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Unlocking NLP Potential: Fine-Tuning with Microsoft Olive

Workshop PRE016

Sam Kemp Principal Program Manager
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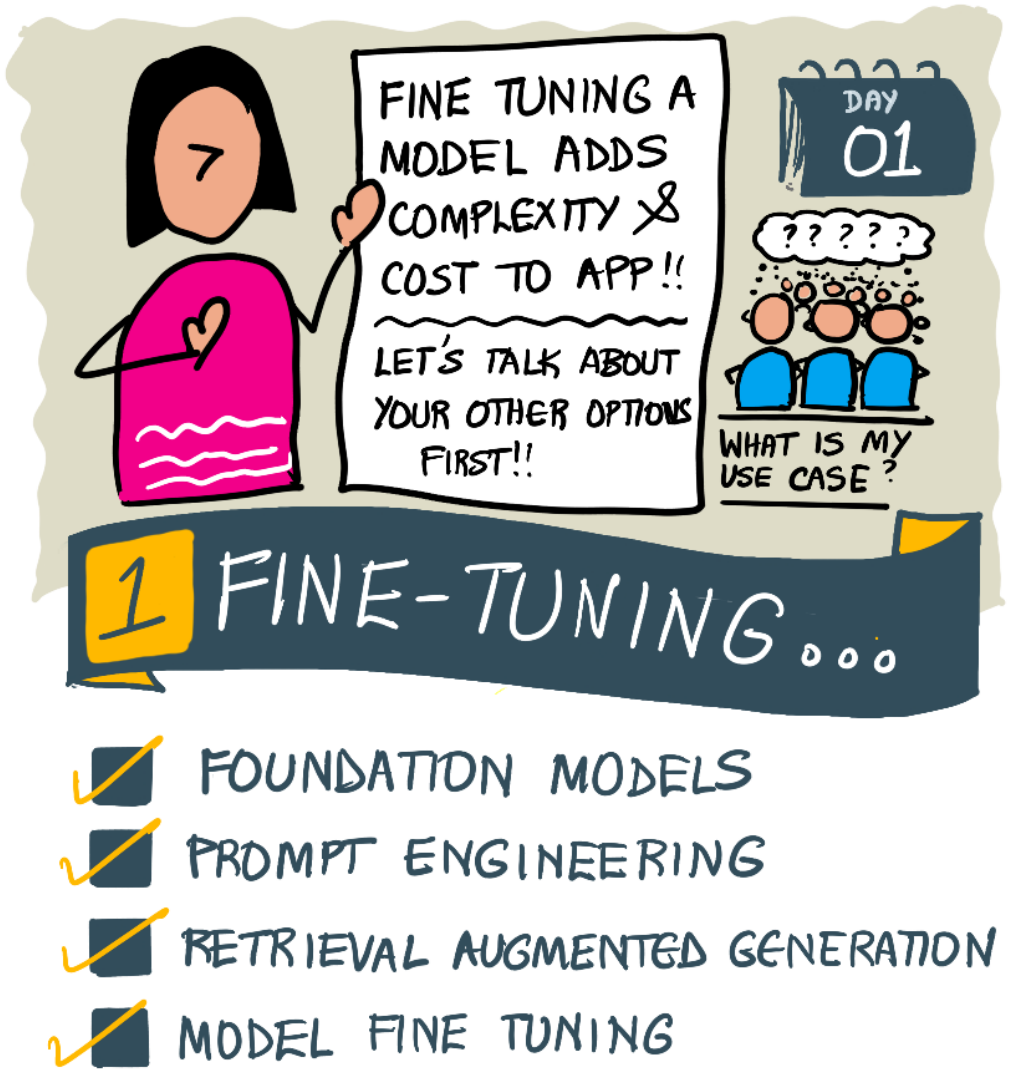
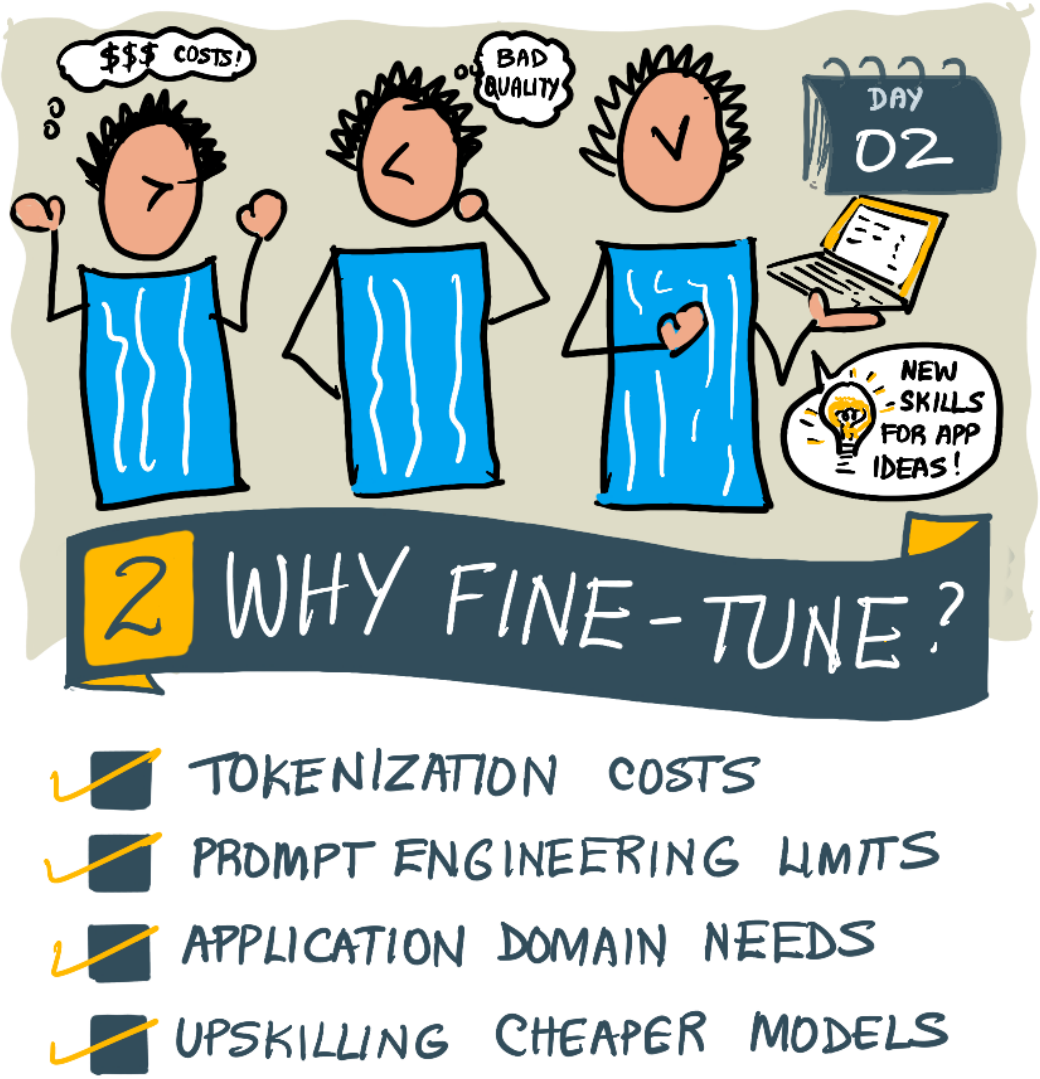


