Profiling Distributed execution in ROOT's DistRDF

Giulio Crognaletti, Vincenzo Padulano, Enric Tejedor

ROOT

Data Analysis Framework

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Project description

Objective: Profile the execution of RDataFrame JIT-ed applications, both

- Locally (i.e. RDataFrame)

  In this context `perf` suffice thanks to ROOT's cling profiling feature.

- Distributedly (i.e. DistRDF)

  In this context profiling is less trivial, because performance metrics in each node have to be collected and merged.

  This mechanism is implemented in the DistRDF.Profiling submodule

How is this achieved? What are the requirements?

Requirements

- Build ROOT with debug options:

```
$ cmake -DCMAKE_CXX_FLAGS_RELWITHDEBINFO="-O2 -g -fno-omit-frame-pointer"
-DCMAKE_BUILD_TYPE="RelWithDebInfo" -DLLVM_BUILD_TYPE="RelWithDebInfo"
```

- Make sure to have permission to collect PMU events of interest in *all* the machines used. Two possible options:
  - Restrict counting to user-space, e.g. use `-e cycles:u` (default option in DistRDF.Profiling)
  - Lower perf paranoid level

Requirements

- The variable `CLING_PROFILE=1` must be set in *all* the environments where RDataFrame code runs to allow profiling of JIT-ed code.

- *All* debug information packages for used libraries should be installed
  e.g. python-debug, glibc-debug, etc

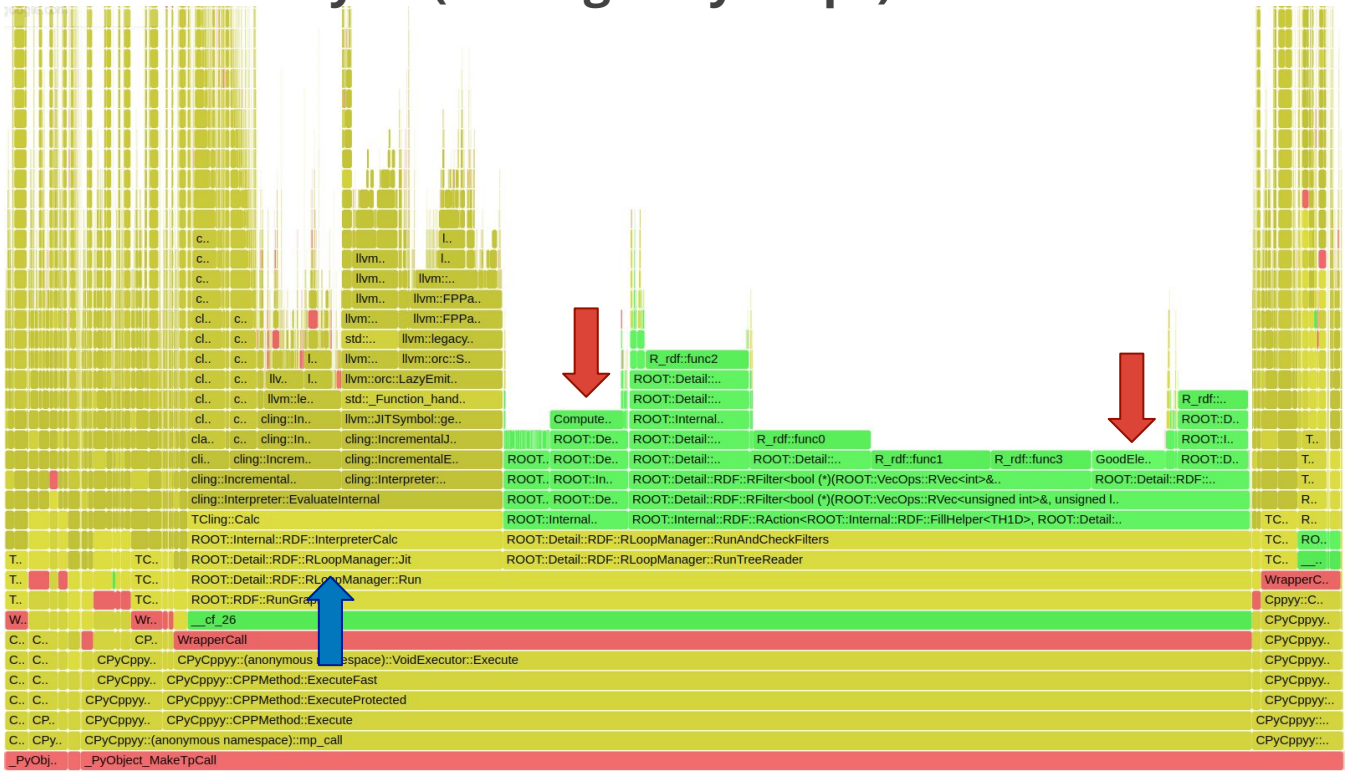
- Tools used to produce visualizations (e.g. FlameGraph) must be in `PATH` in *all* the environments where perf data is processed.

Some example using RDataFrame locally:

- Realistic example
  W boson mass analysis

Profiling RDataFrame: W boson analysis

W boson analysis (adding busy loops):



JIT-ing time

Still relevant contribution with small datasets

Event Loop

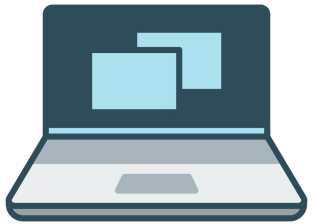
Code here is clearly visible

DistRDF profiling feature

How does it work?

