

Description

This report consists of:

1. **Part 1** (page 3-6): Report, which was written with extensive use of the *Research Assistant* application. 90% of the text was generated by the application.
2. **Part 2** (page 7-10): Evaluation of Part 1, technical description of *Research Assistant*.

How to use Research Assistant?

1. Open <https://my-researchassistant.streamlit.app>

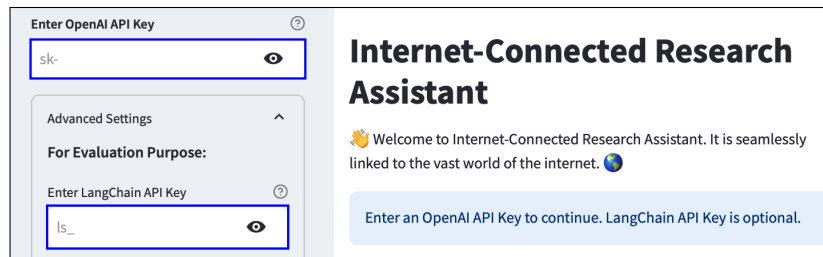


Figure 1: Research Assistant Start Page

2. Insert an OpenAI API key. An OpenAI API key with credit is required. Each execution costs around US \$0.04 using the default setting.
3. Optional: Insert a LangSmith API key. The intermediate steps can be visualized using LangSmith.

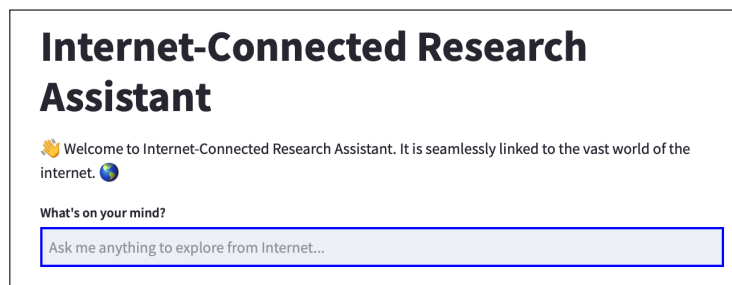


Figure 2: Topic Field

4. Insert a topic and confirm with "Enter". E.g. "Use LLM for content creation"

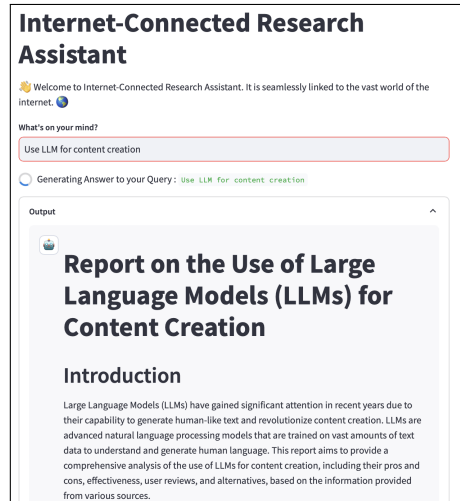


Figure 3: After around 10 seconds, it generates output text.

5. Optional: Scroll to the bottom and click the following link to visualize intermediate steps in LangSmith:

[View intermediate steps on LangSmith](#)

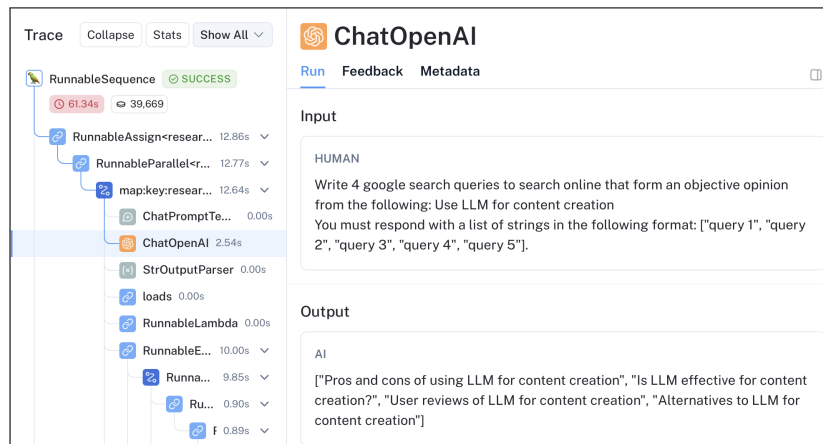


Figure 4: LangSmith View

Transformation of Starbucks and the Role of Howard Schultz in 2008 Financial Crisis

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1 ABSTRACT

The year 2008 was a challenging period for Starbucks, as the company grappled with a range of issues including market saturation, operational inefficiencies, and the impact of the global financial crisis. Howard Schultz, the former CEO, played a crucial role in leading the company through this tumultuous time and implementing strategies to rescue it from financial instability. His transformative leadership was instrumental in steering Starbucks away from the brink of bankruptcy.