What are we going to cover

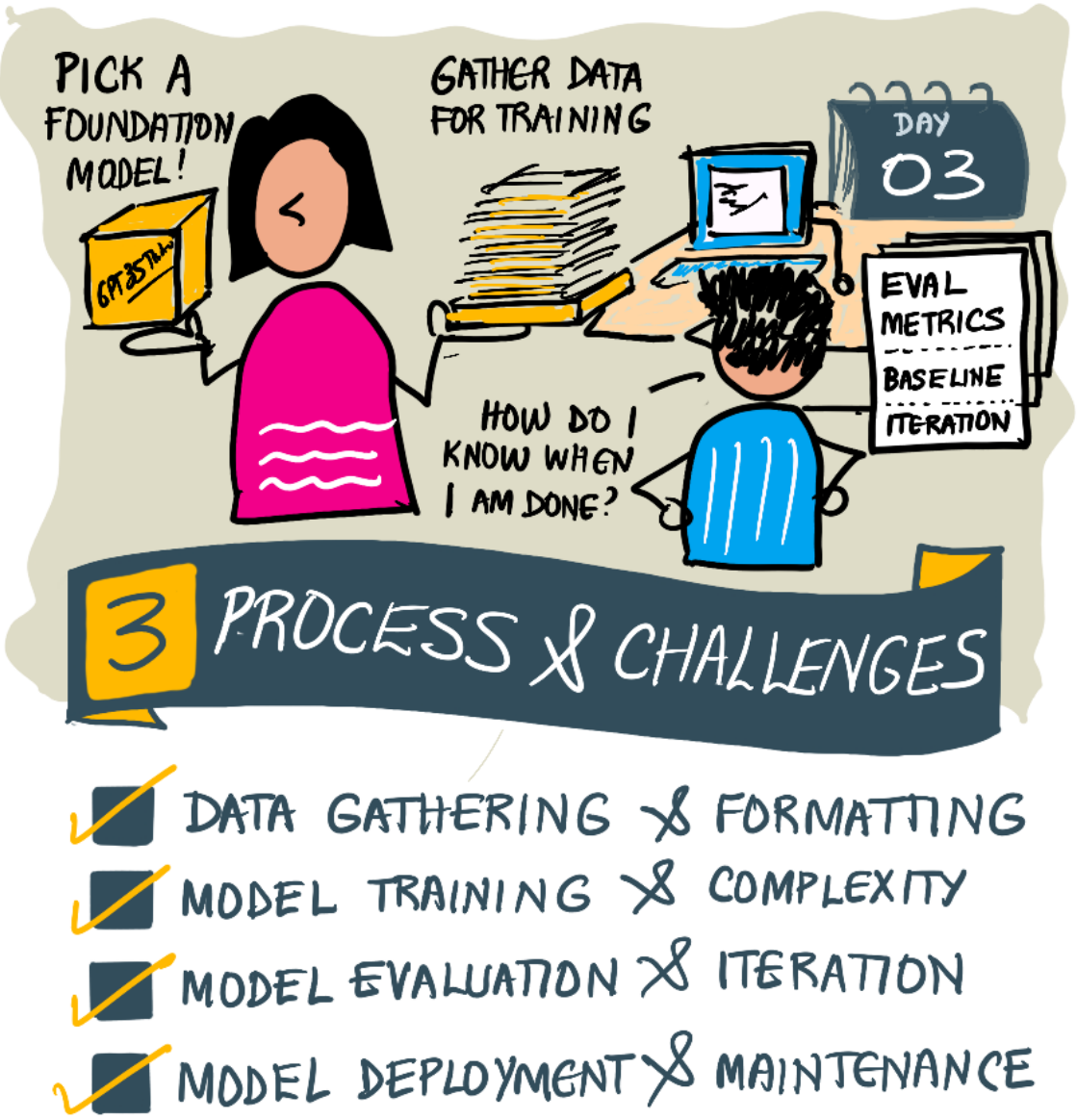
Fine tuning a common practice in machine learning where we retrain an existing model **with new data** to improve performance on task.
This is an advanced technique that **requires some expertise** to get desired results. Incorrect usage may degrade performance.



WHY SHOULD I FINE-TUNE?

Fine-Tuning may be appropriate if your desired **response quality** is not achievable with prompt engineering or RAG approaches.

Another reason may be the **cost efficiency** achieved by reduced token usage or ability to upskill a cheaper model (within reason).

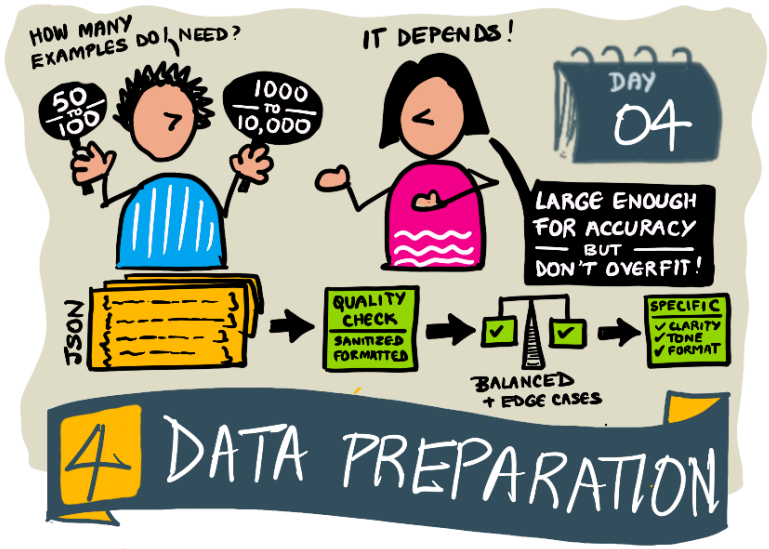


WHEN SHOULD I FINE-TUNE?

But the approach is valid only if the **benefits outweigh costs**.

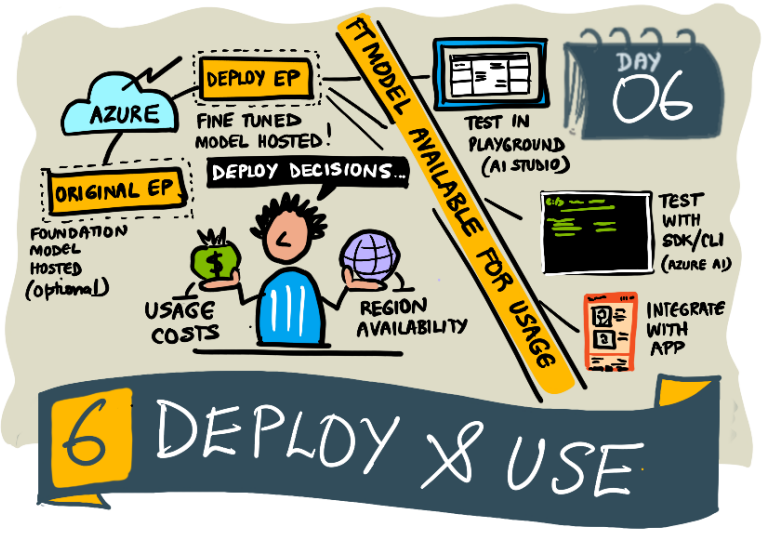
- Do you have a good use case?
  (format, edge cases, new skills)
- Have you tried other options?
- Did you factor in other costs?
  (compute, data, maintenance)
- Did you confirm the benefits?
  (evaluation, region availability)

PREP – Train – Evaluate - deploy



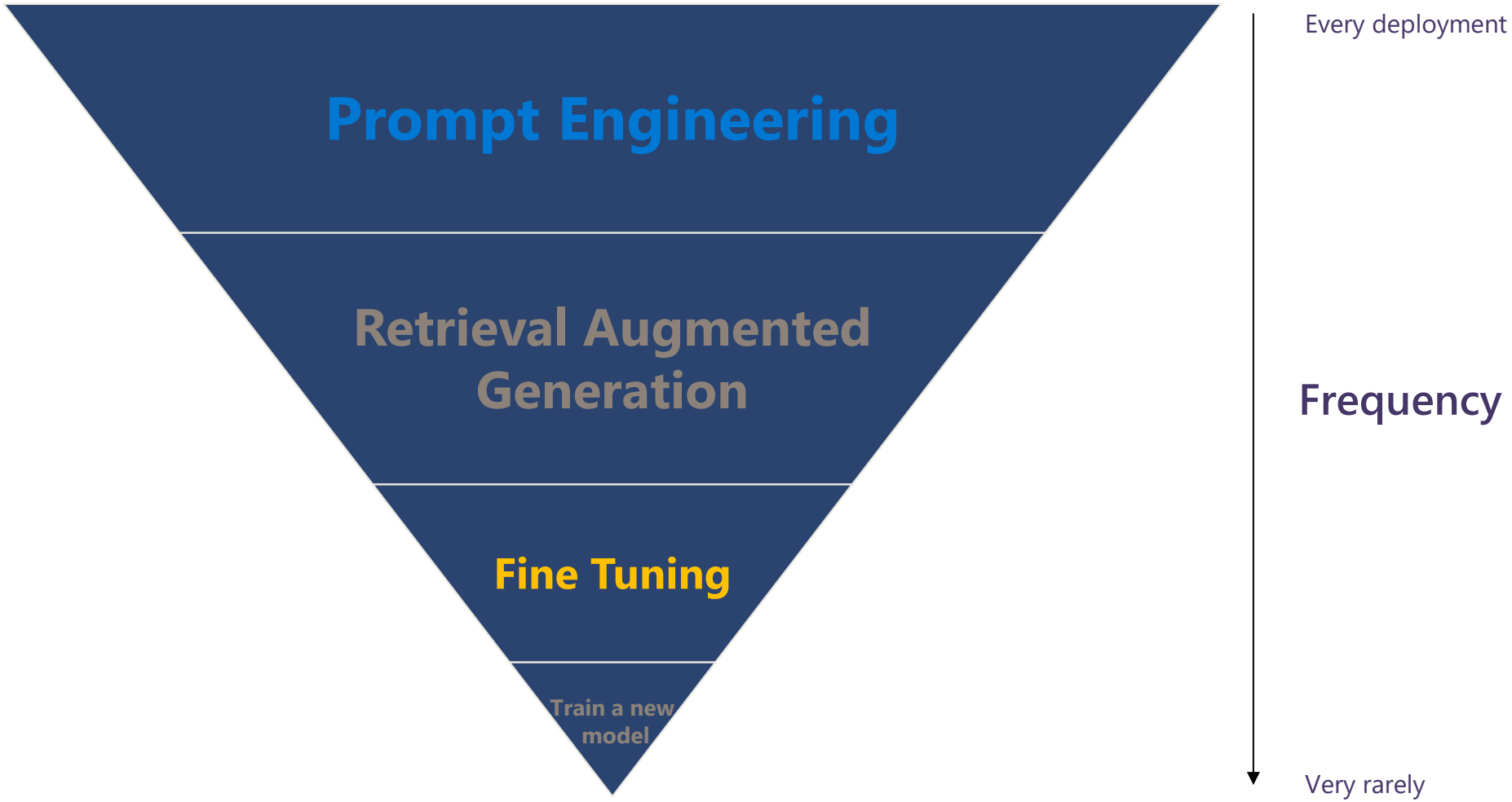
- SIZE OF TRAINING DATA (#examples)
- FORMAT OF EXAMPLE (model based)
- DATA REPRESENTATION (fairness)
- REQUIREMENTS COVERAGE (quality)

