NANYANG TECHNOLOGICAL UNIVERSITY

SCHOOL OF COMPUTER SCIENCE & ENGINEERING

Assignment 02: Study basics of Google Cloud SaaS

Chan Eu Ching

U2021000F

Introduction

In this rapidly evolving landscape of technology education, the fusion of cloud computing services and artificial intelligence (AI) presents a transformative opportunity for enhancing learning experiences. The significance of integrating cloud-based platforms and LLMs in educational tools cannot be overstated. Cloud platforms like Google Cloud and others offer unparalleled scalability, flexibility, and access to powerful computing resources on demand, making them ideal for hosting sophisticated AI-driven applications.

This project delves into the intersection of Google Cloud's Software as a Service (SaaS) offerings, particularly Cloud Shell, with the advanced capabilities of Large Language Models (LLM) such as Google Gen-AI. The primary focus is to develop a quiz generator (specifically Cloud Computing quizzes), leveraging on latest advancements in AI and cloud technology. The application of the quiz generator will also be discussed. Lastly, prompt engineering and LLM functions were experimented with to gain more insights into the importance and significance of their presence in building a quiz generator as well as in LLM models.

Quiz Generator with Google Gen-AI and Cloud Run

Google Gen-AI represents a pioneering initiative by Google Cloud, aimed at harnessing the power of Gen-AI to create and deploy a variety of applications including tools like Quiz Generator. Gen-AI stands out for its ability to understand and process natural language, enabling it to generate quiz questions and answers that are both relevant and challenging.

Google Run is a managed platform that enables developers to deploy containerized applications. It simplifies the deployment process, by running the "`gcloud beta run deploy <project-id>`" command line in the terminal.

The first step to building a quiz generator in Gen-AI is to set up the development environment. This is done by activating the cloud shell, then setting up a new project and ensuring that the billing is enabled for the project. Then enable the necessary APIs such as:

- `cloudbuild.googleapis.com`
- `artifactregistry.googleapis.com`
- `aiplatform.googleapis.com`
- `run.googleapis.com`

Then, the access to Google Gen-AI will have to be allowed. Prompt templates were created. The data of the lecture content were extracted from the PDF files and concatenated into the prompt template to ensure that the questions generated were relevant to the content that was needed. The solutions to the questions are then generated using the inbuilt LLM. Templates were also fed in the LLM to guide the model to generate the quiz in the desired format. Once the quiz generator is done, it is packed into a Docker container and deployed to Cloud Run.

Quiz Generator on Cloud-Based Software

Utilizing cloud-based software platforms to develop a quiz generator offers scalability, flexibility, and access to advanced technologies. In this project, deploying the quiz generator generates a service URL that allows users to call the application as an API. This service URL allows users to append any arguments defined in the main function, to regenerate the content with respect to the appended arguments.

Google Cloud

In this assignment, users have the flexibility to modify the `topicNo` argument, which specifies the topic number of the lecture slides that the quiz should cover. The lecture slides are uploaded to Google Cloud first. After users specify the topic numbers they prefer, the relevant PDF will be loaded, and the quiz will be generated. This link provides the Google Cloud deployed quiz generator: https://quiz-generator-6famce7bfq-uc.a.run.app/. If the user wants to generate a quiz covering Lectures 1 to 3, an array [1, 2, 3] will be the argument of the topicNo. Hence the new quiz generator link address will be https://quiz-generator-6famce7bfq-uc.a.run.app/?topicNo=[1,%202,%203], where '%20' represents spaces. Otherwise, the quiz generator will generate quizzes on Lectures 1 to 7 by default. The web interface will display the questions, answers, and files that the questions were generated from. This could be further improvised by creating a simple web application to take in inputs for the lecture content desired to be covered by the quiz.

Nemobot Platform

Another exploration done in this assignment was to call the service URL generated by Cloud Run as an API in the Nemobot platform where the chatbot is integrated. Integrating the quiz generator into this platform provides a more user-friendly interface for the users to generate quizzes. In this Nemobot exploration, quiz generation with both OpenAI and VertexAI (Google) will be explored.

