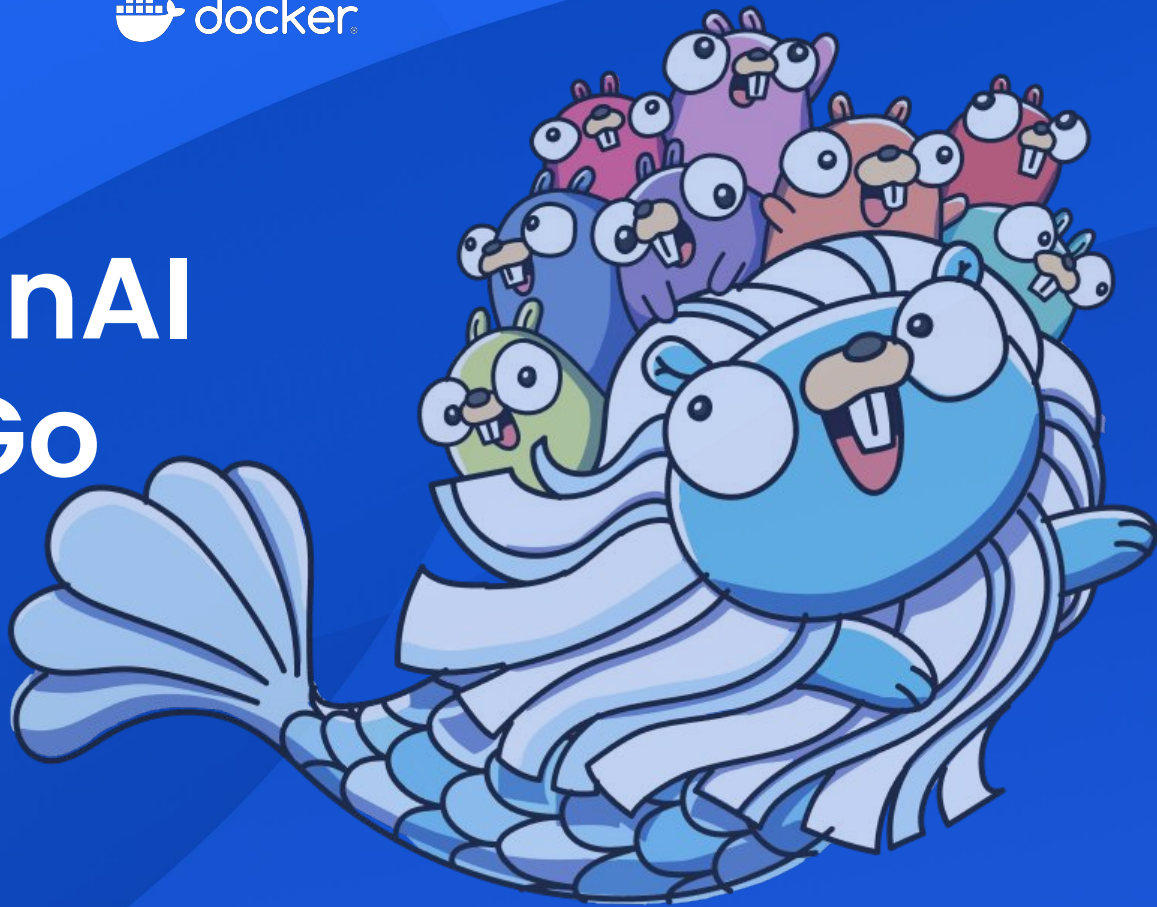




Testing GenAI apps in Go

Gophercon Singapore '25



About me

You can find me as **@mdelapenya** everywhere



Manuel de la Peña

Staff Software Engineer @ Docker

Computer Science degree, Master in Software Engineering

- Testcontainers Go maintainer since 2020
- Engineering Productivity at Elastic Observability
- QA Tech lead at Liferay Cloud
- Core Engineer at Liferay
- In OSS since 2011
- Hitting keyboards since 1994
- First time in Singapore!!! 🇸🇬



What we are going to see today:

01. GenAI in today's software
02. A mental model for testing: Cloud apps
03. Gen AI Tooling in Go
04. Let's talk about tests, b-AI-by!
05. Conclusions





1. GenAI in today's software

GenAI in Today's software

FOMO: Fear Of Missing Out!