The global financial crisis exacerbated the challenges faced by Starbucks in 2008, leading to a decline in customer visits and a significant drop in the company's stock price. Howard Schultz's return as CEO marked a turning point for the company, as he implemented strategies to address the internal and external issues that were threatening its existence. This report delves into the critical events that unfolded at Starbucks in 2008, highlighting the multifaceted crisis faced by the company and the visionary leadership of Howard Schultz in orchestrating its transformation and rescue.

2 INTRODUCTION

Starbucks, a world-renowned coffeehouse chain, has a rich history that spans over five decades. From its humble beginnings in Seattle, Washington, Starbucks has grown into a global brand with thousands of stores across various countries. Starbucks was founded in 1971 near the historic Pike Place Market in Seattle, Washington. The company was established by Jerry Baldwin, Zev Siegl, and Gordon Bowker. These three entrepreneurs shared a common passion for high-quality coffee and tea. The initial vision of Starbucks was to create a place where people could come together to enjoy exceptional coffee and build a sense of community. The founders opened the first Starbucks store, which quickly became a gathering place for locals and a hub for coffee enthusiasts.

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Since its inception in 1971, Starbucks has experienced significant growth, expanding its presence to over 35,000 stores worldwide. The company's growth trajectory involves the use of intensive growth strategies such as market penetration, market development, and product development. Starbucks aims to maximize revenues from existing markets, expand into new markets or market segments, and introduce new products to drive business growth. The company operates in more than 80 countries and territories and continues to focus on expanding its international market presence while maintaining its competitive advantages through product differentiation.

Prior to the 2008 financial crisis, Starbucks was on a trajectory of rapid expansion, which resulted in a high density of stores, often cannibalizing sales from one another. The aggressive growth strategy led to market saturation, and the quality of the Starbucks experience began to wane. This expansion was accompanied by a growing bureaucracy within the company, distancing management from the core values and mission that had once defined Starbucks.

In 2008, the global financial crisis had a significant impact on Starbucks, leading to a decline in revenue, stock price, and consumer spending. The company faced financial challenges, including store closures and layoffs, as a result of the economic downturn. The crisis also posed a threat to Starbucks' unique experience and opened the door to competitors, resulting in a 75% drop in stock value. However, under the leadership of Howard Schultz, the company implemented a major overhaul, leading to a successful turnaround and a 143% increase in stock by 2009.

The crisis was not only financial but also reputational. Starbucks faced increased competition from less expensive alternatives like McDonald's, a shift in consumer preferences toward healthier options, and criticism of being perceived as expensive and elitist. The brand that had once signified a premium, aspirational experience was being questioned, and the company's rapid expansion was seen as a loss of focus on its core coffee business.

To mitigate the impact of the crisis, Starbucks implemented swift and decisive strategic responses to ensure its survival. Howard Schultz, who had previously led the company to unprecedented success, returned as CEO to orchestrate a comprehensive transformation aimed at resuscitating the ailing coffee giant. Howard Schultz has been a key figure in the journey of Starbucks, serving as CEO, chairman, and interim CEO at various points in the company's history. Schultz's tenure at Starbucks saw the company undergo significant expansion and transformation. He was instrumental in leading the company from its early stages to becoming a global powerhouse in the coffee industry.

This report aims to provide a detailed account of the events that transpired at Starbucks in 2008 and the instrumental role played by

Howard Schultz in the company's turnaround and positioning it for sustained growth and success.

3 STARBUCKS' STRUGGLES IN 2008

In the following section, we provide information about different challenges Starbucks confronted during 2008 financial crisis.

3.1 Financial Crisis and Decline in Sales

During the 2007-2008 financial crisis, Starbucks experienced a severe downturn in profits and faced challenges such as market saturation, economic recession, shifting consumer preferences, and brand perception issues. This financial distress culminated in the closure of 600 underperforming stores in the United States and layoffs of thousands of employees, shaking the morale of the Starbucks workforce and threatening the company's survival.

The general economic downturn in 2008 led to consumers cutting back on discretionary spending, impacting Starbucks' sales and financial performance. Declining customer traffic, reduced consumer spending and intensified competition from lower-priced coffee alternatives exacerbated further the already dire Starbucks' financial situation.