Here is the list of LLM Functions defined in the Nemobot:

- GenerateQuiz({userMessage}, {memory}) → detect whether the student wants to generate a quiz through lecture contents of OpenAI. If OpenAI, then it will generate a quiz using prompts stated on the platform.
- getLectureChoice({userMessage}) → retrieve the 'topicNo' wanted to generate the quiz. Returns array format i.e. [1, 2, 3] for Lectures 1 to 3 (space between comma and number is necessary!)
- ConvertToMarkdown({content}) → organize the quiz generation format by topics

The way that the Nemobot will behave is as such:

1. The chatbot will detect whether the user wants to generate a quiz from OpenAI or a specific lecture content quiz.
2. If it is OpenAI, details regarding the subject, number of questions, difficulty level and whether is it MCQ or short answered will be asked. Then the relevant quiz will be generated via the API.
3. If it is a lecture content quiz, the chatbot will request for the topics to be included in the quiz. The chatbot will then fetch the service URL acting as an endpoint to run the quiz generator and produce the quiz in the chatbot itself.

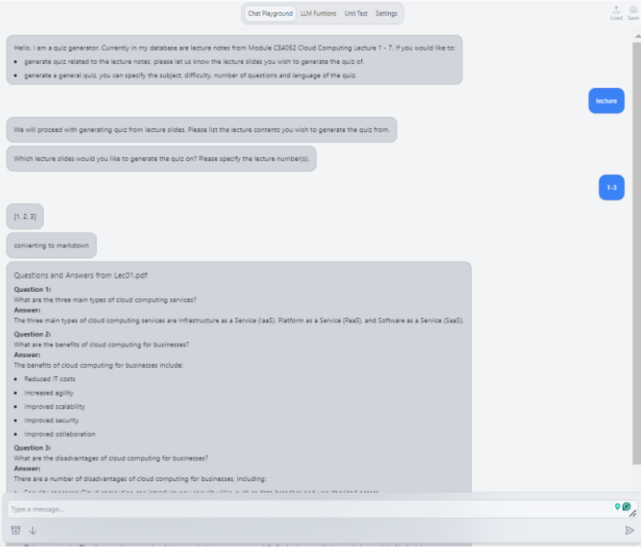
Since the Nemobot platform has an in-built API call for OpenAI API, the LLM functions that are used to generate the quiz will employ OpenAI by default. As long as the prompt for the function to generate a quiz is properly instructed, the chatbot will be able to produce high-quality quizzes.

In this project, Nemobot acts as software to prompt the users for the lecture contents to be included in the text. The input will then be passed into the LLM function which appends to the endpoint and generates the quiz accordingly. However, the fetching of the API took a bit of time if there was more than 1 lecture slide required for the quiz. This invoked a time-out error from Vercel, the cloud platform that deploys Nemobot, which does not allow a fetch call with no response for more than 25 seconds. Since it is also not a JavaScript fetch timeout error, it would not be effective to implement a timeout abortion on JavaScript as well.

Hence, to solve this issue, the quiz generator is coded to stream a set of questions and answer topic by topic to prevent a time-out error. This is done by having an inner function that uses a generator to generate data then invoke that function and pass it to a response object. The inner function will include a yield function and each yield expression is directly sent to the browser.

Nemobot also has a restriction on the length of response that is allowed for its response, hence there is a limitation of 3 questions per topic and the user can only call for a maximum of 3 topics at a time.

Below is a snippet of the quiz generation in Nemobot.



Hello. I am a quiz generator. Currently in my database are lecture notes from Module CE4052 Cloud Computing Lecture 1 - 7. If you would like to:

- generate quiz related to the lecture notes, please let us know the lecture slides you wish to generate the quiz of.
- generate a general quiz, you can specify the subject, difficulty, number of questions and language of the quiz.

lecture

We will proceed with generating quiz from lecture slides. Please list the lecture contents you wish to generate the quiz from.

Which lecture slides would you like to generate the quiz on? Please specify the lecture number(s).

1-3

[1, 2, 3]

converting to markdown

Questions and Answers from Lec01.pdf

Question 1:
What are the three main types of cloud computing services?
Answer:
The three main types of cloud computing services are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

Question 2:
What are the benefits of cloud computing for businesses?
Answer:
The benefits of cloud computing for businesses include:

- Reduced IT costs
- Increased agility
- Improved scalability
- Improved security
- Improved collaboration

Question 3:
What are the disadvantages of cloud computing for businesses?
Answer:
There are a number of disadvantages of cloud computing for businesses, including:

Implementing Google Gen-AI Quiz Generator in LLM functions

After running through the Quiz Generator tutorial to build a simple quiz generator using prompts, the generation of high-quality quizzes for this module was explored. To ensure that the quizzes were relevant to the course, the course lecture slides had to be taken in by the LLM model to generate both the questions and the answers.