Every day there is a new company offering AI services, exposing their models for you to consume them, and new papers are published every day.

→ OpenAI

→ Google

→ Anthropic

→ Meta

→ ...



The M/L + AI + Data (MAD) landscape

Sources:

<https://www.linkedin.com/pulse/ai-landscape-2024-trends-top-startups-leta-capital-orqpe>

<https://mad.firstmark.com>

2011 logos

In 2024

1416

In 2023

578

Newcomers in 2024





Develop with LLMs

Langchain (Python, Node), **Langchain4j**, **SpringAI** (Java), **LlamaIndex**, and many more tools:

- Allow you to talk to LLMs
- Design prompts
- Create chats, tools and agents
- Talk to Vector databases

Depending on the model you talk to, you can use it for:

- Image recognition
- Text to text generation
- Text to image/video/audio
- Multimodal generation
- ...more in 3,2,1



LLMs



LLMs SDKs



A GenAI application



2. A mental model for testing: Cloud apps

Develop with the Cloud

How it works

- Our company uses a given Cloud provider
- We setup that Cloud's SDKs into your project
- We configure the credentials
- We start coding...

Seems pretty similar to the LLM approach, doesn't it?

But how do you test these applications?



GCloud, AWS, Azure



Cloud SDKs in Go



Your application

Testing Cloud applications

- ~~No tests, my code is perfect!~~
- Local Service emulating a given Cloud service
- Test environment in the Cloud provider
 - Per team?
 - Per developer?
 - Shared across the company?
 - How long does it take to have them?
 - Do you prune outdated resources?
 - Do you measure costs?
- Do you know Localstack, Google Cloud and Azurite emulators?
 - Standalone applications, or
 - Docker containers.



