Seamless TinyML lifecycle management

In Software Engineering Project with University of Helsinki CS

16/01/2023

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Basic info (1/2)

- Here's the original announcement
- Here's our proposal, Seamless TinyML lifecycle management
- 5 students are assigned to our project.
- 15 working hours / week / student is expected.
- The project duration, 14 weeks (week 3-16), is scheduled.
  - 15 hours * 14 weeks * 5 students
  - = 1050 hours / 7.5 hour
  - = 140 man days / 22
  - = 6.4 man month

Basic info (2/2)

Milestone

1. Around week 9.
2. Around week 13.

Project duration:

1. Originally, 14 weeks, week 3-16
2. Preferably, 12 weeks, week 3-14
3. Ideally, 10 weeks, week 3-12

Weekly work hours

- 15 hours * 14 weeks = 210 hours
  1. Originally, 210 hours / 14 weeks = 15 hours/week
  2. Preferably, 210 hours / 12 weeks = 17.5 hours/week
  3. Ideally, 210 hours / 10 weeks = 21 hours/week

Can UI (Dashboard & Control panel) parts be prioritized to meet some milestones?

Project goal

To make things easier, it is recommended that the students start familiarizing with the different concepts of Machine Learning (ML) lifecycle. Also, prior jumping in the implementation of the lifecycle management of TinyML-tailored models, it is perhaps a good idea start implementing/executing some of the steps of the original project proposal (e.g., step 2, step 3, step 5, step 6) in a more resourceful computing environment than a microcontroller (MCU). For example, the students could use their own laptop, a cloud environment, or Single-Board Computer (e.g., Jetson Nano)

Tutorial

The following demos/tutorials can provide an high-level overview on how to deploy the above mentioned steps:

1. Jetson Nano Custom Object Detection - how to train your own AI
2. Jetson AI Fundamentals - S3E4 - Object Detection Inference
3. Jetson AI Fundamentals - S3E5 - Training Object Detection Models

Please note that online it is possible to find plenty of tutorials/demos that can help you on deploying the ML lifecycle management for such resourceful computing environments. Feel also free to reach out to us for asking additional references.

UI

As for the dashboard/user interface deployment, here are a few minimalistic examples and references that can help but feel free to be fancy as you like:

1. Explainer Dashboard — Build interactive dashboards for Machine learning models
2. Model Monitoring Dashboards made easy
3. Building MLGUI, user interfaces for machine learning applications

Why Edge to TinyML (1/2)

While these demos uses relatively large hardware which may not belong to TinyML strictly (e.g. TinyML should run on RTOS but not on Linux), we are gradually migrating to TinyML MCUs. There are 4 benefits of starting with the original setting:

1. Jetson nano is a standalone GPU, where we run the following app locally at once before starting pipe-lining on other nodes.
   - Computer Vision apps, inc. ML models
   - dashboard on a web server
   - Jupyter notebook

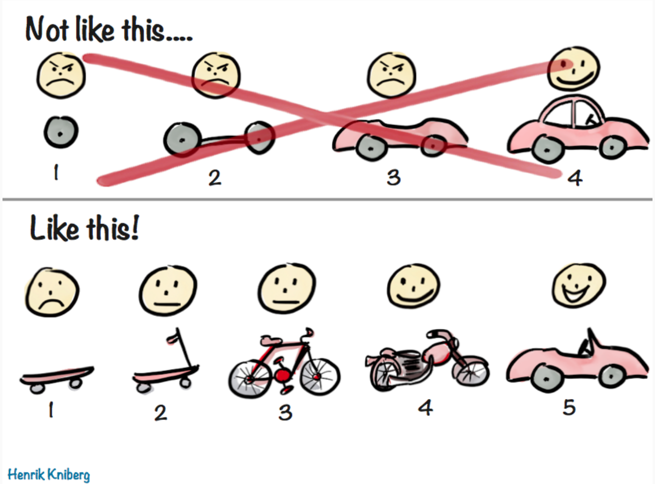
Why Edge to TinyML (2/2)

2. We could learn from Jetson nano mature tool-stack what kind of tool-stack is still missing to implement TinyMLaaS.
3. We could start with this existing demo immediately with runnable CI, and
4. We are polishing it more fancy gradually towards TinyML as-a-Service.
5. We could gradually migrating to TinyML by adding or replacing a node one by one.
    - For example, we could replace the data acquisition node with:
        a. Camera sensor + Arduino Nano 33 BLE Sense + RPI (for IP)
        b. Camera sensor + RPI pico with WiFi

Although Our final goal is to run ML on a mirocontrooler node, it's better to start with the safer configuration at first.