Loading content

Firstly, the lecture contents are loaded into the server by `PyPDFLoader`. It will then go through a `CharacterTextSplitter` encoder to convert the contents into chunks. The `chunk_size` defines the maximum size (in characters) of each text chunk after the splitting operations. It is crucial to set a balance between being small enough to comply with LLM's limitations and large enough to maintain the context and coherence necessary for the model to generate meaningful outputs. Meanwhile, `chunk_overlap` mitigates the risk of losing context or cutting sentences in the middle when splitting text into chunks. It refers to the number of characters at the end of one chunk that is repeated at the beginning of the next chunk. After splitting and overlapping, the chunks will be output and fed into the LLM sequentially.

Inspired by AIAnytime, the questions and answers will undergo different values of `chunk_size` and `chunk_overlap.` To increase the quality of the questions generated, more `chunk_size` and `chunk_overlap` were assigned for question generation to ensure that more context was available for the model, facilitating the generation of questions that are well-informed by text.

However, some PDF files were too large for the LLM model to load even after splitting into chunks. Therefore, in the data processing stage, for every 10 slides, the extracted content will be fed into a `TextGenerationModel` "text-bison@001" to summarize the content. Since presentation slides usually have very little content per slide in them, grouping the content into 10 slides was considerably reasonable to not miss out on any important content within the file.

Generating Questions

In this assignment, the approach to generating the quiz was to first generate the questions. Hence, an LLM for the question generator was defined using "text-bison@001" with a temperature of 0.3. This temperature represents the degree of randomness in the token selection, ranging from 0 to 1. By setting the temperature low for question generator LLM, it aims to generate high-quality, relevant, and precise questions that are customized towards the chunks fed.

The LLM model will then be used to generate the questions through the `load_summarize_chain` function that generates a response by iterating over the input documents, progressively refining its answer with each step. For each document, it passes all the non-document inputs, current documents, and the most recent answer to an LLM chain to generate a new response.

Generating Answers

Before the answers for the LLM-generated questions were produced, the documents for generating answers were embedded in FAISS, into a searchable vector space using embeddings generated by `VertexAIEmbedding()`.

This vector store then serves as a retriever for the `RetrievalQA` chain. When generating answers to the questions, the system first retrieves the most relevant documents from the vector store. This retrieval is based on semantic similarity between the question embeddings and the document embeddings stored in the vector store. The role of vector store is critical in ensuring efficiency during semantic search. As FAISS is designed to handle very large datasets efficiently, it is deemed suitable for this scenario.

Exploration of Prompt Engineering and LLM functions

Prompt engineering involves designing and refining the input text provided to an LLM to elicit specific, desired outputs. In the world of quiz generators, this means generating prompts that guide the LLM to produce questions, answers, and distractors that are relevant and tailored to the context's complexity and scope.

In this section, the exploration of both prompt engineering and LLM functions that are created will be discussed.

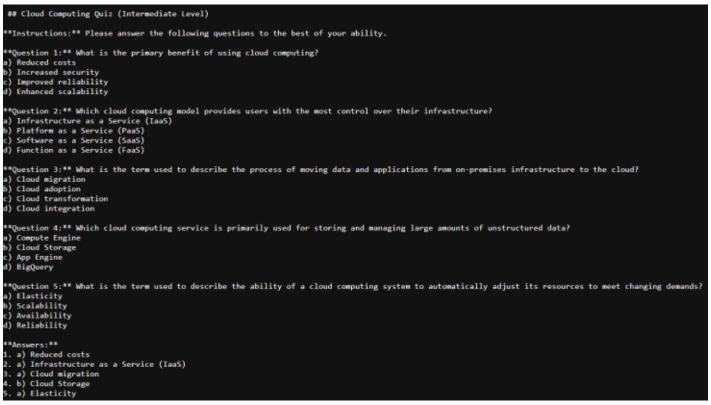
Prompt Engineering

The prompts fed into the LLM model to generate quiz questions were explored.

Case 1: General prompt: Brief statement with no context.

i.e. Generate a quiz about Cloud Computing.