Test Environments

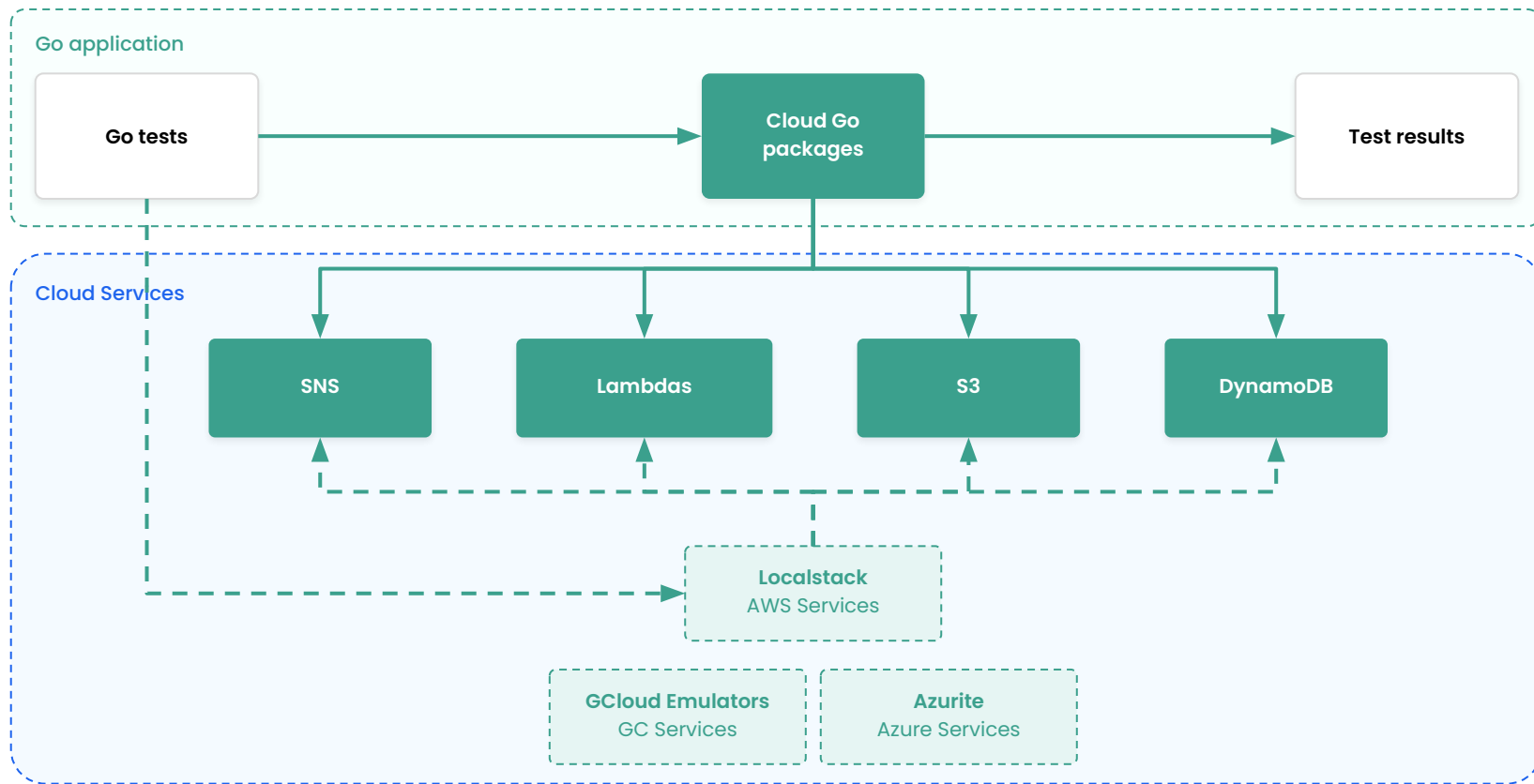


Cloud SDKs in Go



Your application

Testing Cloud applications with emulators





3. Gen AI Tooling in Go

Langchaingo

Go implementation for Langchain: <https://github.com/tmc/langchaingo>

Community driven project, led by Travis Cline.

- Generate completions from an LLM (OpenAI, Anthropic, Google...)
- Calculate embeddings for words, texts, images...
- Talk to Vector databases to look for similar/relevant documents to augment LLM responses (Retrieval Augmented Generation)
 - ◆ Chroma, Milvus, pgVector, Pinecone, Qdrant, Weaviate...



langchaingo: completions

Create a completion from an LLM, using a streaming function so that the answer is printed at the moment it's produced by the LLM.

It comes with APIs to abstract the LLM creation, obtaining it from multiple providers: Google, OpenAI, Mistral, LlamaFile, Ollama:

- The completion code would be exactly the same.

<https://github.com/mdelapenya/generative-ai-with-testcontainers/tree/main/02-streamin/main.go>



```
// llm is llama3.2:3b
ctx := context.Background()
completion, err := llms.GenerateFromSinglePrompt(
    ctx, llm, "Give me a detailed and long explanation of why
Testcontainers for Go is great",
    llms.WithTemperature(0.8),
    llms.WithStreamingFunc(func(ctx context.Context, chunk []byte)
error {
    fmt.Print(string(chunk))
    return nil
}),
)
if err != nil {
    log.Fatal(err)
}
```


langchaingo: embeddings

Using the right model, you can generate the embeddings for a text.

Embeddings are dense numerical representation (n-dimensional vectors) of texts, that can be used to calculate similarity between them.

<https://github.com/mdelapenya/generative-ai-with-testcontainers/tree/main/06-embeddings/main.go>



```
// llm is all-minilm:22m
embedder, err := embeddings.NewEmbedder(llm)
if err != nil {
    return fmt.Errorf("embedder new: %w", err)
}
docs := []string{
    "Testcontainers is a Go package that provides lightweight,
    throwaway instances of common databases, web browsers, or anything
    else that can run in a Docker container",
    "Docker is a platform designed to help developers build, share,
    and run container applications.",
}
vecs, err := embedder.EmbedDocuments(context.Background(), docs)
if err != nil {
    log.Fatal("embed query", err)
}
```

langchaingo: RAG

Retrieval and Augmented
Generation.

It's possible to pass a vector of embeddings to a vector database, and leverage the power of these systems to obtain relevant documents to enrich the response from the LLM.