MVP journey

We should always have a runnable MVP automatically generated by CI/CD at every Sprint (or PR).



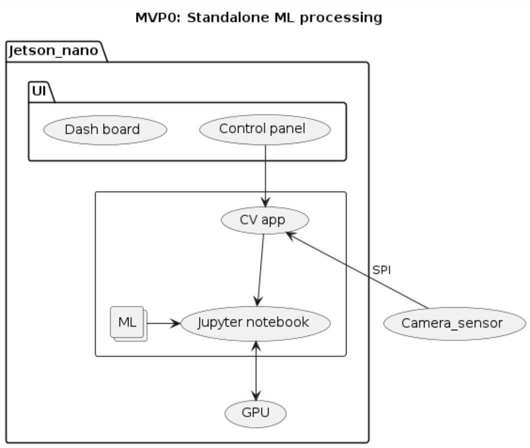
MVP0

Jetson nano is almost a laptop with GPU so that everything should work standalone.

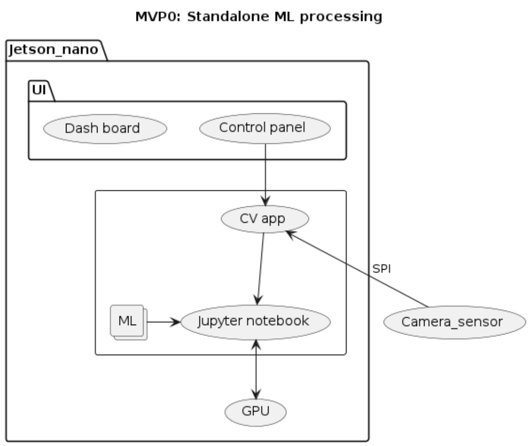
ML pipeline

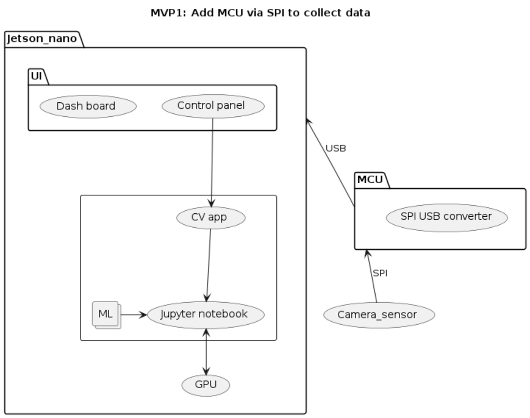
1. Object detection
2. -> face detection
3. -> Person identification pipeline

A VM can be used to test the similar functionality with mock camera.



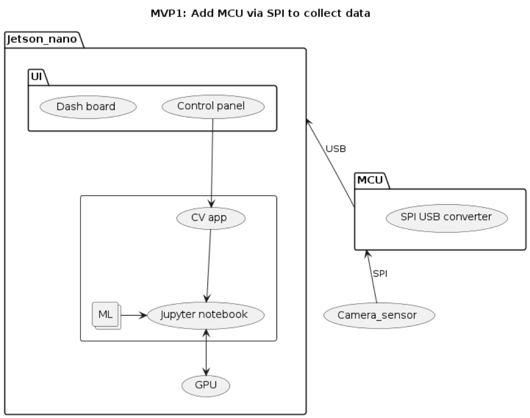
MVP0 -> MVP1

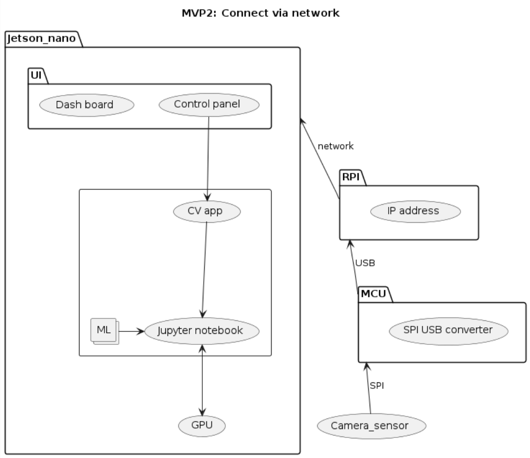




At first, we could push sensor part out via USB.