Response:



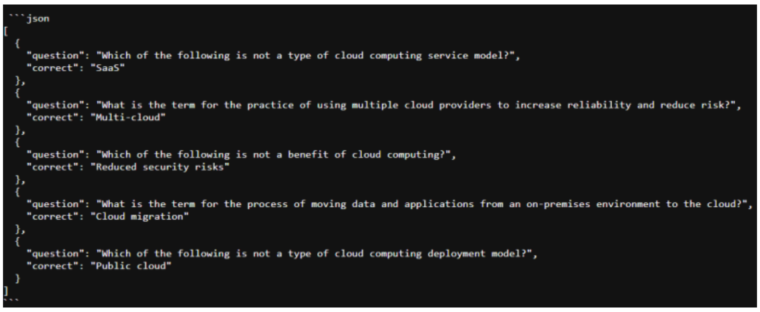
```
## Cloud Computing Quiz (Intermediate Level)

**Instructions:** Please answer the following questions to the best of your ability.

**Question 1:** What is the primary benefit of using cloud computing?
a) Reduced costs
b) Increased security
c) Improved reliability
d) Enhanced scalability

**Question 2:** Which cloud computing model provides users with the most control over their infrastructure?
a) Infrastructure as a Service (IaaS)
b) Platform as a Service (PaaS)
c) Software as a Service (SaaS)
d) Function as a Service (FaaS)

**Question 3:** What is the term used to describe the process of moving data and applications from on-premises infrastructure to the cloud?
a) Cloud migration
b) Cloud adoption
c) Cloud transformation
d) Cloud integration

**Question 4:** Which cloud computing service is primarily used for storing and managing large amounts of unstructured data?
a) Compute Engine
b) Cloud Storage
c) App Engine
d) BigQuery

**Question 5:** What is the term used to describe the ability of a cloud computing system to automatically adjust its resources to meet changing demands?
a) Elasticity
b) Scalability
c) Availability
d) Reliability

**Answers:**
1. a) Reduced costs
2. a) Infrastructure as a Service (IaaS)
3. a) Cloud migration
4. b) Cloud Storage
5. a) Elasticity
```

Case 2: Refined General prompt: Statement with more context.

i.e. You are an expert in generating Cloud Computing quiz…

Generate in JSON array format.

Response:

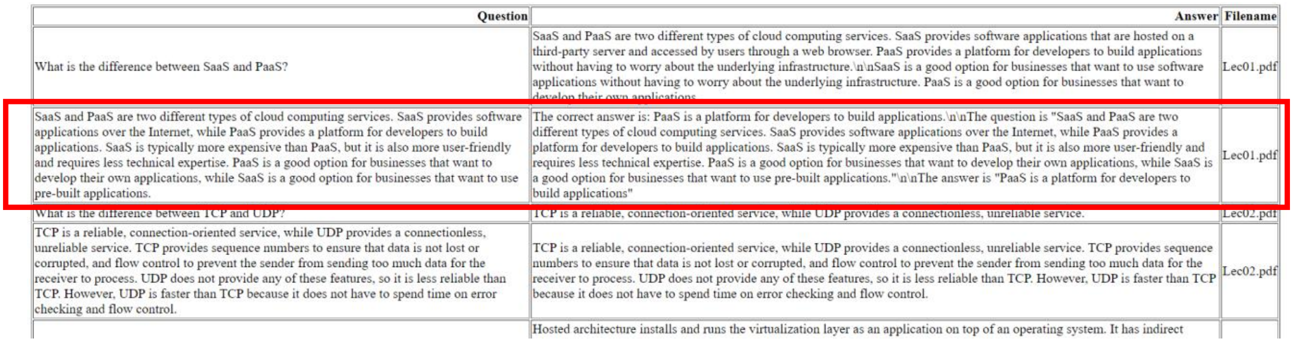


~~~~
```json
[
  {
    "question": "Which of the following is not a type of cloud computing service model?",
    "correct": "SaaS"
  },
  {
    "question": "What is the term for the practice of using multiple cloud providers to increase reliability and reduce risk?",
    "correct": "Multi-cloud"
  },
  {
    "question": "Which of the following is not a benefit of cloud computing?",
    "correct": "Reduced security risks"
  },
  {
    "question": "What is the term for the process of moving data and applications from an on-premises environment to the cloud?",
    "correct": "Cloud migration"
  },
  {
    "question": "Which of the following is not a type of cloud computing deployment model?",
    "correct": "Public cloud"
  }
]
```
~~~~

From both cases above, it is not that obvious that there is any difference in the quality of the quizzes. Both are very relevant to Cloud Computing and only a professor would notice which is more relevant to the course. However, for Case 2, the prompt specified the format to be output hence the output is in JSON array format and returns "question" and "correct" which implies that it is not a multiple-choice quiz. This shows how prompt engineering can also achieve a desired output format.