- UPLOAD DATA FOR TRAINING
- CREATE FINE TUNING JOB
- MONITOR JOB STATUS
- TEST FINE TUNED MODEL



- REGION AVAILABILITY (constraint)
- MODEL RATE LIMITS (shared)
- USE IN PLAYGROUND (validate)
- USE IN SDK/APP (integrate)

Hierarchy of language model customization



What about on-device AI?

Why now?

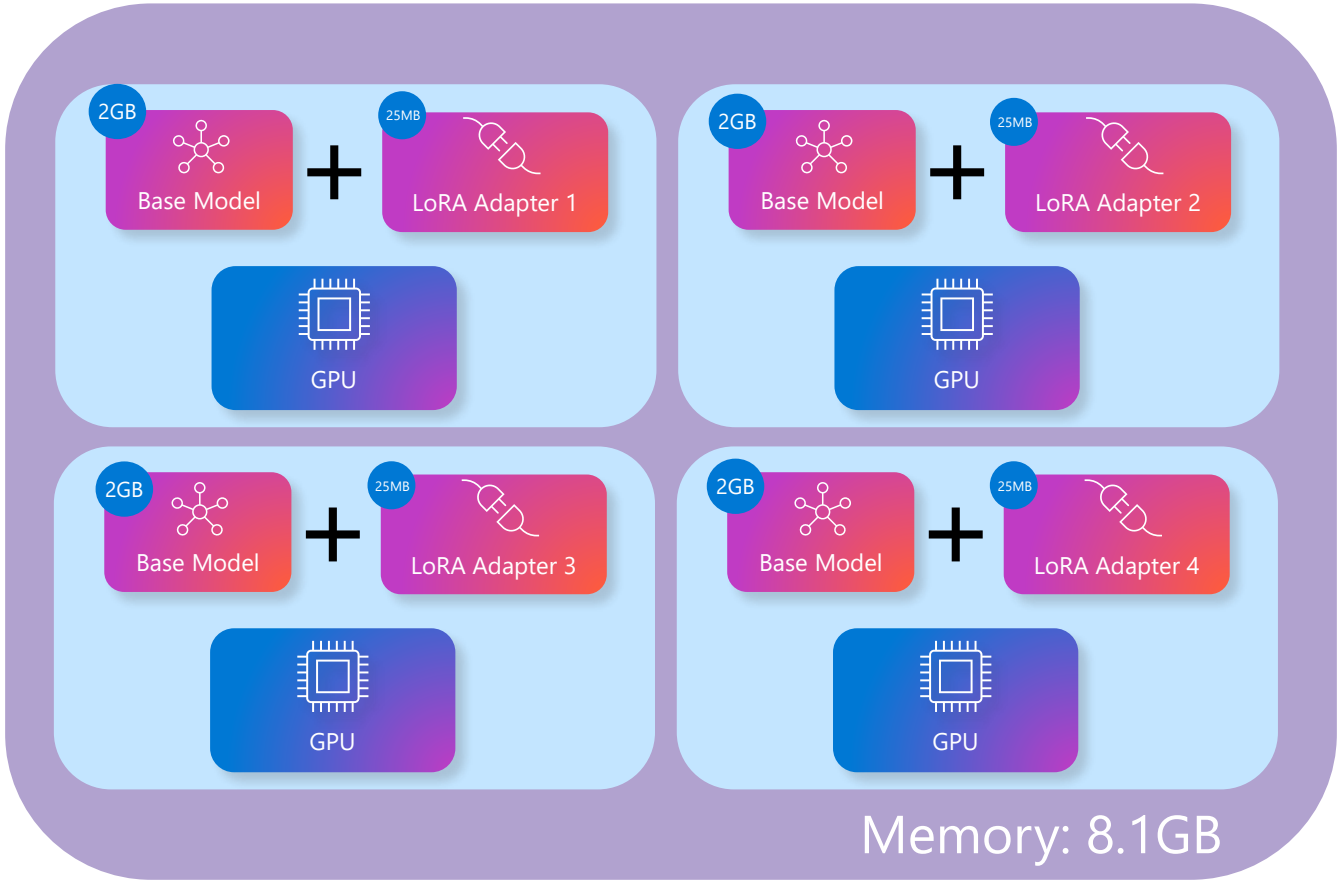
- Fine-tuning boosts model efficacy for SLMs that can be inferenced on-device.
- NPUs boost performance and ease power consumption.
- Multi-LoRA serving paradigm means device can *efficiently* host many fine-tuned adapters that give high model quality.
- It is not *all on device* or *all on cloud* BUT… ***Hybrid***

Motivation

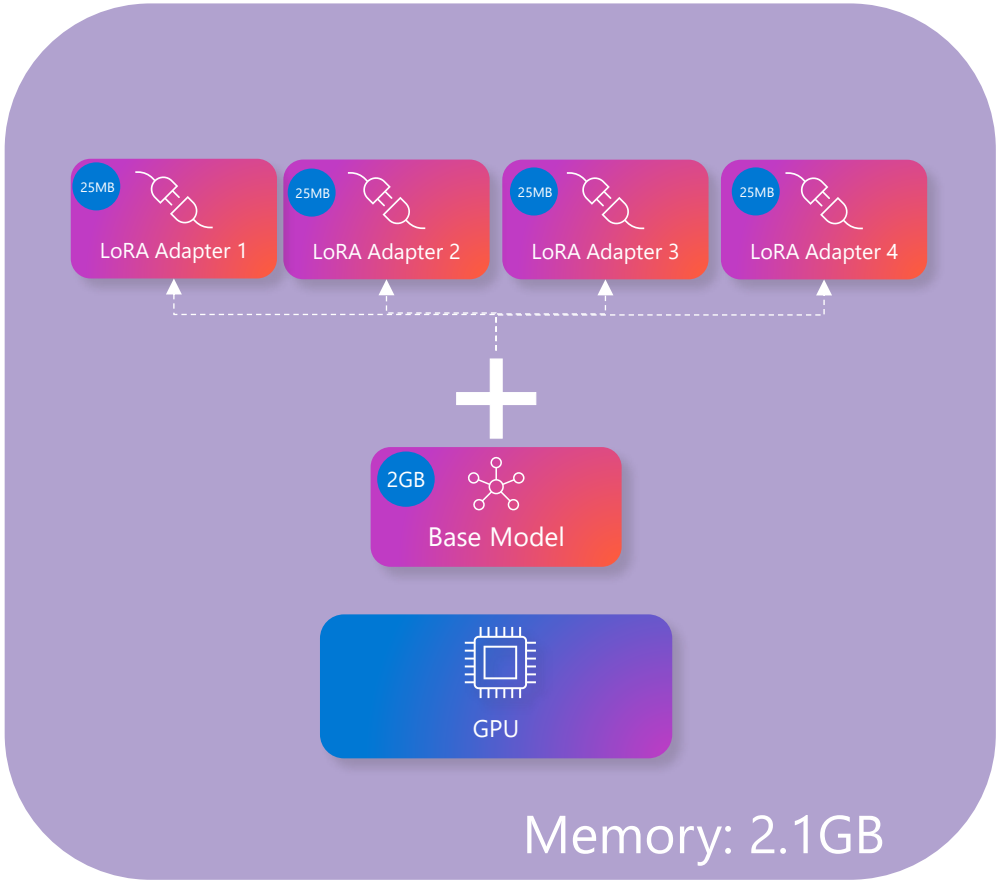
- COGs
- Privacy
- Improve latency
- Disconnected scenarios

Multi-LoRA Serving

Smaller resource footprint



Serving LoRA models separately



Multi-LoRA Serving

Hybrid AI Patterns

Fallback

- Prefer client and fallback to cloud when client is not capable, or
- Prefer cloud and fallback to client when no network

Offload

- Run part of model pipeline locally and rest of models on cloud, or
- Run part of model pipeline in cloud and rest of models locally

Gating

- Run lightweight model locally and use results to decide whether to call cloud

Federated

- Use local SLM to determine which cloud models to use, or
- Use cloud LLM to determine client models to use

What you will build in this lab...

