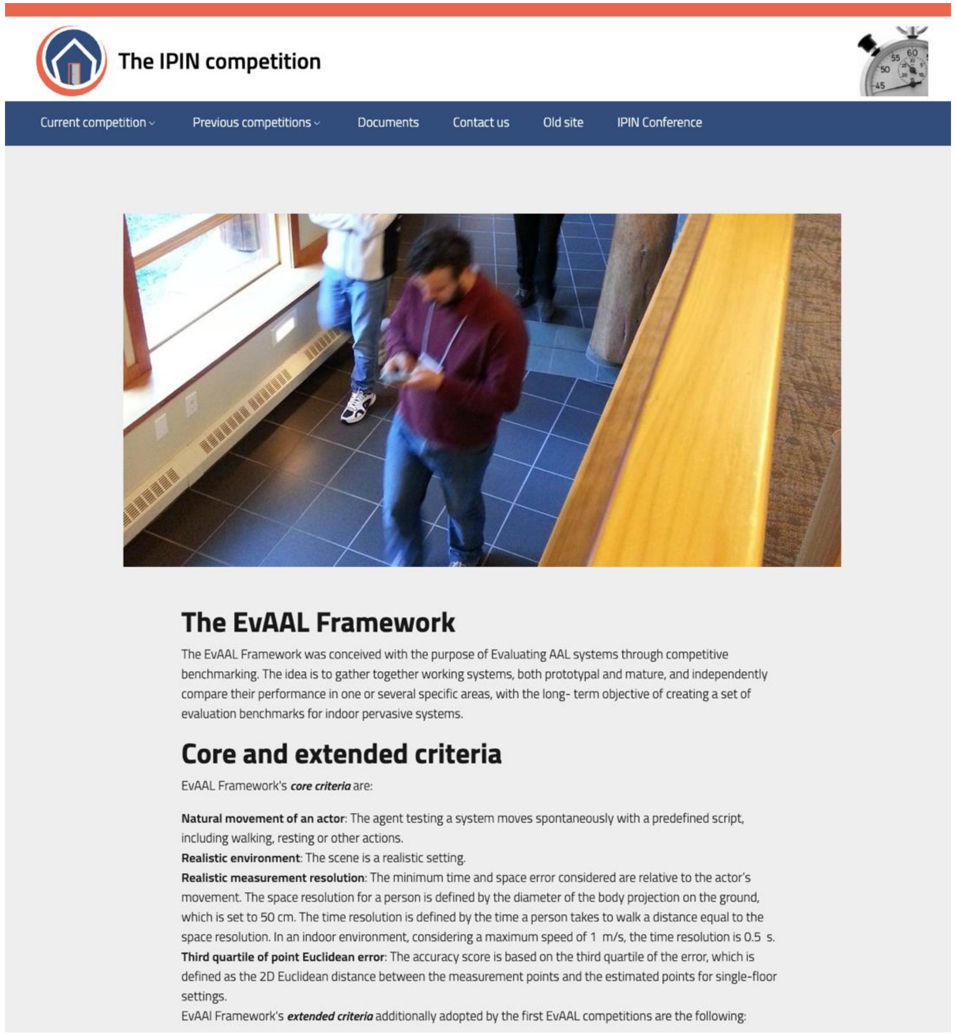
Create the Future, Collaborate Together

Overview of the xDR Challenge 2025

This year's xDR Challenge 2025 is one of the tracks of the IPIN competitions

IPIN 2025 Competition Track 5 = xDR Challenge 2025

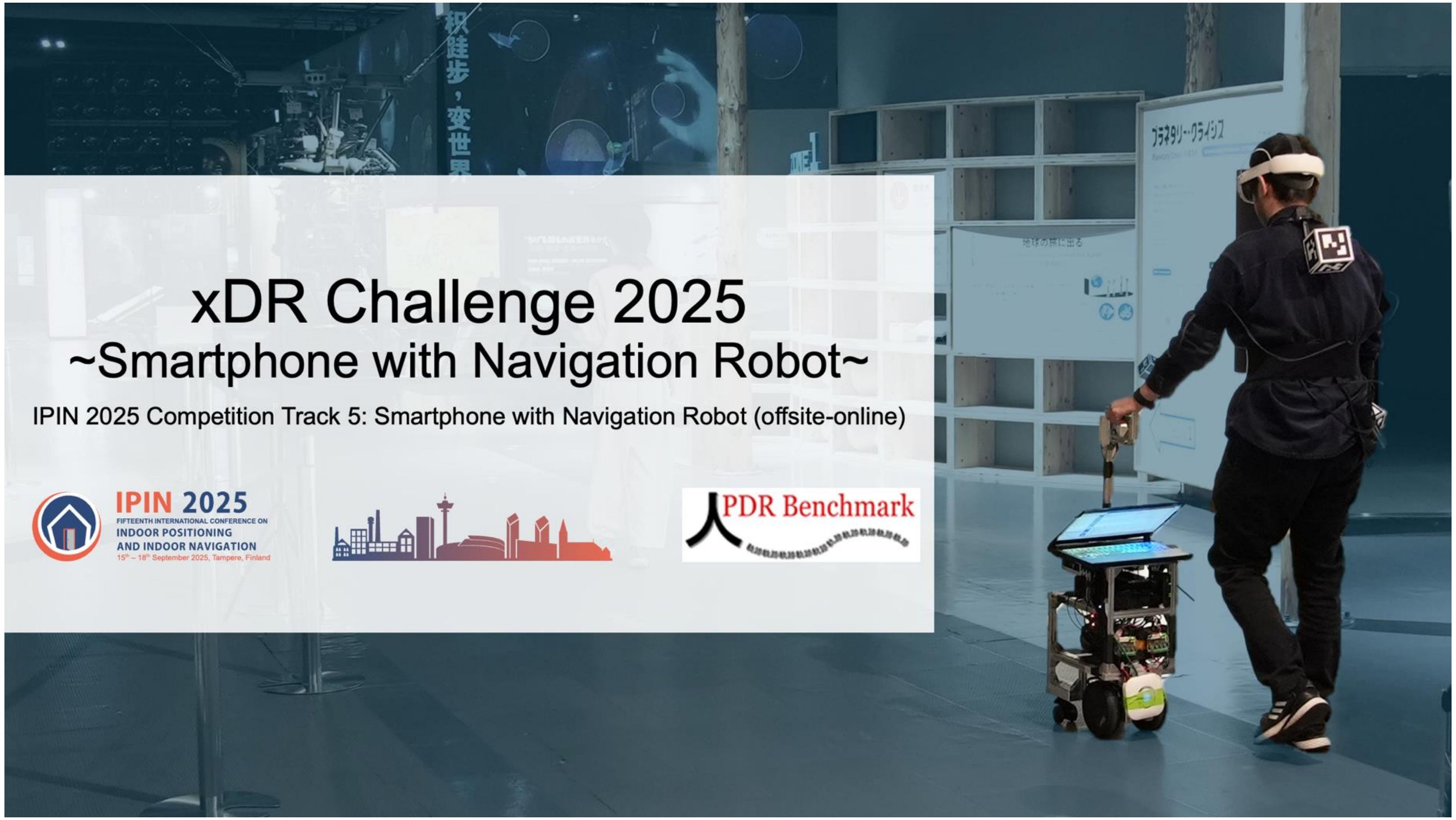
https://ipin-conference.org/2025/index.html



https://competition.ipin-conference.org/

IPIN : INTERNATIONAL CONFERENCE ON INDOOR POSITIONING AND INDOOR NAVIGATION

xDR Challenge 2025 – Smartphone with Navigation Robot –

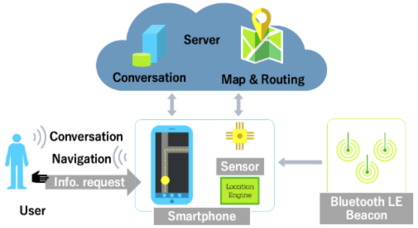


Acknowledgement :
The dataset for this competition is obtained in the joint research with Carnegie Mellon University (Daisuke Sato, Chieko Asakawa and Kris Kitani) and Miraikan - The National Museum of Emerging Science and Innovation (Hironobu Takagi)
This competition is based on a result of a project, Programs for Bridging the gap between R&D and the IDeal society (society 5.0) and Generating Economic and social value (BRIDGE)/Practical Global Research in the AI × Robotics Services, implemented by the Cabinet Office, Government of Japan.

Background

Understanding of spatial relationship   Ability to move from place to place

- Support for **Orientation & Mobility (O&M)** of people with visual impairment
- Navigation assistants with smartphones
  - Do not limit user's **mobility** while inaccurate **orientation**
  - Requires investment in the environment (tags, feature point maps, etc.) & maintenance
  - Difficult to point at markers for people with VI
- Navigation robot
  - Reduces user’s cognitive load by precise **orientation**
  - Sometimes restricts user’s **mobility**
- Combination of these methods enables complementary navigation

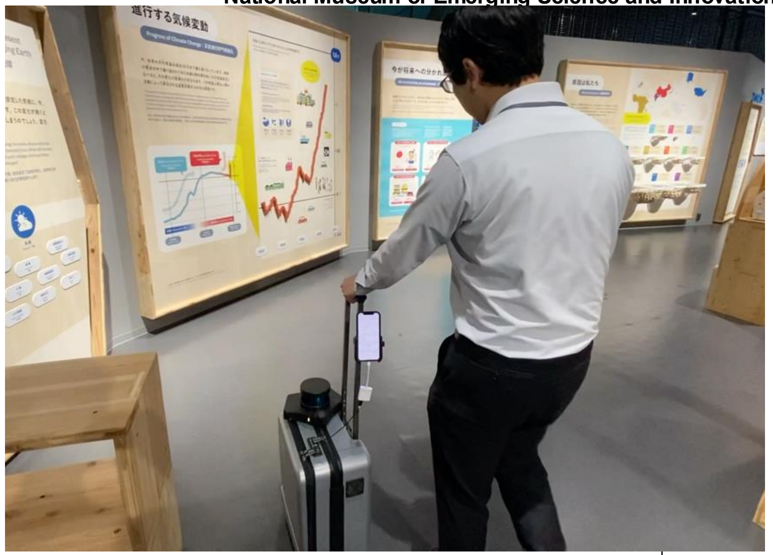


[D. Sato+, 2017]

https://www.linkx.dev/shikai


[T. Takagi+, 2022]

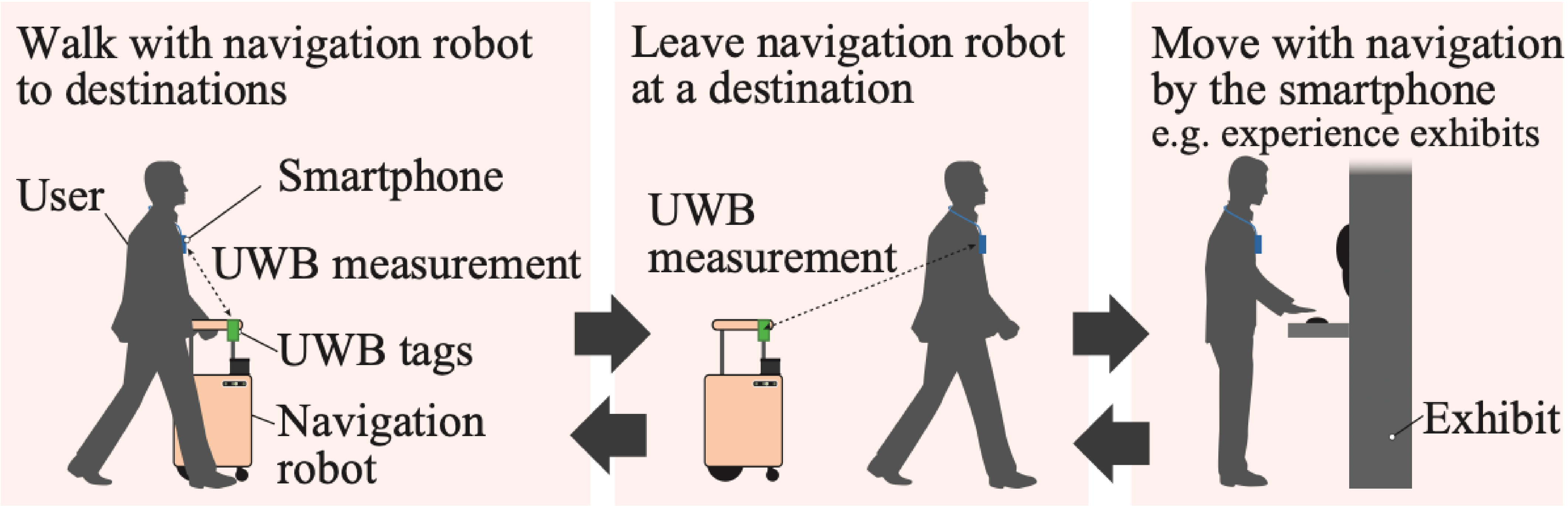
Permanent operation in EXPO 2025 & Miraikan - The National Museum of Emerging Science and Innovation