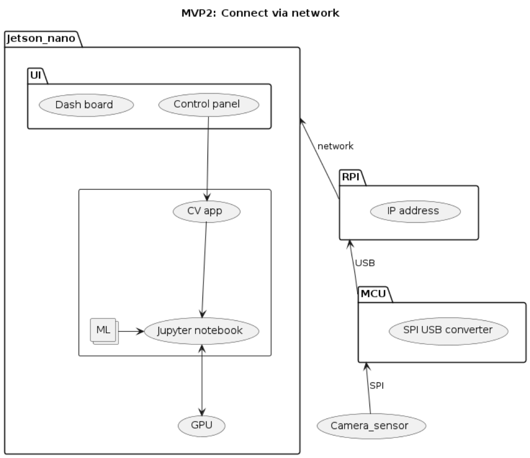
MVP1 -> MVP2

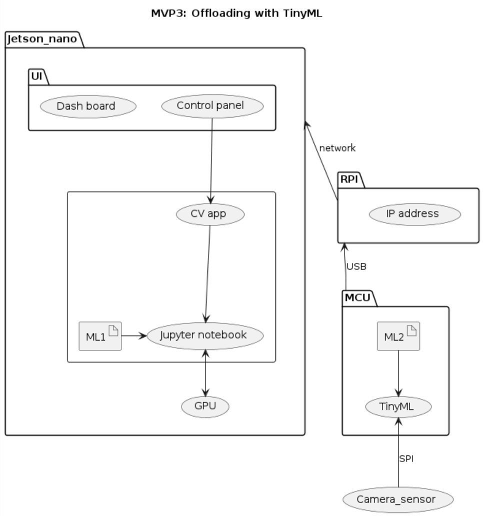




To orchestrate ML, IP connection is convenient so that we insert RPI between Jetson and MCU.

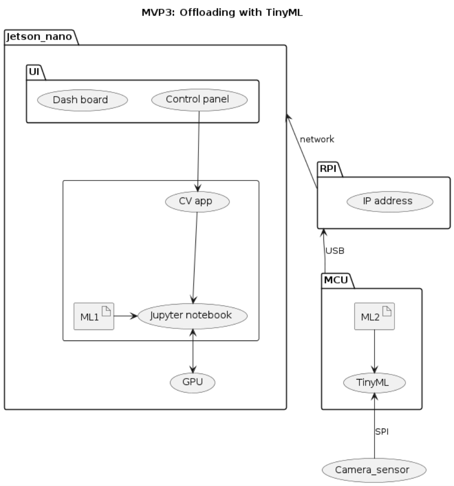
MVP2 -> MVP3

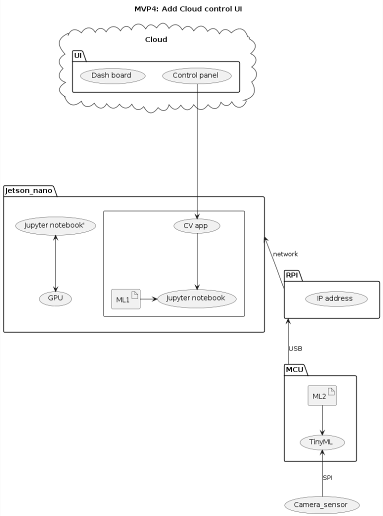




Run a small part of ML processing (ML2) as TinyML on MCU.

