# Self-Hosted LLMs on Kubernetes: A Practical Guide

Kubecon EU 2024

**Aakanksha Duggal, *Senior Data Scientist***

**Hema Veeradhi, *Senior Data Scientist***

**Emerging Technologies Data Science**

Office of the CTO - Red Hat

Hema Veeradhi
*Senior Data Scientist*

Aakanksha Duggal
*Senior Data Scientist*

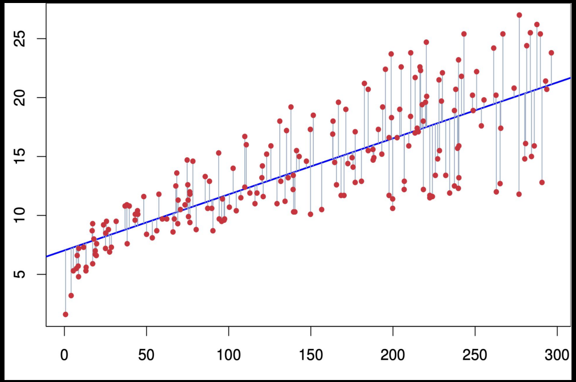
Emerging Tech, Office of the CTO

## Agenda

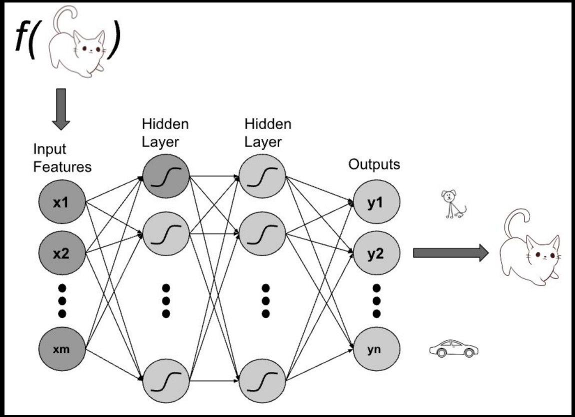
- Introduction to LLMs
- Open source LLMs
- Steps for building an LLM application
- Concept of self-hosting LLMs
- Setting up LLMs using Kubernetes
- Demo
- Q&A

## Language Models

A **language model** is a type of machine learning model trained to conduct a probability distribution over words.



Source: Numerary



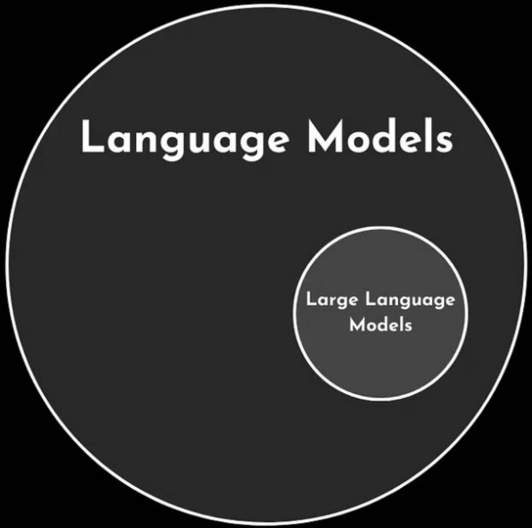
**Types of Language Models:**

- **Statistical language models**
- **Neural language models**
  - **RNN**
  - **LSTM**
  - **Transformers**

## Large Language Models

- **L**arge **L**anguage **M**odel - **LLM** is just a larger version of a language model

- **WHY LLMs?**
  - **Quantitative :** Number of Parameters, **10–100 billion** parameters
  - **Qualitative :** Self-supervised learning