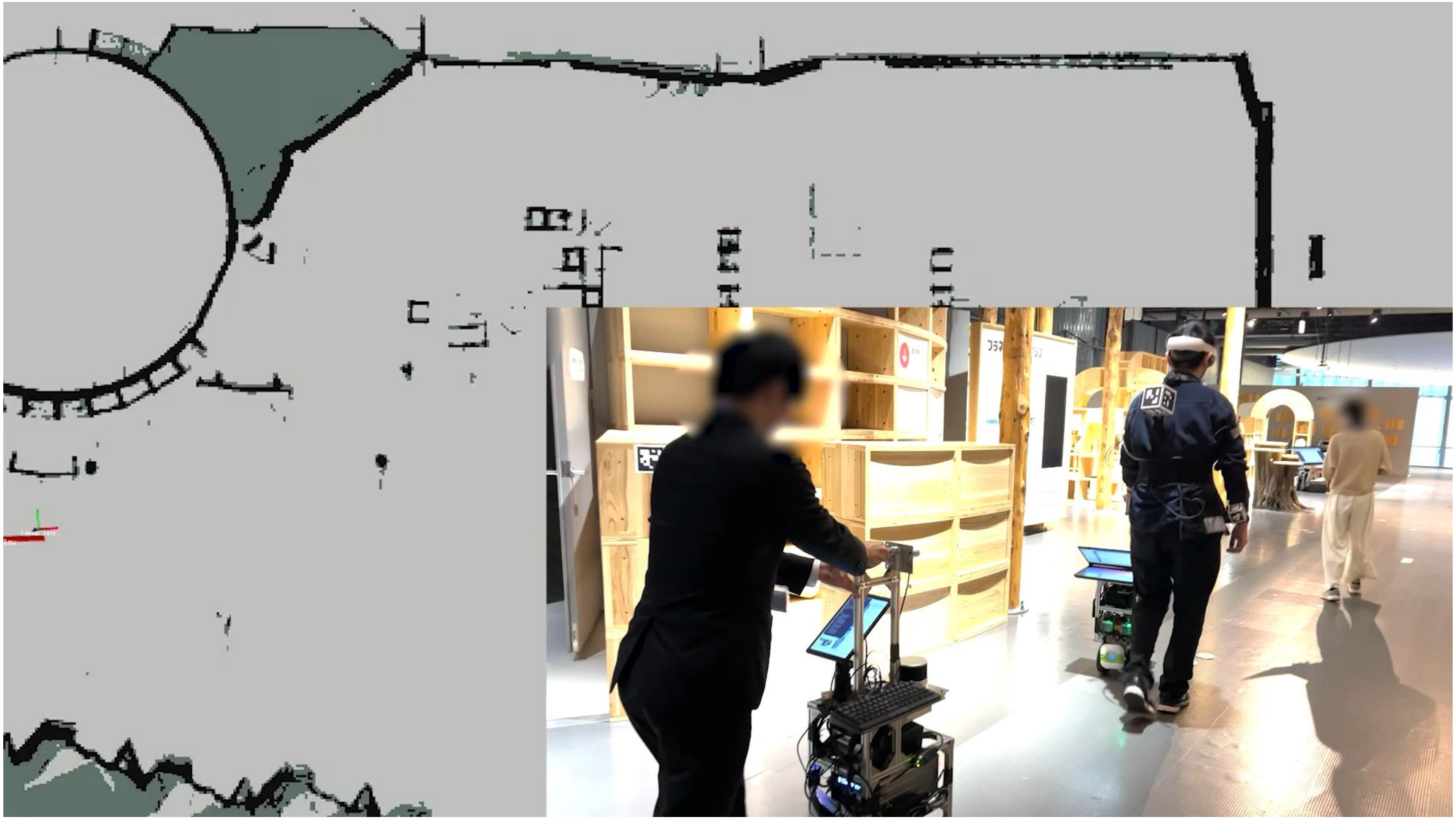
VI: Visual impairment

Scope of the competition

- **Assumption**: navigation robot is available in the target venue
- **Purpose of this paper**: smartphone's localization in sub-meter accuracy without additional infrastructural investment & maintenance
- **Approach**: estimate the smartphone's location by utilizing a navigation robot as a reference point using relative position measurement by UWB



Example of localization



Experimental condition for dataset - Overview

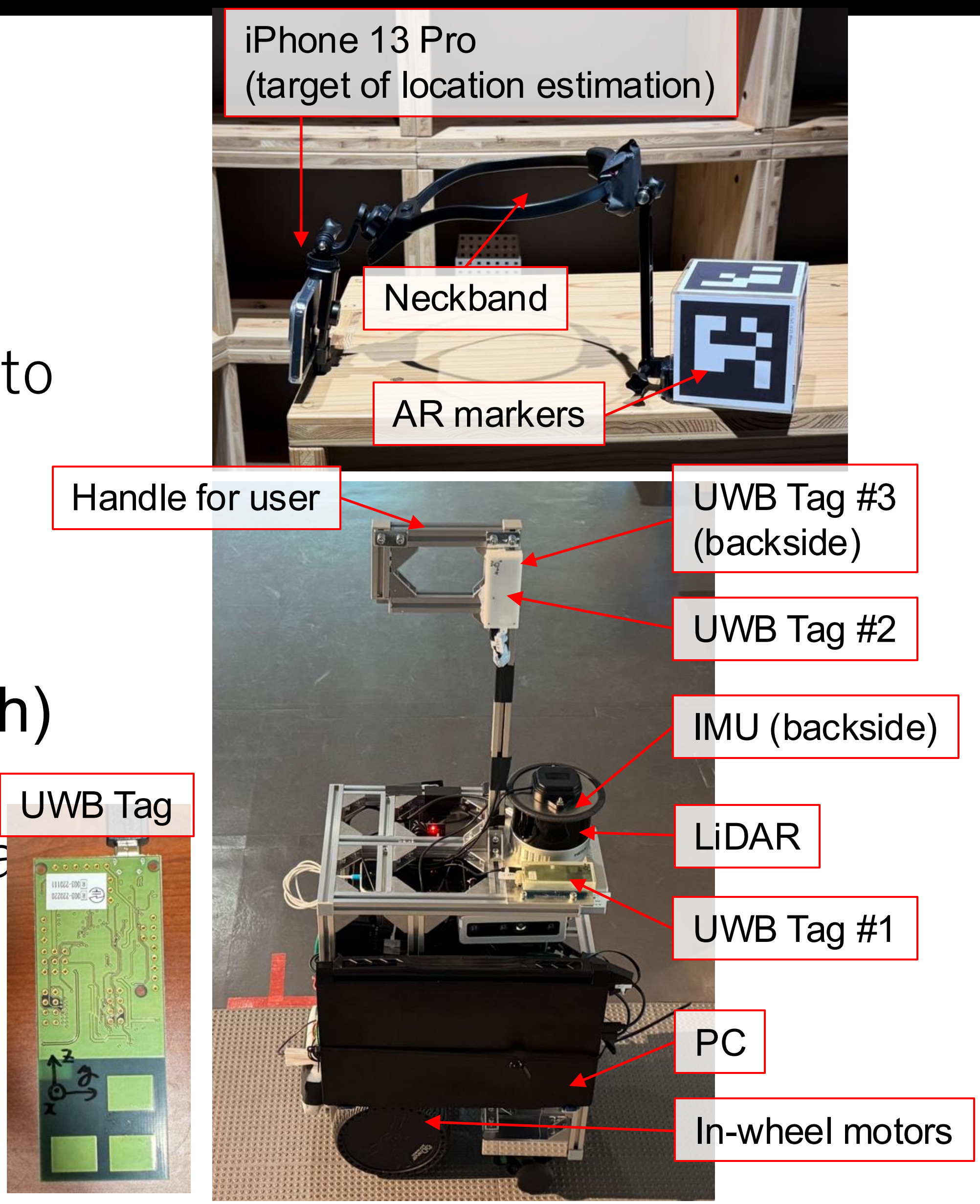
AIST
Create the Future, Collaborate Together

- Measure sensor data with mock tours in a museum
  - 15 to 30 minutes per tour
  - 2 to 6 tours per participant
- Participants were asked to
  - Wear smartphone & AR markers on the neck
  - Hold navigation robot and walk as the robot moves
  - Move without navigation robot based on a narrator’s voice
  - Touch the exhibits to experience them
- Participants
  - 2 people with visual impairment (not distributed for development)
  - 4 people without visual impairment
- Evaluation
  - Ground truth: AR markers with another camera-equipped mobile robot
  - 2D and 3D location errors

IRB number: HF2024-1438

Experimental condition - Equipment

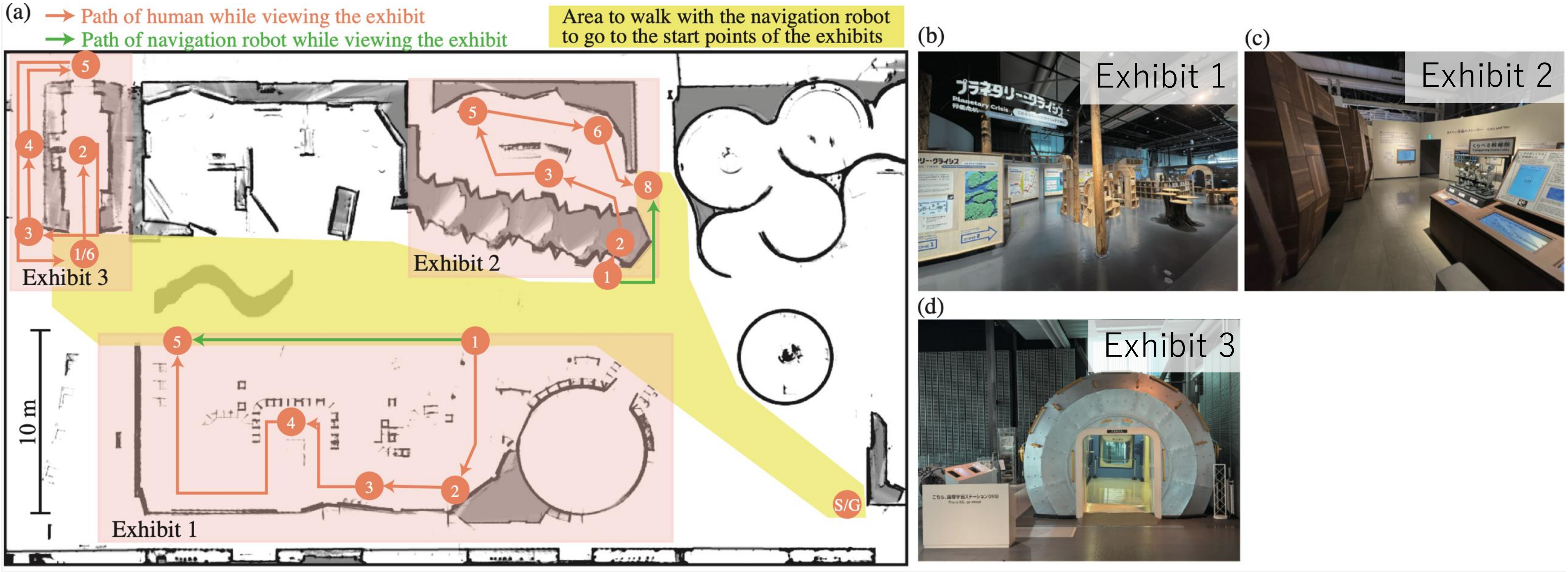
- Smartphone (iPhone 13 Pro, Apple)
  - Hanged at the neck of subjects
  - Equipped with AR markers for ground truth
  - Sends sensor data (VIO (ARKit) , IMU, UWB) to the navigation robot with MQTT over WiFi
  - UWB: without camera-assistance features
- Navigation robot (AI Suitcase)
  - **LiDAR (XT-16, Hesai) and IMU (BNO055, Bosch) for localization in a pre-built 2D floor map**
  - UWB tags (Type 2BP development kit, Murata
  - Personal Computer (PC)
  - Remote controlled by an experimenter
    - Pulls user's hand toward destinations



VIO: Visual-inertial odometry
MQTT: Message Queuing Telemetry Transport
IMU : Inertial measurement unit
LiDAR: Light detection and ranging
AoA : Angle of arrival

