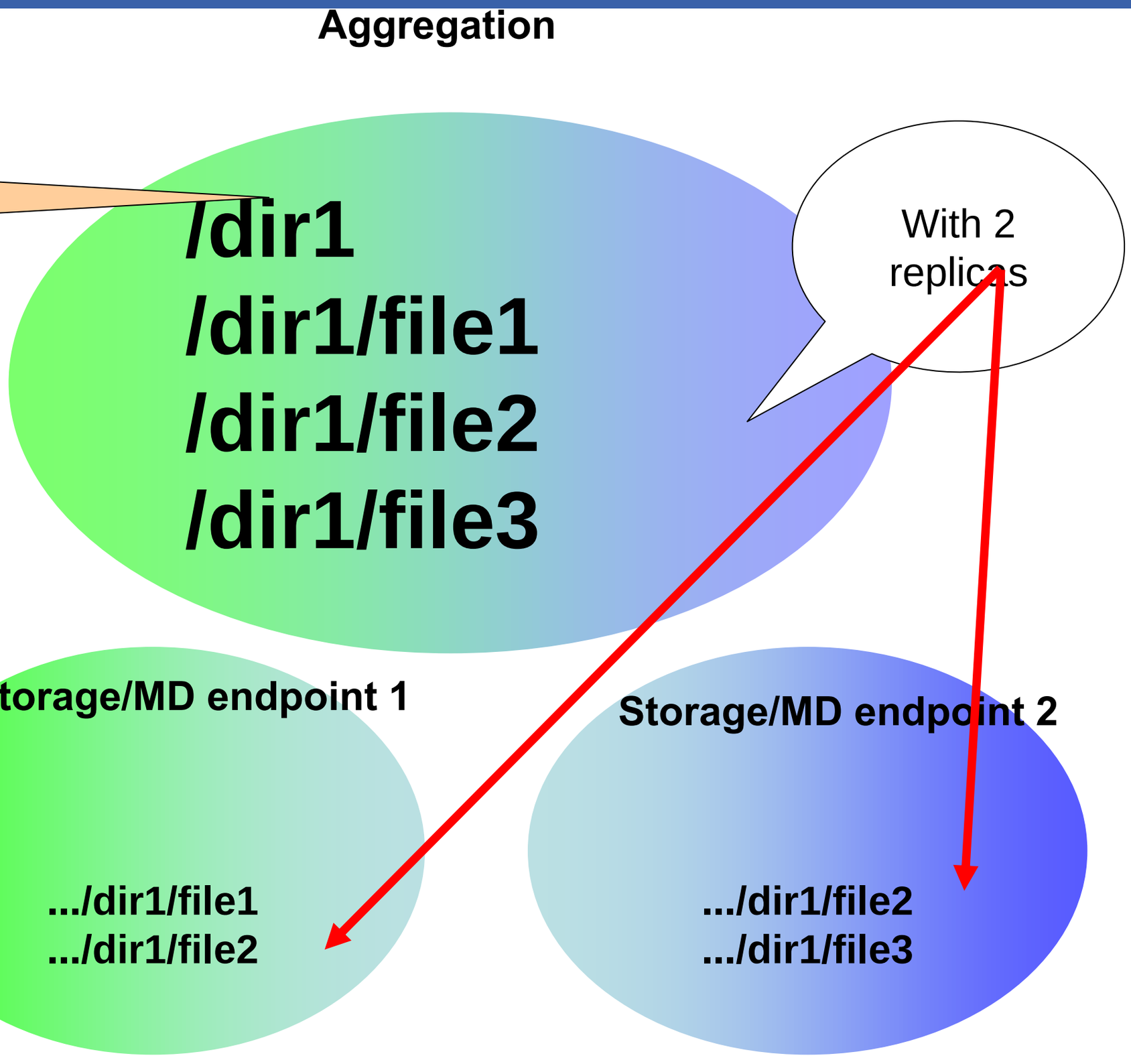
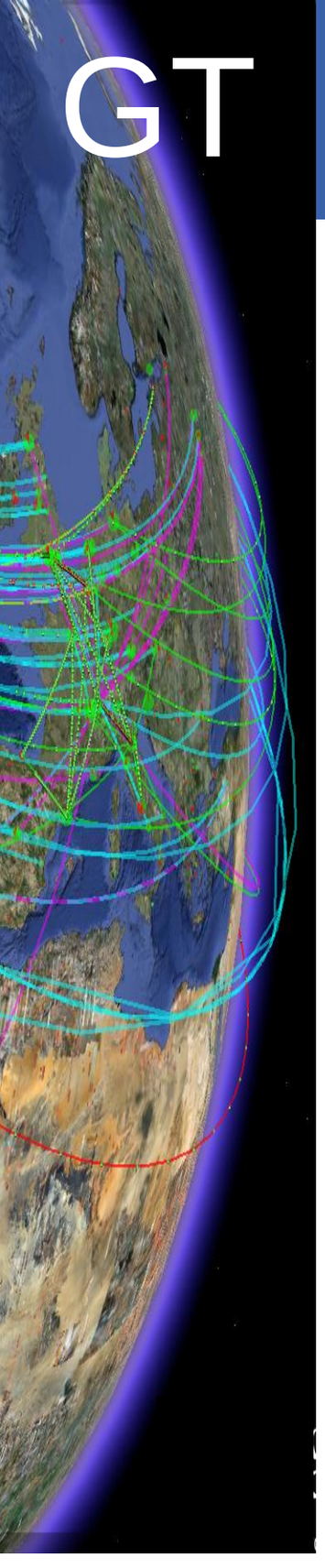
The basic idea