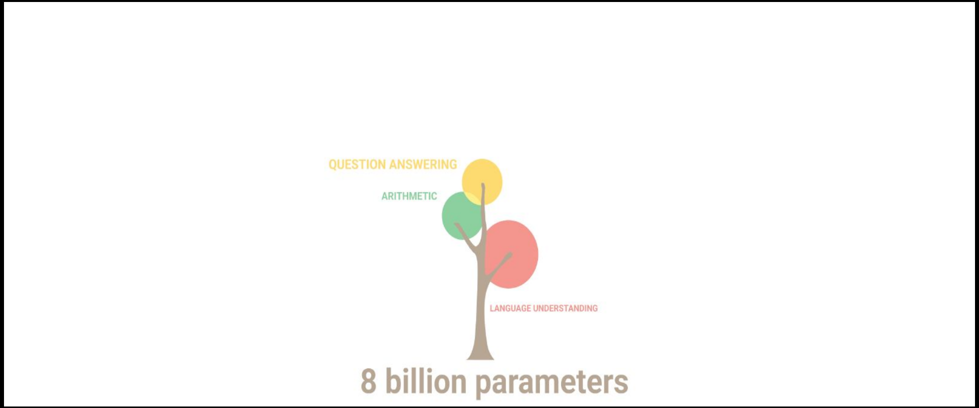
Source: Medium Blog

## LLM Applications

A Large Language Model is a type of Artificial Intelligence that is trained on a massive dataset of text and code. This allows the model to learn **statistical relationships between words and phrases which in turn allows it to generate text, translate languages, write creative content and answer your questions in an informative way.**

Here are common LLMs:

- **GPT3.5 and GPT 4**
- **Gemini**
- **Llama, Llama2**



Source: Medium Blog

# Open Source vs Closed Source Models

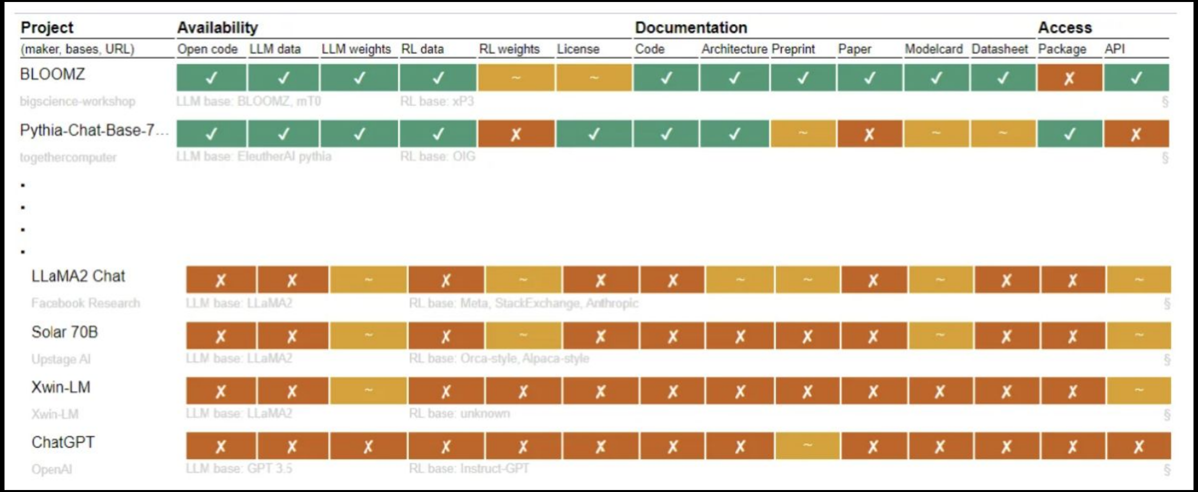
**List of Open Source Models available for commercial use**

## Open Source models

- LLaMA-2 by Meta
- Falcon by Technology Innovation Institute in Abu Dhabi
- Mistral by Mistral AI

