

3. Chaining and Summarization

In this chapter, you will learn how to chain calls to a Large Language Model (LLM) and use it to summarize texts, such as articles, books, or transcripts. You will implement those methods with the ChatGPT API to build artificially intelligent applications.

3.1. Why chaining?

Chaining is a technique that allows you to send multiple requests to an LLM in a sequence, using the output of one request as the input of another. This way, you can leverage the power of an LLM to perform complex tasks that require multiple steps, such as summarization, text simplification, or question answering.

This gave birth to a new science (or art?) and a buzzword: **prompt engineering**. Essentially, Prompt engineering¹ is the process of creating and refining prompts to get specific responses from AI models. Prompts are questions or instructions that are structured in natural language to describe a task for an AI to perform. I doubt that “Prompt Engineer” will become a real job (but what is a “real” job really...?)

The benefits of chaining are the following:

- **Enhanced contextual understanding:** By chaining calls, the LLM can maintain context over a longer interaction, leading to more coherent and relevant responses.
- **Complex task handling:** Chaining allows for the breakdown of complex tasks into simpler sub-tasks, which the model can handle more effectively.

Chaining enables to “fix” some of the inherent limitations of LLMs:

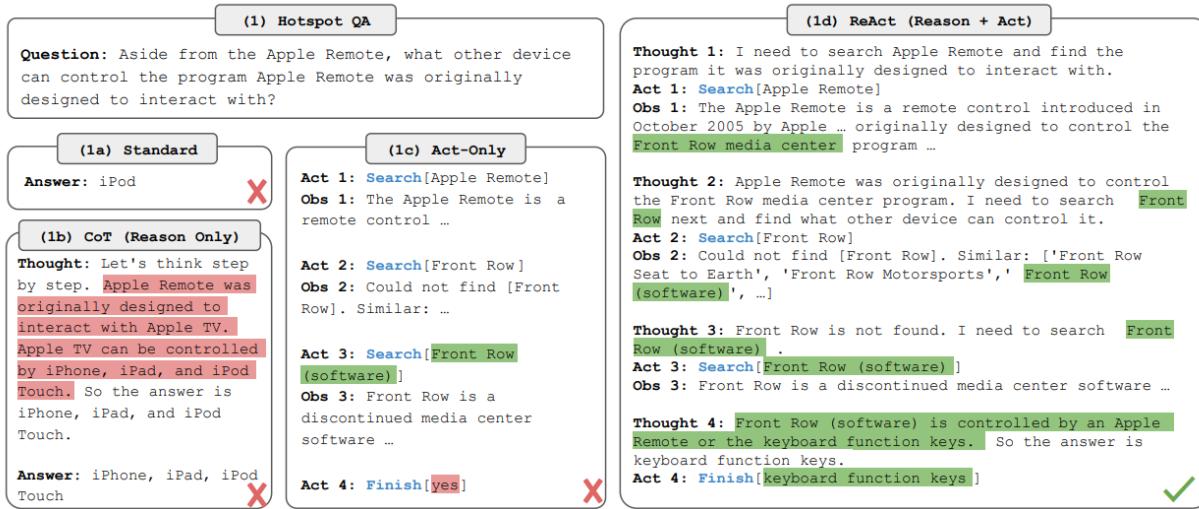
- **Reasoning:** LLMs are not proceeding like the human brain – remember, they simply infer the next logical word in a sentence. As such they are not good at solving basic math problems.
- **Access to Data and Tools:** LLMs do not have access to your data, only the ones they have seen during the training phase. By default they do not have access to search over the internet. As such, it would not make sense to compare ChatGPT with Google search, even if their use cases overlap significantly.
- **Training set fixed in time:** You probably remember ChatGPT saying that he did not have access to information after September 2021. This date is gradually updated by OpenAI but there is always a lag.

 You
what is your knowledge cutoff date?

 ChatGPT
My knowledge is based on information available up to January 2022.

¹ <https://www.datacamp.com/blog/what-is-prompt-engineering-the-future-of-ai-communication>

A major paper that has been at the origin of many of the improvements of the usage of LLMs is **React: Synergizing Reasoning and Acting in Language Models**².



Instead of directly answering a question, this approach breaks down the process into Reasoning + Acting. It does so by implementing a method called **Chain-of-Thoughts**³.