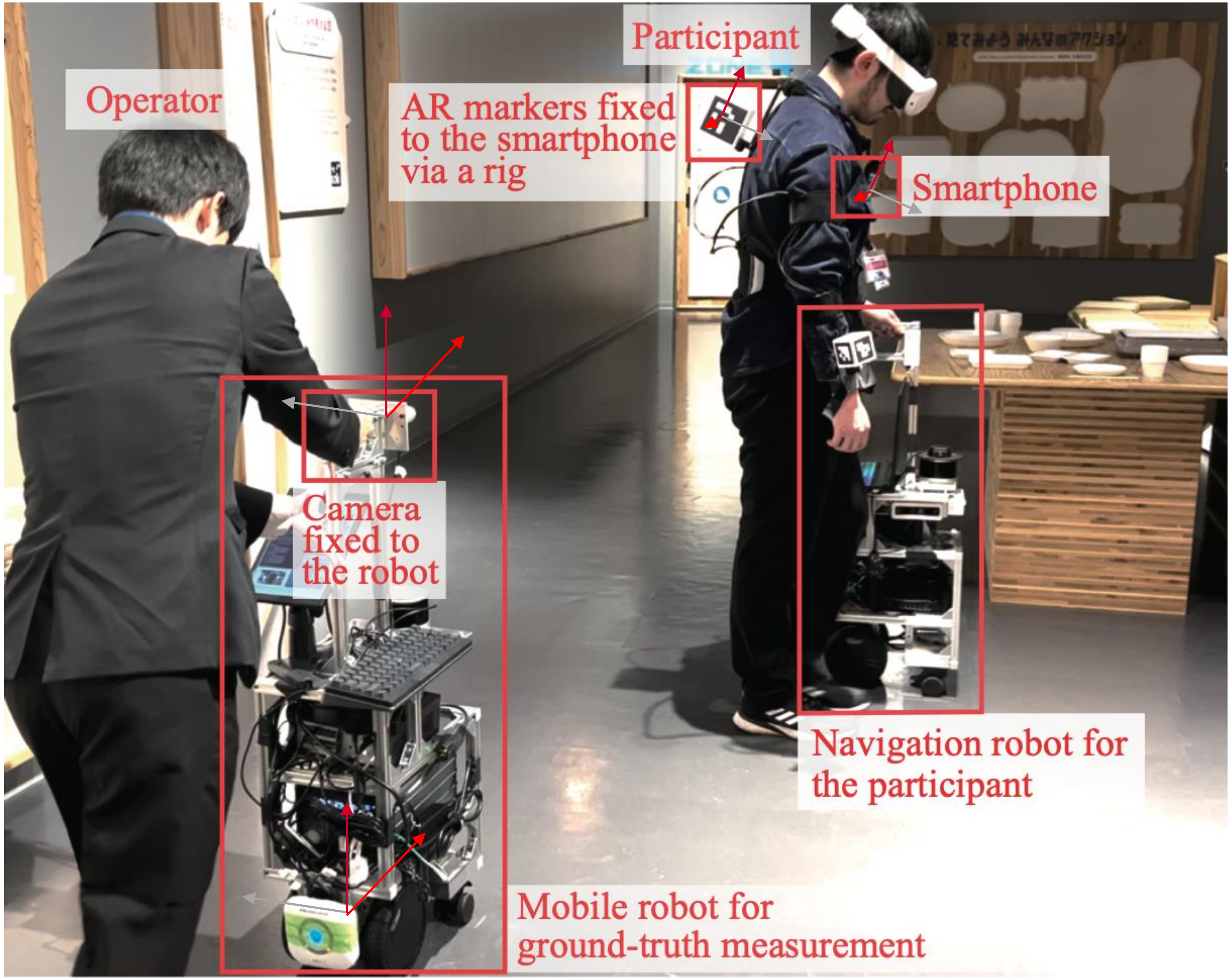
Experimental condition - Venue and paths

- Miraikan - The National Museum of Emerging Science and Innovation
- 5th floor, following 3 exhibits
  - Exhibit 1: Relatively open space (some data contains tours with AI suitcase inside exhibit)
  - Exhibit 2: Small room with curtains at the start
  - Exhibit 3: Mockup of international space station module, made of metal



Method to measure ground truth

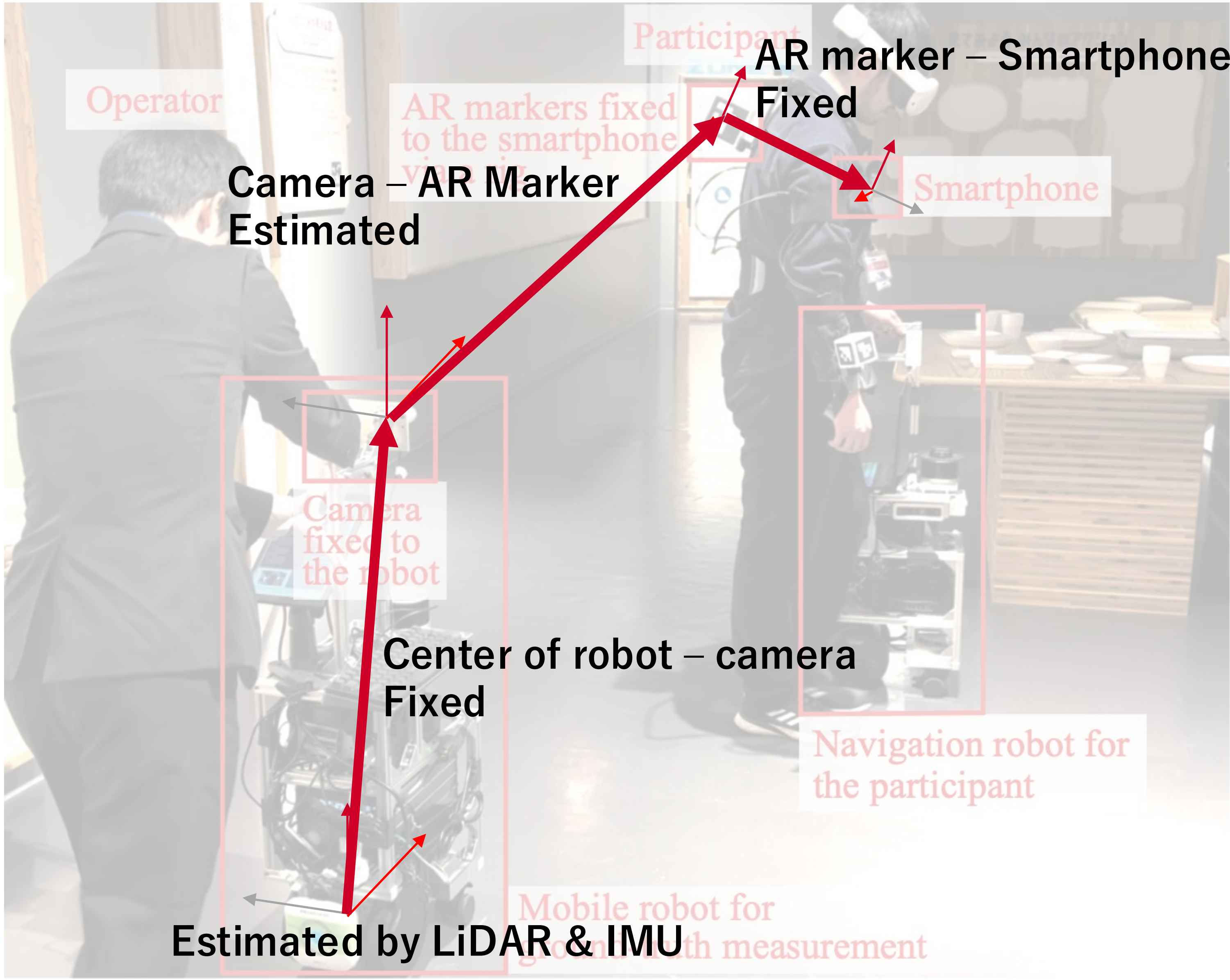
- Measure sensor data with best-effort ground truth
  - AR markers at the neck
  - Another mobile robot tracks markers
  - AR markers on 5-faces of a cube
- Only for ground truth & evaluation
  - Proposed method do not use this information in estimation



IMU : Inertial measurement unit
LiDAR: Light detection and ranging

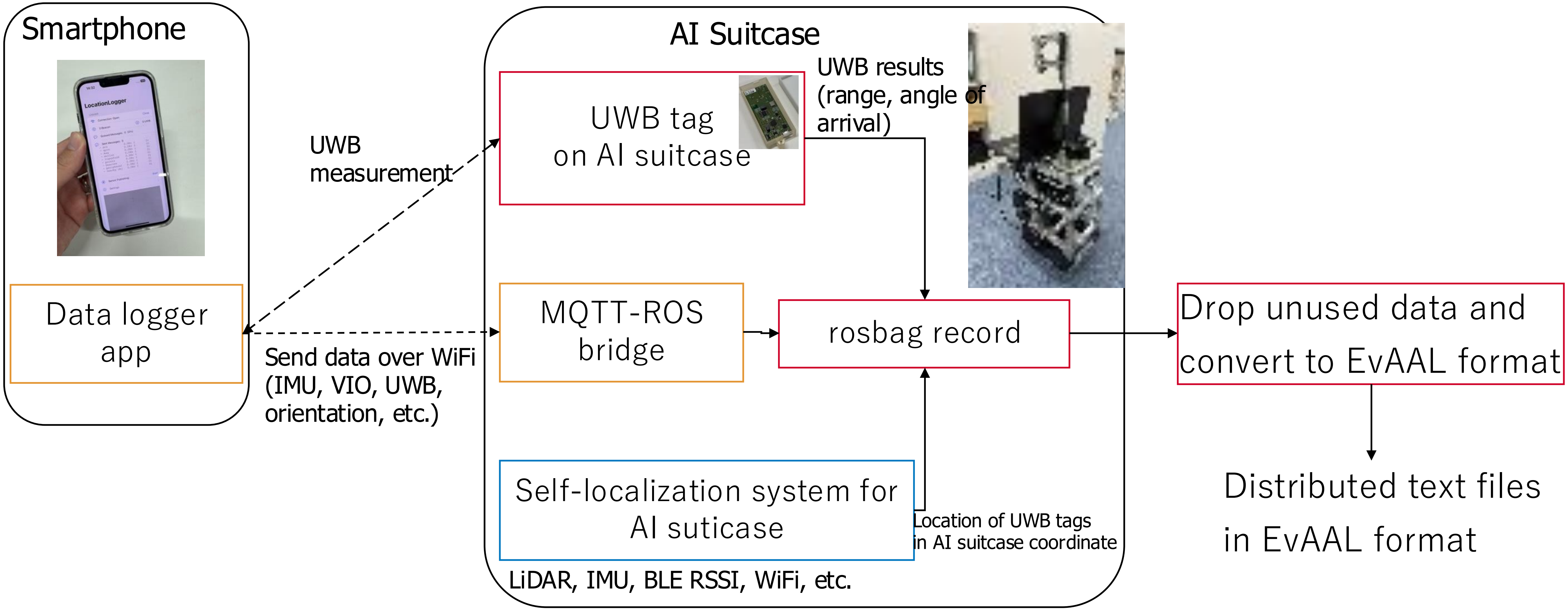
Method to measure ground truth

- Measure sensor data with best-effort ground truth
  - AR markers at the neck
  - Another mobile robot tracks markers
  - AR markers on 5-faces of a cube
- Only for ground truth & evaluation
  - Proposed method do not use this information in estimation



IMU : Inertial measurement unit
LiDAR: Light detection and ranging

Measurement system outline



Datasets for competition

- **Trial dataset**: Dataset provided for testing and tuning the localization and tracking methods (LTM) before the actual scoring trial. The trial dataset is small subset of the dataset and provided with ground-truth data.
  - We distribute this dataset prior to the competition.
- **Scoring dataset**: Dataset provided for actual benchmarking. The scoring dataset is provided without ground-truth data. The benchmarking participants are asked to submit the result of LTM by processing the scoring dataset. In this competition, the scoring dataset may includes unseen subjects and/or paths

Contained data for competition

- **Dataset includes following data**
  - **Sensor data (evaanapi_server/trials/{data_name}.txt)**
  - **Ground truth data (ground_truth/{data_name}.txt)**
    - These data will not be distributed for scoring dataset
    - Will contain destination information when evaluation tools are distributed.
  - **Supplemental data**
    - Map of the venue (map/*.bmp)

Limitation

Due to limited band-with of the real-time localization competition, not all the data from smartphone and navigation robot are provided.

e.g.: no raw LiDAR point cloud → only localization result of the robot will be provided, etc.

Contents of sensor data

- iPhone’s measurement
  - (ACCE) 3-axis accelerometer: CMAccelerometerData
  - (GYRO) 3-axis gyroscope: CMGyroData
  - (MAGN) 3-axis magnetometer: CMMagnetometerData
  - (AHRS) Orientation: CMDeviceMotion
  - (UWBP) UWB Phone-side measurement: NINearbyObject (distance, AoA, tag ID)
  - (VISO) Visual-Inertial Odometry: ARKit world tracking
    - Note that this output is intentionally dropped in the exhibit 1. It is to evaluate pedestrian dead reckoning performance (e.g. use case such as minimizing battery drain by not using camera)
- AI Suitcase’s measurement
  - (GPOS) Location of AI Suitcase and UWB tags: base_link, tag’s locations
  - (UWBT) UWB Tag-side measurement: distance, AoA, tag ID

Limitation

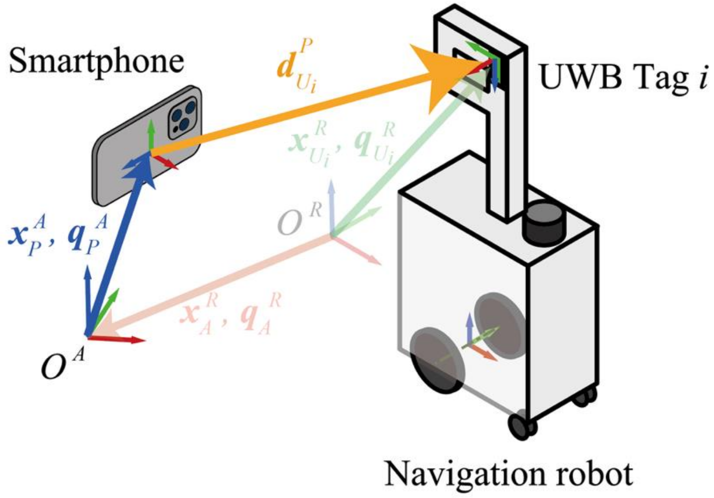
・iPhone’s measurements are sent over MQTT without resend. Some of the data will be missing.