## Closed Source models

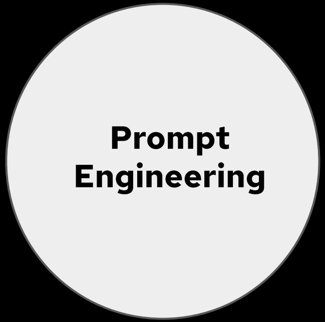
- GPT-4 by OpenAI
- Gemini by Google
- Claude by Anthropic



| Project | Availability | | | | | | Documentation | | | | | | Access | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (maker, bases, URL) | Open code | LLM data | LLM weights | RL data | RL weights | License | Code | Architecture | Preprint | Paper | Modelcard | Datasheet | Package | API |
| BLOOMZ | ✓ | ✓ | ✓ | ✓ | ~ | ~ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ |
| bigscience-workshop | LLM base: BLOOMZ, mT0 | | | RL base: xP3 | | | | | | | | | | § |
| Pythia-Chat-Base-7… | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ~ | ✗ | ~ | ~ | ✓ | ✗ |
| togethercomputer | LLM base: EleutherAI pythia | | | RL base: OIG | | | | | | | | | | § |
| . | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | |
| LLaMA2 Chat | ✗ | ✗ | ~ | ✗ | ~ | ✗ | ✗ | ~ | ~ | ✗ | ~ | ✗ | ✗ | ~ |
| Facebook Research | LLM base: LLaMA2 | | | RL base: Meta, StackExchange, Anthropic | | | | | | | | | | § |
| Solar 70B | ✗ | ✗ | ~ | ✗ | ~ | ✗ | ✗ | ✗ | ✗ | ✗ | ~ | ✗ | ✗ | ~ |
| Upstage AI | LLM base: LLaMA2 | | | RL base: Orca-style, Alpaca-style | | | | | | | | | | § |
| Xwin-LM | ✗ | ✗ | ~ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ~ |
| Xwin-LM | LLM base: LLaMA2 | | | RL base: unknown | | | | | | | | | | § |
| ChatGPT | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ~ | ✗ | ✗ | ✗ | ✗ | ✗ |
| OpenAI | LLM base: GPT 3.5 | | | RL base: Instruct-GPT | | | | | | | | | | § |

Source, Source 2

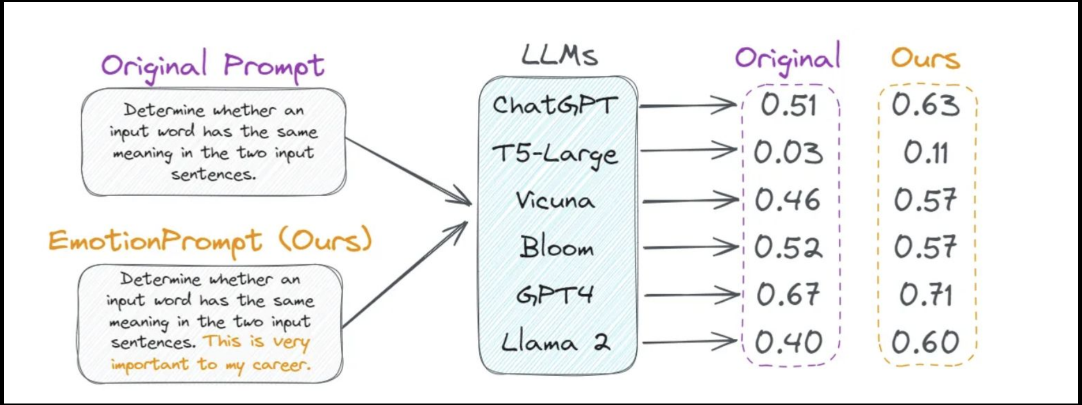
## Levels of LLMs



# Levels of LLMs

**Prompt Engineering**

- “Let’s think step by step”
- “Take a deep breath and work on this problem step-by-step“
- “This is very important to my career”