A number of frameworks emerged to provide developers with the ability to integrate LLMs into their applications, by implementing those concepts. I'll cover the few main ones in this blog:

- Semantic Kernel
- LangChain
- LlamaIndex
- Haystack

Most of those frameworks that appeared in 2023 came to complement LLMs like ChatGPT or open-source alternatives such as Llama2. But it is good to note that with new features enabled by OpenAI throughout the year, the need for those frameworks became less and less relevant as OpenAI has increasingly been providing an end-to-end integrated solution.

We will break down the analysis of those frameworks over the course of the next 3 chapters:

- First, we will look at the basics of chaining to go around the limitations of the LLM context
- Second, we will look at methods such as vector search to extend the LLM context
- Third, we will look at properties that appear when we extend the reasoning of LLMs

3.1.1. Semantic Kernel by Microsoft

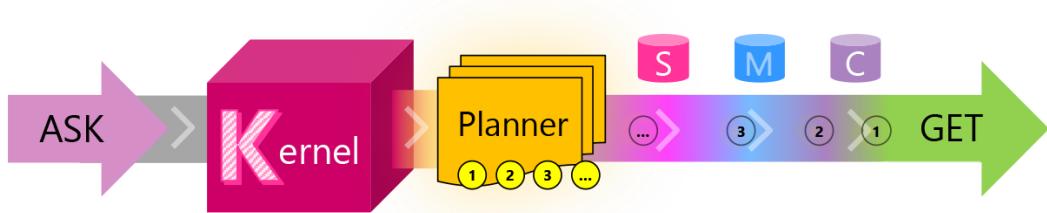
I'm choosing to start with Semantic Kernel, as Microsoft provides good educational material on the main concepts around chaining. Semantic Kernel⁴ is a lightweight Software Development Kit (SDK) developed by Microsoft that enables to mix conventional programming languages and Large Language Models with

² ReAct paper: <https://arxiv.org/abs/2210.03629>

³ Chain-of-Thought: <https://blog.research.google/2022/05/language-models-perform-reasoning-via.html>

⁴ Semantic Kernel: <https://learn.microsoft.com/semantic-kernel/>

templating, chaining, and planning capabilities. Here is a diagram that explains the workflow triggered by the user asking a question:



Journey	Short Description
ASK	A user's goal is sent to SK as an ASK
Kernel	The kernel orchestrates a user's ASK
Planner	The planner breaks it down into steps based upon resources that are available
Resources	Planning involves leveraging available skills, memories, and connectors
Steps	A plan is a series of steps for the kernel to execute
Pipeline	Executing the steps results in fulfilling the user's ASK
GET	And the user gets what they asked for ...

3.1.2. LangChain

LangChain is a framework that enables developers to chain calls to Large Language Models (such as ChatGPT). It offers implementations both in Python and Typescript (in order to migrate easily your experimentations into a JavaScript web app). We won't be needing this as we will reuse Streamlit.

Many of the concepts introduced in the early days of the LangChain framework were meant to complement the Large Language Models such as GPT 3.5:

- Extend the length of the context (limited to 4096 tokens)
- Augment generation by retrieving elements not in the context (Retrieval Augmented Generation)
- Add tools such as loading documents, searching the internet or doing basic math

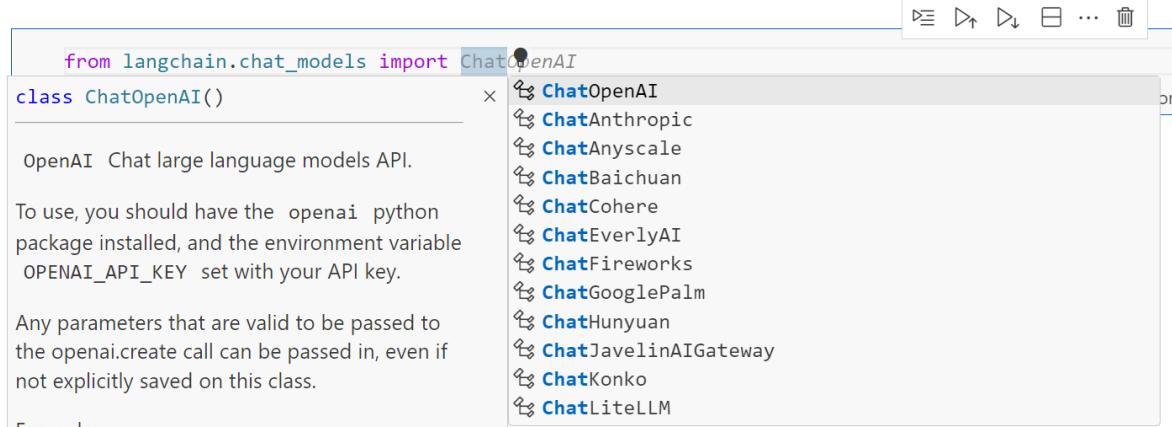
Before ChatGPT was introduced (with the underlying 3.5 turbo model), you could already abstract the call to OpenAI GPT 3 models with LangChain, with a very simple syntax:

```
from langchain.llms import OpenAI
llm = OpenAI()
joke = llm('tell me a joke')
print(joke)
```

Q: What did the fish say when he hit the wall?