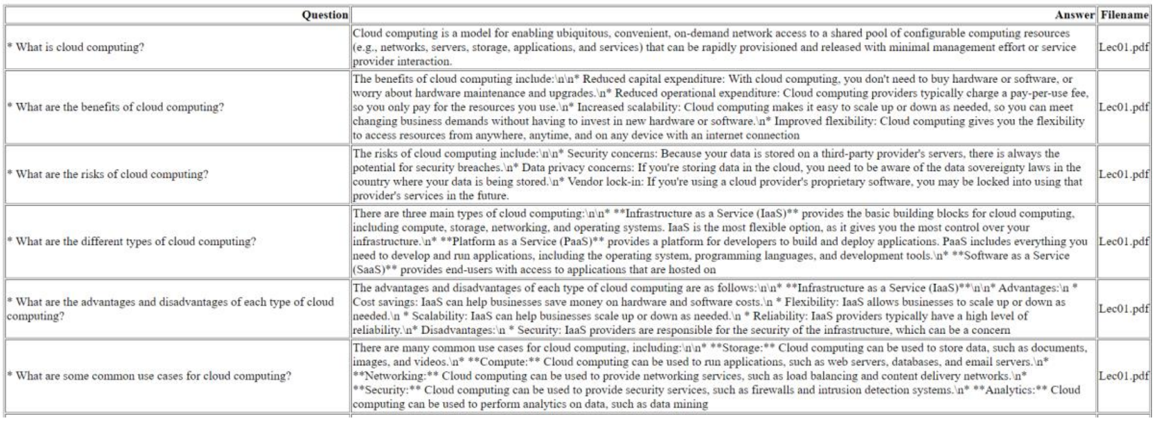
Now we will explore the General prompting (Case 3) and Refined General prompting (Case 4) for prompt templates with extracted lecture information concatenated into them. This enables the model to tune the questions towards the content of the lecture slides. In both Case 3 and Case 4, there is an extra iterative process where the first generation of question sets from the model will be refined by being fed to the same LLM model again (with the extracted texts from PDF) to enhance the quality of the questions.

Case 3 Result:



Question	Answer	Filename
What is the difference between SaaS and PaaS?	SaaS and PaaS are two different types of cloud computing services. SaaS provides software applications that are hosted on a third-party server and accessed by users through a web browser. PaaS provides a platform for developers to build applications without having to worry about the underlying infrastructure.\n\nSaaS is a good option for businesses that want to use software applications without having to worry about the underlying infrastructure. PaaS is a good option for businesses that want to develop their own applications.	Lec01.pdf
SaaS and PaaS are two different types of cloud computing services. SaaS provides software applications over the Internet, while PaaS provides a platform for developers to build applications. SaaS is typically more expensive than PaaS, but it is also more user-friendly and requires less technical expertise. PaaS is a good option for businesses that want to develop their own applications, while SaaS is a good option for businesses that want to use pre-built applications.	The correct answer is: PaaS is a platform for developers to build applications.\n\nThe question is "SaaS and PaaS are two different types of cloud computing services. SaaS provides software applications over the Internet, while PaaS provides a platform for developers to build applications. SaaS is typically more expensive than PaaS, but it is also more user-friendly and requires less technical expertise. PaaS is a good option for businesses that want to develop their own applications, while SaaS is a good option for businesses that want to use pre-built applications."\n\nThe answer is "PaaS is a platform for developers to build applications"	Lec01.pdf
What is the difference between TCP and UDP?	TCP is a reliable, connection-oriented service, while UDP provides a connectionless, unreliable service.	Lec02.pdf
TCP is a reliable, connection-oriented service, while UDP provides a connectionless, unreliable service. TCP provides sequence numbers to ensure that data is not lost or corrupted, and flow control to prevent the sender from sending too much data for the receiver to process. UDP does not provide any of these features, so it is less reliable than TCP. However, UDP is faster than TCP because it does not have to spend time on error checking and flow control.	TCP is a reliable, connection-oriented service, while UDP provides a connectionless, unreliable service. TCP provides sequence numbers to ensure that data is not lost or corrupted, and flow control to prevent the sender from sending too much data for the receiver to process. UDP does not provide any of these features, so it is less reliable than TCP. However, UDP is faster than TCP because it does not have to spend time on error checking and flow control.	Lec02.pdf
	Hosted architecture installs and runs the virtualization layer as an application on top of an operating system. It has indirect	