We see this

All the metadata interactions are hidden

NO persistency needed here, just efficiency and parallelism





Dynamic Federations

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- What's the goal?
  - Make different storage clusters be seen as one
  - Make global file-based data access seamless
- How should this be done?
  - No strange APIs, everything looks "banal"
  - Participate in the HTTP HEP/HPC ecosystem that is growing now
  - Use dynamic systems that are easy to setup/maintain:
    - no complex metadata persistency
    - no DB babysitting (keep it for the experiment's metadata)
    - no replica catalogue inconsistencies, by design
  - Head to high performance
- Local SE as a preference, give the freedom to point to an efficient and reliable global federation
  - Optimize redirections based on **on-the-fly client-data proximity**
  - Avoid inconsistencies, just looking at where the files are now, and at the real status of the endpoint (working/not working)
  - Limit complexity: read only (by now), as usually writes happen to well-known, close islands

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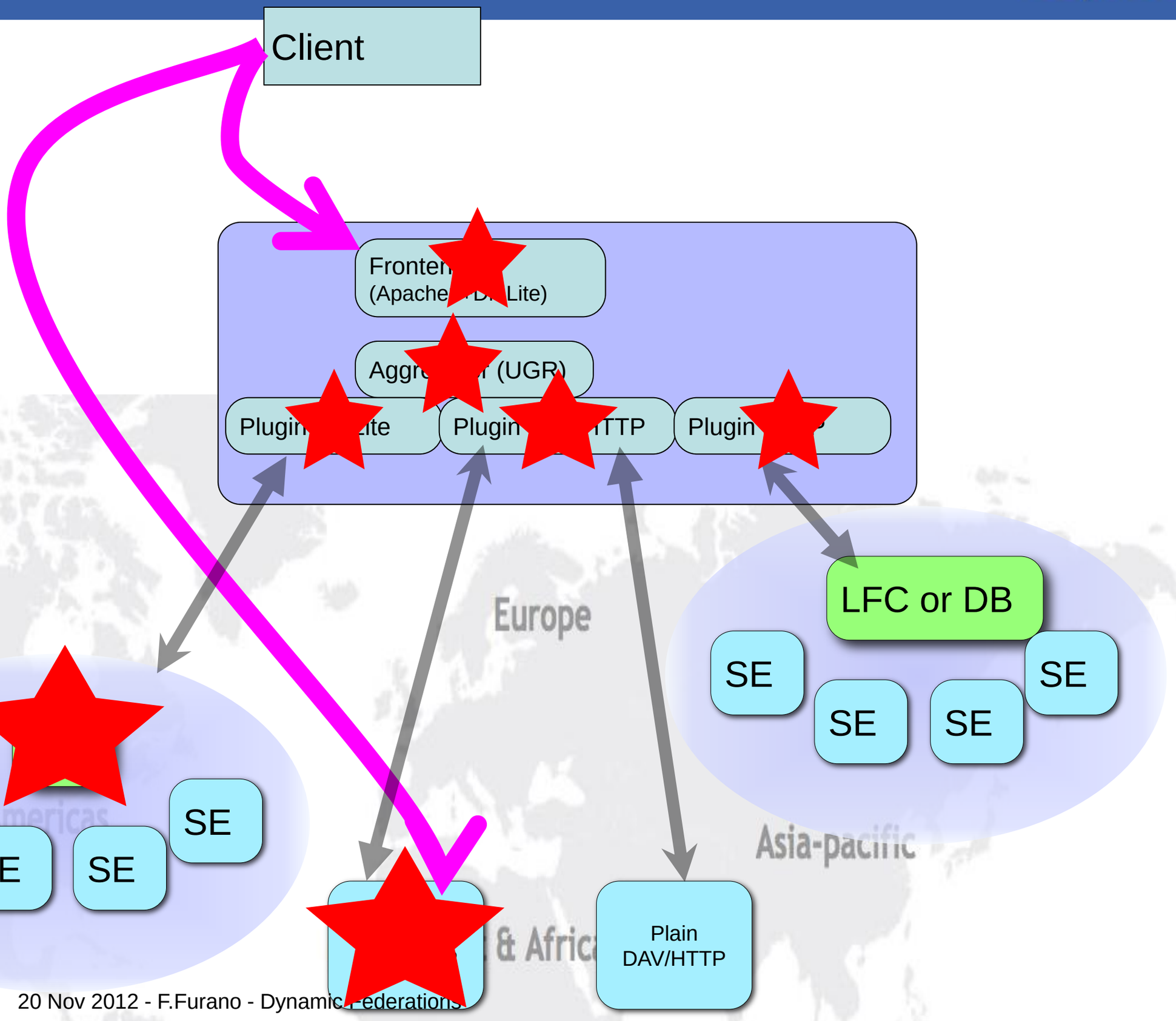
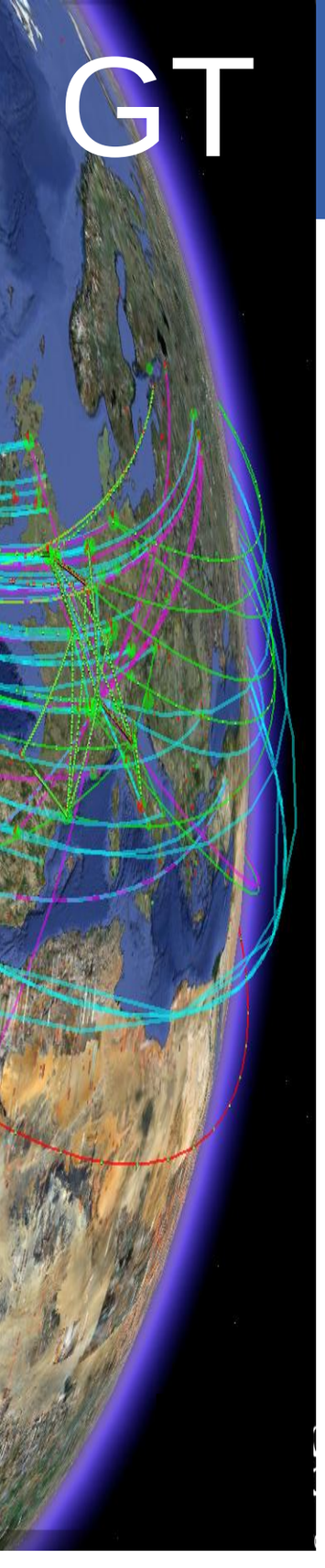
Example