<https://github.com/mdelapenya/generative-ai-with-testcontainers/tree/main/07-rag/main.go>



```
// llm is all-minilm:22m
embedder, err := embeddings.NewEmbedder(llm)
if err != nil {
    log.Fatalf("embedder new: %w", err)
}
store, err := weaviate.NewStore(context.Background(), embedder)
if err != nil {
    return fmt.Errorf("weaviate new store: %w", err)
}
// ingest relevant documents in the store
if err := ingestion(store); err != nil {
    log.Fatalf("ingestion: %w", err)
}
// similarity search
relevantDocs, err := store.SimilaritySearch(context.Background(),
    "What is my favorite sport?", 1, optionsVector...)
if err != nil {
    log.Fatalf("similarity search: %w", err)
}
```

Ollama

Inference Engine: <https://github.com/ollama/ollama>

Like Docker, but for running models! Wrapper of Llama.cpp written in Go

→ `ollama pull $MODEL`

→ `ollama run $MODEL`

→ It has Modelfiles for customising models (temperature, system messages...)

→ It has a native app for Linux, Mac and Windows...

→ ... or you can run it as a Docker container

◆ used in the demos, thanks to

<https://github.com/mdelapenya/dockerize-ollama-models/>

◆ <https://hub.docker.com/u/mdelapenya>



→ Ollama has native access to the GPUs of the host, which is key for speed.

Testcontainers Go

An Open Source Go package (MIT license) providing developer-friendly API's on top of the Docker engine.

<https://github.com/testcontainers/testcontainers-go>

- Start, stop, terminate containers and networks
- Wait for containers on custom conditions
- Lifecycle hooks to inject custom code (Pre/Post)
- Copy files to/from containers
- Garbage collection of Docker resources



Go package: `docker/docker`



Go package: `testcontainers-go`



Your Go app

Testcontainers Go: modules

Go packages providing access to the most used technologies:

- Relational DBs: Mysql, Postgres, ...
- **Vector DBs: Weaviate, Chroma, Qdrant, Milvus...**
- Non Relational DBs: Elasticsearch, Redis, MongoDB, Neo4j, Opensearch...
- Cloud Emulators: Localstack, Google Cloud, Azurite
- **Inference Engines: Ollama**
- Keycloak, OpenFGA, Vault...
- 60 different Go modules!
- Convenient API specific to each module.

<https://www.testcontainers.com/modules>



Go package: testcontainers-go



Go packages: testcontainers-go/modules



Your Go app

Remember Ollama?