A: Dam!

It also provided the ease of swapping models providers:



The screenshot shows a code editor window with Python code. A dropdown menu is open next to the word 'ChatOpenAI' in the code, listing various model options: ChatOpenAI, ChatAnthropic, ChatAnyscale, ChatBaichuan, ChatCohere, ChatEverlyAI, ChatFireworks, ChatGooglePalm, ChatHunyuan, ChatJavelinAIGateway, ChatKonko, and ChatLiteLLM.

```
from langchain.chat_models import ChatOpenAI
class ChatOpenAI():

    OpenAI Chat large language models API.

    To use, you should have the openai python package installed, and the environment variable OPENAI_API_KEY set with your API key.

    Any parameters that are valid to be passed to the openai.create call can be passed in, even if not explicitly saved on this class.

    Example:

        from langchain.chat_models import ChatOpenAI
        openai = ChatOpenAI(model_name=
```

But the use of chat models (like gpt-3.5-turbo) were preferred to those base models like davinci⁵. They've been significantly optimized, and the price is 10 times cheaper⁶, so it is best to standardize your code on those chat models.

```
from langchain.chat_models import ChatOpenAI
from langchain.schema import HumanMessage
chat = ChatOpenAI()
text = "Tell me a joke"
messages = [HumanMessage(content=text)]
res = chat.invoke(messages)
print(res.content)
```

Sure, here's a classic joke for you:

Why don't scientists trust atoms?

Because they make up everything!

To learn more about LangChain, I would recommend the Youtube channel of Greg Kamradt⁷.

⁵ GPT 3 legacy models: <https://platform.openai.com/docs/models/gpt-3>

⁶ GPT 3.5 turbo prices: <https://openai.com/pricing#gpt-3-5-turbo>

⁷ Langchain tutorials:

<https://youtube.com/playlist?list=PLgZXAkF1bPNQER9mLmDbntNfSpzdDIU5>

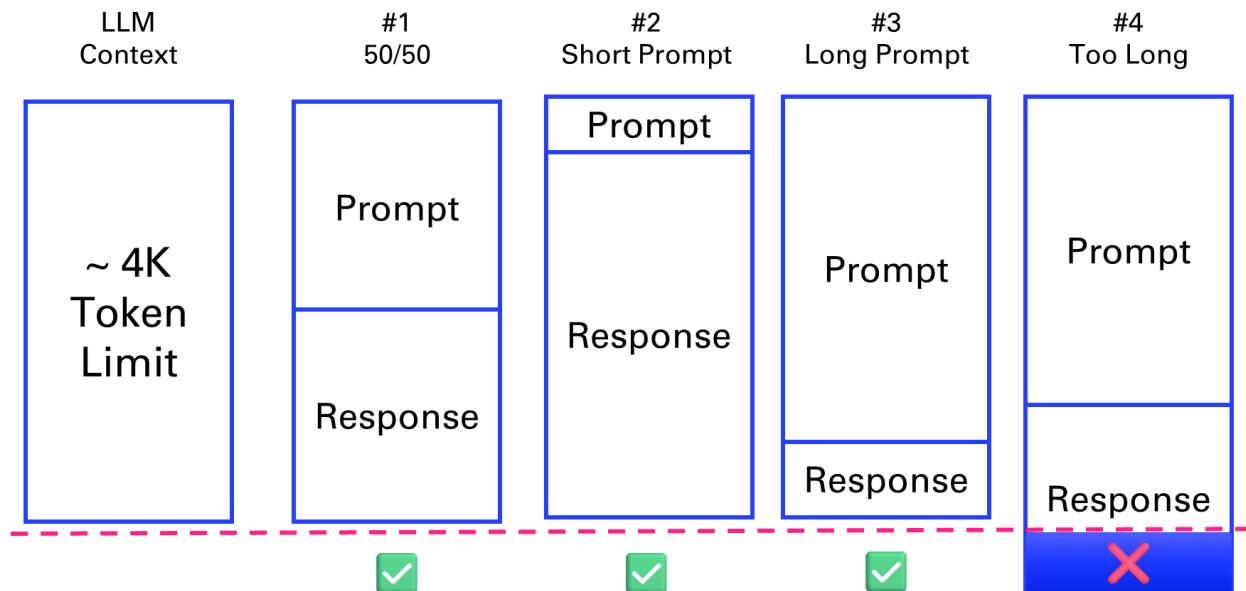
<https://github.com/gkamradt/langchain-tutorials>