Client
Fronten
(Apache
Lite)
Aggr
(UGR)
Plugin
ite
Plugin
TTP
Plugin
LFC or DB
SE
SE
SE
SE
SE
SE
SE
SE
Plain
DAV/HTTP
Europe
Asia-pacific



Demo

- We have a stable demo testbed, using HTTP/DAV
  - Federator head node in DESY: http://federation.desy.de/myfed
  - Federating a number of endpoints. This list changes, as we agree on what to federate:
    - a DPM instance at CERN
    - a DPM instance at ASGC (Taiwan)
    - a dCache instance in DESY
    - a Cloud storage account by Deutsche Telecom
    - two endpoints in LBNL
- The feeling it gives is surprising
  - Metadata performance is in avg much higher than contacting the endpoints
- We see the directories as merged, as if it were only one system
- 10K files are interleaved in a 4-levels deep directory /myfed/dteam/ugrtest/interleaved
  - Oddly-numbered files are at CERN
  - Evenly-numbered files are at Desy
- 10K files have 2 replicas in DESY and CERN: /myfed/dteam/ugrtest/all
- One more interesting directory, with replicated files: /myfed/atlas/fabrizio/
- When a choice is possible, clients are redirected to the endpoint that is closer to them

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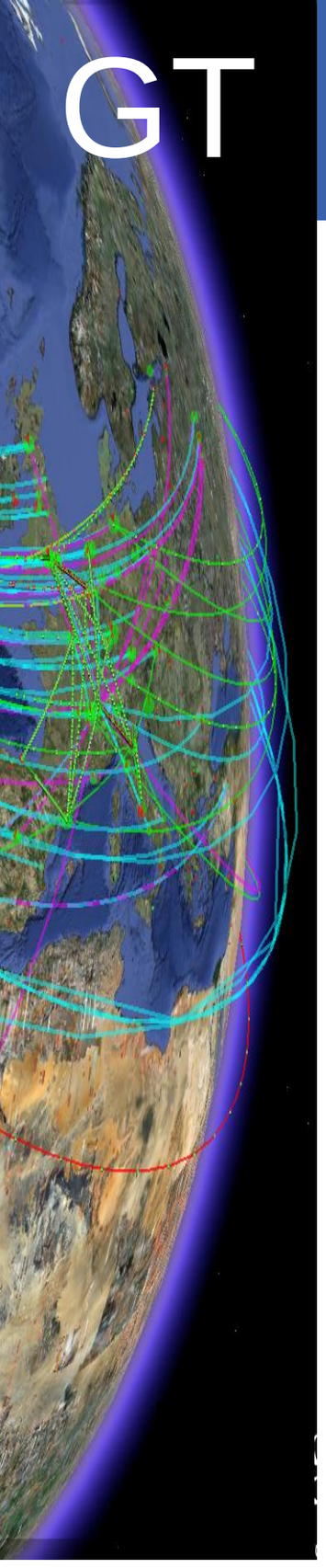

Dynamic Federations

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- Currently in advanced beta, available!
- Technically TODAY we can aggregate:
  - dCache DAV/HTTP instances
  - DPM DAV/HTTP instances
  - LFC DAV/HTTP instances
  - Cloud DAV/HTTP services
  - Native LFC and DPM databases
  - Anything that can be plugged into DMLite (the new architecture for DPM/LFC)
  - **Can be extended to other metadata sources**
- The system also can load a “Geo” plugin
  - Gives a geographical location to replicas and clients
  - Allows the core to choose the replica that is closer to the client
- The Geo plugin that we wrote uses GeoIP (free)

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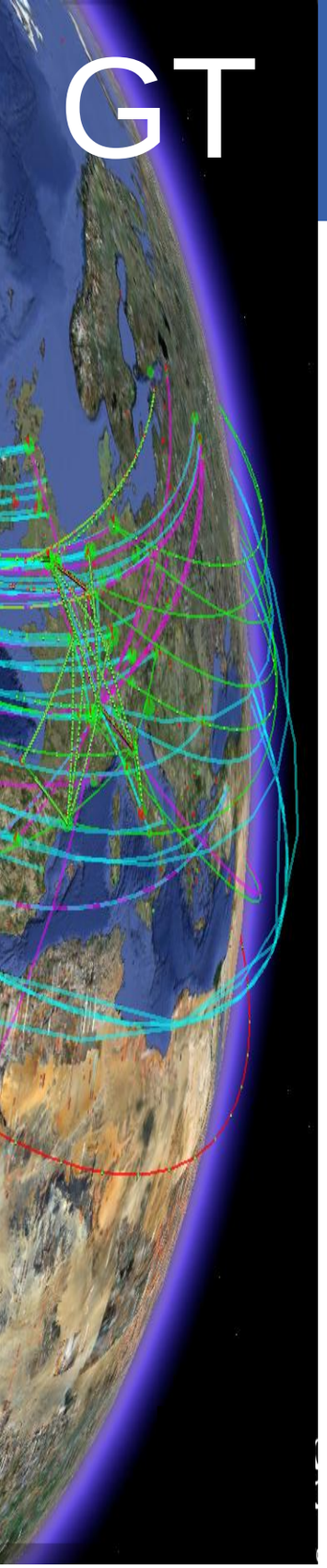

Why HTTP/DAV?