Client

Distributed workers



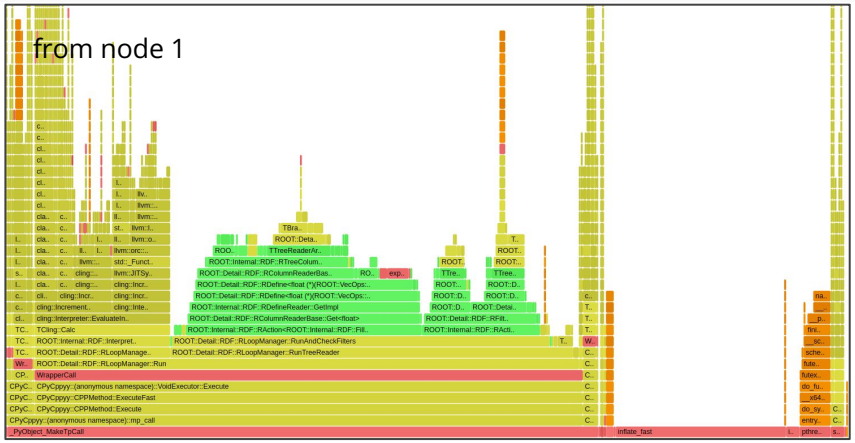
activate profiling features

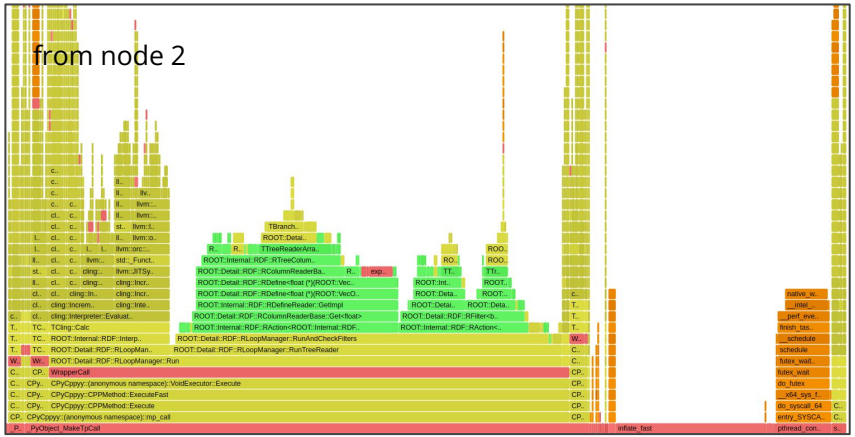
merge pre-processed data
(e.g. merge stacks)

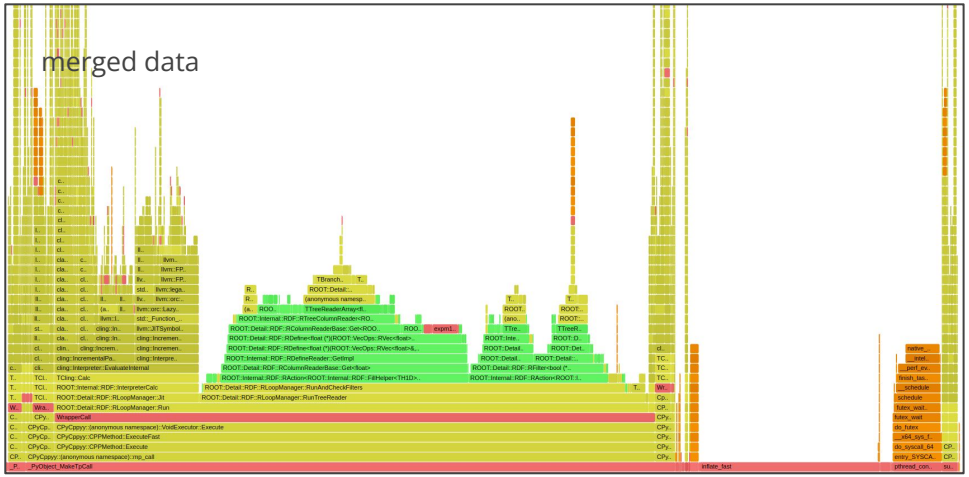
produce visualization
(e.g. flamegraph)

- collect profiling data
  (e.g. using perf)
- pre-process it
  (e.g. collapse equal stacks)

Example: Di-muon analysis







User interface

The proposed solution is contained in **DistRDF.Profiling** module.
It allows to activate the feature using the `ClingProfile` context manager:

```
RDataFrame = ROOT.RDF.Experimental.Distributed.Dask.RDataFrame
ClingProfile = ROOT.RDF.Experimental.Distributed.ClingProfile
...

df = RDataFrame("Events", files, npartitions=npartitions,
daskclient=client)

with ClingProfile(df, perf_options = {...}):

    df = df.Filter(...)
    ...
    df.GetValue()
```

additional kwargs (e.g. perf options, ecc...) are passed here

The event loop must be triggered *inside* the context manager

Conclusion

- The precise requirements to build accurate call stacks using Cling's profiling feature have been identified

  (i.e. build root with -g -fno-omit-frame-pointer, etc)

- A mechanism to produce the same analysis for the distributed case have been devised and implemented (PR in review!)

  (i.e. DistRDF.Profiling submodule)

Thank you for your attention

Questions?

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