3.2. Summarization

Summarization is one of the main use cases of Natural Language Processing that is used productively in a professional setting. The first application that came to my mind to leverage ChatGPT was summarizing meetings. This way I could simply turn on the transcription on Microsoft Teams and skip long overcrowded meetings. The same could be applied to long documents that I don't want to read.

3.2.1. Working around the context length

Now there is one problem with this: a typical one-hour meeting is around 8k to 10k tokens. But initially the GPT-3.5 model powering ChatGPT could only handle 4096 tokens.



What are tokens anyway? A helpful rule of thumb is that one token generally corresponds to ~4 characters of text for common English text. This translates to roughly $\frac{1}{4}$ of a word (so 100 tokens \approx 75 words). OpenAI provides a tokenizer⁸ to help you compute the number of tokens of your text. In what follows, we will use the package tiktoken⁹ from OpenAI anytime we need to compute precisely the number of tokens within our applications.

What does this mean in terms of pages? One page in average is 500 words¹⁰ (like the first page of the forewords in Letter format 8.5" x 11"). Which means that 4k tokens can fit 6 pages of text. As the previous diagram suggests, this context length is shared between the prompt and the response.

Let's illustrate this with a basic example of a conversation recorded as WebVTT file¹¹:

```
import os, webvtt
```

⁸ OpenAI tokenizer page: <https://platform.openai.com/tokenizer>

⁹ Tiktken package: <https://github.com/openai/tiktoken>

¹⁰ Words per page: <https://wordcounter.net/words-per-page>

¹¹ WebVTT file: https://developer.mozilla.org/en-US/docs/Web/API/WebVTT_API

```

files = os.listdir('../data/vtt')
file = files[1]
cap = webvtt.read('../data/vtt/'+file)
for caption in cap[1:5]:
    # print(f'From {caption.start} to {caption.end}')
    # print(caption.raw_text)
    print(caption.text)

```

I want to start doing this experiment where.

We have a conversation we record it's generating a VTT file.

And I have a parser. I developed a small app in Python that can retrieve the VTT file process it.

And then.

We can extract the text from the conversation and save it as a plain text file.

```

txt = file.replace('.vtt','.txt')
m = [caption.raw_text for caption in cap]
sep = '\n'
convo = sep.join(m)
with open('../data/txt/'+txt,mode='w') as f:
    f.write(convo)

```

Let's count the numbers of token in the conversation.

```

import tiktoken
def num_tokens(string: str) -> int:
    """Returns the number of tokens in a text string."""
    encoding_name = 'cl100k_base'
    encoding = tiktoken.get_encoding(encoding_name)
    num_tokens = len(encoding.encode(string))
    return num_tokens

num_tokens(convo)