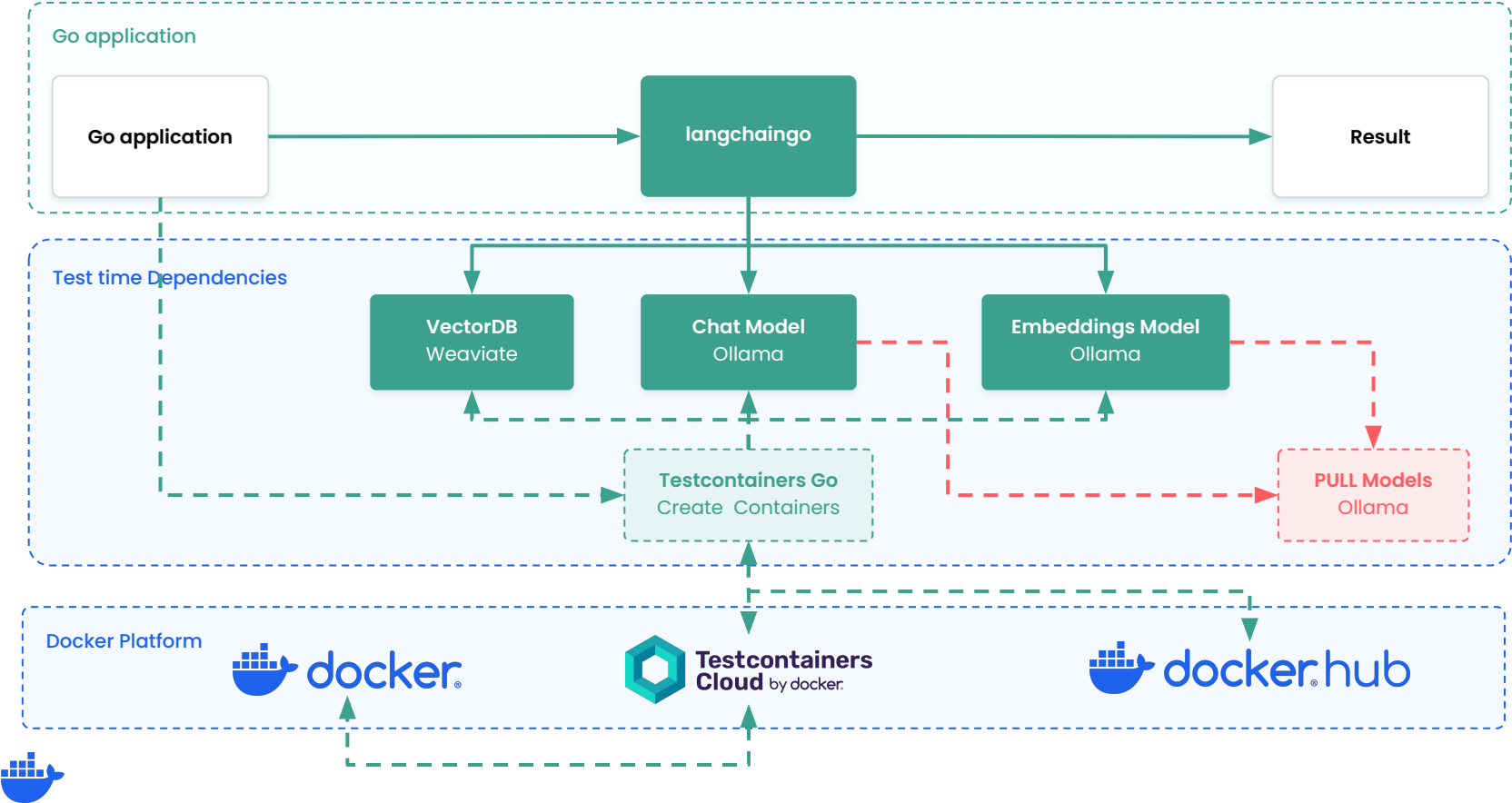
A module exists! <https://testcontainers.com/modules/ollama/?language=go>

Since v0.35.0, it's possible to interact with the local Ollama process as it was a container, honoring the create/start/stop/terminate container lifecycle.

```
ollamaContainer, err := ollama.Run(ctx, "ollama/ollama:0.5.4")
if err != nil {
    log.Printf("failed to start container: %s", err)
    return
}
code, reader, err := ollamaContainer.Exec(ctx, []string{"ollama", "pull", "all-minilm"})
```



Dockerised workflow





4. Let's talk about tests, b-AI-by!

The application

- An application talking to two models:
 - ◆ Raw calls to the model
 - ◆ Calls to the same model using RAG
- It uses langchaingo, ollama and testcontainers-go
- How can we verify that non-deterministic LLM responses are correct?

<https://github.com/mdelapenya/generative-ai-with-testcontainers/blob/main/08-testing>





Round 1: strings comparison

<https://github.com/mdlapenya/generative-ai-with-testcontainers/blob/main/08-testing>





Round 2: cosine similarity

<https://github.com/mdelapenya/generative-ai-with-testcontainers/blob/main/08-testing>

