Hyperparameter Optimization as a Service on INFN Cloud

in *21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research* (ACAT 2022)

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1. Motivation

Hyperparameter optimization is a crucial step in the late development of machine learning models to improve their performance. Optimization campaigns require training the models multiple times, possibly **in parallel**, to explore the hyperparameter space, focusing on those regions where the model performs better.

Accessing *opportunistic resources* can drastically increase the number of trials in a campaign, especially when training involves the usage of GPUs. **Diversity** in the computing environment of the resource providers and **untrusted** storage solutions represent challenges to the existing services.

2. Hyperparameter optimization as a service

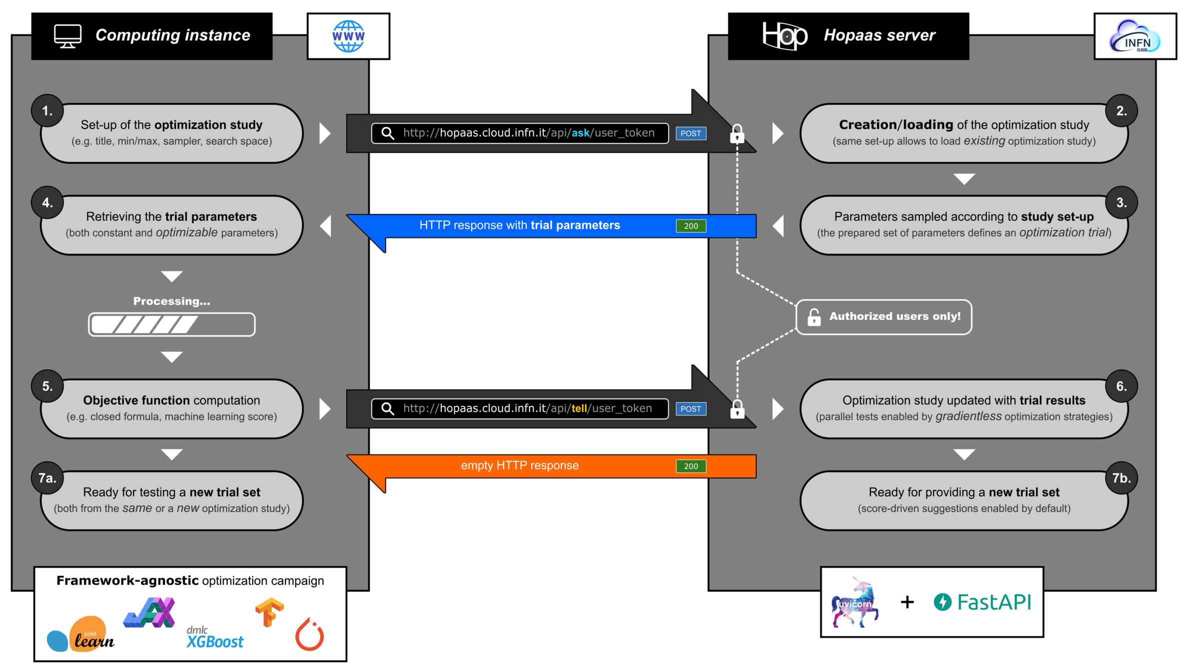
Hopaas (*Hyperparameter OPtimization As A Service*) is a service hosted by INFN Cloud that allows to orchestrate optimization studies across multiple computing instances via **HTTP requests**. Hopaas provides a set of REST APIs and a web interface to enable **user authentication** and to monitor the status of the user studies.

- **Back-end** based on FastAPI;
- Underlying databases powered by PostgreSQL;
- **Bayesian optimization** powered by Optuna;
- Service provided by Uvicorn and NGINX;
- Python **front-end** available (hopaas_client).

3. Authorization via token

Accessing the Hopaas service is enabled through **API tokens** passed directly within the URL of the HTTP requests. Such tokens can be generated with user-selected validity interval (ranging from one day to one year), through a dedicated webpage at hopaas.cloud.infn.it after an **OAuth2 login** via the INFN official GitLab instance (baltig.infn.it).