```

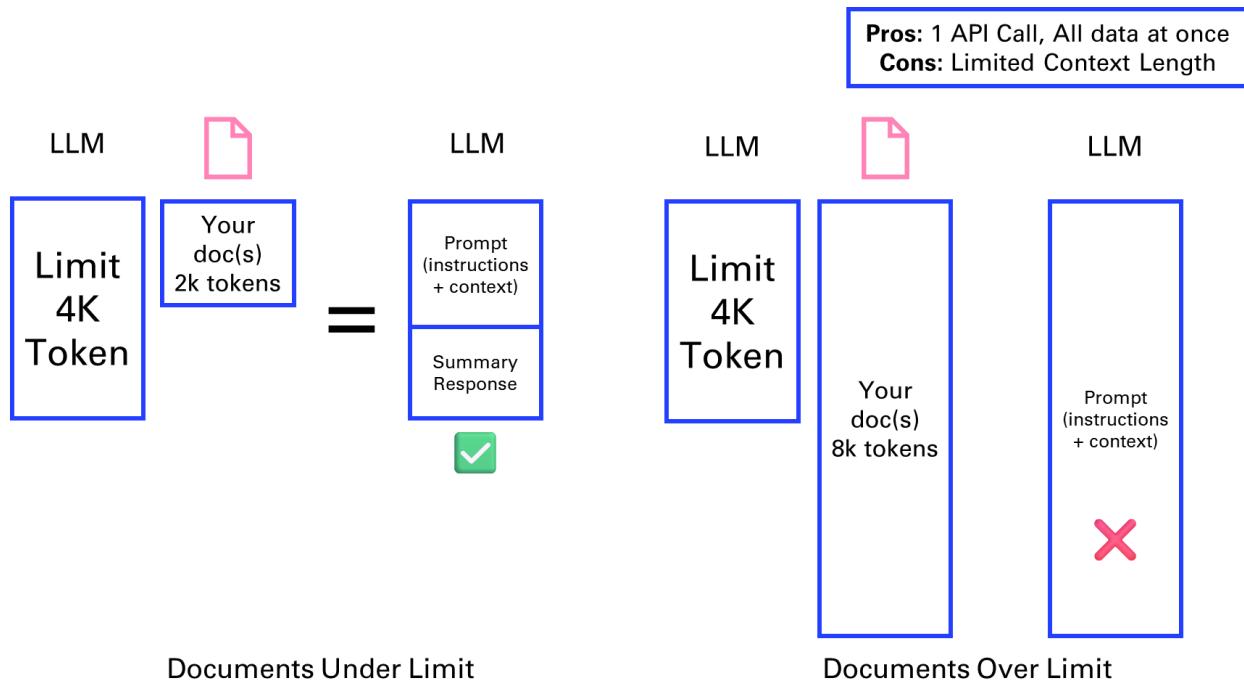
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In the next parts, we will go over different chain types to address the limitation of the context length¹².

3.2.2. Stuffing

The first solution presented is "stuffing". If a document is within the model's context limit (4k tokens here), it can be directly fed into the API for summarization. This method is straightforward but limited by the maximum context length.

¹² Workaround OpenAI's Token Limit With Chain Types: https://www.youtube.com/watch?v=f9_BWhCI4Zo



This is how the code would look like with LangChain:

```
from langchain.chains.summarize import load_summarize_chain
from langchain.chat_models import ChatOpenAI
from langchain.document_loaders import WebBaseLoader, TextLoader
loader = TextLoader('../data/txt/*txt')
docs = loader.load()
llm = ChatOpenAI(temperature=0, model_name="gpt-3.5-turbo")
chain = load_summarize_chain(llm, chain_type="stuff")
chain.run(docs)
```

'Yann wants to improve his French accent and plans to conduct an experiment where he records conversations and generates VTT files. He has developed a Python app to process the VTT files and wants to use the ChatGPT API to further analyze them. Mike has not yet used the API due to lack of time.'

Try summarizing a longer text, like the content of a webpage like the LangChain doc page.

```
def summarize(page, model = "gpt-3.5-turbo"):
    loader = WebBaseLoader(page)
    docs = loader.load()
    llm = ChatOpenAI(temperature=0, model_name=model)
    chain = load_summarize_chain(llm, chain_type="stuff")
```

```

    return chain.run(docs)

page = "https://python.langchain.com/docs/use_cases/summarization"
try:
    summary = summarize(page)
    print(summary)
except Exception as e:
    print(str(e))

```

Error code: 400 - {'error': {'message': "This model's maximum context length is 4097 tokens. However, your messages resulted in 7705 tokens. Please reduce the length of the messages.", 'type': 'invalid_request_error', 'param': 'messages', 'code': 'context_length_exceeded'}}}

Luckily as we will see in the last part of this chapter we can use a model with a larger context window:

```

page = "https://python.langchain.com/docs/use_cases/summarization"
summarize(page,model = "gpt-3.5-turbo-16k")