You will develop a travel companion application that leverages the **Hybrid AI pattern**:

- **Large** Language Models (LLMs) **hosted in the cloud**, and
- **Small** Language Models (SLMs) **hosted on the end-user device**

The application provides personalized travel recommendations, itinerary planning, and real-time assistance to travellers.

We will focus on the specific areas

1. Setting up **Azure AI Compute**
2. Prepare **Training Data**
3. One-Button **Fine-Tuning of a LLM** (GPT3.5-Turbo) with Azure AI Studio
4. **Deploy** the Fine-Tuned **LLM** (GPT3.5-Turbo) to a **cloud endpoint**
5. **Fine-tune and optimize** an **SLM** (Phi-3.5-Mini-Instruct) for **on-device inference** using Olive and the ONNX Runtime.
6. **Evaluate** the model's performance and compare it with the Azure-deployed model.
7. Create a **.NET/Python application** that inferences *both* the LLM in the cloud (from #4) and SLM on-device (from #5)
8. Clean up and delete resources.

Microsoft AI tooling and services

Best-in-class AI foundation models

Azure AI Services

Pre-trained, turnkey solutions for intelligent applications

Azure Machine Learning

Full-lifecycle tools for designing and managing AI models

Responsible AI Tooling

Build and manage apps that are trustworthy by design

Azure AI Studio

A comprehensive platform to develop and deploy custom copilots

AI Toolkit for VS Code

End-to-end AI Developer toolkit download, finetune, deploy

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Lab 1. Environment Setup

EasyTimer

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Lab 2 Data Preparation

Synthetic Dataset Generation Using GPT

Prompt

Generate me some sample travel agent interactions which could happen in the commercial travel industry with realise content of a maximum of 80 words be accurate and realistic.

Extact conversations from each discussion in JSON Format

here are some examples
{"messages": [{"role": "system", "content": "You are an AI travel assistant that helps people plan their trips. Your objective is to offer support for travel-related inquiries, such as visa requirements, weather forecasts, local attractions, and cultural norms. You're helpful, friendly, and engaging. You do not provide answers not related to travel."}, {"role": "user", "content": "What's a must-see in Paris?"}, {"role": "assistant", "content": "Oh la la! You simply must twirl around the Eiffel Tower and snap a chic selfie! Want to feel like royalty? How about a visit to the grand Palace of Versailles next?"}]}

The final output should be in this format

Considerations for Dataset Preparation

Remove	- Personal/sensitive information
Ensure	- Diverse and high-quality examples
Use	- Weights for specific assistant messages

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Lab 3. Simple Fine Tuning using Azure AI Studio