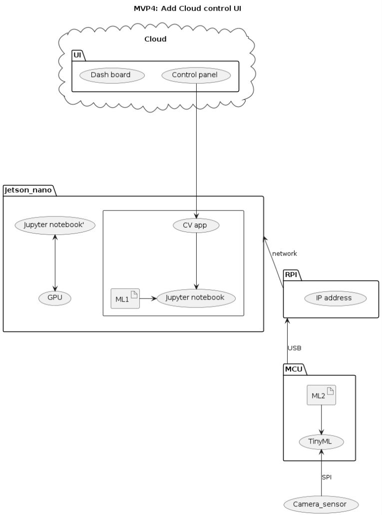
MVP3 -> MVP4

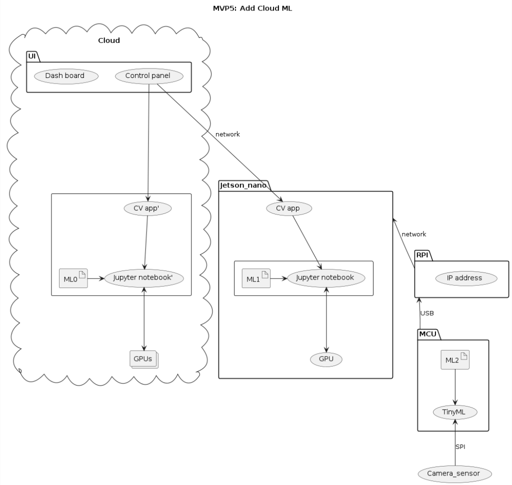




CLOUD'ification should be done earlier independently to meet early demo (between

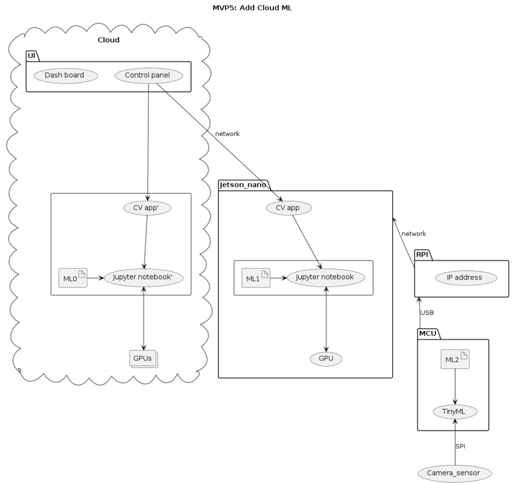
MVP4 -> MVP5

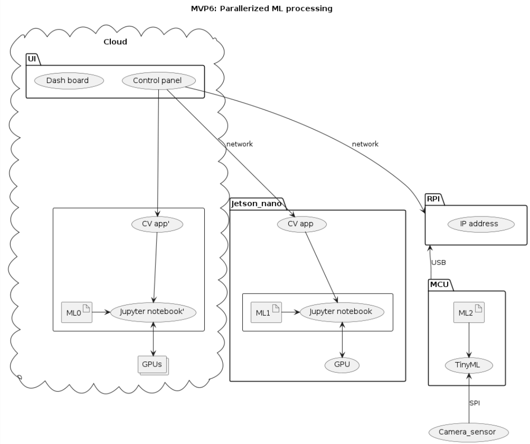




Run some part of ML processing (ML0) on Cloud.

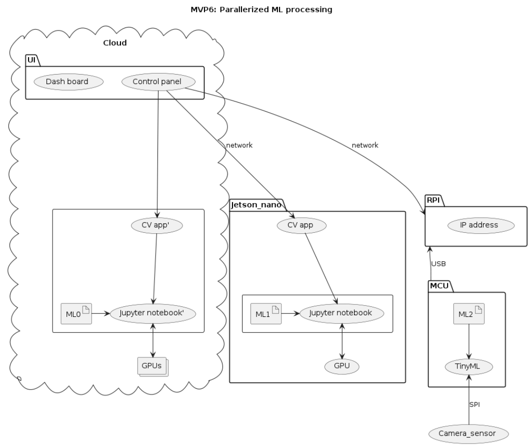
MVP5 -> MVP6

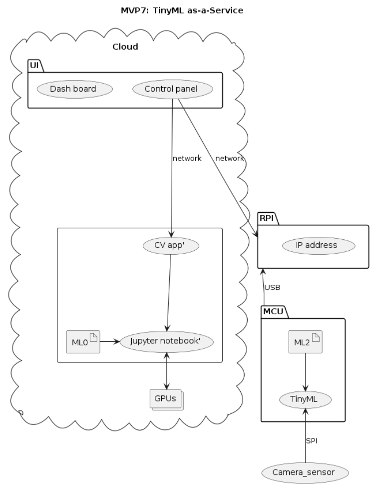




No cascading MLs but paralleling with nodes.