```

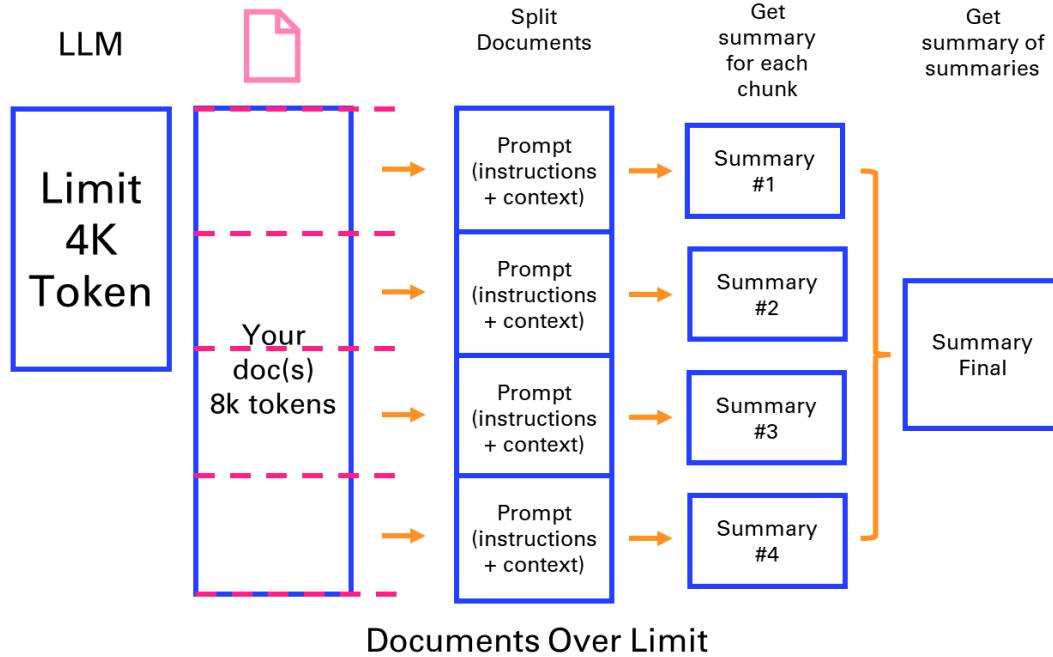
'The LangChain platform offers tools for document summarization using large language models (LLMs). There are three approaches to document summarization: "stuff," "map-reduce," and "refine." The "stuff" approach involves inserting all documents into a single prompt, while the "map-reduce" approach summarizes each document individually and then combines the summaries into a final summary. The "refine" approach iteratively updates the summary by passing each document and the current summary through an LLM chain. The platform provides pre-built chains for each approach, and users can customize prompts and LLM models. Additionally, the platform offers the option to split long documents into chunks and summarize them in a single chain.'

3.2.3. Map reduce

The MapReduce method involves splitting a large document (e.g., 8k tokens) into smaller chunks, summarizing each separately, and then combining these summaries into a final summary. This approach allows for processing larger documents in parallel API calls but may lose some information.

This is a term that some might be familiar with, from the space of big data analysis, where it represents a distributed execution framework that parallelized algorithms over data that might not fit on a single core.

Pros: Scales to larger docs, can be parallelized
Cons: Maybe API Calls. Loses information



As an example, we will take another source of VTT files: Youtube transcripts¹³. The video we will summarize is the LangChain Cookbook - Beginner Guide To 7 Essential Concepts¹⁴.

```

from youtube_transcript_api.formatters import WebVTTFormatter
from youtube_transcript_api import YouTubeTranscriptApi
video_id = "2xxziIWmaSA" # https://www.youtube.com/watch?v=2xxziIWmaSA
transcript = YouTubeTranscriptApi.get_transcript(video_id)
formatter = WebVTTFormatter()
formatted_captions = formatter.format_transcript(transcript)
vtt_file = f'../data/vtt/subtitles-{video_id}.vtt'
with open(vtt_file, 'w') as f:
    f.write(formatted_captions)
sep = '\n'
caption = sep.join([s['text'] for s in transcript])
num_tokens(caption)
  
```

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```
# Turn VTT file into TXT file
```

¹³ <https://pypi.org/project/youtube-transcript-api/>

¹⁴ <https://www.youtube.com/watch?v=2xxziIWmaSA>

```

txt_file = vtt_file.replace('vtt', 'txt')
with open(txt_file, mode='w') as f:
    f.write(caption)

```

Now comes a new concept that will be important anytime you are breaking down content into chunks: a **text splitter**¹⁵.

The default recommended text splitter is the `RecursiveCharacterTextSplitter`. This text splitter takes a list of characters. It tries to create chunks based on splitting on the first character, but if any chunks are too large it then moves onto the next character, and so forth. By default, the characters it tries to split on are `["\n\n", "\n", " ", ""]`

In addition to controlling which characters you can split on, you can also control a few other things:

- `length_function`: how the length of chunks is calculated. Defaults to just counting number of characters, but it's pretty common to pass a token counter here.
- `chunk_size`: the maximum size of your chunks (as measured by the length function).
- `chunk_overlap`: the maximum overlap between chunks. It can be nice to have some overlap to maintain some continuity between chunks (e.g. do a sliding window).
- `add_start_index`: whether to include the starting position of each chunk within the original document in the metadata.