The financial impacts of this dire situation were:

- (1) Revenue and Profit Decline: By March 30, 2008, the company reported a 28% decline in profit compared to the same period in 2007.
- (2) Stock Price Decline: Starbucks stock value decreased by approximately 80% during 2008, reflecting the challenges faced by the company and the concerns of investors regarding its financial stability and future prospects.

3.2 Market Saturation and Competition

Starbucks experienced rapid expansion, nearly doubling its number of locations over the past decade. By 2008, the company had more than 16,200 coffee shops globally, leading to market saturation in many neighborhoods. This aggressive expansion resulted in the oversaturation of Starbucks outlets, where multiple stores were competing for the same customer base. The oversaturation of stores contributed to the cannibalization of sales, as the company's outlets were vying for the same pool of customers, impacting the overall revenue and profitability of individual stores.

Emerging competitors, including fast-food chains and convenience stores, began offering quality coffee at more affordable prices, posing a threat to Starbucks' market position. Shifting consumer preferences towards more value-oriented options and the perception of Starbucks as an expensive and elitist brand further intensified the competitive landscape for the company.

One notable competitor during this time was McDonald's, which entered the specialty coffee market and posed a significant threat to Starbucks. McDonald's started setting up coffee bars that sold espresso, directly competing with Starbucks' core product offerings. The entry of fast-food chains into the premium coffee segment intensified the competitive landscape for Starbucks, requiring the company to innovate and differentiate itself to maintain its market position.

3.3 Low Public Perception

The 2008 crisis had implications for Starbucks' public perception, as the company faced challenges in maintaining customer loyalty and attracting new customers. The "Starbucks experience" was deemed overpriced, leading to the perception of the brand as an unnecessary extravagance during the economic recession. This perception was further exacerbated by the company's struggle to align its menu with evolving consumer tastes, ultimately impacting its revenue and stock performance.

Additionally, an incident in which two black men were arrested at a Starbucks store in Philadelphia severely tarnished the company's public perception, leading to accusations of racial bias and calls for a boycott.

3.4 Supply Chain Issues

Another critical challenge that Starbucks encountered in 2008 pertained to supply chain issues. Starbucks experienced rapid expansion during the early 2000s, which led to oversaturation in certain markets. This overexpansion resulted in a neglect of existing stores, increased costs, and delivery delays, ultimately impacting the company's bottom line and customer satisfaction.

The economic recession of 2008 had a profound impact on consumer behavior, leading to a decline in sales as customers began choosing cheaper coffee options. Additionally, shifting consumer preferences towards healthier and more diverse food and beverage options added complexity to Starbucks' supply chain management.

Furthermore, the rising costs of ingredients, including coffee beans, and delivery delays further exacerbated Starbucks' supply chain challenges. These issues impacted the company's cost structure, operational efficiency, and overall profitability. The failing supply chain and a lack of innovation in the supply chain processes led to product shortages, stagnated sales, and a strain on the company's supply chain.

3.5 Fierce Competition in Coffee Industry

In 2008, Starbucks faced significant challenges from fierce competition in the coffee industry. The company encountered competition from traditional rivals as well as new entrants in the market. Some of the key competitors were Dunkin Donuts, Costa Coffee, McCafé, Peet's Coffee, and Café Coffee Day, among others.

These competitors employed various strategies to capture market share in the specialty coffee industry. For example:

- (1) Dunkin Donuts focused on quick service and competitive pricing.
- (2) Costa Coffee emphasized exceptional quality arabica coffee plantations with over 3,800 stores worldwide.
- (3) McCafé aggressively promoted its coffee line as a significant competitor to Starbucks with its global reach and recognition.
- (4) Peet's Coffee stood out through its commitment to sourcing high-quality beans globally, presenting a challenge to Starbucks in terms of market share.

The entry of McDonald's into the specialty coffee market posed a significant threat to Starbucks in 2008. McDonald's began setting up coffee bars that sold espresso, intensifying the competition in the coffee industry.

4 STRATEGIC RESPONSE

In response to the financial challenges posed by the 2008 crisis, Starbucks implemented various strategic measures to mitigate the impact and drive recovery. Howard Schultz, who returned as CEO in 2008, played a pivotal role in leading the company through this challenging period. Schultz emphasized the need to shift focus back to customers, reconnect with them, and reemphasize core values (LinkedIn, How Starbucks Weathered the Storm: Lessons from, 2021).

In the following section, we provide information about several critical decisions Starbucks took under the leadership of Howard Schultz.