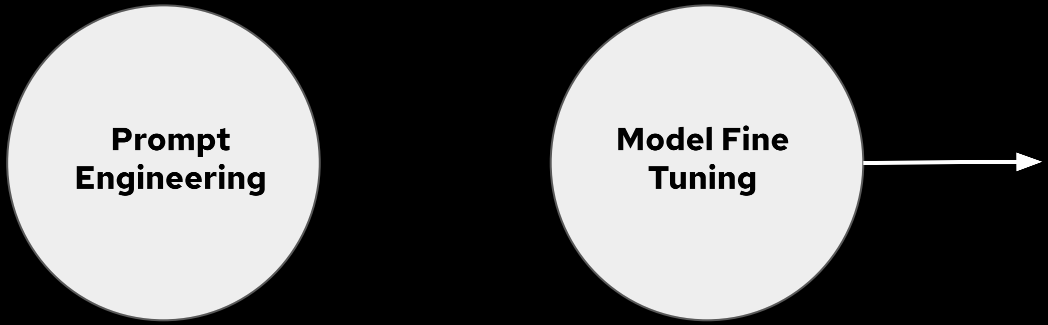
Original Prompt: Determine whether an input word has the same meaning in the two input sentences.

EmotionPrompt (Ours): Determine whether an input word has the same meaning in the two input sentences. This is very important to my career.

| LLMs | Original | Ours |
|---|---|---|
| ChatGPT | 0.51 | 0.63 |
| T5-Large | 0.03 | 0.11 |
| Vicuna | 0.46 | 0.57 |
| Bloom | 0.52 | 0.57 |
| GPT4 | 0.67 | 0.71 |
| Llama 2 | 0.40 | 0.60 |