```

text_splitter = RecursiveCharacterTextSplitter(
    chunk_size = 1000,
    chunk_overlap = 0,
    length_function = num_tokens,
)

def doc_summary(docs):
    print(f'You have {len(docs)} document(s)')
    num_words = sum([len(doc.page_content.split(' ')) for doc in docs])
    print(f'You have roughly {num_words} words in your docs')
    print()
    print(f'Preview: \n{docs[0].page_content.split(". ")[0][0:42]}')

docs = text_splitter.split_documents(doc)
doc_summary(docs)

```

You have 11 document(s)
 You have roughly 7453 words in your docs

Preview:
 hello good people have you ever wondered

¹⁵ https://python.langchain.com/docs/modules/data_connection/document_transformers/#text-splitters

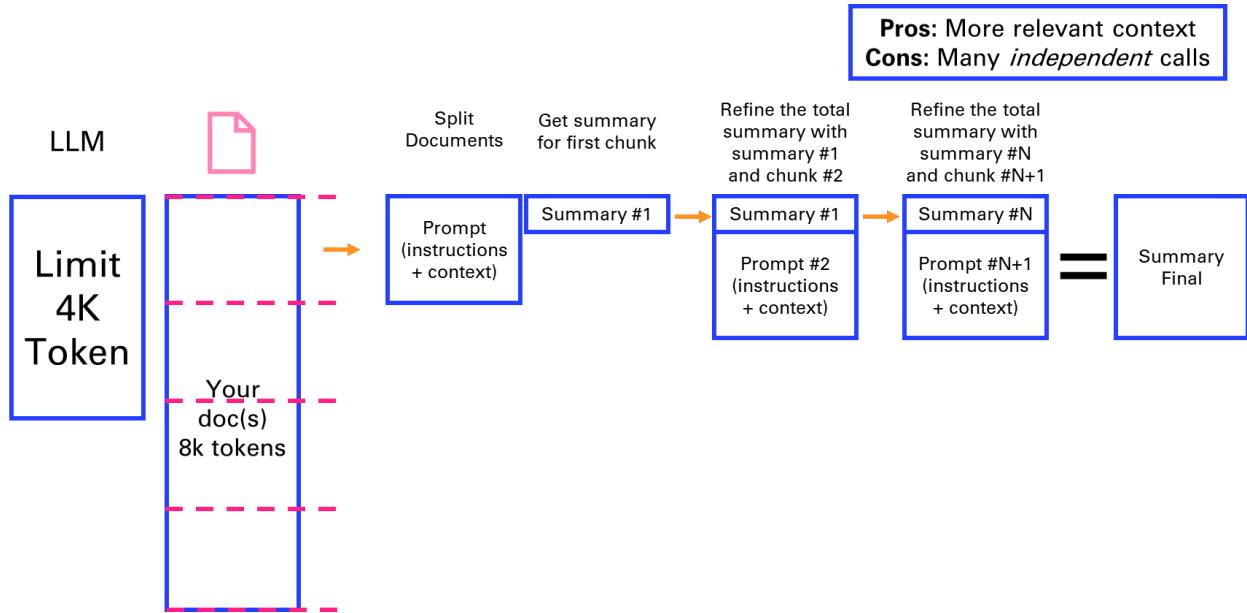
We can now perform the MapReduce method. We can enable the mode `verbose=True` to view the breakdown of each intermediate summary.

```
llm = ChatOpenAI(model_name='gpt-3.5-turbo')
chain = load_summarize_chain(llm, chain_type="map_reduce", verbose=True)
chain.run(docs)
```

"The video introduces Lang chain, a framework for developing applications powered by language models. It explains the components and benefits of Lang chain, and mentions a companion cookbook for further examples. The video discusses different types of models and how they interact with text, including language models, chat models, and text embedding models. It explains the use of prompts, prompt templates, and example selectors. The process of importing and using a semantic similarity example selector is described. The video also discusses the use of text splitters, document loaders, and retrievers. The concept of vector stores and various platforms are mentioned. The video explains how chat history can improve language models and introduces the concept of chains. It demonstrates the creation of different chain types in Lang chain, such as location, meal, and summarization chains. The concept of agents and their application in decision making is discussed, along with the process of creating an agent and loading tools into its toolkit. The speaker shares their positive experience using Lion Chain software and its ability to dynamically search for information. They mention the debut album of Wild Belle and encourage viewers to check out the band's music. The video concludes by mentioning future videos on the topic and encouraging viewers to subscribe and provide feedback."

3.2.4. Refine

In the Refine method, the document is split into chunks, and each chunk is summarized sequentially, with each summary informed by the previous one. This method provides relevant context but is time-consuming due to its sequential nature. This is one of my favorite methods for summarizing.



We can directly try this method on the same content as the previous section, and see how it compares.