Fine Tuning with Azure AI

Data

Curate 100s+ examples

Format as chat or completion

Define training & validation sets

Upload data to the service

Training

Select base model

Set hyperparameters

Specify data

Executes on Shared Compute

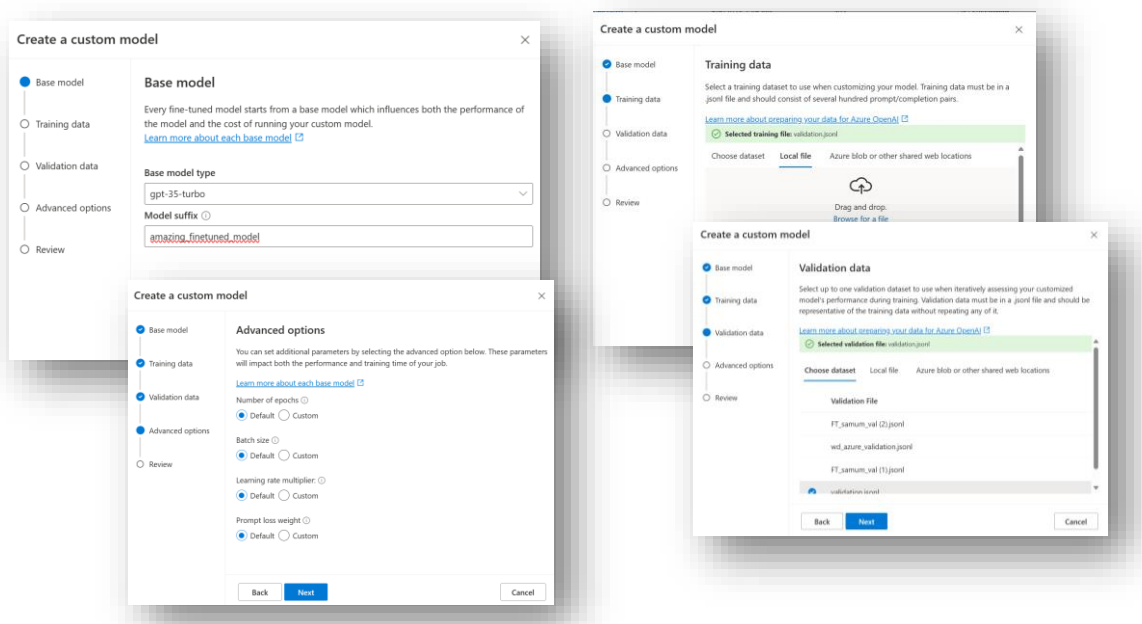
Evaluation

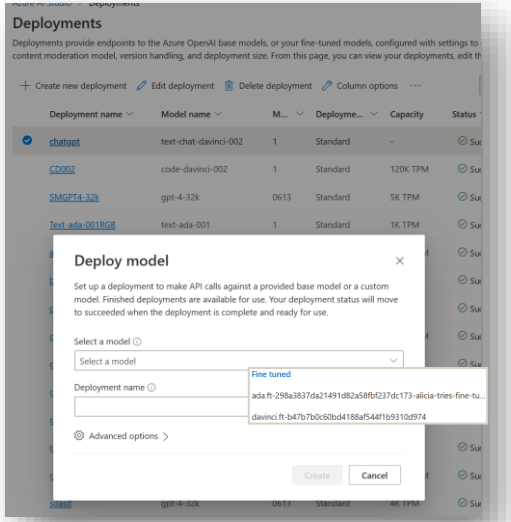
Training & validation loss

Training & validation accuracy

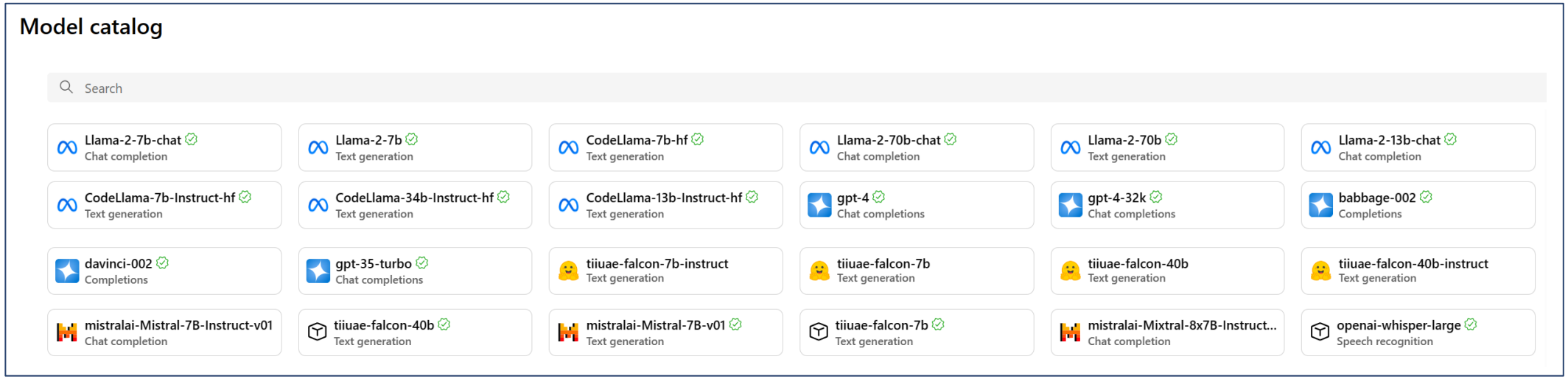
Deployment

Model endpoint for inferencing with AOAI





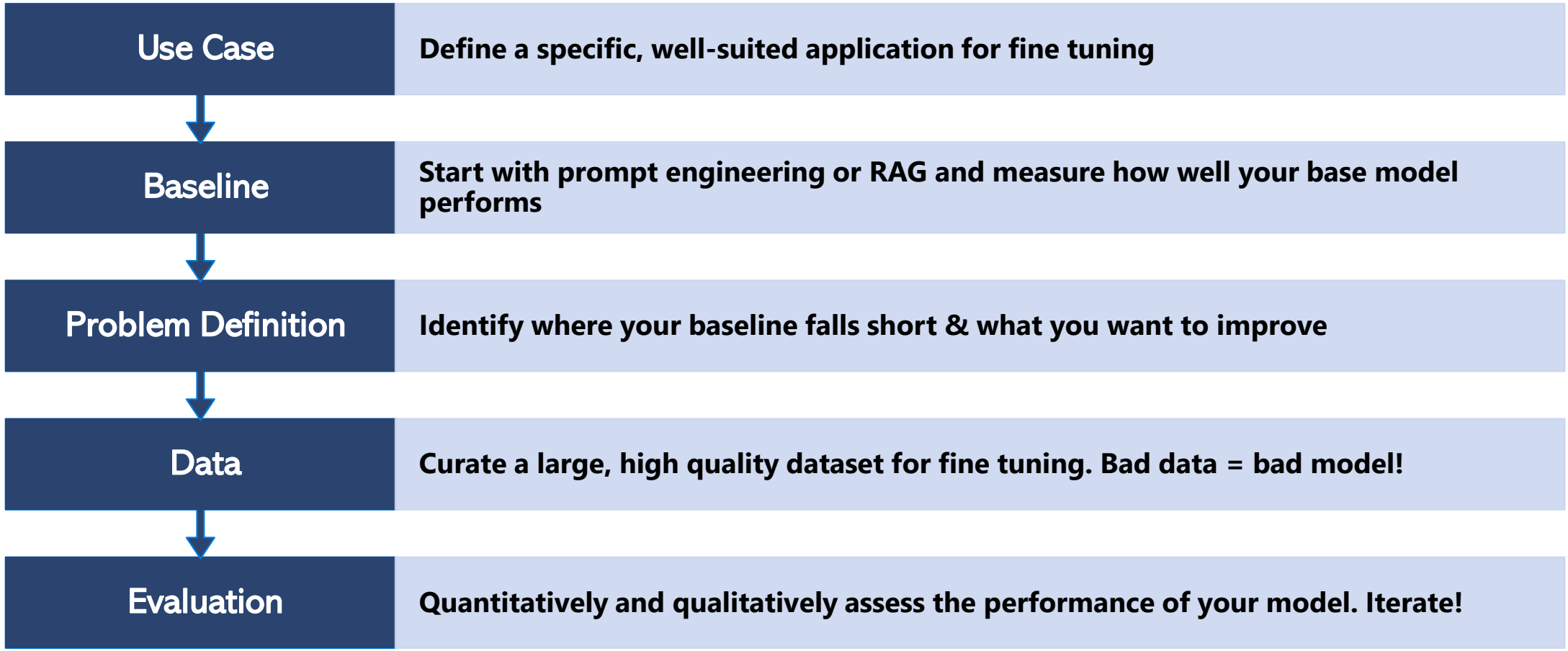
Selecting a model to fine tune



- **Considerations:**

  - **Capabilities**: Which models are fine tunable? What can the base model be fine tuned to do?
  - **Cost**: What's the pricing model for fine tuning
  - **Customizability**: How much can I modify the base model – and in what ways?
  - **Convenience**: How does fine tuning actually happen – do I need to write custom code? Do I need to bring my own compute?
  - **Safety:** Fine tuned models are known to have safety risks – are there any guardrails in place to protect against unintended harm?

Fine Tuning Best Practices



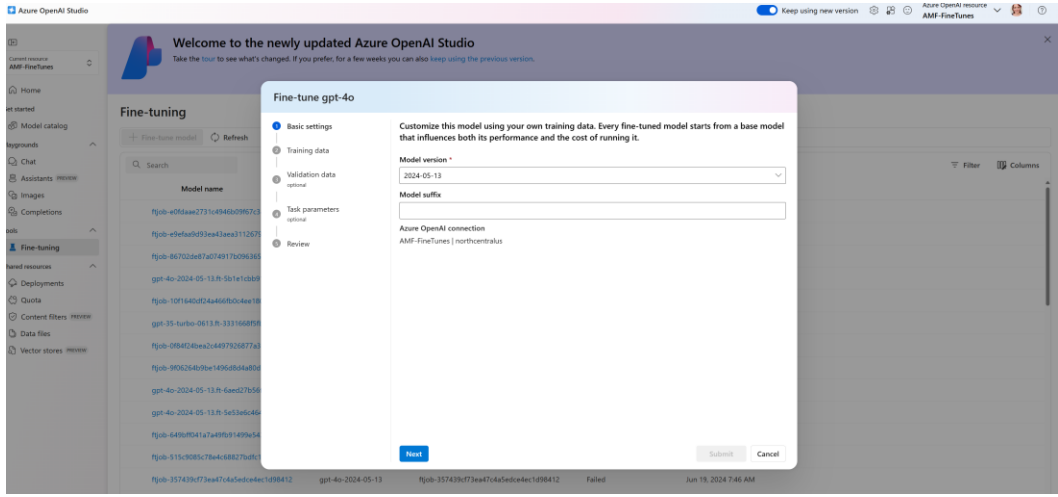
Fine Tuning: Built in Safety

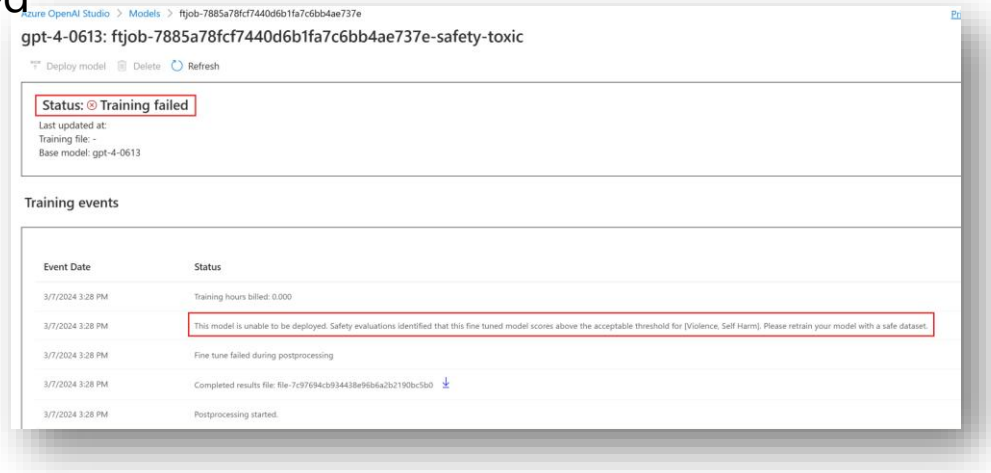
Automatic safety assessments:

- Training data is sampled for potentially harmful content
- Simulated adversarial conversations with fine tuned models
- No charge for rejected jobs – and pointers to how to fix!

Private & Secure

- Evaluated in dedicated, customer specific, private workspaces
- Evaluation endpoints in same geography as AOAI resource
- Assessments are not stored or visible – only final status is persisted