・Due to limited band-with of the real-time localization competition, not all the data from smartphone and navigation robot are provided.

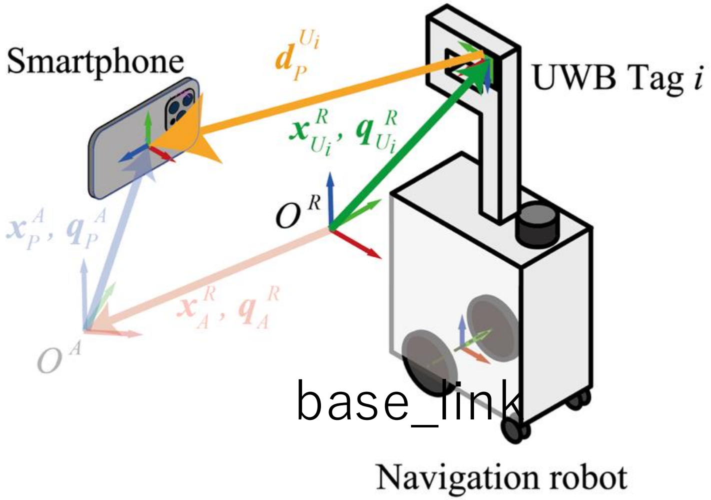
e.g.: no raw LiDAR point cloud → only localization result of the robot will be provided, etc.

Contents of sensor data (UWB)

- iPhone’s measurement (data name: source)
  - 3-axis accelerometer: CMAccelerometerData
  - 3-axis gyroscope: CMGyroData
  - 3-axis magnetometer: CMMagnetometerData
  - Orientation: CMDeviceMotion
  - UWB Phone-side measurement: NINearbyObject (distance, AoA, tag ID)
  - Visual-Inertial Odometry: ARKit world tracking
    - Note that this output is intentionally dropped in the exhibit 1

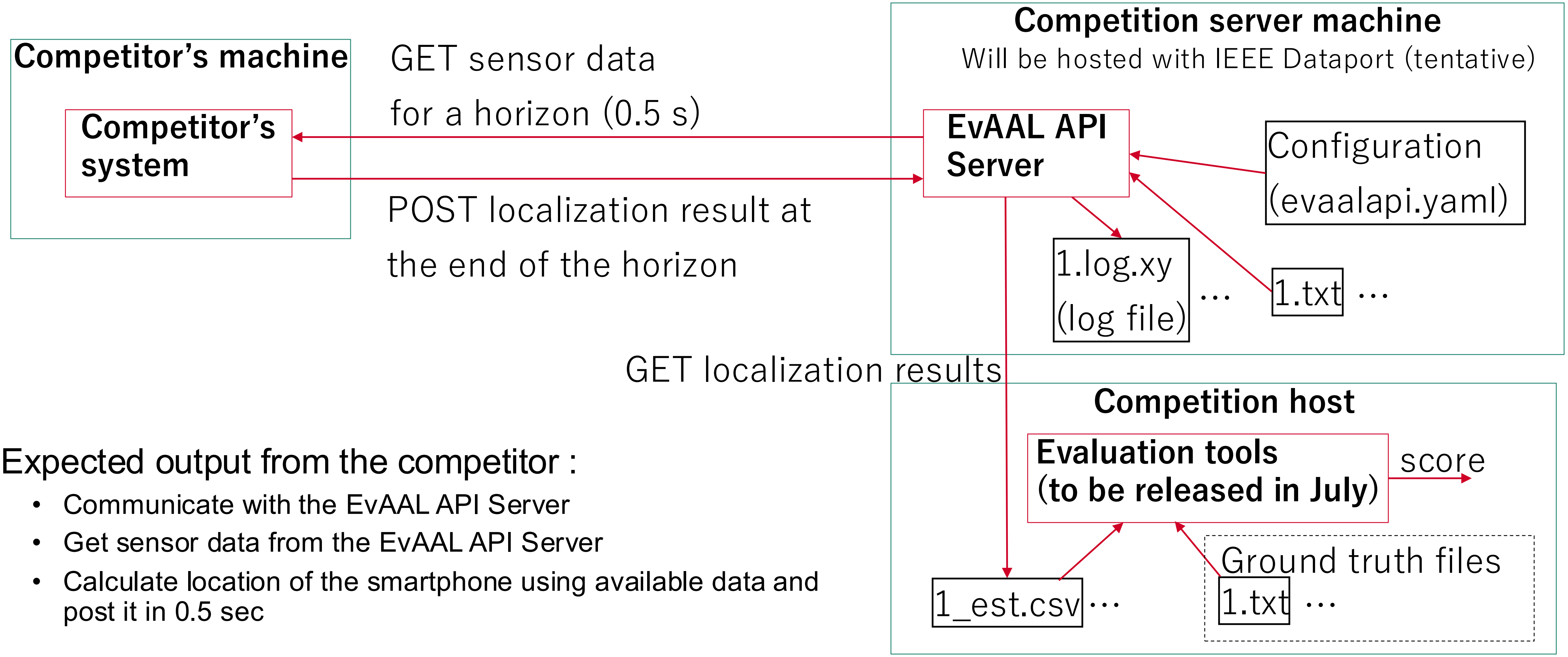


- AI Suitcase’s measurement
  - Location of AI Suitcase and UWB tags: base_link, tag’s locations
  - UWB Tag-side measurement: distance, AoA, tag ID



Overview of the competition process at scoring trials

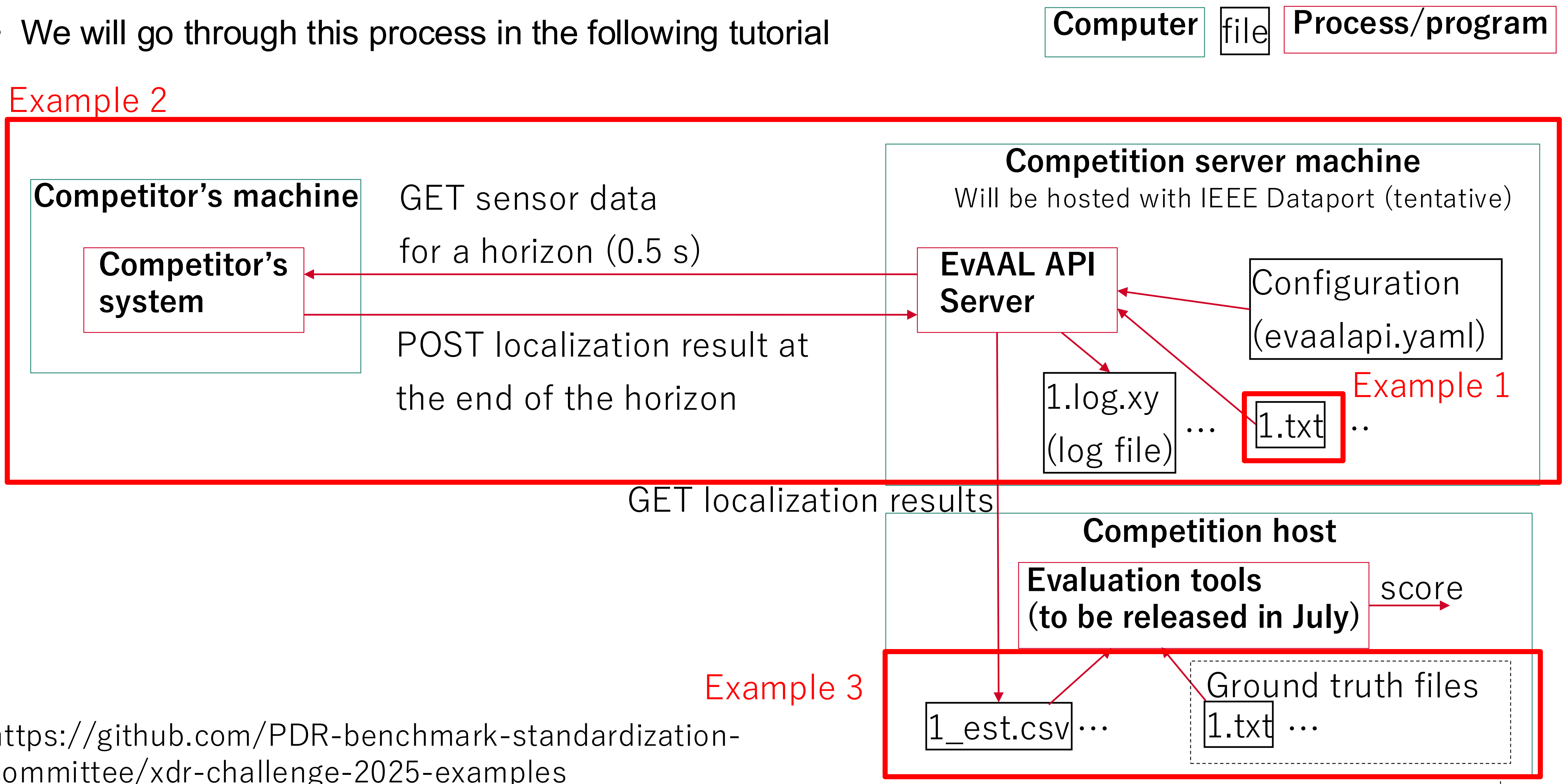
- We will go through this process in the following tutorial



- Expected output from the competitor :
  - Communicate with the EvAAL API Server
  - Get sensor data from the EvAAL API Server
  - Calculate location of the smartphone using available data and post it in 0.5 sec

Overview of the competition process at scoring trials

- We will go through this process in the following tutorial



https://github.com/PDR-benchmark-standardization-committee/xdr-challenge-2025-examples

Evaluation metrics (tentative)

Multi-faced evaluation

Absolute location error is important, but no everything.

CE95: 95 percentile of circular error (m)
HE95: 95 percentile of heading error (rad)
RDA95: 95 percentile of relative distance accuracy (m)
RPA95: 95 percentile of relative pose accuracy (rad)
w_* : weights to calculate score

$$\text{score} = w_{\text{CE}}\, e_{\text{CE95}} + w_{\text{HE}} e_{\text{HE95}}$$ …Evaluation in the map's coordinate

$$+ w_{\text{RDA}}^{\text{exhibit}} e_{\text{RDA95}}^{\text{exhibit}} + w_{\text{RPA}}^{\text{exhibit}} e_{\text{RPA95}}^{\text{exhibit}}$$ …Evaluation of relative location from exhibits

$$+ w_{\text{RDA}}^{\text{robot}} e_{\text{RDA95}}^{\text{robot}} + w_{\text{RPA}}^{\text{robot}} e_{\text{RPA95}}^{\text{robot}}$$ …Evaluation of relative location from robot

***Evaluation tools and detailed calculation will be released by July**

Relative metrics (overview)

Relative distance error (RDA) and relative pose error (RPA)

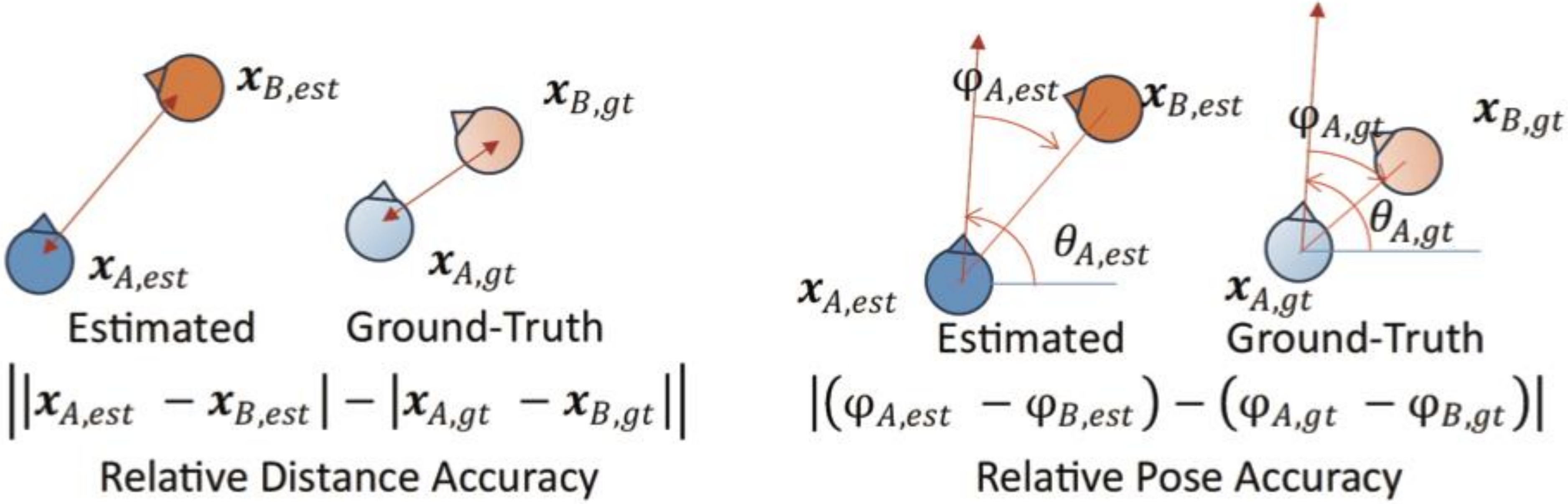


Figure 6 — Examples of calculation for indicators related to relative relationship

Why these are important?