```
chain = load_summarize_chain(llm, chain_type="refine", verbose=True)
chain.run(docs)
```

You can observe in the verbose output that the chain uses the following prompt:

```
Given the new context, refine the original summary.
If the context isn't useful, return the original summary.
```

Finally, I'll implement my own **text splitter** and **summarizer** using the refine method.

```
def my_text_splitter(text, chunk_size=3000):
    # Split text into chunks based on space or newline
    chunks = text.split()

    # Initialize variables
    result = []
    current_chunk = ""

    # Concatenate chunks until the total length is less than 4096 tokens
    for chunk in chunks:
        # if len(current_chunk) + len(chunk) < 4096:
        if num_tokens(current_chunk+chunk) < chunk_size:
            current_chunk += " " + chunk if current_chunk else chunk
        else:
            result.append(current_chunk.strip())
            current_chunk = chunk
    if current_chunk:
```

```

    result.append(current_chunk.strip())
    return result

```

```

import openai
def summarize(text, context = 'summarize the following text:', model = 'gpt-3.5-turbo'):
    completion = openai.chat.completions.create(
        model = model,
        messages=[
            {'role': 'system', 'content': context},
            {'role': 'user', 'content': text}
        ]
    )
    return completion.choices[0].message.content

```

```

def refine(summary, chunk, model = 'gpt-3.5-turbo'):
    """Refine the summary with each new chunk of text"""
    context = "Refine the summary with the following context: " + summary
    summary = summarize(chunk, context, model)
    return summary

```

```

# Requires initialization with summary of first chunk
chunks = my_text_splitter(caption)
summary = summarize(chunks[0])
for chunk in chunks[1:]:
    summary = refine(summary, chunk)
summary

```

'In this video, the presenter discusses the Lang chain framework and its various components, including Vector Stores, Memory, Chains, and Agents. They provide code examples and highlight the versatility and functionality of using Lang chain. In the end, they encourage viewers to subscribe for part two and ask any questions they may have. They also share tools on Twitter and encourage feedback and comments from viewers.'

3.2.5. Evolutions of the context window

This early view of limitations of Large Language Models has to be updated over time as the context length of new generations of LLMs are growing:

- GPT 4¹⁶ (introduced on March 14, 2023) originally had an 8k tokens context window. A 32k tokens version was made available gradually in parallel. In November 2023, an 128k token version was introduced.
- GPT 3.5 got a 16k version in September 2023.
- Anthropic Claude¹⁷ extended its context window to 100k tokens in May 2023, enabling to process an entire book like the Great Gatsby of around 200 pages (standard paperback edition).
- Claude 2.1¹⁸ (Nov 2023) and Claude 3 (Mar 2024) propose an impressive 200k tokens context.
- LLaMa¹⁹ from Meta initially came with a 2k tokens context window in February 2023.
- Llama2²⁰ released in July 2023 has a 4k tokens context window. Llama3 released in April 2024 doubles it again to 8k tokens. This is considered one of the leading open-source LLM.
- GPT 4o²¹ (introduced on May 13, 2024) has a 128k tokens context window.

There are still advantages to apply the previous methods, either to mitigate the cost of long context windows and larger models, or to use smaller more dedicated models that can be open-source for certain specific tasks like summarizing.

¹⁶ GPT 4 model: <https://platform.openai.com/docs/models/gpt-4>

¹⁷ Anthropic Claude 100k context window: <https://www.anthropic.com/index/100k-context-windows>

¹⁸ Claude 2 & 3: <https://www.anthropic.com/news/clause-2-1> - <https://www.anthropic.com/news/clause-3-family>

¹⁹ LLaMa: <https://ai.meta.com/blog/large-language-model-llama-meta-ai/>

²⁰ Llama 2 & 3: <https://llama.meta.com/llama2/> - <https://llama.meta.com/llama3/>

²¹ <https://openai.com/index/hello-gpt-4o/>