3. Client-server optimization system

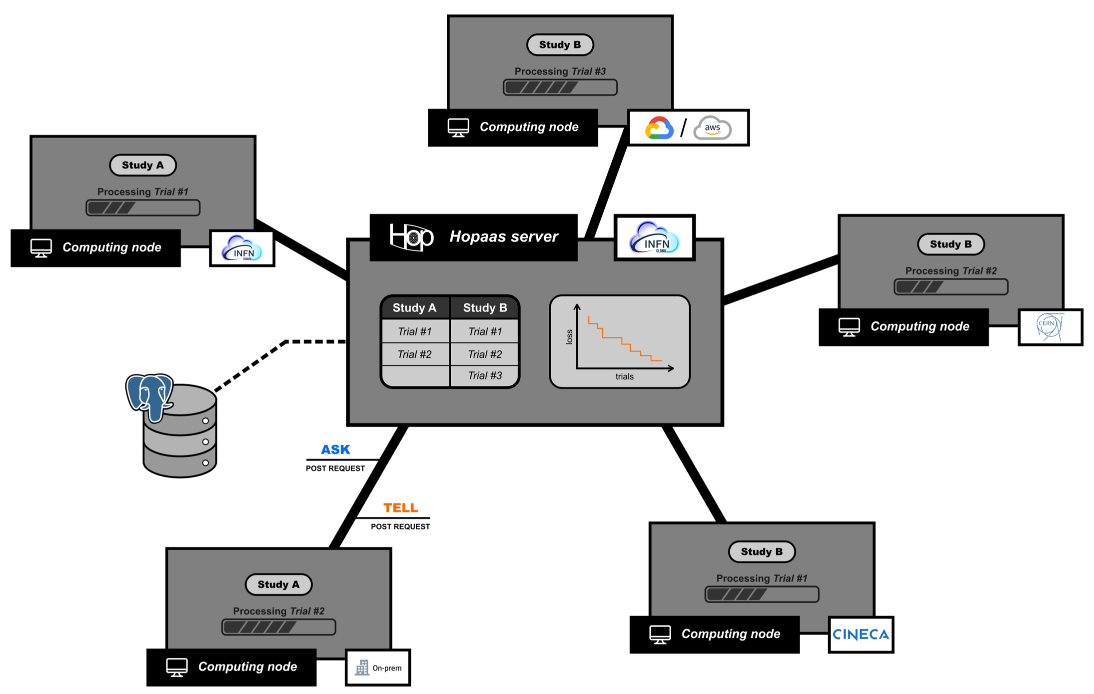


Workflow of the client-server system defined by Hopaas to run optimization studies, and based on an *ask-and-tell* interface where the trial parameters and the objective score computed are retrieved from HTTP requests.

5. Multi-nodes optimization campaigns

Multiple **HPC centers** can concur to the same optimization study, requesting to the Hopaas server a new set of hyperparameters to be tested and then communicating the outcome of the training instance. Several trials of **one or more studies** can be tracked and

monitored through the web interface provided by the Hopaas service.



Schematic representation of the Hopaas server as an orchestrator of two optimization studies ("Study A" and "Study B") distributed across five computing instances, and powered by a PostgreSQL database.

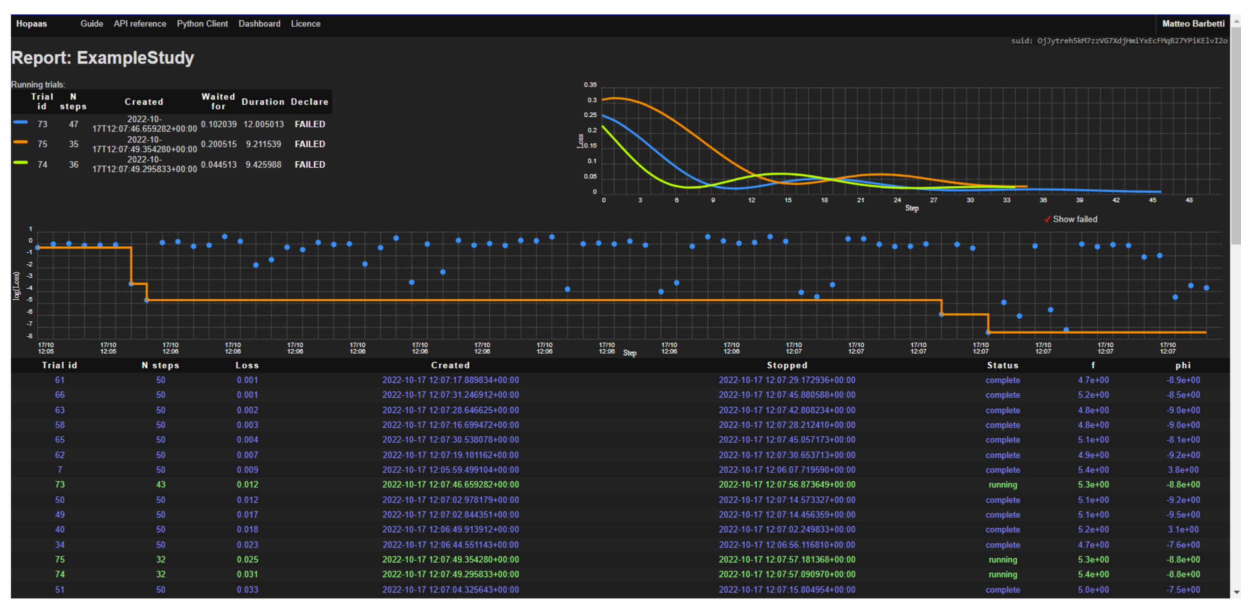
6. Example use-cases

```python
import hopaas_client as hpc

## Create the client
client = hpc.Client(server="https://hopaas.cloud.infn.it",
                    token="user-api-token")

## Create (or retrieve) the study
study = hpc.Study(name="ExampleStudy",
                  properties=dict(
                    int_param = hpc.suggestions.Int(0, 10),
                    float_param = hpc.suggestions.Float(-1, 1)
                  ),
                  direction="minimize",   # or "maximize"
                  client=client)

## Start polling trials
while True:
  with study.trial() as trial:
    ## Retrieve hopaas-suggested parameters
    int_param = trial.int_param
    float_param = trial.float_param

    ## Define the training loop (if any)

    for iStep in range(50):
      my_loss = # compute the loss at this epoch/step
      trial.loss = my_loss

      ## Discards poorly-started trials
      ## to save computing time
      if trial.should_prune:
        break
```

Fully runnable example at l.infn.it/hopaascolab.

7. Web-powered monitoring

A simple **web interface** based on Chartist enables live monitoring of the ongoing optimization trials, while organizing the history of the past studies.



Web dashboard produced by Hopaas for l.infn.it/hopaascolab. The top right plot shows three ongoing trial trainings, while the center plot reports the global status of the optimization study. Finally, the bottom table traces general information from all the trials.

8. Conclusions

Several optimization campaigns has been successfully distributed and coordinated by the Hopaas server using **diverse computing instances**, from scientific HPC resources (like INFN Cloud and CINECA MARCONI100), and from public Cloud Provider (like GCP or AWS).

Hopaas is currently in **alpha testing** and is made available to a limited amomunt of INFN researchers. The source code will be *open-sourced* once a more advanced state of development will be reached.

References

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