Case 4 Result:



Question	Answer	Filename
* What is cloud computing?	Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.	Lec01.pdf
* What are the benefits of cloud computing?	The benefits of cloud computing include:\n\n* Reduced capital expenditure: With cloud computing, you don't need to buy hardware or software, or worry about hardware maintenance and upgrades.\n* Reduced operational expenditure: Cloud computing providers typically charge a pay-per-use fee, so you only pay for the resources you use.\n* Increased scalability: Cloud computing makes it easy to scale up or down as needed, so you can meet changing business demands without having to invest in new hardware or software.\n* Improved flexibility: Cloud computing gives you the flexibility to access resources from anywhere, anytime, and on any device with an internet connection	Lec01.pdf
* What are the risks of cloud computing?	The risks of cloud computing include:\n\n* Security concerns: Because your data is stored on a third-party provider's servers, there is always the potential for security breaches.\n* Data privacy concerns: If you're storing data in the cloud, you need to be aware of the data sovereignty laws in the country where your data is being stored.\n* Vendor lock-in: If you're using a cloud provider's proprietary software, you may be locked into using that provider's services in the future.	Lec01.pdf
* What are the different types of cloud computing?	There are three main types of cloud computing:\n\n* **Infrastructure as a Service (IaaS)** provides the basic building blocks for cloud computing, including compute, storage, networking, and operating systems. IaaS is the most flexible option, as it gives you the most control over your infrastructure.\n* **Platform as a Service (PaaS)** provides a platform for developers to build and deploy applications. PaaS includes everything you need to develop and run applications, including the operating system, programming languages, and development tools.\n* **Software as a Service (SaaS)** provides end-users with access to applications that are hosted on	Lec01.pdf
* What are the advantages and disadvantages of each type of cloud computing?	The advantages and disadvantages of each type of cloud computing are as follows:\n\n* **Infrastructure as a Service (IaaS)**\n\n* Advantages:\n * Cost savings: IaaS can help businesses save money on hardware and software costs.\n * Flexibility: IaaS allows businesses to scale up or down as needed.\n * Scalability: IaaS can help businesses scale up or down as needed.\n * Reliability: IaaS providers typically have a high level of reliability.\n* Disadvantages:\n * Security: IaaS providers are responsible for the security of the infrastructure, which can be a concern	Lec01.pdf
* What are some common use cases for cloud computing?	There are many common use cases for cloud computing, including:\n\n* **Storage:** Cloud computing can be used to store data, such as documents, images, and videos.\n* **Compute:** Cloud computing can be used to run applications, such as web servers, databases, and email servers.\n* **Networking:** Cloud computing can be used to provide networking services, such as load balancing and content delivery networks.\n* **Security:** Cloud computing can be used to provide security services, such as firewalls and intrusion detection systems.\n* **Analytics:** Cloud computing can be used to perform analytics on data, such as data mining	Lec01.pdf

The difference in this scenario is clearer. There are a few 'questions' generated in the General prompting (with context) that were statements rather than sentences. With more explicit prompts fed into the LLM, it guides the model to produce more desirable outputs hence being able to produce a more accurate, refined quiz. This is evident to show that prompt engineering plays a crucial role in generating high-quality quizzes.

LLM Functions

For LLM functions, only the Temperature parameter was explored. Temperature controls the randomness in the model's responses. Lower temperature leads to more predictable and conservative outputs. This is very essential when generating questions as the questions should be predictable and directed towards the prompt. It was tested that higher temperature not only produced questions that might not be relevant to the lectures, but the answers were also very abstract such that it would not be able to be classified as a legitimate Cloud Computing quiz.

There are many other token-based control functions within LLM such as top-k and top-p sampling that decide how a model selects its tokens for output.

Conclusion

The exploration and development of a quiz generating using Google Cloud's SaaS platforms especially Cloud Shell, alongside the capabilities of LLM such as Google Gen-AI, represents a significant stride towards redefining educational tools. By carefully leveraging the advanced text generation capabilities of LLMs, high-quality quiz content that is both engaging and informative was generated.

Furthermore, the exploration of prompt engineering and LLM functions has shed light on the iterative process of optimization that underpins the effective use of AI in education.

In this project, two quiz generators were deployed to Google Cloud Run. One was designed for Nemobot hence it could only generate limited content due to the limitations of the software, and the other one was a web application for users to view the data frame easily. More functions like file uploads could be implemented to generate quizzes of any fields relevant to the uploaded files.