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- **It's there**, whatever platform we consider
  - A very widely adopted technology
- **We (humans) like browsers**, they give an experience of **simplicity**
- Goes towards **convergence**
  - Users can use their devices to access their data easily, out of the box
  - Jobs just go straight to the data
- With direct access to data, pre-location becomes an optimization choice, not a constraint of the technology

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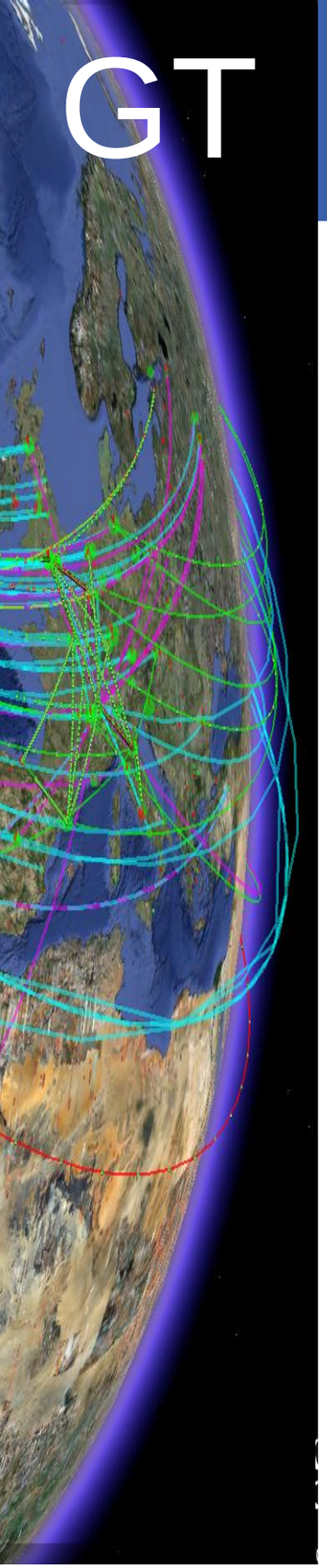

System design

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- A system that only works is not sufficient
- To be usable, it must privilege speed, parallelism, scalability
- The core component is a plugin-based component called originally “Uniform Generic Redirector” (Ugr)
  - Can plug into an Apache server thanks to the DMLITE and DAV-DMLITE modules (by IT-GT)
  - Composes on the fly the aggregated metadata views by managing parallel tasks of information location
    - Never stacks up latencies!
  - Makes browsable a sparse collection of file/directory metadata
  - Able to redirect clients to replicas of hosts known to be working in that moment
  - By construction, the responses are a data structure that models a partial, volatile namespace
  - Keep them in an LRU fashion and we have a fast 1st level namespace cache
    - Peak performance is ~500K->1M hits/second per core by now

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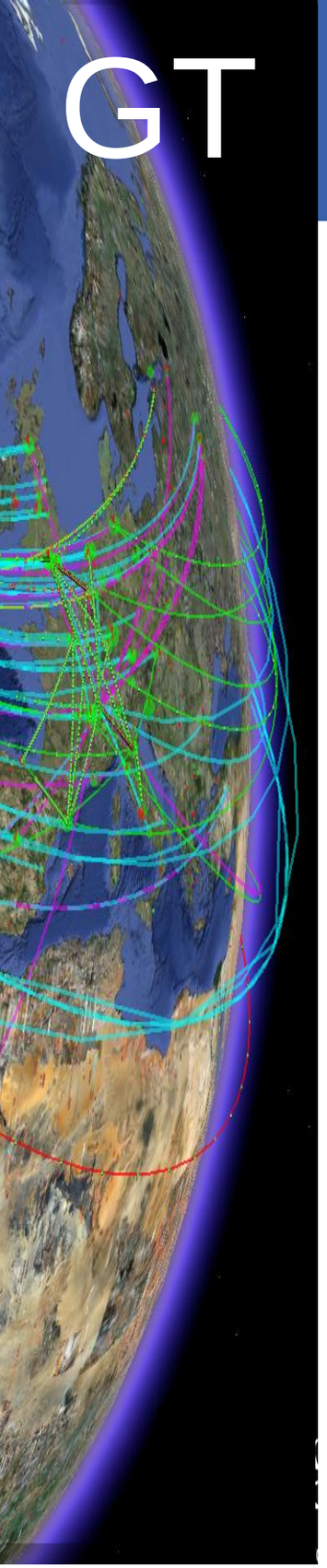

Endpoints

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- **Pure DAV** endpoints give *metadata of files*
  - Listings, directories, stat, ...
- **Pure HTTP** endpoints give *replicas of files*
  - and no way to know their metadata
- **DAV+HTTP** endpoints give *both*
- Other kinds of endpoints... depends!

- Sysadmins decide the service that they want to provide
- UGR can *quickly* discover metadata and replicas in a population of many endpoints
- UGR can *quickly* discover metadata and replicas even if they are not yet shown in a cached listing

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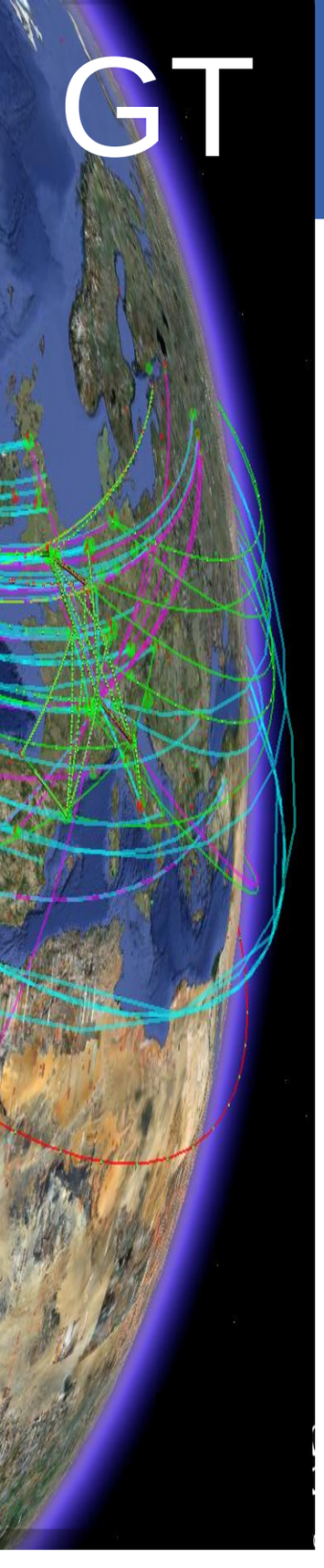