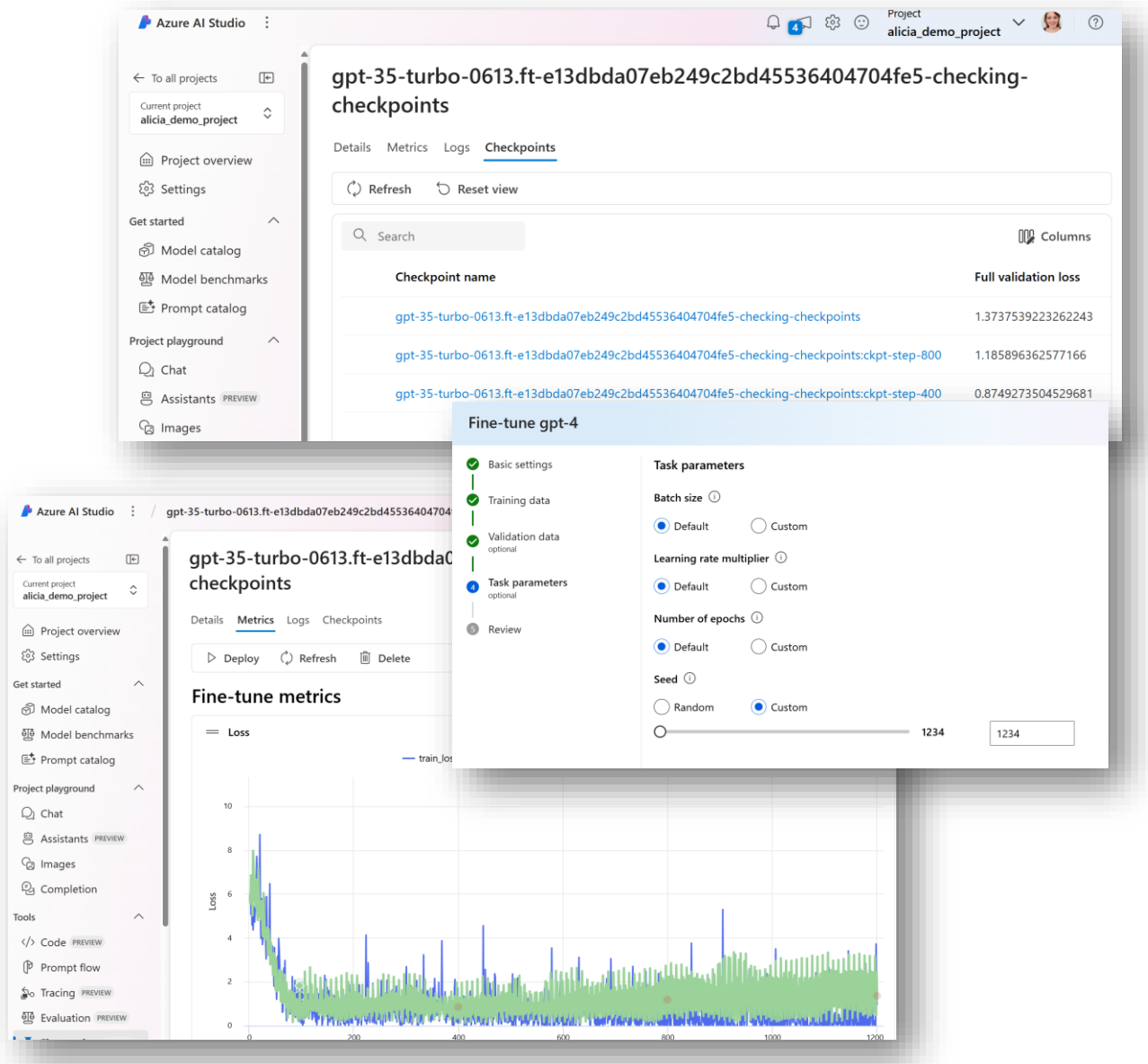
Checkpoints, full validation metrics, and more!

Checkpointing support in API, AI: view and deploy training checkpoints

Full Validation Statistics: Detailed information on accuracy & loss

Seed Property for reproducible training runs

Epochs, Learning Rate, Batch Size parameters to optimize for your data



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Break

20 Mins

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Lab 4. Deployment

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Move on Lab 5

Whilst your Fine Tuned Model is deploying

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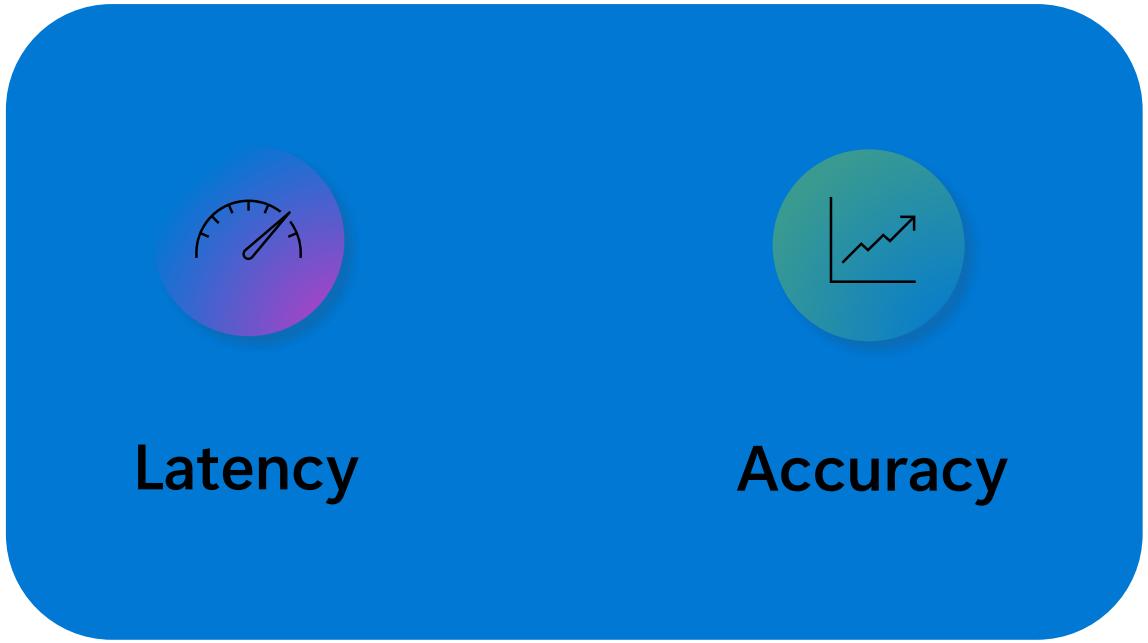
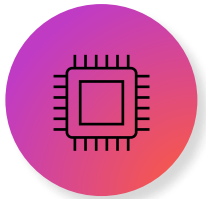
Lab 5. Optimizing an SLM for On-device inference with Olive

The key challenge with on-device AI

How can we ship an accurate model with low latency within given hardware constraints?





Hardware

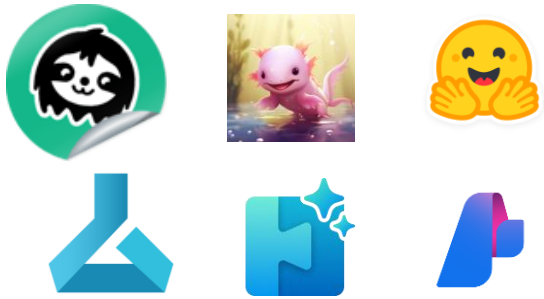
Techniques

What can an AI Engineer do to deliver high accuracy with low-latency on a hardware constrained device?

- Choose a high-quality small model (e.g. <3B parameters)
- Finetune a model
- Quantize the model
- Optimize the model graph
- Choose an efficient model runtime
- Exploit rapidly evolving hardware (e.g. NPU)
- Optimize the serving (e.g. single-LoRA vs multi-LoRA)
- Compress the model

Solution Landscape

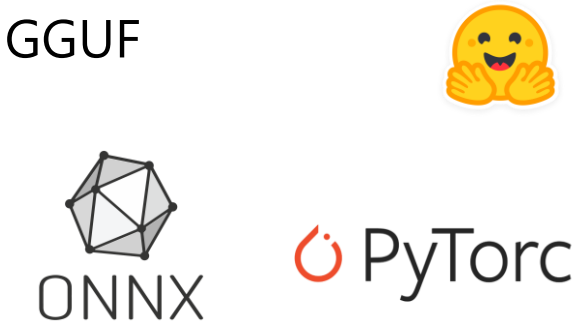
What are the current solution offerings for on-device