4.1 Store Closures and Cost Reductions

One of the key initiatives undertaken by Howard Schultz was the closure of approximately 600 underperforming Starbucks coffee shops in January 2009. This strategic decision led to a significant cost reduction of \$850 million, enabling Starbucks to streamline its operations and focus on more profitable locations. The closure of underperforming stores was a critical step in optimizing the company's store portfolio and improving overall financial performance.

4.2 Refocusing on Core Values and Customer-Centricity

Under Schultz's leadership, Starbucks refocused on its core values and emphasized customer-centricity. The company reinvested in its stores, introduced new store formats, and leveraged digital technology to enhance customer engagement. Schultz's emphasis on reconnecting with customers and the core essence of coffee helped Starbucks weather the financial crisis and emerge stronger. By reinforcing its commitment to quality and customer experience, Starbucks was able to rebuild trust and reignite brand loyalty. This involved:

- reintroducing comprehensive barista training,
- reintroducing coffee grinding in stores to create a multisensory experience,
- expanding product offerings with healthier and diverse menu options such as milder coffee blend, Pike Place Roast, to appeal to a wider range of customers,
- reinvesting in store environments to reinforce Starbucks as a premium destination and
- introducing new store format such by adding drive-thrus.

4.3 Mandatory Racial Bias Training

The incident in which two black men were arrested at a Starbucks store in Philadelphia severely tarnished the company's public perception. This event sparked widespread controversy and public outrage, leading to accusations of racial bias and calls for a boycott of Starbucks.

The crisis presented a critical test for the company's crisis management capabilities, and Starbucks took immediate action by announcing the closure of more than 8,000 company-owned stores across the United States for a half-day of racial bias training (Change Management Insight, 2021). This proactive response aimed to address the public's concerns and rebuild trust and reputation.

4.4 Digital Innovations

Starbucks was an early adopter of digital initiatives, launching the "Order & Pay" app and the Starbucks Card Rewards Program in April 2008. These technological advancements were later consolidated into the My Starbucks Rewards program, bolstering customer retention and enhancing the convenience of the Starbucks experience.

4.5 Embracing Social Media and Customer Engagement

Starbucks leveraged social media platforms to align its operations with customer demands and rebuild brand trust. The "My Starbucks Idea" initiative allowed customers to exchange ideas and directly engage with the company, resulting in over 93,000 ideas shared by about 1.3 million users on social media (LinkedIn, How Starbucks Weathered the Storm: Lessons from, 2021). This demonstrates the company's commitment to leveraging digital channels to enhance customer engagement and rebuild its brand image during a challenging economic environment.

4.6 Supply Chain Optimization

The company's supply chain also underwent significant transformation during the crisis. Starbucks focused on innovating its supply chain, investing in sustainability, and developing new products and services. This resulted in a reduction of the supply chain lead time by over 80%, thereby improving operational efficiency and saving the company over \$500 million in the following years (Supply Chain Nuggets, 2021).

5 THE RESULTS OF SCHULTZ'S TRANSFORMATION

Despite the challenges faced during the 2008 financial crisis, Howard Schultz's turnaround plan and strategic initiatives were highly effective in reviving Starbucks.

Starbucks regained market share, improved brand value, and increased operational efficiency, demonstrating the importance of effective leadership in achieving business success. The strategic cost-saving measures, including store closures and supply chain optimization, yielded tangible benefits for Starbucks such as:

- The company's shares reached a low of \$2.85 during the crisis. By the end of 2009, Starbucks shares closed at \$9.16,
- By 2013, the company's profits had increased from \$315 million in 2008 to \$1.4 billion.

Furthermore, the turnaround of Starbucks under Howard Schultz's leadership provides us several following valuable lessons:

- (1) Effective crisis management requires acknowledging mistakes and taking swift, decisive action,
- (2) Employee engagement and customer experience are critical components of a successful brand,
- (3) Innovation and adaptation are essential in a rapidly changing market and
- (4) Digital technology can be a powerful tool for customer retention and brand loyalty.

6 CONCLUSION

In conclusion, the Starbucks 2008 crisis was a challenging period for the company, characterized by financial struggles, strategic responses, and the need to navigate public perception challenges. Despite facing a notable decline in revenue, stock price, and the need to close underperforming stores, Starbucks implemented strategic measures focused on customer engagement, supply chain innovation, and crisis management. These efforts, under the leadership of Howard Schultz, ultimately led to the company's recovery and emergence as a stronger and more resilient brand. The comprehensive transformation and strategic initiatives undertaken during the crisis period reflect the company's adaptability, strong leadership, and commitment to staying true to its core values.