Focus: performance

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- Performance and scalability have primary importance
  - Otherwise it’s useless...
- Full parallelism
  - No limit to the number of outstanding clients/tasks
  - No global locks/serializations!
  - The endpoints are treated in a completely independent way
  - Thread pools, prod/consumer queues used extensively (e.g. to stat N items in M endpoints while X clients wait for some items)
- Aggressive metadata caching
  - A relaxed, hash-based, in-memory partial name space
  - Juggles info in order to always contain what’s needed
  - Stalls clients the minimum time that is necessary to juggle their information bits
  - Peak caching perf per CPU core: 0.5~1M stats/sec
- Spurred a high performance DAV client implementation (DAVIX)
  - Wraps DAV calls into a POSIX-like API, saves from the difficulty of composing requests/responses
  - Loaded by the core as a “location” plugin
  - Performance is privileged: uses libneon w/ sessions caching
  - Compound list/stat operations are supported

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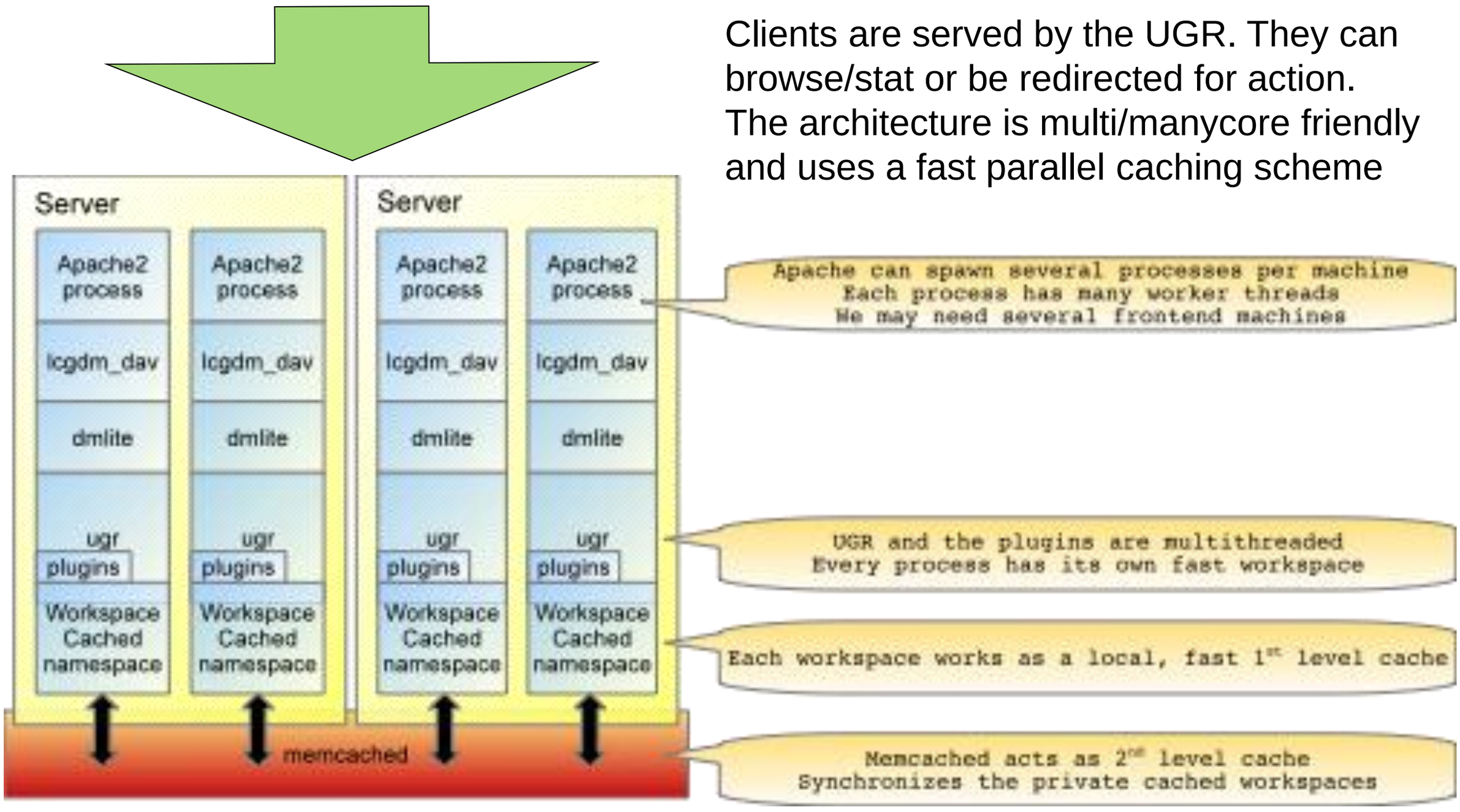
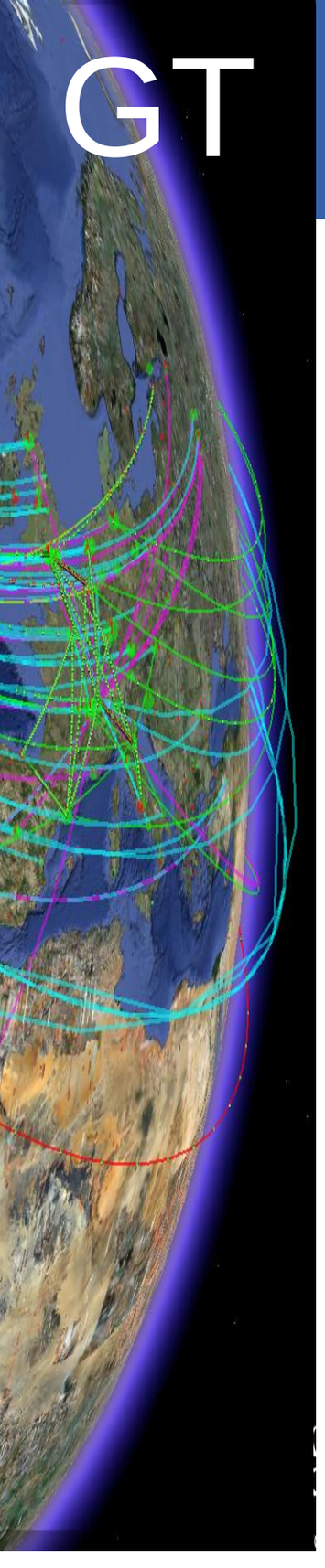
Concurrent metadata caching