The navigated user should be facing to the exhibit.

Directly used in the return phase to the navigation robot

***Evaluation tools and detailed calculation will be released by July**

Competition steps

Step1 Request for Trial Dataset (done for tutorial participants)

If potential competitors have an interest in our competition, please register in the data request form (to be opened in June). We will provide you the trial dataset after we confirm your registration.

Step2 Downloading Trial Dataset

We will provide link to the trial dataset for those who completed the request for data form. You can download the dataset with provided ID and password. Note that the organizers will manully check the request form contents so it may take a few days to send the access information. After downloading the sample data, the competitor can start testing trials.

Step3 Application of the Competition

If you decide to join the competition, please register final admission in IPIN Competition's official application form. The competitors are required to provide short and long descriptions of the system

Step4 Payment of subscription fee

In addition to the application, the competitors are required to pay the registration fee. The detail of the payment will be announced later

Step5 Scoring trial

On a track-specific day during the second week of September, the competitors are required to join the scoring trial. We will provide unreferenced data for scoring trial through EvAAL API. Competitors will be asked to call the EvAAL API to get sensor data and submit estimated location in real-time.

Step6 Announcement of the results

The result of the xDR Challenge 2025 will be announced during the IPIN 2025 conference

Filled conformance checklist (ISO/IEC DIS 21134) of xDR Challenge 2025

AIST
Create the Future, Collaborate Together

		items	Check / Value
Dataset	Specification of the dataset	Scenario of the dataset	Evaluating indoor localization of a neck-worn smartphone that works with a navigation robot. They communicate over UWB and measures distance and angle of arrival each other. Visual-inertial odometry is available from the smartphone, except one exhibit to test pedestrian dead reckoning performances.
		Movement contained, Size of the target area.	Walk, stand, touch exhibits, touch walls, walk with a navigation robot One venue (a floor of a museum)
		Scale of the dataset (length of the dataset)	(TBA) 15 minutes to 30 minutes per tour
		Format and contents of the dataset	map(bmp), sensor information(txt), reference information(csv)
		Device used for the measuring dataset	iPhone 13 Pro (worn by participant), AI Suitcase with 3 UWB tags Type 2BP development kit (moves with participant)
	Ground-truth	How to collect ground-truth	Attach AR markers at the back of the participant and follow with camera- and LiDAR-equipped mobile robot that localize itself in the map. The location and attitude of the phone is calculated from the AR marker's detection result and transformation.
		Accuracy and precision of the ground truth (reference data)	Approx. 0.1 m (median)
		Frequency of the ground-truth	Depends on visibility of AR marker, max. 30 Hz
		Contents of the ground-truth data	timestamp, x, y, z, qx, qy, qz, qw
Evaluation Metrics	Indicators related to position	PEAG (Time/Distance/Angular change normalized)	-
		Circular Error	95 percentile
		Circular Accuracy (in world/local coordinate systems)	-
		Area Detection Performance	-
		Validity of trajectory	-
	Indicators related to series of positional estimation	Velocity Error (VE)	-
		Distance Error	-
		Moving Velocity Check	-
	Indicators related to orientation	OEAG (Time/Distance/Angular change normalized OEAG)	-
	Indicators related to relative relationship	Relative Distance Accuracy	95 percentile, evaluated against exhibits and the navigation robot
		Relative Pose Accuracy	95 percentile, evaluated against exhibits and the navigation robot
	Indicator related to integrated localization	Difference between the performances in ALIP and ALAP	-
	Indicators related to practicability of localization system	Set-up time, Cost, Easiness for users, Availability, Through-put, Latency	-
	Indicators related to data used for the benchmarking	Number of datasets, Variety on properties of datasets	(TBA)

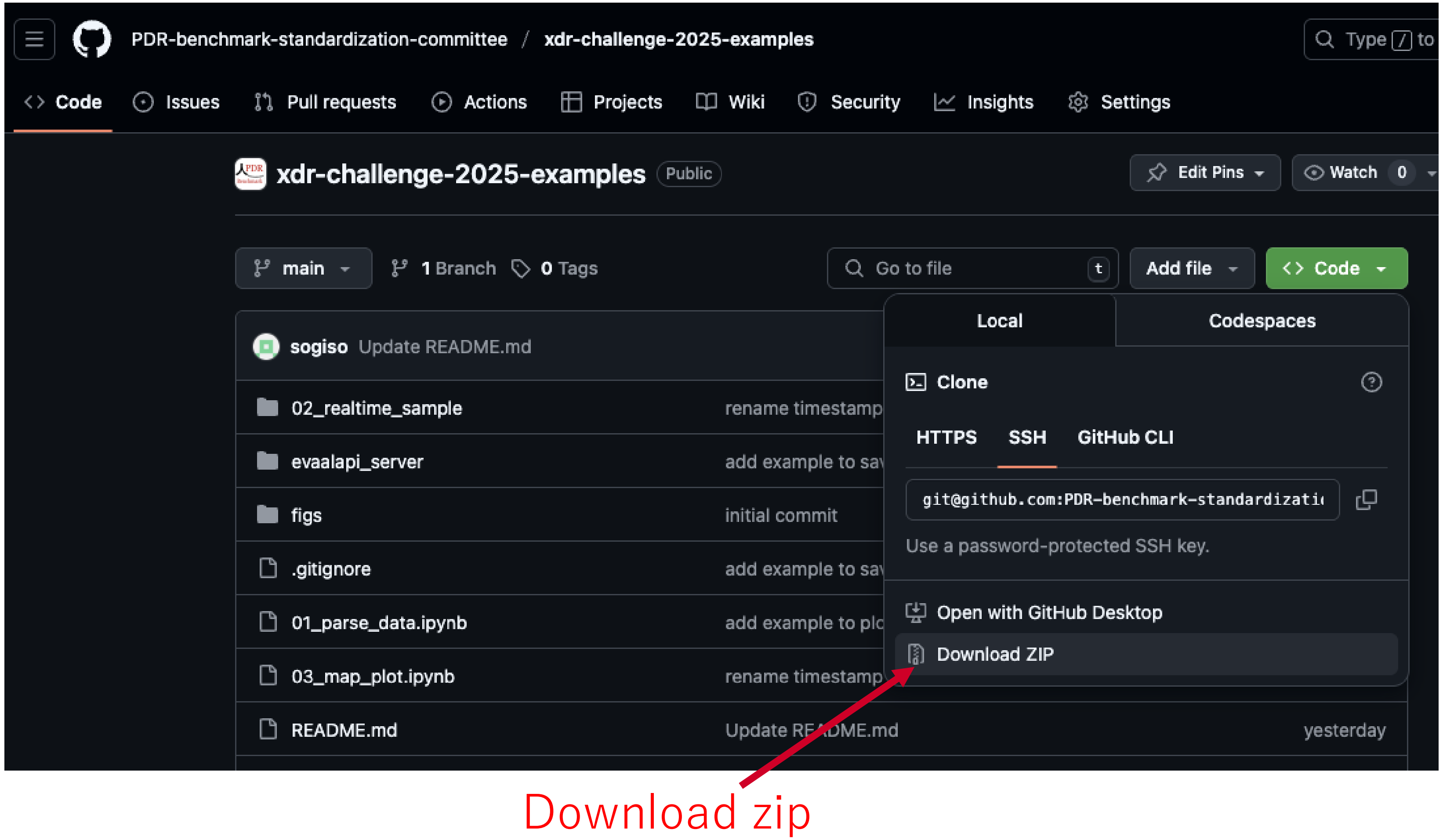
Create the Future, Collaborate Together

Hands-on

Creating the environment

Download or clone the sample code

https://github.com/PDR-benchmark-standardization-committee/xdr-challenge-2025-examples



Setup python environment

AIST
Create the Future, Collaborate Together

If you do not have python, please install. We recommend to use pyenv as follows.

if you use pyenv, we recoomend to make a virtual environment for this project.

```
pyenv install 3.12.4 # recommended but not required
pyenv virtualenv 3.12.4 2025competition
pyenv local 2025competition
```

```
pip install -r requirements.txt
```

In any ways, the demo works if all packages in the requirements.txt are installed

Download required data & scripts

EvAAL API script

Please copy evaalapi.py from the EvAAL API webpage and place it to both 02_realtime_sample/ and evaalapi_server/. (e.g. Make blank file "evaalapi.py" with a text editor and copy contents of evaalapi.py from the above page.)

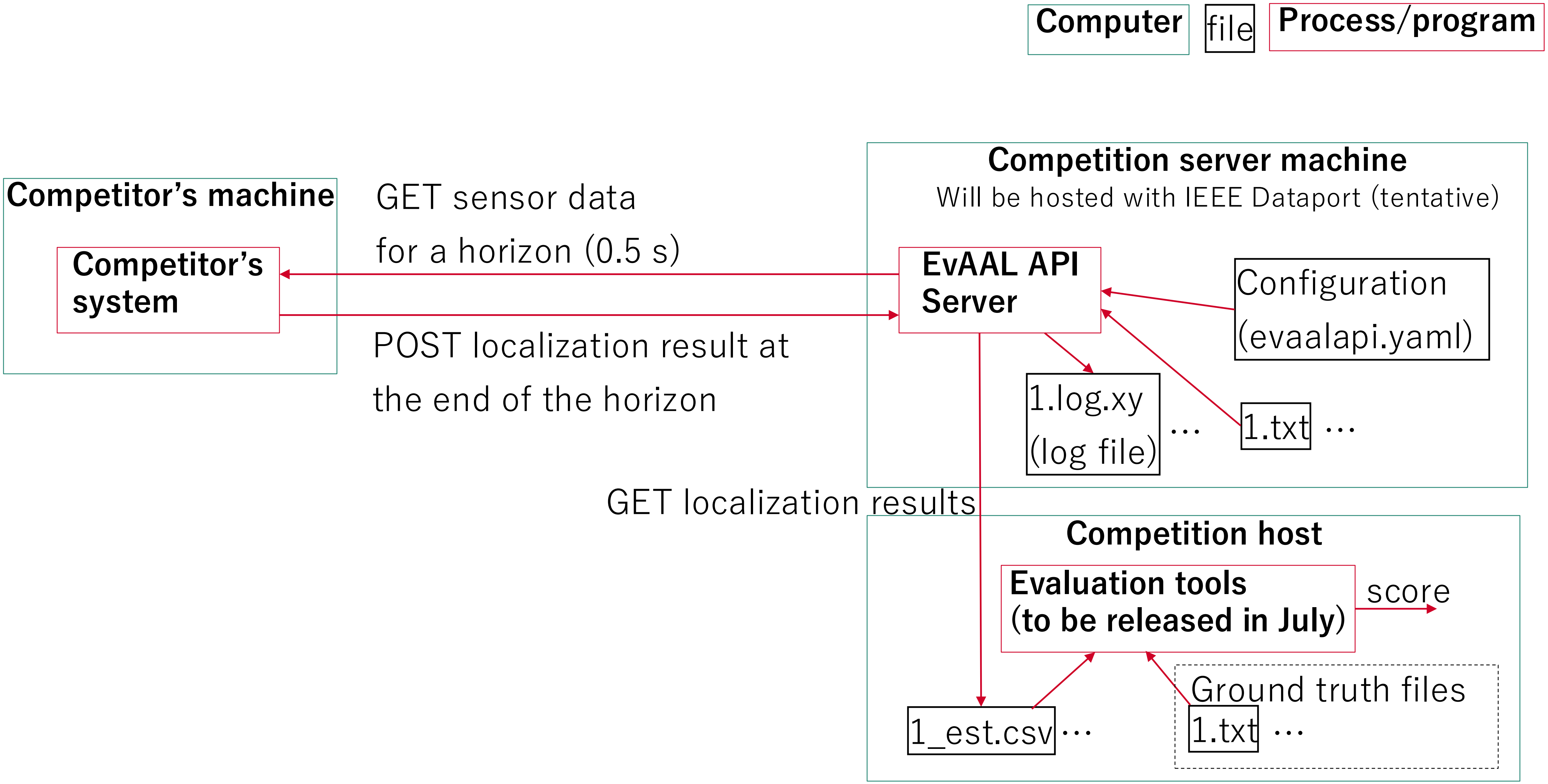
xDR Challenge 2025 dataset

Please download from the provided link and place it into this folder. (for non-tutorial attendee) If you have not requested the data, please fill in the request form on the xDR Challenge 2025 website. We will manually check and distribute the dataset link.