MVP6 -> MVP7



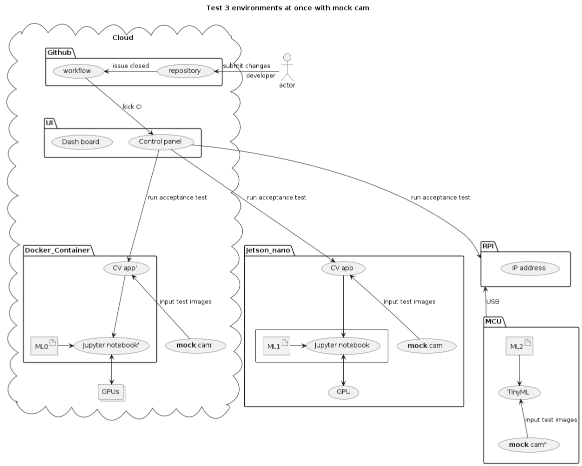


Get rid of Jetson nano but only with TinyMLaaS.

TDD / CI / CD / Acceptance test

How it works

1. Developer sends PR to repository
2. Kicked Github workflow (action)
3. Starts CI / CD
4. Run acceptance tests on 3 envs
    a. Container with **mock** Cam
    b. Jetson nano with **mock** Cam
    c. MCU with **mock** Cam
5. Merge Changes once all tests pass.
6. Store Artifacts
    - install-able images
7. Always Runnable system to demo



Kick-off meeting Agenda (1/4)

Scheduled on 16th JAN (MON)

Get familiar with all participants. Everyone introduces oneself

1. What one can do
2. What one wants to do
3. How one sees this project

Agree on Project goal

Will explain Project goal

Kick-off meeting Agenda (2/4): SCRUM team

Role	Name	Note
SM	Michihito Mizutani	
PO	Roberto Morabito	
Developer	5 students	names to fill here
ML support	Hiroshi Doyu	
Customer	Perttu, Samuli	Review incremental

Kick-off meeting Agenda (3/4)

User story mapping

- Specify PBIs always as GitHub issues, which need to be a PR and it automatically runs CI/CD as acceptance tests.
- PBI == SBI?
- Estimate PBI effort (PBI workload unit?)
- Specify acceptance tests and implement in CI before implement features
- the 1st increment == 1 sprint
- For the rest, 1 increment == 2 sprint
- 1st sprint planning should be done on 16th.

Kick-off meeting Agenda (4/4)

Agree on WoW in SCRUM

- Use Github project KANBAN
- Use Discord channel to communicate or Slack?
- Agree on scheduling a Daily meeting day & time
- 1 increment == 2 sprint
- 1st sprint should have some Architecture investigation to find out which components are reusable.
- 1st sprint should have a ZFR (Zero Feature Release) to make sure that CI/CD works on Github workflow (action) without any features (or just with existing components)
- We should run CI/CD to reproduce the current Roberto's demo story at first, without a training part. If HW is not available, it could be simulated.

Architecture investigation @Roberto?

- How should we understand Roberto's demo architecture?
  - Any architecture document?
  - Any architecture block diagram?
  - Any flow diagram?
  - Any list of components used? which could be reused and which not, since the outcome of this project would be opensource'ed.
  - Any list of software frameworks each components uses?
- Should we map each Seamless TinyML lifecycle management's phase on this demo scenario?
- Should we make sure which phases are still missing? (e.g. "2. Model training")

Mapping 6 Seamless TinyML lifecycle to this project

Phase #	Name	Early phase	Demo
1	Data collection	Simulated	RPI pico + Cam
2	Model training	Missing	On Cloud VM?
3	Model squeezing	ML compiler	ML compiler
4	Model splitting	Standalone	Pipelining
5	Model deployment	Standalone	TBI
6	Model update	Dashboard	Control panel

Contact information

Origami

https://Origami-TinyML.github.io/blog/about.html