Source: Medium Blog

## Levels of LLMs



**Step 1:**
A Pre-trained LLM

**Step 2:**
Update model parameters for a specific task

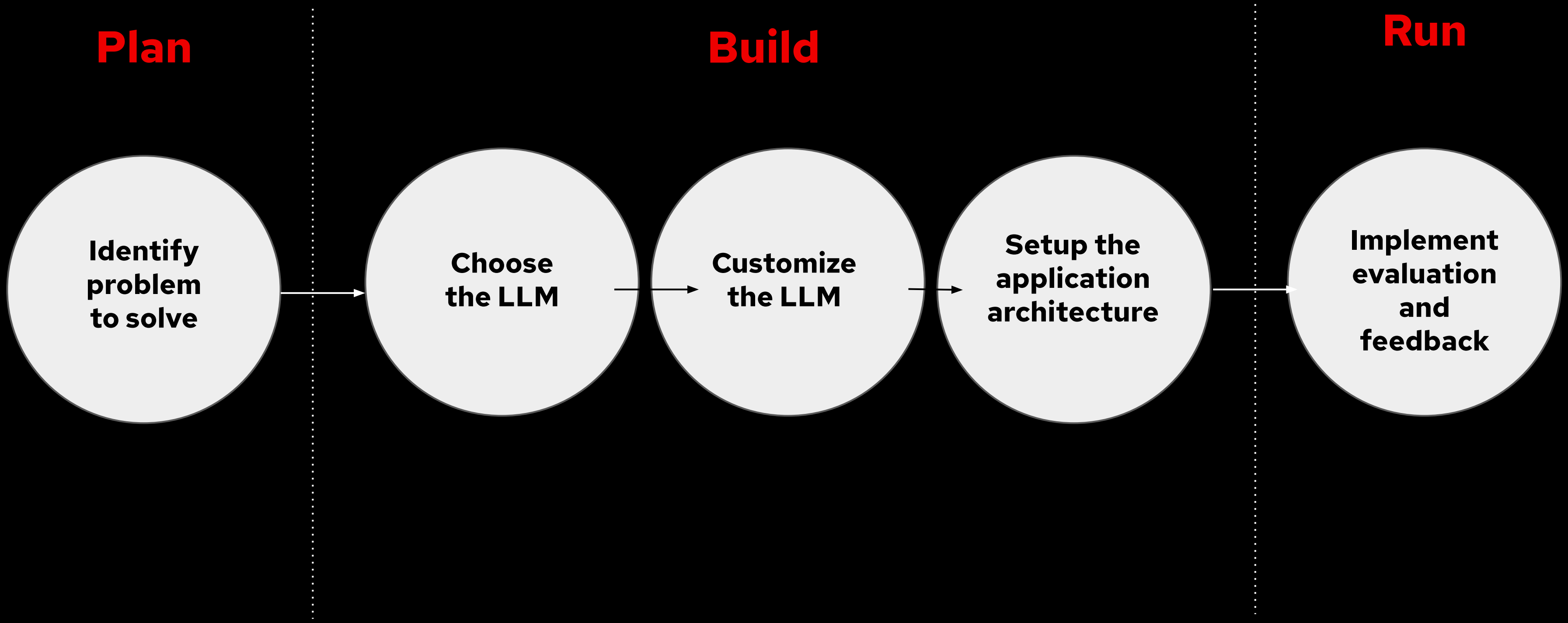
## Levels of LLMs

Prompt Engineering

Model Fine Tuning

Build your own LLM

## Steps for Building an LLM Application


Plan
Build
Run
Identify problem to solve
Choose the LLM
Customize the LLM
Setup the application architecture
Implement evaluation and feedback

## To self-host or not to?

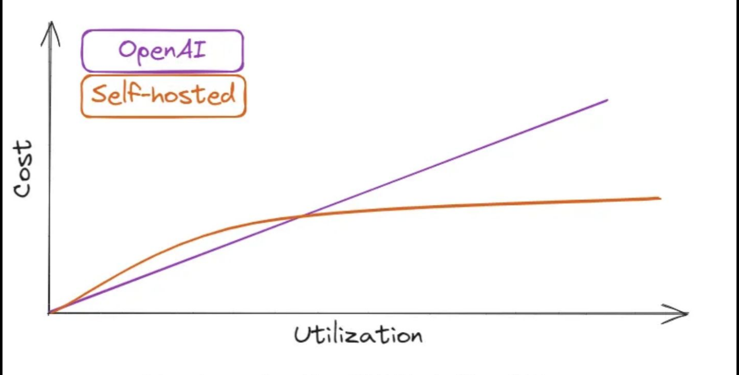
- In the past year, the discussion surrounding LLMs has evolved, transitioning from **"Should we utilize LLMs?"** to "**Should we opt for a self-hosted solution or rely on a proprietary off-the-shelf alternative?"**

- Depending on your use-case, computational needs and engineering architecture availabilities you can decide whether to self-host your LLM

- Hosted models are **necessary** for privacy, reliability, or compliance.

## Benefits of self-hosting LLMs

- Greater security, privacy, and compliance
- Customization
- Avoid vendor lock-in
- Save computational costs
- Easy to get started for those new to or just starting their journey with LLMs