Clients come and are distributed through:
- different machines (DNS alias)
- different processes (Apache config)



Clients are served by the UGR. They can browse/stat or be redirected for action. The architecture is multi/manycore friendly and uses a fast parallel caching scheme



A performance test

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- Measuring the worst case performance becomes difficult
  - The cache caches also the intermediate actions, e.g. the directory lookups in a path
- Two endpoints: DESY and CERN (poor VM)
- One UGR in DESY (federation.desy.de)
- 10K files are interleaved in a 4-levels deep directory
  - Oddly-numbered files are at CERN
  - Evenly-numbered files are at Desy
- The test (written in C++) invokes Stat only once per file, using 100 to 1500 parallel clients doing stat() at the maximum pace from 3 machines
  - The clients run at CERN
  - Hence it's supposed to be a worst-case, measuring the full roundtrip. In practice the cache has a role anyway, as the files share the path.
  - The crude speed of 2K stats/s per frontend machine is satisfying. Seems somehow capped by Apache, as the backend UGR is up to 100 times faster

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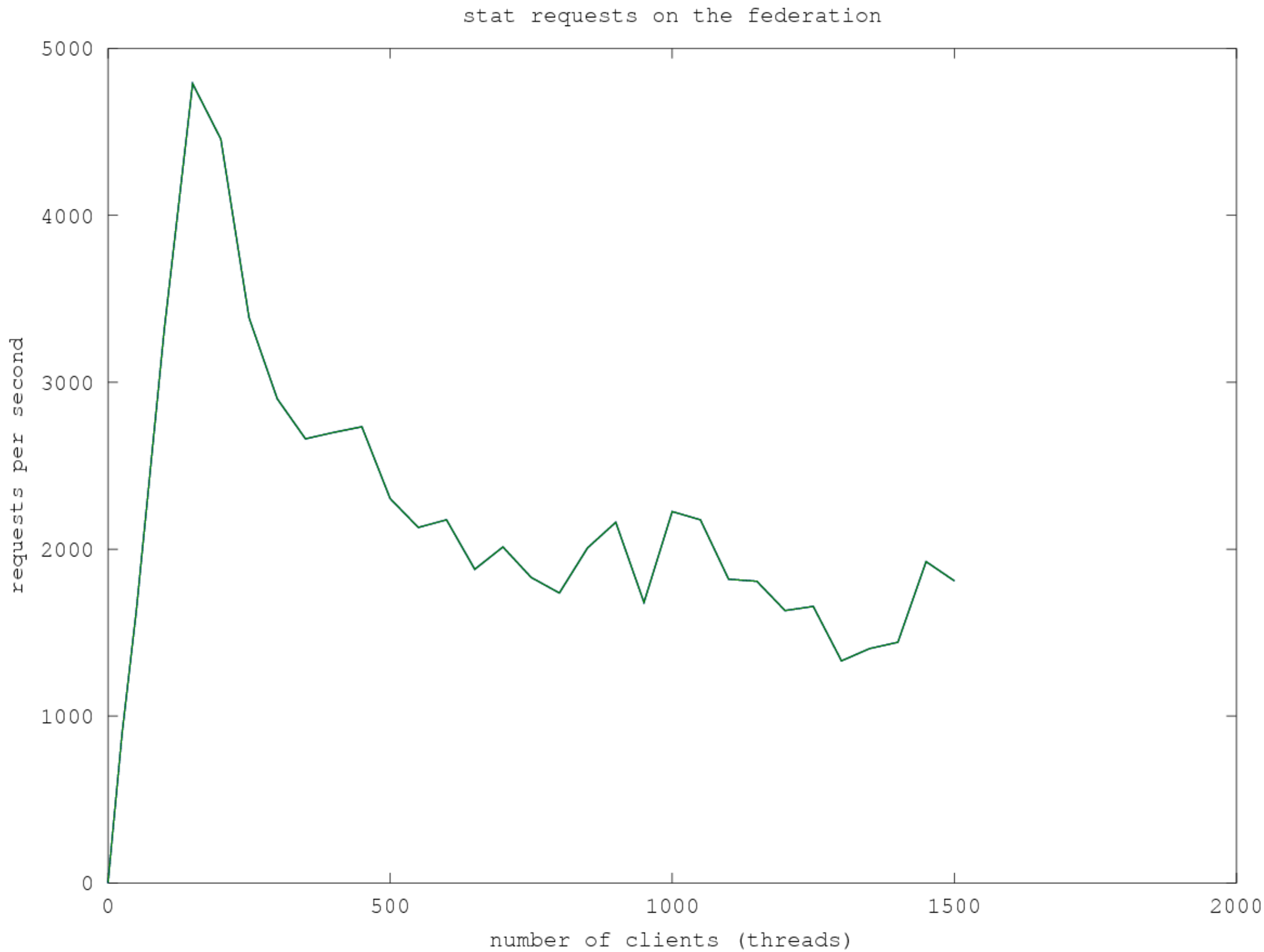
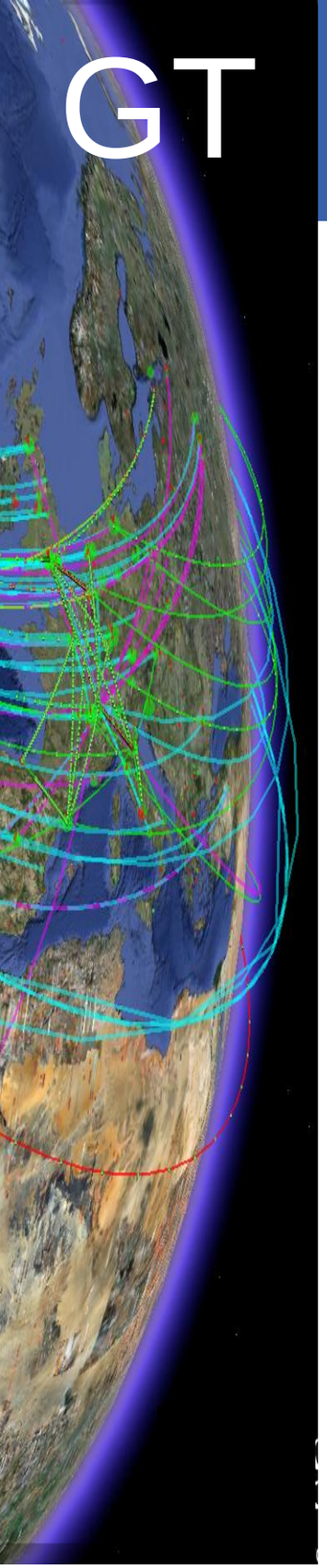
WAN access (CERN-DESY)