Finetuning

Runtimes

Hardware

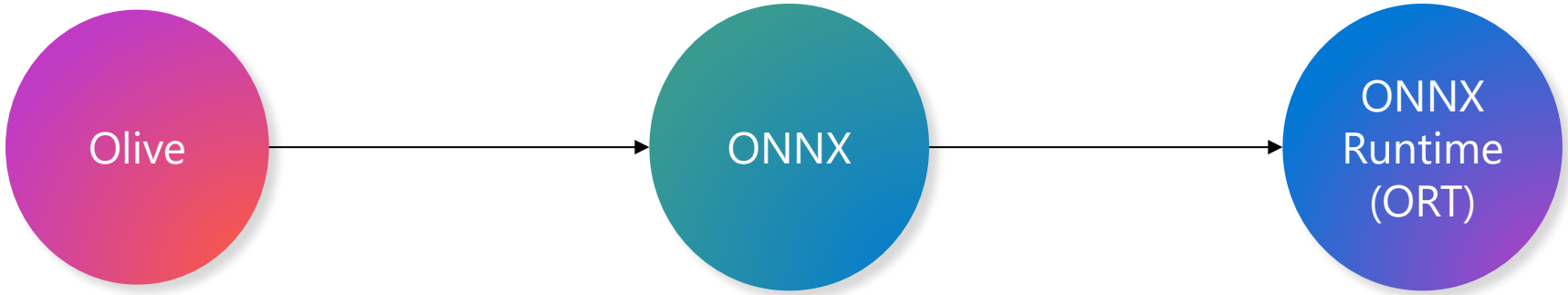


Model Format

Optimization

The ONNX Trilogy

an E2E solution for On-Device AI



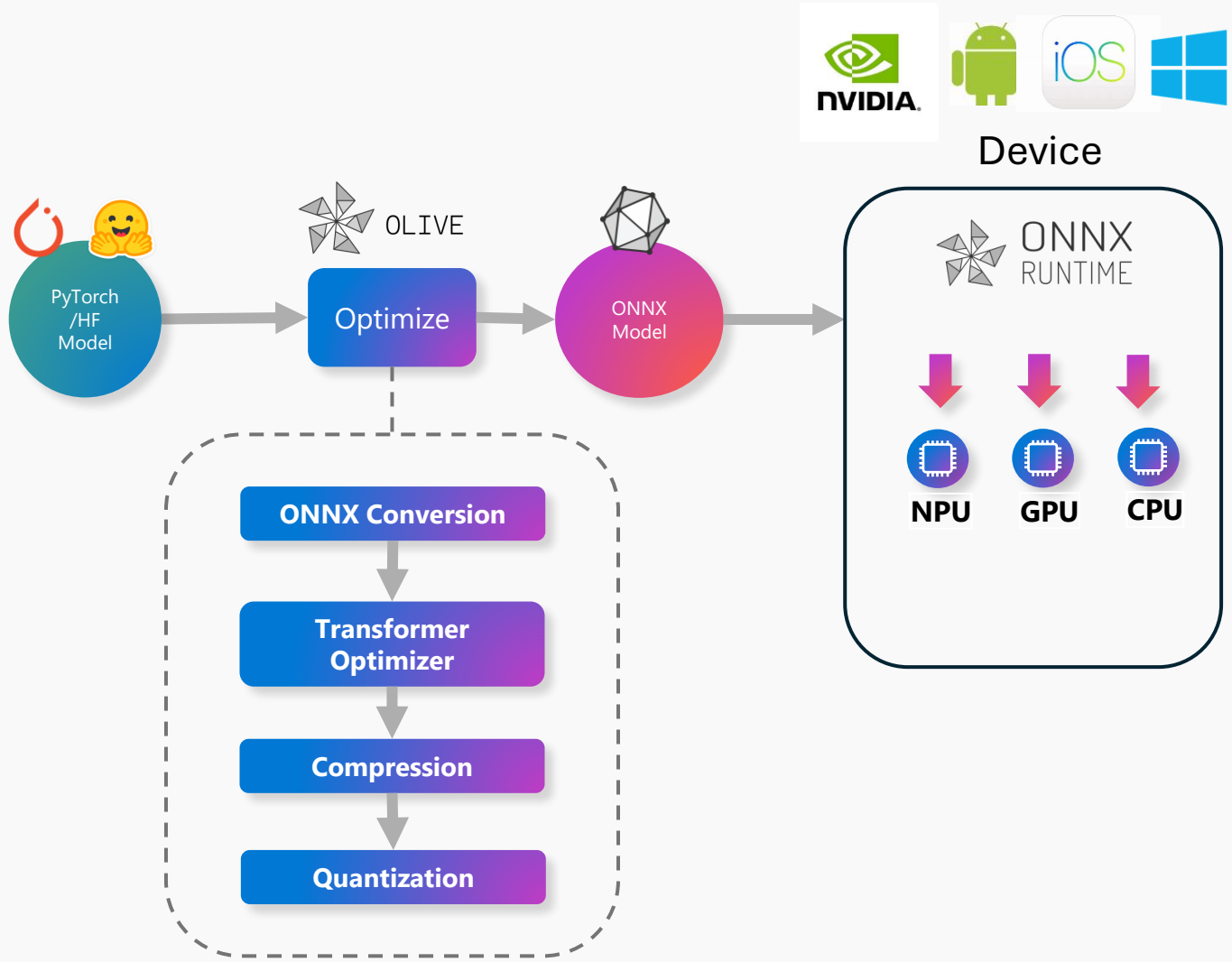
A toolchain creates optimized ONNX models

Open and interoperable file format for ML and DNN models.

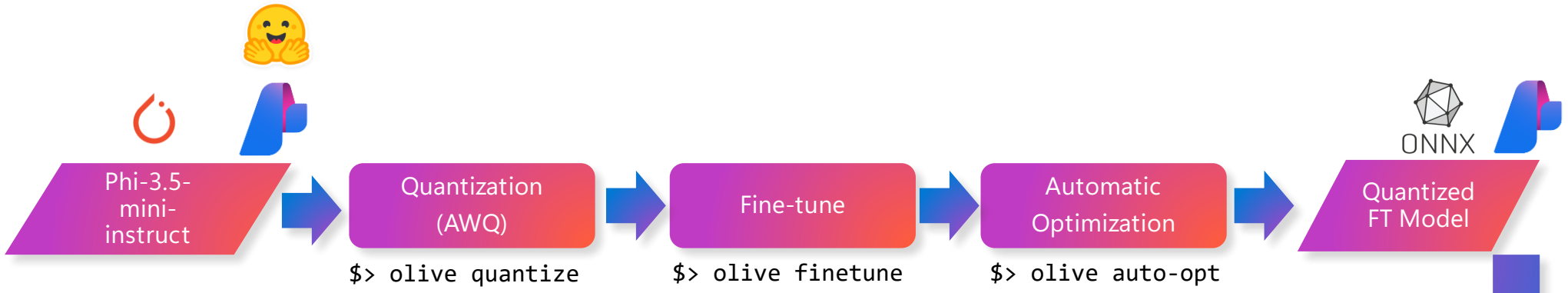
Fast and efficient *model inference engine* that works across a diverse range of hardware accelerators and platforms.

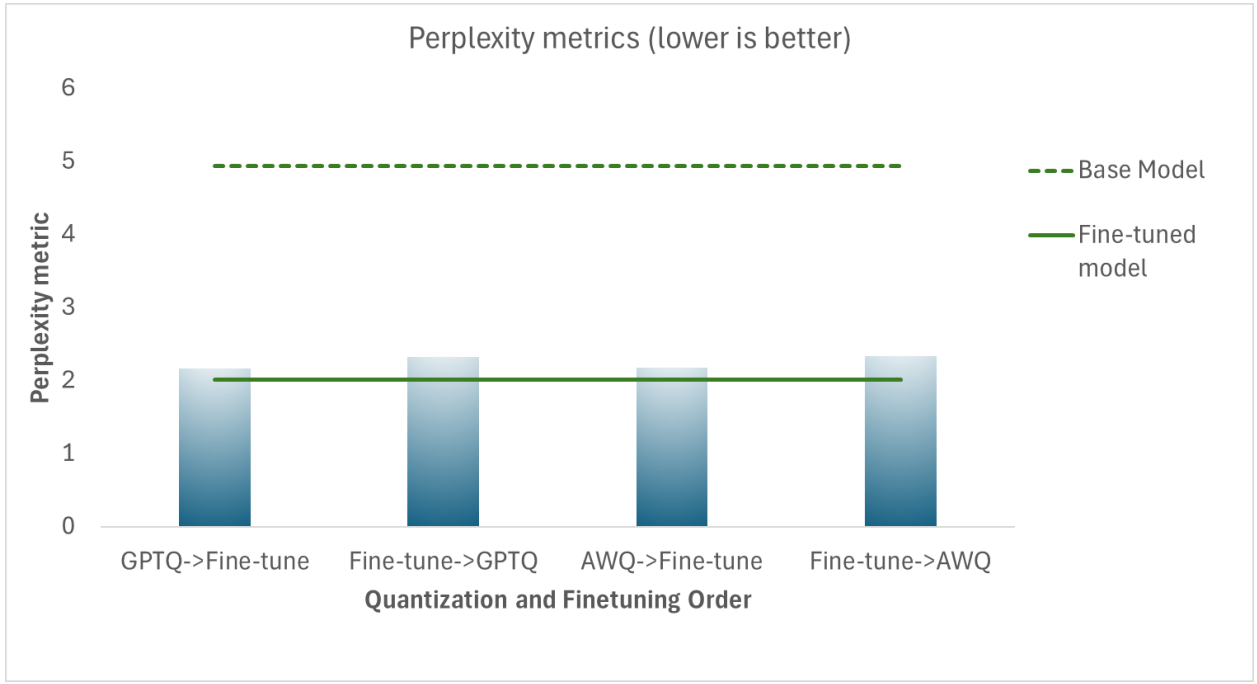
What is Olive?