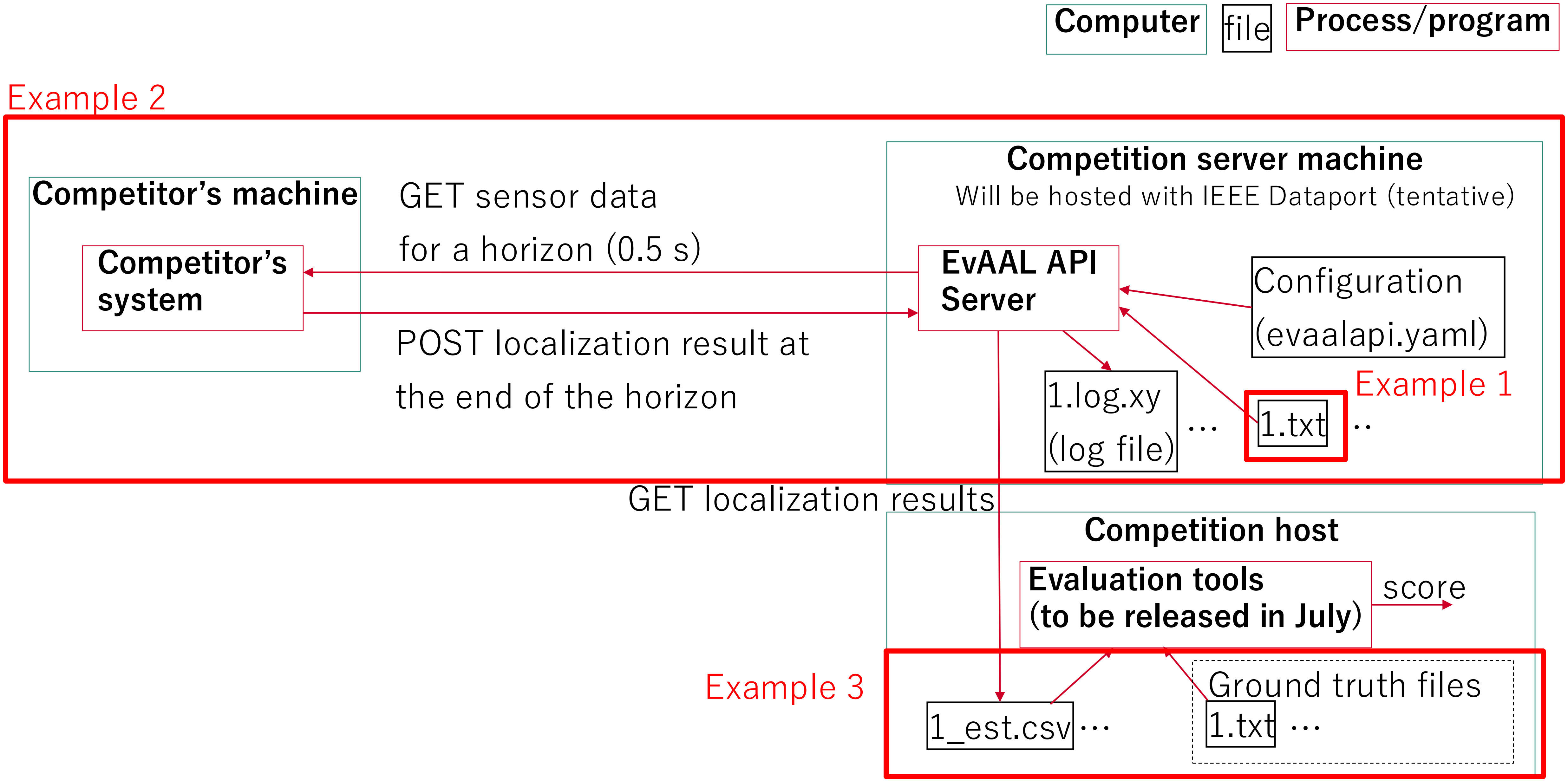
After placing, the directory should look like this

```
.
├── 01_parse_data.ipynb
├── 02_realtime_sample
│   ├── 01demo_simple_request.py
│   ├── 02demo_class.py
│   ├── 03demo_location_estimate.py
│   ├── 04demo_data_realtime_plot.py
│   ├── 05demo_get_estimates.py
│   ├── evaalapi.py
│   └── place_evaalapi.py_here
├── 03_map_plot.ipynb
├── README.md
├── evaalapi_server
│   ├── evaalapi.py
│   ├── evaalapi.yaml
│   ├── place_evaalapi.py_here
│   ├── place_trials_directory_here
│   └── trials
│       └── 1.txt
├── figs
│   └── example2-4.png
├── ground_truth
│   └── 1.csv
├── map
│   └── miraikan_5.bmp
└── requirements.txt
```