Next steps

- Release our beta, as the nightlies are good
- Improve the Wiki page, consider a website
- More massive tests, with many endpoints, possibly distant
- Immediate sensing of changes in the endpoints' content, e.g. add, delete
  - SEMsg in EMI2 SYNCAT would be the right thing in the right place
- Some more practical experience (getting used to the idea, using SQUIDs, CVMFS, EOS, clouds,... <put your item here>*)
- Power users helping in getting the best out of the system
  - Cooperation is very appreciated

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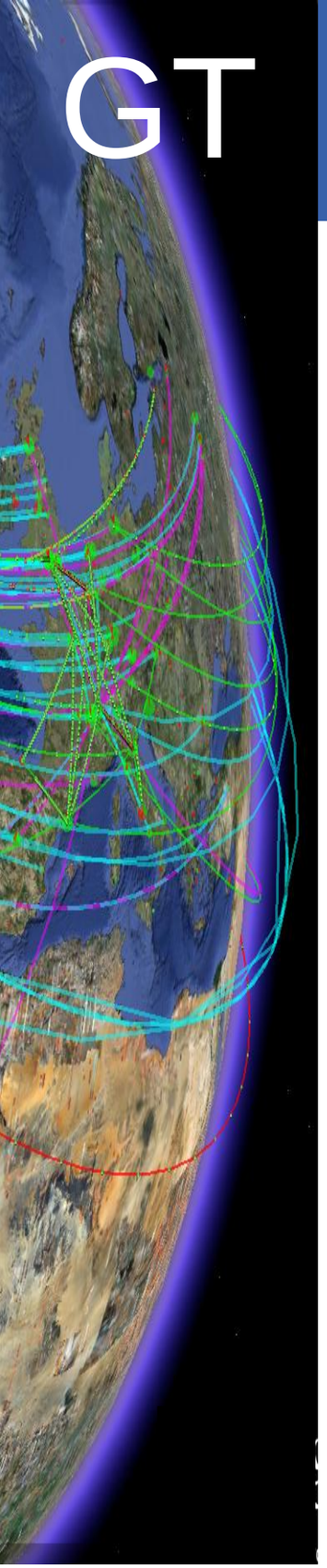

Get started

- Get it here:
  - https://svnweb.cern.ch/trac/lcgdm/wiki/Dynafeds
- What you can do with it:
  - Easy, direct job/user data access, WAN friendly
  - Friend sites can share storage
  - Storage-less sites, storage-only sites
  - Federating catalogues
    - Combining catalogue-based and catalogue-free data

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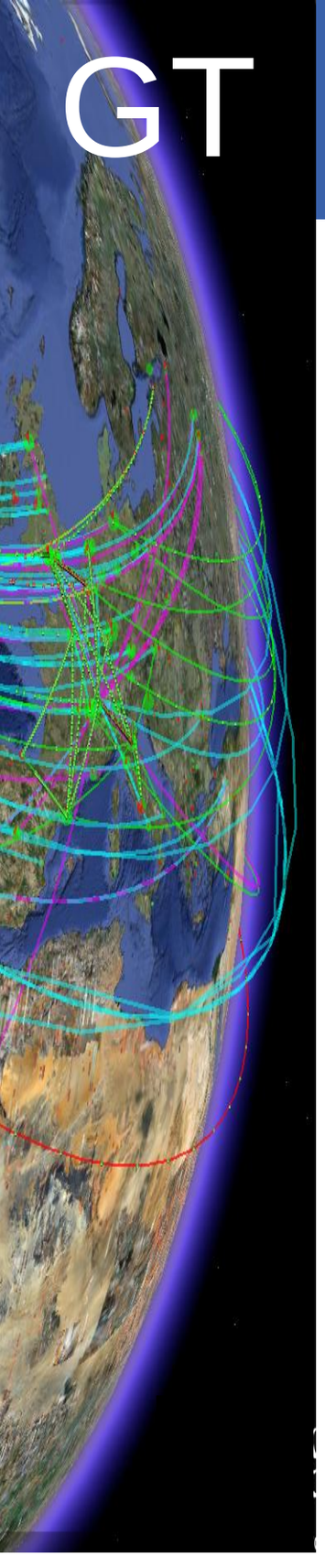

Xrootd and HTTP

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- Many instances of xrootd, not only HEP
  - Generally high quality deployments of a high quality framework
  - Sometimes very important ones (e.g. CERN with EOS)
  - Advanced features: tapes, data movements, monitoring, etc.
- Many instances of http/dav compliant SEs
- Once a site/organization has chosen a framework, changing it can be very expensive
  - Also quality of service is at risk
- Risk is having islands of protocols within the same community
- Risk is having to write glue code in the client applications, to wrap the two protocols

- DPM can join an Xrootd federation and an HTTP one as well
- dCache too, STORM has GPFS behind
- How to accommodate Xrootd-based SEs in an HTTP environment?