- **O**(NNX)**Live** – an AI model optimization toolkit for the ONNX Runtime.
- An **easy-to-use** and **integrated** toolchain for AI Engineers where the following tasks can be composed into a workflow (pipeline):
  - Finetuning (QLoRA/LoRA/LoftQ)
  - Graph Capture (Dynamo Exporter/Model Builder)
  - Model Optimization (CPU/GPU/NPU/DirectML)
  - Quantization (GPTQ, AWQ, WOQ)
  - Runtime tuning
  - Creates models for Multi-LoRA serving
  - Deployment
- **Automatically** finds the optimized model for a given hardware target without requiring specialized knowledge and manual work.



Lab 5 – Finetune and Optimize a model for on-device Inference





Lab 7 – Consumption of Model in App

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Finish Lab 4

Test your deployed GPT3.5-Turbo Fine tuned Model from Lab 4

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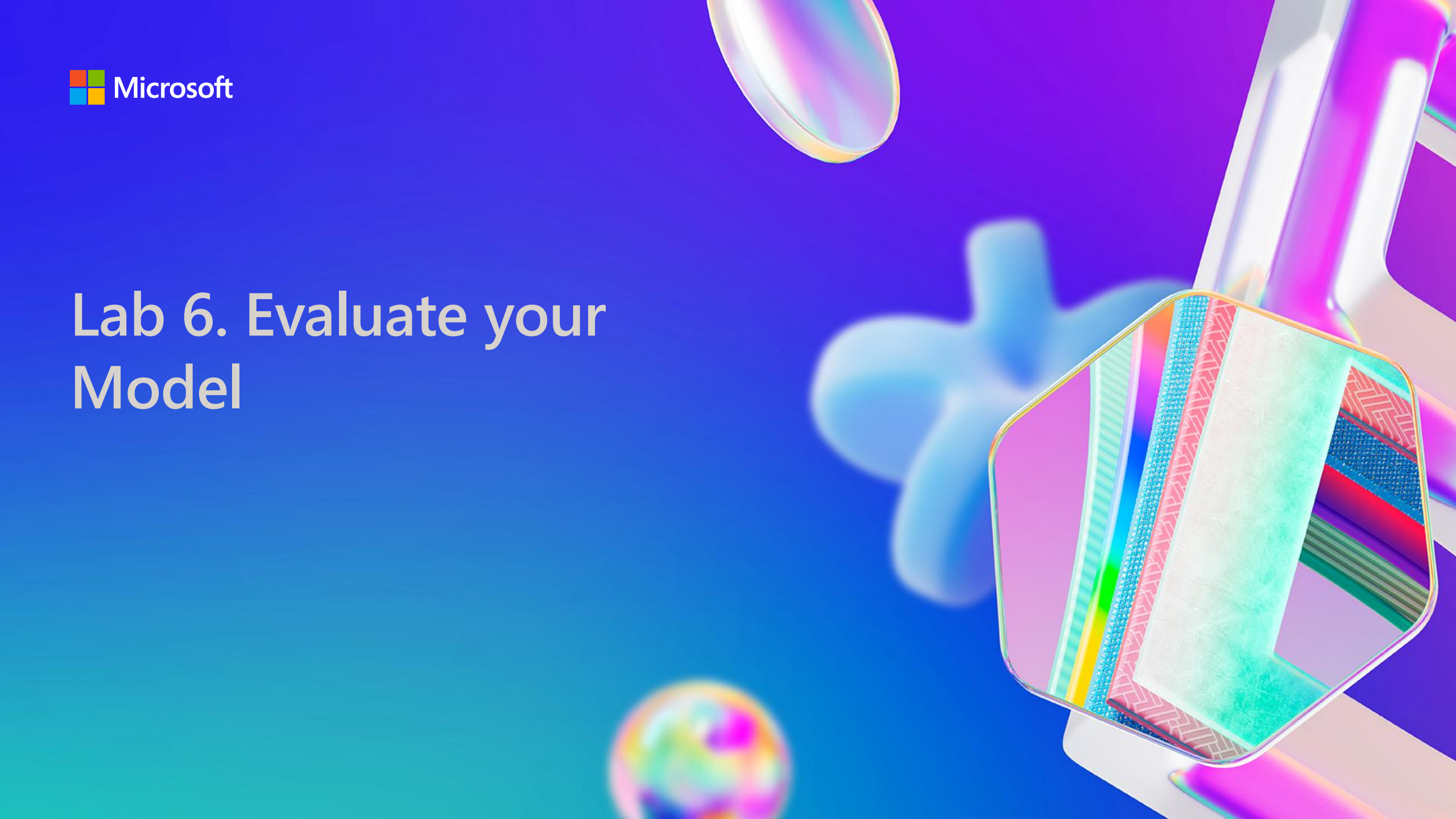
Lab 6. Evaluate your Model



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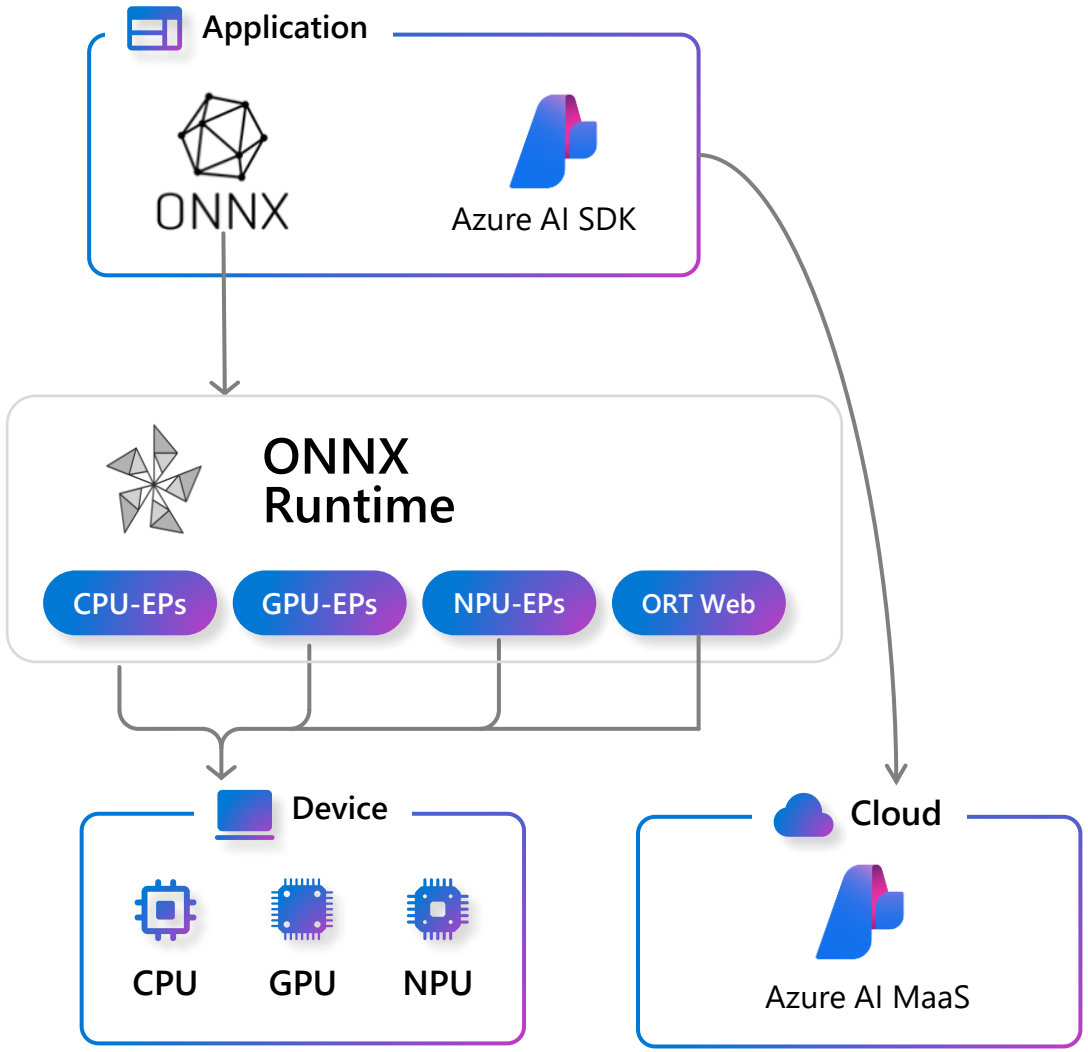
Lab 7. Consumption of Model in App

Optimization and performance ONNX runtime



Execution provider	Company
Azure	Microsoft
QNN	Qualcomm
OpenVino	Intel
Vitis AI	AMD
DirectML	Microsoft
WebNN	Microsoft, Intel

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Take the survey!

ONNX Ecosystem Feedback

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Lab 8. Clean Up

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Q&A

Continue to try this at
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