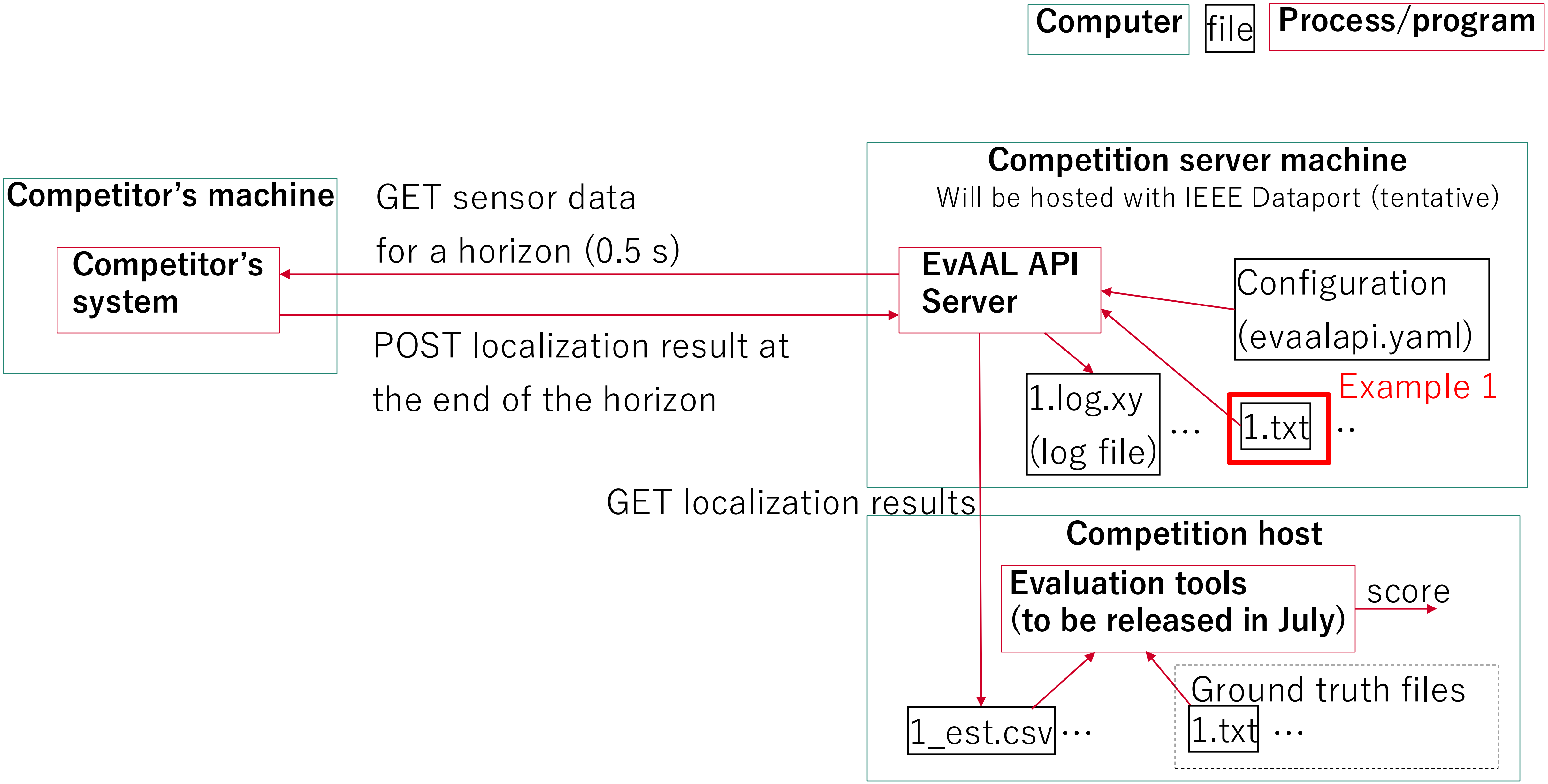
Overview of the competition process



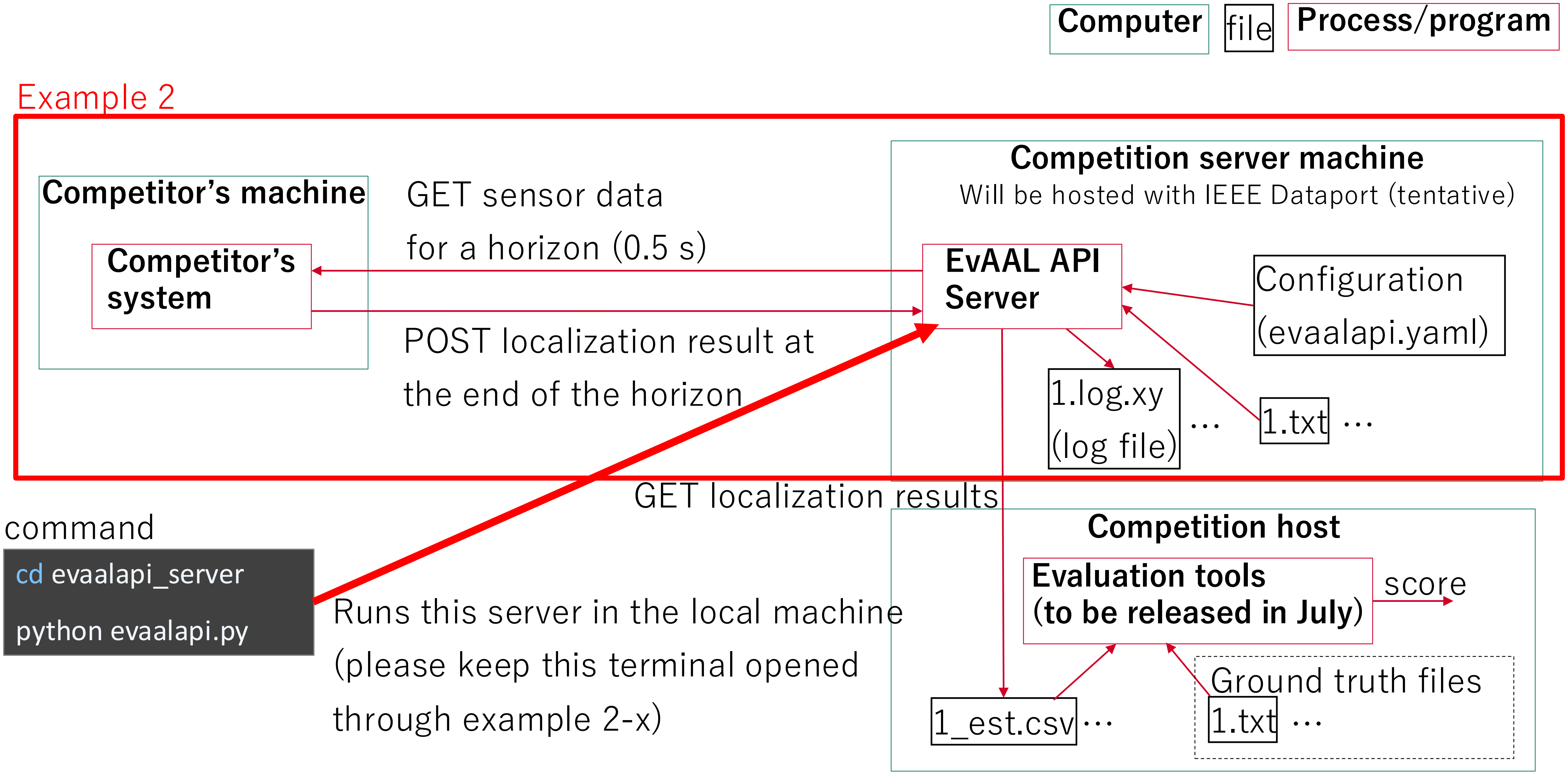
Overview of the competition process



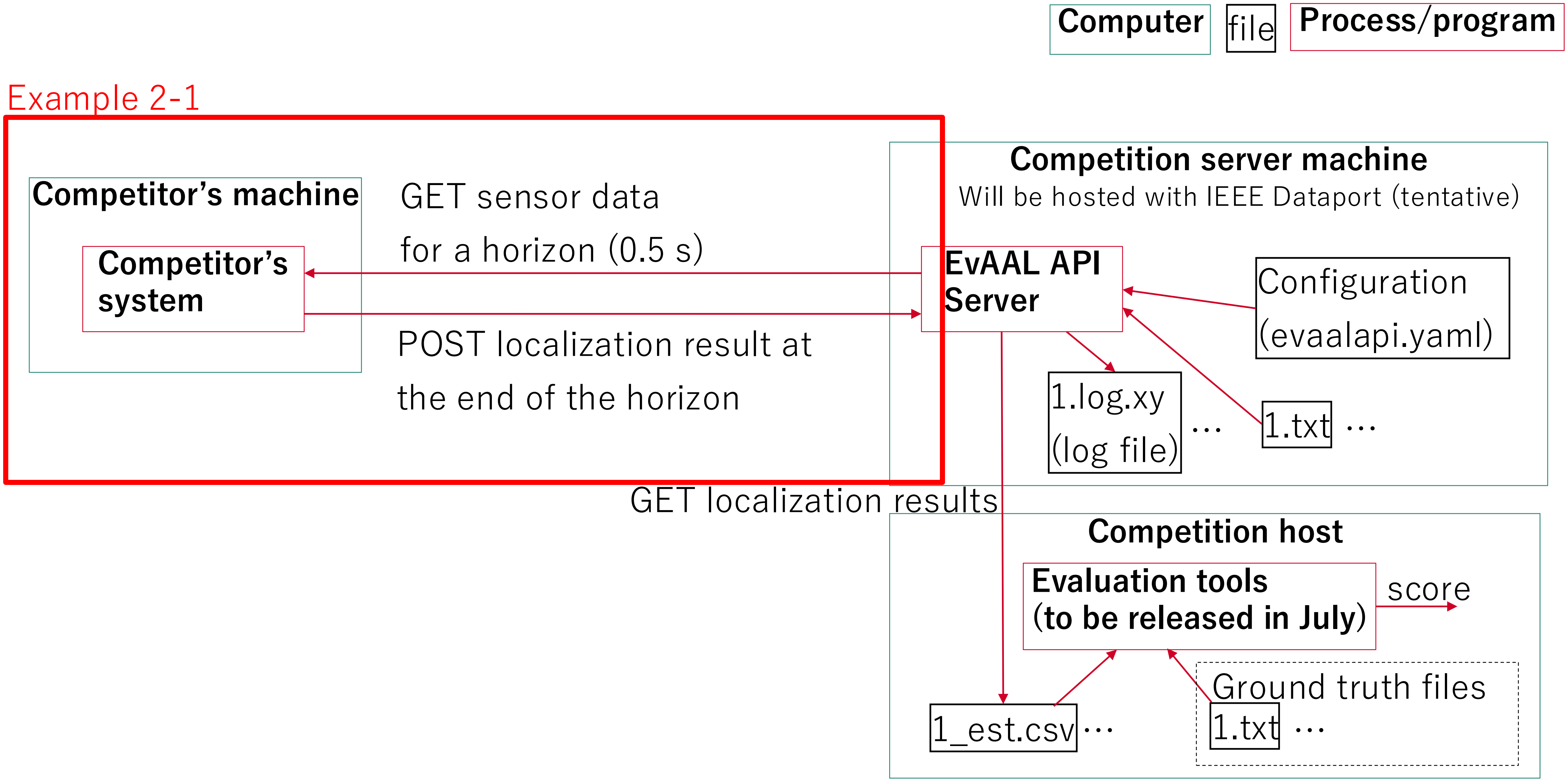
Example 1


Computer
file
Process/program
Competition server machine
Will be hosted with IEEE Dataport (tentative)
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
POST localization result at
the end of the horizon
EvAAL API Server
Configuration (evaalapi.yaml)
1.log.xy (log file)
…
1.txt
Example 1
GET localization results
Competition host
Evaluation tools (to be released in July)
score
1_est.csv
Ground truth files
1.txt

Example 2

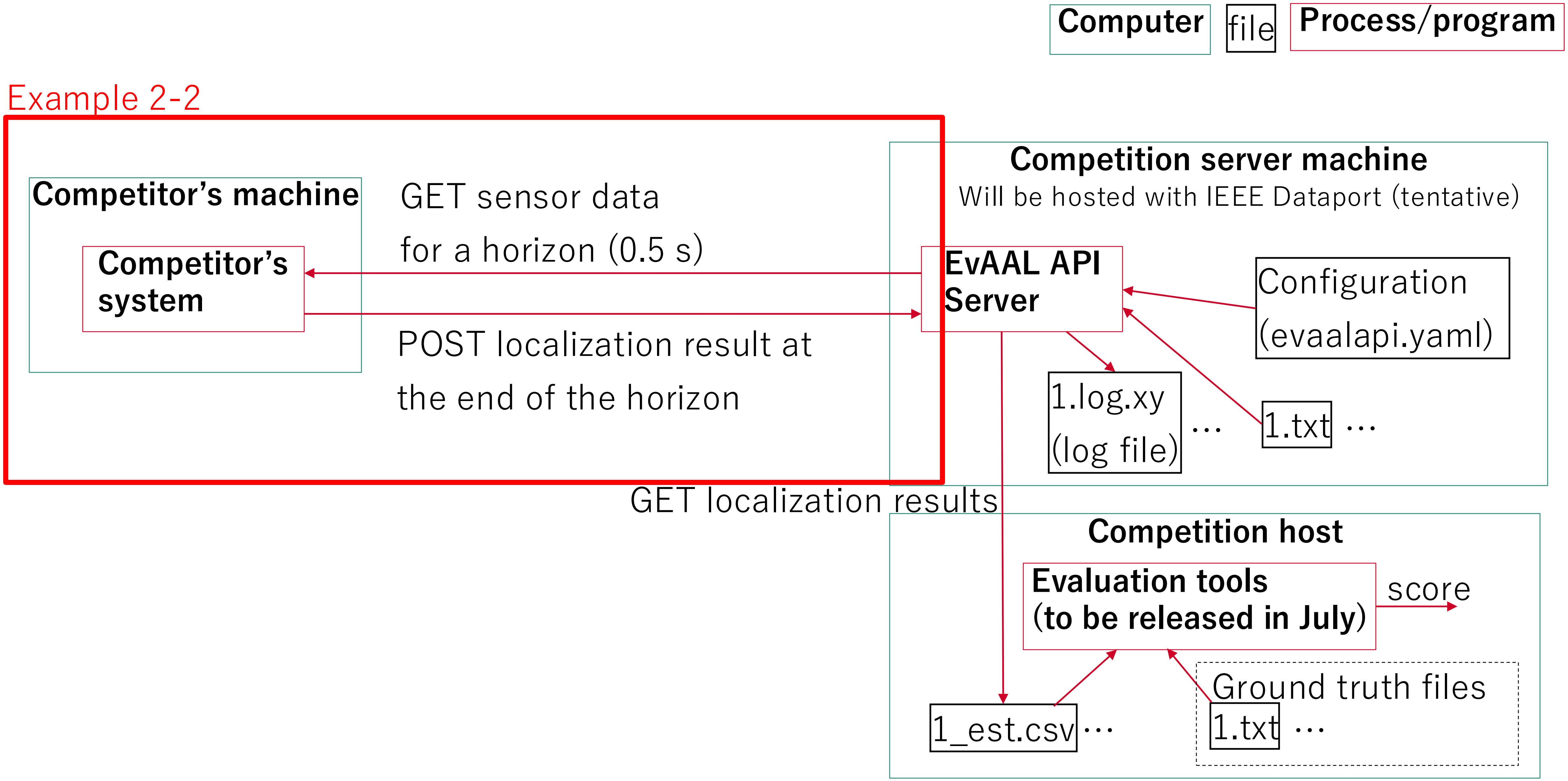

Computer
file
Process/program
Example 2
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
POST localization result at
the end of the horizon
Competition server machine
Will be hosted with IEEE Dataport (tentative)
EvAAL API Server
Configuration (evaalapi.yaml)
1.log.xy (log file) …
1.txt …
GET localization results
command
cd evaalapi_server
python evaalapi.py
Runs this server in the local machine
(please keep this terminal opened
through example 2-x)
Competition host
Evaluation tools
(to be released in July)
score
1_est.csv …
Ground truth files
1.txt …

Example 2-1

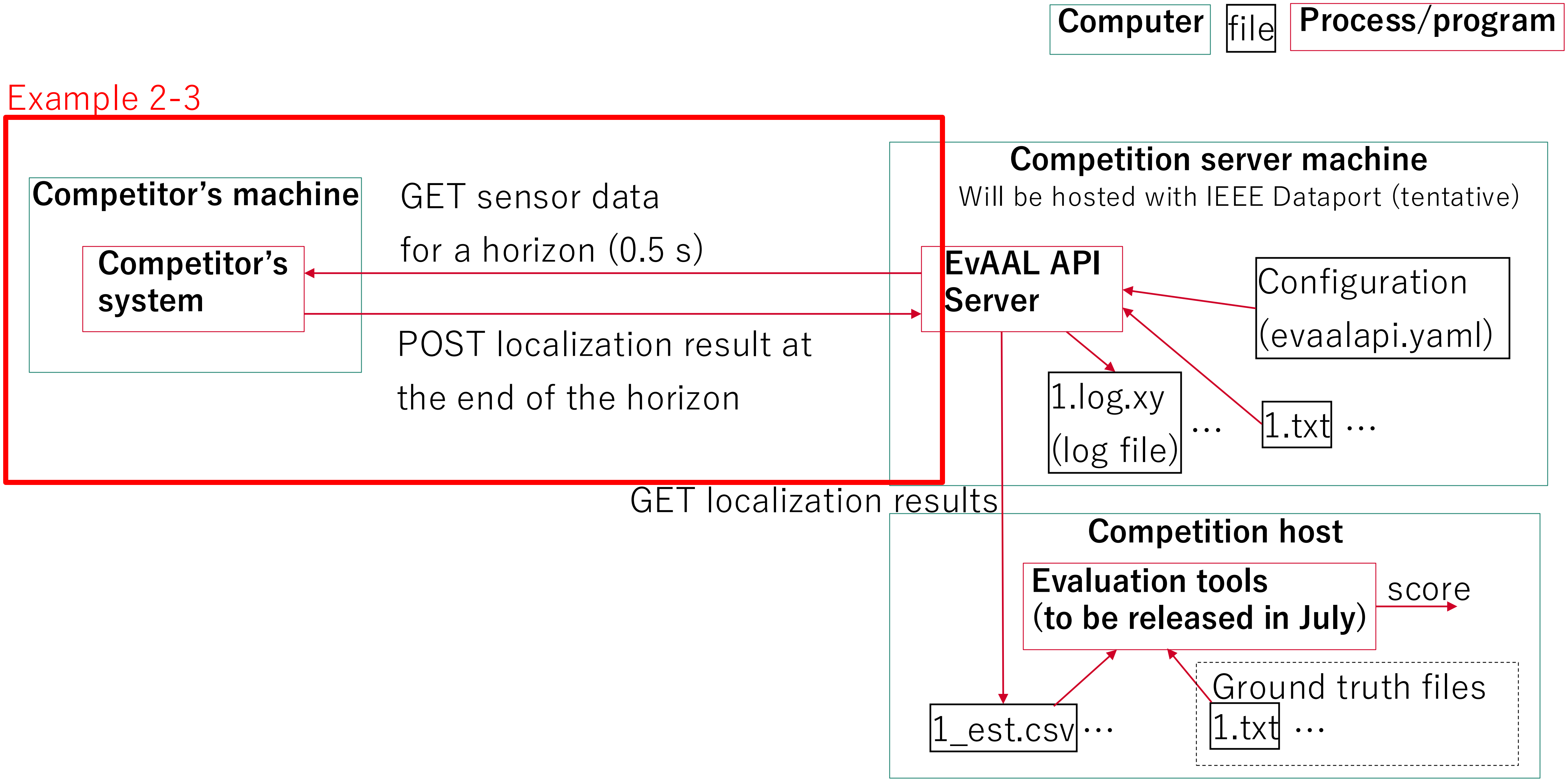


Computer
file
Process/program
Example 2-1
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
POST localization result at
the end of the horizon
Competition server machine
Will be hosted with IEEE Dataport (tentative)
EvAAL API Server
Configuration
(evaalapi.yaml)
1.log.xy
(log file)
…
1.txt …
GET localization results
Competition host
Evaluation tools
(to be released in July)
score
1_est.csv…
Ground truth files
1.txt …