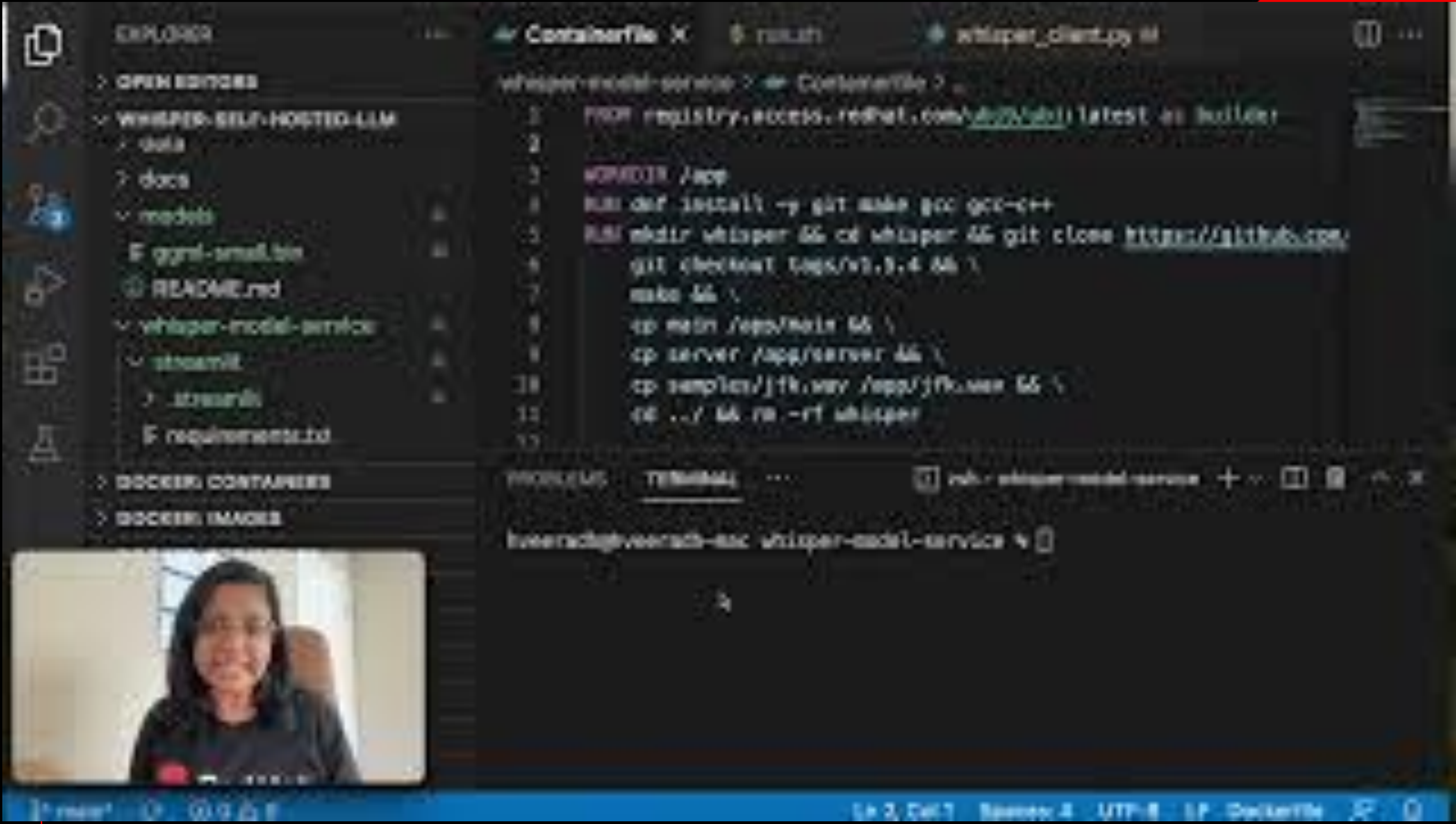
Schematic comparison of OpenAI GPT-3.5 and self-hosted LLMs

Source: Medium Blog

# Self-Hosting Containerized LLMs

Selecting the LLM based on the problem being solved → Containerization of the model → Model serving and inference

https://huggingface.co/



```
FROM registry.access.redhat.com/ubi9/ubi:latest as builder

WORKDIR /app
RUN dnf install -y git make gcc gcc-c++
RUN mkdir whisper && cd whisper && git clone https://github.com/
    git checkout tags/v1.5.4 && \
    make && \
    cp main /app/main && \
    cp server /app/server && \
    cp samples/jfk.wav /app/jfk.wav && \
    cd ../ && rm -rf whisper
```

```
hveeradh@veeradh-mac whisper-model-service % 
```

## Future Direction

- **Enhanced developer experience** enabling “non-data scientists” to follow a simple workflow for setting up and interacting with LLMs via microservices

- Implement a **seamless workflow** for transitioning from a local development environment to a production grade environment

- **End-end tooling**/framework for setting up LLMs locally for various applications such as text generation, document search, RAG applications etc

## Resources

- **GitHub repository:** https://github.com/redhat-et/whisper-self-hosted-llm
- **Slides:** https://github.com/redhat-et/whisper-self-hosted-llm/tree/main/docs
- **HuggingFace models**: https://huggingface.co/ggerganov/whisper.cpp
- **Whisper at the Edge with Microshift:**
  https://github.com/redhat-et/whisper-edge-microshift

## THANK YOU!

aduggal@redhat.com