How to make a petabyte ROOT file: proposal for managing data with columnar granularity

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Motivation: start by stating the obvious

ROOT's selective reading is very important for analysis.

Datasets have about a thousand branches[1], so if you want to plot a quantity from a terabyte dataset with `TTree::Draw`, you only have to read a few gigabytes from disk.

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Because... because...

Evidence that it matters: the CMS NanoAOD project

Stated goal: to serve 30–50% of CMS analyses with a single selection of columns.

Need to make hard decisions about which columns to keep: reducing more makes data access easier for 50% of analyses while completely excluding the rest.

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There's a steep popularity distribution across columns, but we cut it abruptly with file schemas (data tiers).

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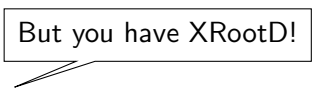

Except for the simplest TTree structures, we can't pull individual branches out of a file and manage them on their own.

But you have XRootD!

Yes, but only ROOT knows how to interpret a branch's relationship with other branches.

What would it look like if we could?

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CREATE TABLE derived_data AS
    SELECT pt, eta, phi, deltaphi**2 + deltaeta**2 AS deltaR
    FROM original_data WHERE deltaR < 0.2;
```

creates a new `derived_data` table from `original_data`, but *links*, rather than *copying*, `pt`, `eta`, and `phi`.[2]

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For users, there is much less cost to creating derived datasets— many versions of corrections and cuts.

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(the "ROOT becomes the database" approach)

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- No user-facing partition boundaries: huge dataset appears as one TTree.
- Users work in shared TFile: home TDirectories; permissions managed by database.

Direct connection

User launches ROOT, does `TFile::Open("rootdb://data.cern/cms")`, and extracts objects for analysis: `Get("home/username/myhist")->Draw()`.

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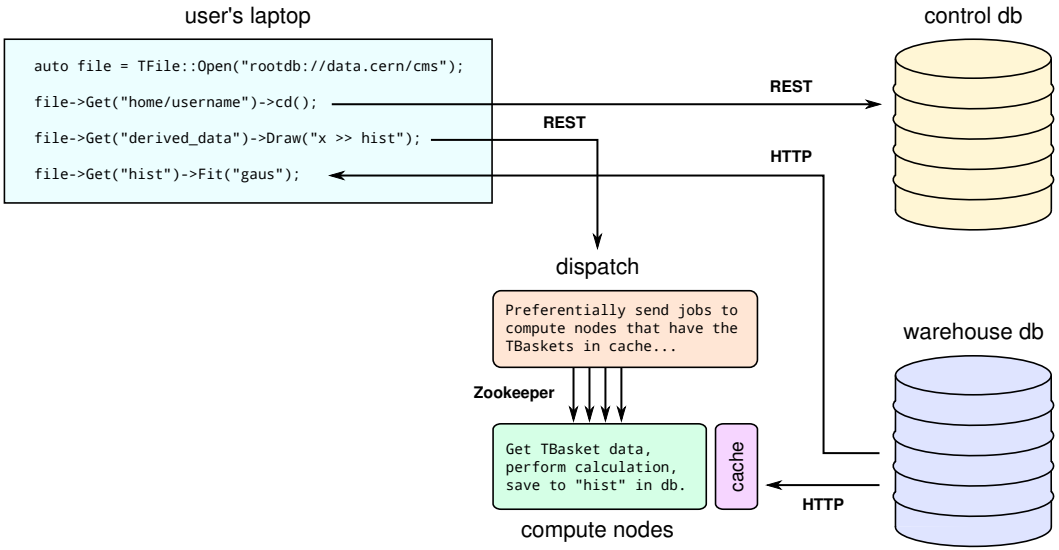
This is the "query server" idea I've been exploring for some time now, except that all of the interface is ROOT.


user's laptop
auto file = TFile::Open("rootdb://data.cern/cms");
file->Get("home/username")->cd();
file->Get("derived_data")->Draw("x >> hist");
file->Get("hist")->Fit("gaus");
control db
REST
REST
HTTP
dispatch
Preferentially send jobs to compute nodes that have the TBaskets in cache...
Zookeeper
warehouse db
Get TBasket data, perform calculation, save to "hist" in db.
cache
HTTP
compute nodes

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(Subject of another talk.)