Example 2-2

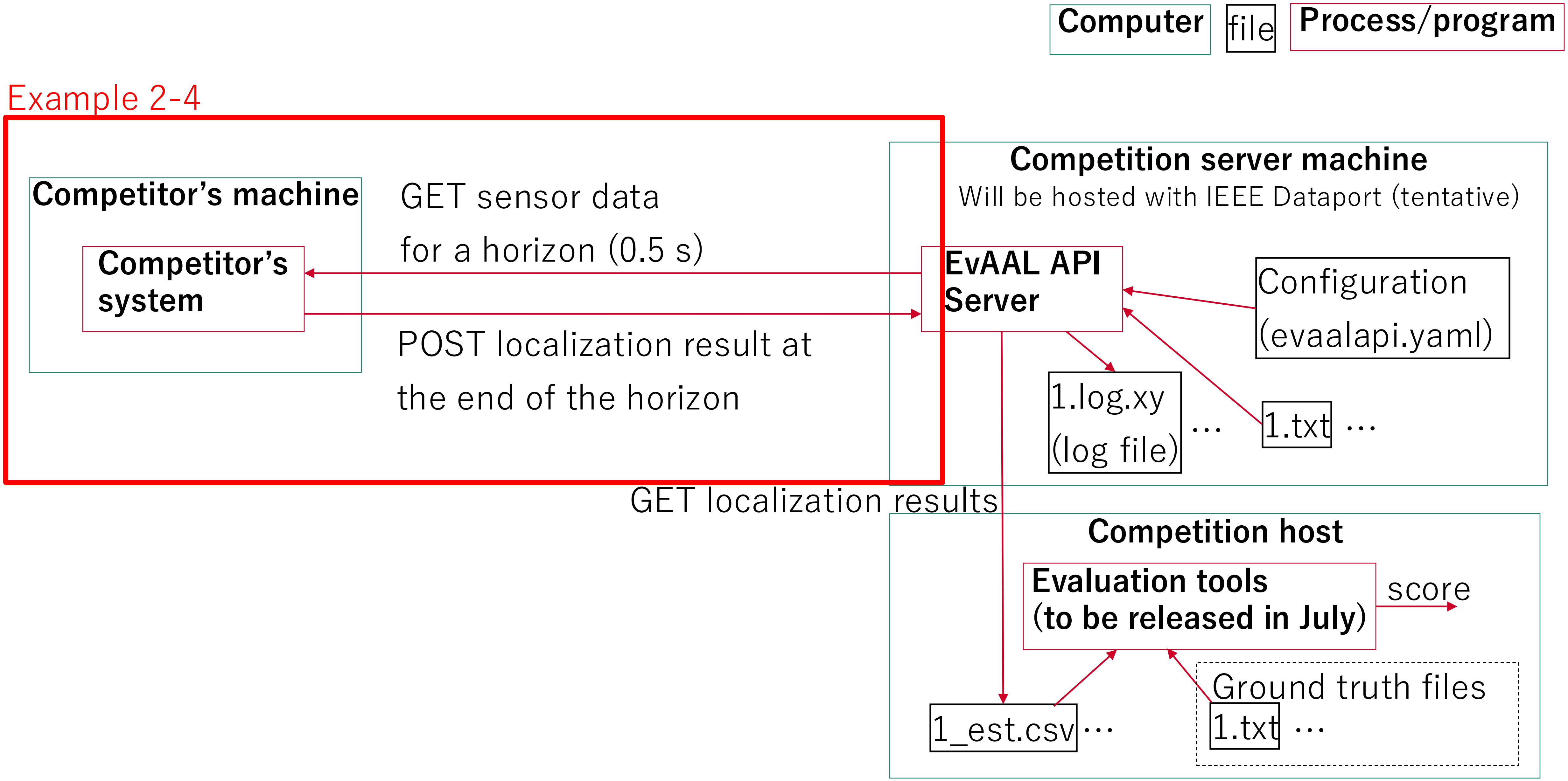

Computer
file
Process/program
Example 2-2
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
POST localization result at
the end of the horizon
Competition server machine
Will be hosted with IEEE Dataport (tentative)
EvAAL API Server
Configuration
(evaalapi.yaml)
1.log.xy
(log file)
…
1.txt …
GET localization results
Competition host
Evaluation tools
(to be released in July)
score
1_est.csv …
Ground truth files
1.txt …

Example 2-3



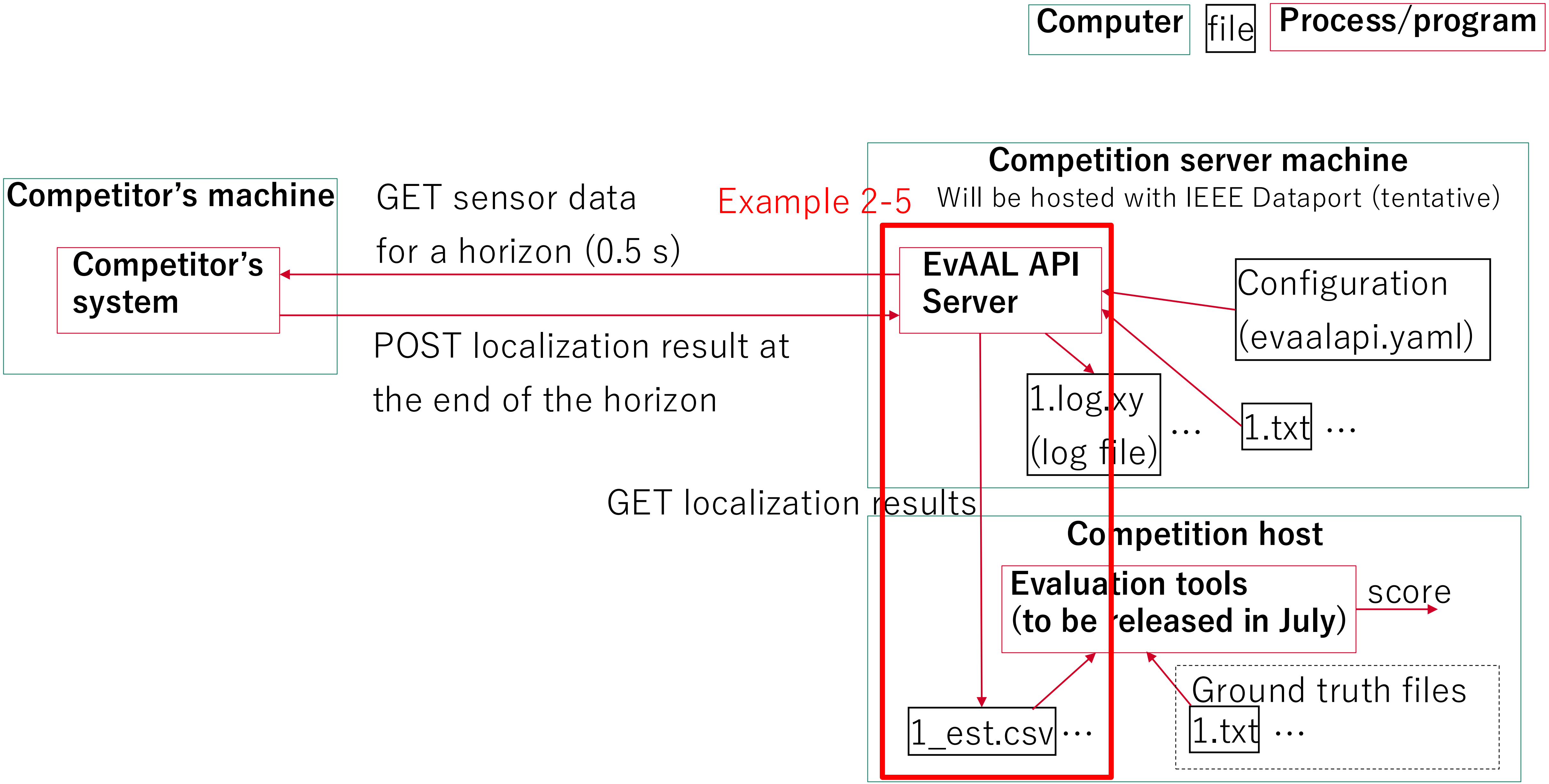
Computer
file
Process/program
Example 2-3
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
POST localization result at
the end of the horizon
Competition server machine
Will be hosted with IEEE Dataport (tentative)
EvAAL API Server
Configuration (evaalapi.yaml)
1.log.xy (log file) …
1.txt …
GET localization results
Competition host
Evaluation tools (to be released in July)
score
1_est.csv …
Ground truth files
1.txt …

Example 2-4



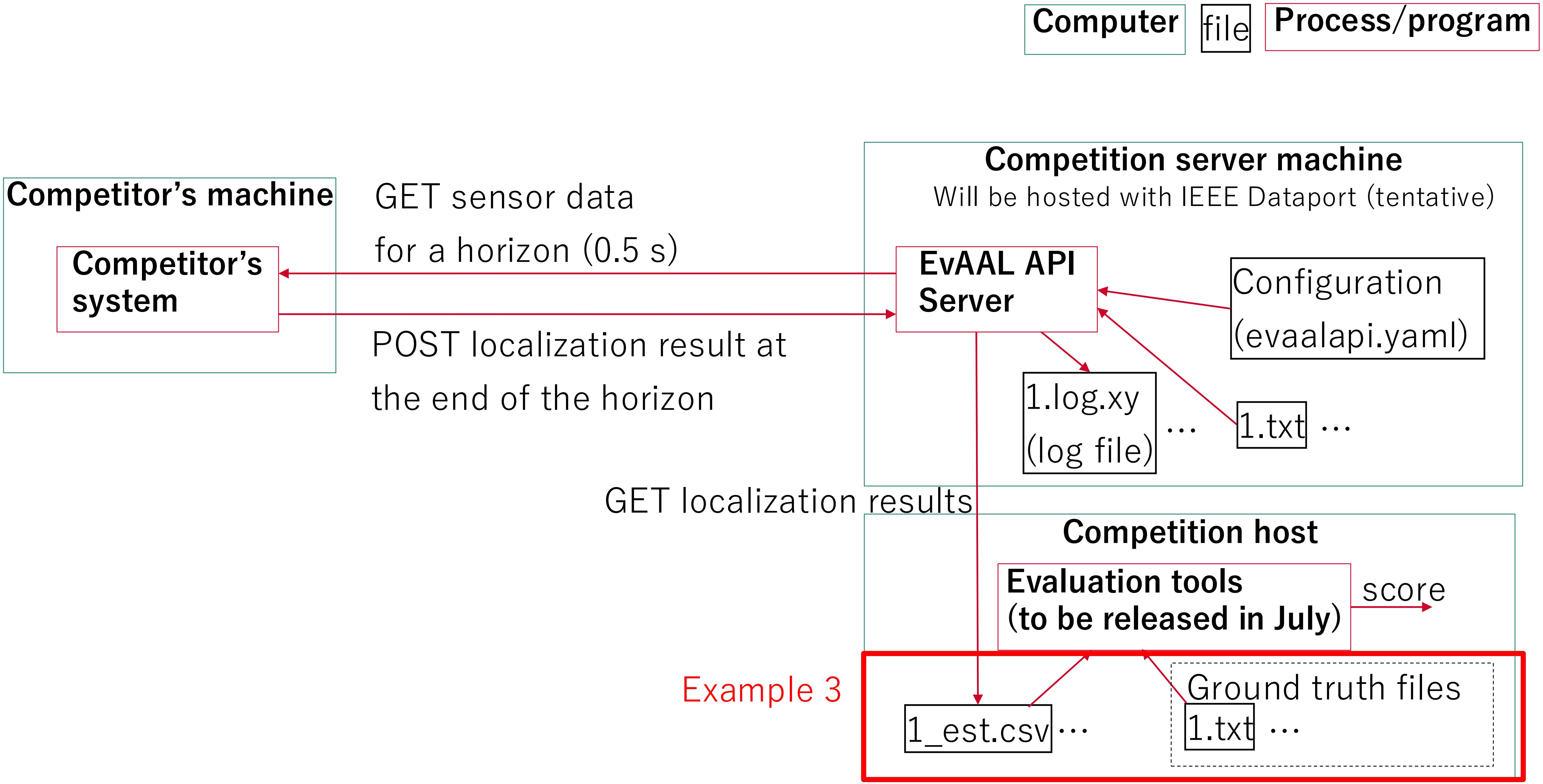
Computer
file
Process/program
Example 2-4
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
POST localization result at
the end of the horizon
Competition server machine
Will be hosted with IEEE Dataport (tentative)
EvAAL API Server
Configuration (evaalapi.yaml)
1.log.xy (log file) …
1.txt …
GET localization results
Competition host
Evaluation tools (to be released in July)
score
1_est.csv …
Ground truth files
1.txt …

Example 2-5



Computer
file
Process/program
Competition server machine
Will be hosted with IEEE Dataport (tentative)
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
Example 2-5
EvAAL API Server
Configuration (evaalapi.yaml)
POST localization result at
the end of the horizon
1.log.xy (log file) …
1.txt …
GET localization results
Competition host
Evaluation tools (to be released in July)
score
Ground truth files
1.txt …
1_est.csv …

Example 3



Computer
file
Process/program
Competitor's machine
Competitor's system
GET sensor data
for a horizon (0.5 s)
POST localization result at
the end of the horizon
Competition server machine
Will be hosted with IEEE Dataport (tentative)
EvAAL API Server
Configuration (evaalapi.yaml)
1.log.xy (log file) …
1.txt …
GET localization results
Competition host
Evaluation tools (to be released in July)
score
Example 3
1_est.csv …
Ground truth files
1.txt …

Other basic usage of the EvAAL API

For more about EvAAL API, please visit EvAAL API website

Revision 3.10.3.8

IPIN competition interface

For official use at the IPIN competition you need a trial name.

More demo usages

For unofficial testing you can freely use the `demo` trial, either by writing your own tests or by running the demo program at your premises. Calling `demo auto` produces this output on your terminal. Calling `demo interactive` allows one to choose the timing by pressing Return at the terminal.

If you want to run `demo` with an API server at your premises, you need to download the API server source code and the demo configuration in the same directory, plus the `Logfiles/01-Training/01a-Regular/T03_02.txt` file taken from Indoorloc, to be put under a `trials/` subdirectory.

Documentation

API Documentation

You should start by carefully reading the API complete documentation (Markdown source) which begins with an overall decription of the API. Once you are familiar with it, you can use the OpenAPI description as a reference with examples.

Source code

Copyright 2021-2024 Francesco Potortì

The Python evaalapi.py source code is released under the GNU Affero General Public License v3.0 or later.

https://evaal.aaloa.org/evaalapi/