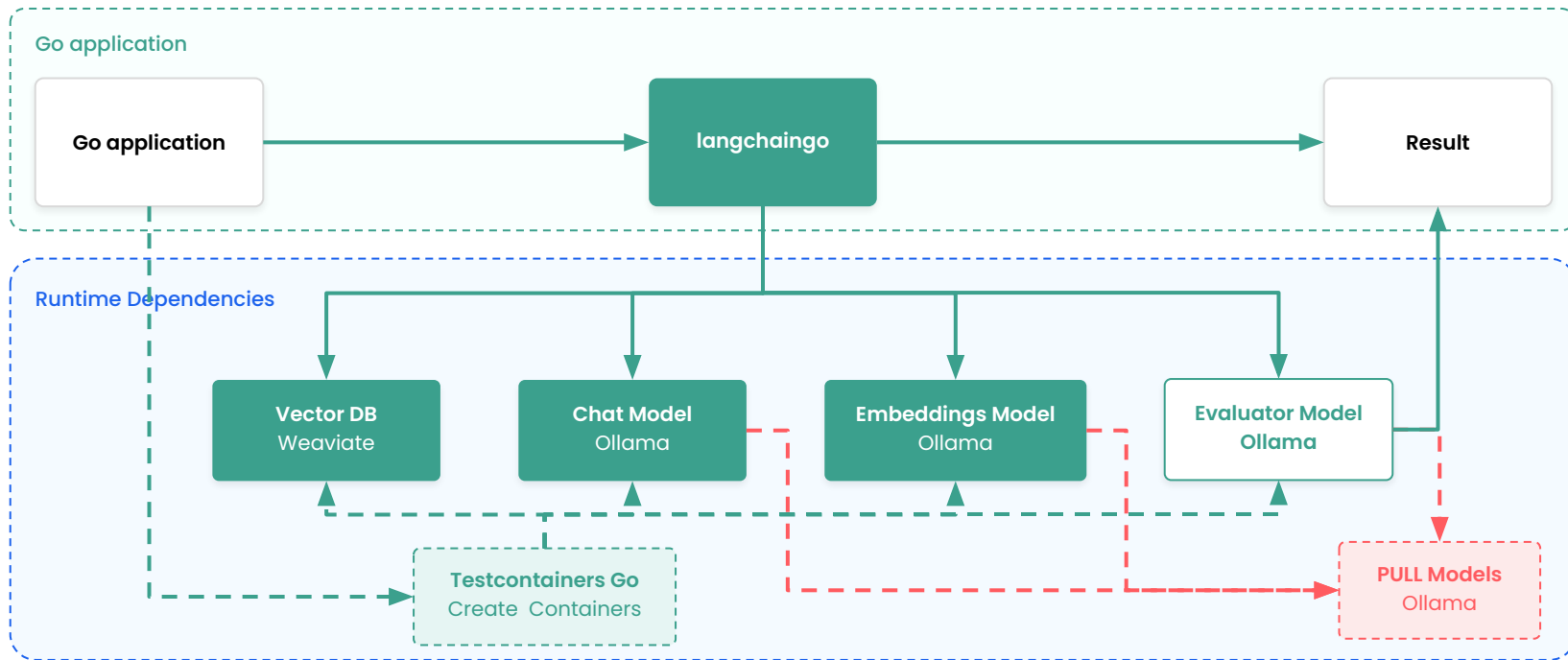


Enter Evaluators

- AKA “LLM-as-a-Judge” (<https://eugeneyan.com/writing/llm-evaluators/>).
- Evaluate the quality of another LLM’s response to an instruction or query.
- Define a very strict **System** Prompt:
 - ◆ Provide Instructions: e.g. response format
 - ◆ Provide reference examples
- Define a very strict **User** Prompt:
 - ◆ Provide a detailed format: *### question ### answer ### reference ###*.
 - ◆ Provide a reference (e.g. in the test as an expectation)
 - ◆ Structured output, semantic/style constraints
 - Respond with “yes” or “no” including the reasoning.



Adding an Evaluator





Final Round: using an Evaluator

<https://github.com/mdelapenya/generative-ai-with-testcontainers/blob/main/08-testing>





5. Conclusions

Conclusions

- **Langchaingo**: contribute!
- **Testcontainers Go** + **Ollama**: a really powerful and easy-to-use combo for local development experience.
- Using **Evaluators** (models with a very strict system prompt) helps us in identifying if the model our application is using responds correctly:
 - ◆ Helps us tuning up our application: e.g. choosing a different model, a different vector store, or even modifying the metrics used to classify/correlate the responses at test time.
- Different models can produce different responses:
 - ◆ E.g. Ollama + Llama3.2:3b can excel in one task, but its response could be different than using OpenAI + o4 (220b???)
- **Integration tests** will give you enough confidence so you can make progress with speed, but you still need to test against the real thing, e.g. with OpenAI.
 - ◆ Run lots of integration tests but you still need to run **some E2E tests** against the real thing!





Thank you!

Gophercon Singapore '25





Resources

<https://github.com/mdelapenya/generative-ai-with-testcontainers>

<https://github.com/testcontainers/testcontainers-go>

<https://github.com/testcontainers/workshop-go>

@mdelapenya everywhere