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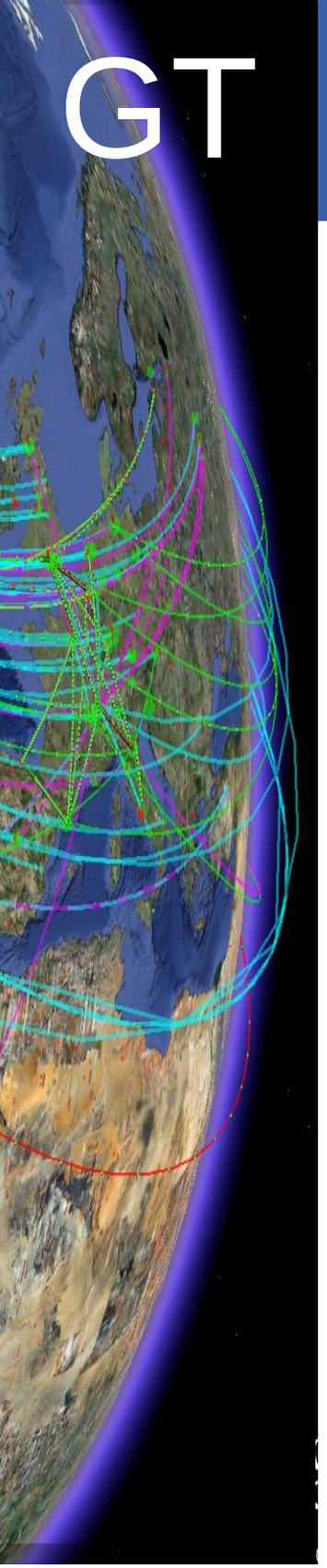

An XrdHTTP plugin

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- ...writing an HTTP plugin for the Xrootd framework!
- Evaluation work started, to evaluate the needed effort:
  - support basic HTTP[S] and DAV with the DM extensions (replicas, etc.)
  - plug into the framework to use its features (e.g. tapes or monitoring) without reconfiguring the site
- A newer version of the Xrootd framework will drastically reduce the need for code duplication and the effort
- Work in progress...
- Goal is getting the best from each system or framework and respect the choices

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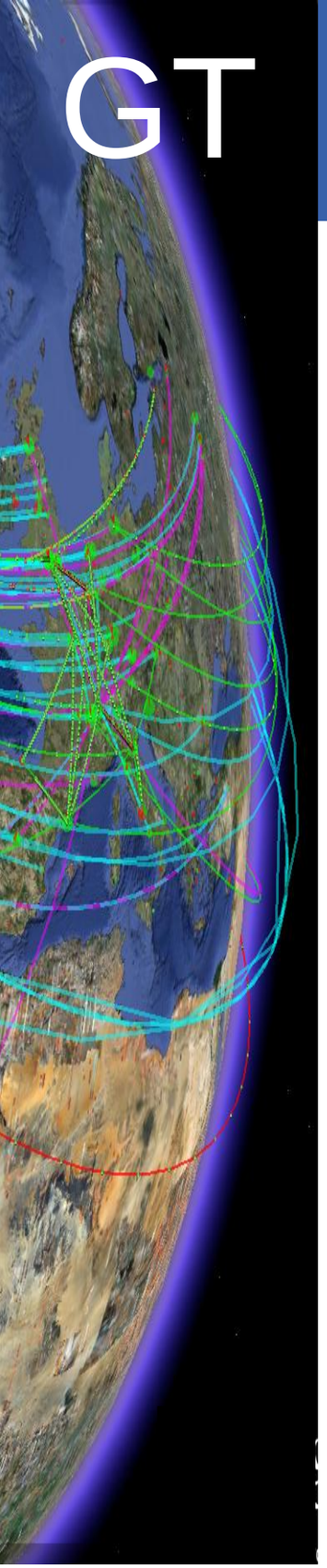

Conclusions

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- Dynamic Federations: an efficient, persistency-free, easily manageable approach to federate remote storage and metadata endpoints
- Usable for fast changing caches and clouds
- Gives ways to solve some nasty Data Management problems
- Work in progress, status is very advanced, demoable, installable, documented.
- There will be an Application Area seminar on the 27th, about the whole HTTP story... do not miss it!
  - https://indico.cern.ch/conferenceDisplay.py?confId=218328

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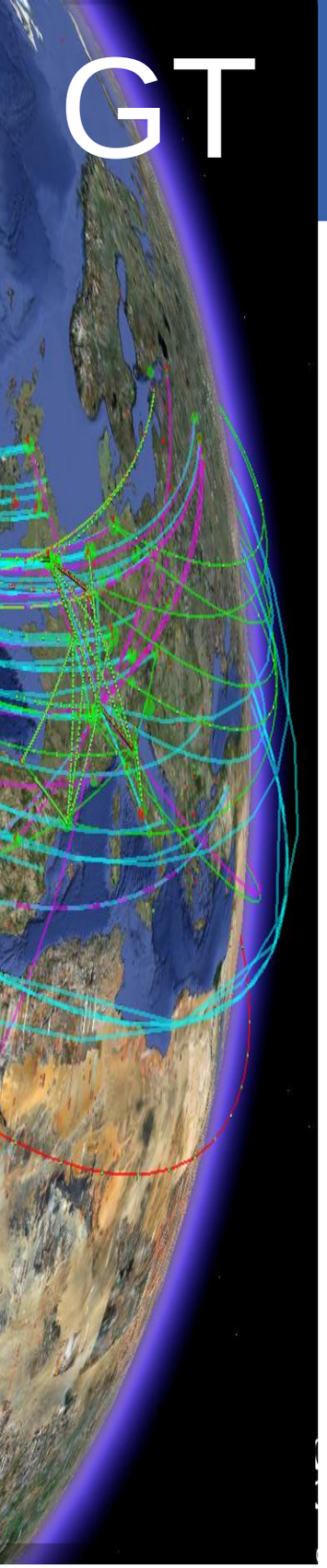

Thank you

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- Questions?

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