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Evaluating Paper Written with LLM as Research Assistant

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1 ABSTRACT

Since the launch of ChatGPT by OpenAI, large language models (LLMs) have become more accessible for non-technical users. LLMs have proved to be invaluable tools for various human language tasks. Examples include text summarization, text and code generator, question-answering chatbot, machine translation, and sentiment analysis.

To test the performance of LLM, we wrote/generated a four-page report about Starbucks's transformation in 2008. It is written using LLM as our research assistant. We leveraged the power of LLM by designing a program using Python programming language. After the user enters a desired topic, the program generates several related queries based on the input topic. Afterward, it loads the top K links for each query found using a search engine. The content of top K links is then summarized in parallel. The program generates a final short research report in response using the combined summaries. Generating multiple summaries from top K links is necessary to minimize the risk of hallucinations. Furthermore, it enables the user to ask about topics that are more recent than the outdated training data of LLM. By performing this experiment, we want to determine to what extent LLM can help in report writing.

This follow-up report aims to provide comprehensive documentation about how we utilized LLM as a research assistant. Furthermore, it describes the benefits and some considerations before generating the text. Additionally, it also points out where the LLM fails.

2 INTRODUCTION

ChatGPT, a large language model (LLM) launched by OpenAI, has gained significant attention for its ability to generate human-like text. It is easy to use and accessible to a wide range of users. Moreover, its response mimics human-like interaction in conversation. Hence, it has enormous potential for customer service, for example, by providing intuitive self-service options and 24/7 availability [1, 4]. Furthermore, it can generate coherent and well-structured content. Hence, it could automate the report-writing process to a certain extent.

However, LLM has some limitations, such as inaccurate responses when little or no data is available. Combined with the risk of hallucination, LLM may generate compelling but factually incorrect or misleading information. Therefore, it is crucial to do fact-checking before using the text generated by LLM[8].

To test how helpful LLM is, we wrote the preceding report of four pages using LLM intensively. The final report should fulfill the following requirements:

- (1) It should be a report of four pages length or about 3100 words [9].
- (2) In-text citations should be used to indicate the source of particular statement.

- (3) A reference list should appear at the end of the document.
- (4) The text must be in accordance with the actual facts.

We used an LLM with the **goal** of automating the report-writing process completely. This is being inspired by an online service Tavily AI¹ and the GPT Researcher project². Tavily AI claims to be able to generate a comprehensive research report from online sources. Instead of using this service out of the box, we replicated the same logic pipeline to some extent using Python programming language to allow his own customization and improvement. It can be seen in Figure 1 below.

The customization enables some experimentation with different LLM pipelines. Based on this experiment, we have addressed the following research questions (RQ):

- RQ1:** Is it possible to generate multi-page report about specific topic using LLM?
RQ2: If not possible, to what extent can a report-writing process be automated?

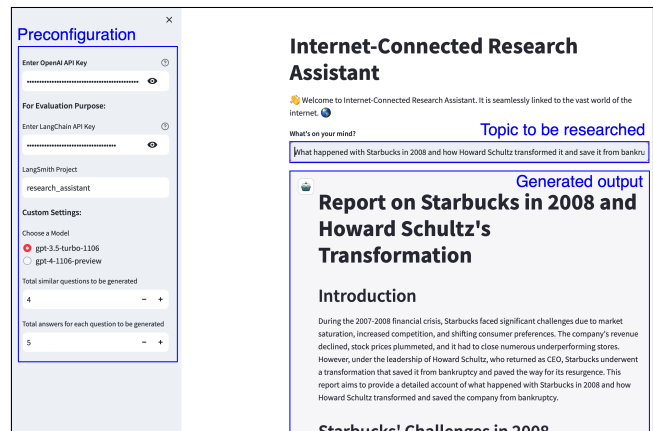


Figure 1: Overview of the Replicated Research Assistant

3 METHODOLOGY

In this section, we describe every executed step to achieve our objective. To some extent, we implemented³ the LLM pipeline from Tavily AI, as shown in Figure 2 below.

3.1 Insert Task or Topic

An OpenAI API key is required to use the research assistant. Additionally, for evaluation purposes, the LangChain API key is necessary because, through its tool called LangSmith, the user can

¹Research Assistant Tavily AI: <https://tavily.com>

²GPT Researcher: <https://blog.langchain.dev/gpt-researcher-x-langchain/>

³The application can be accessed at <https://my-researchassistant.streamlit.app>

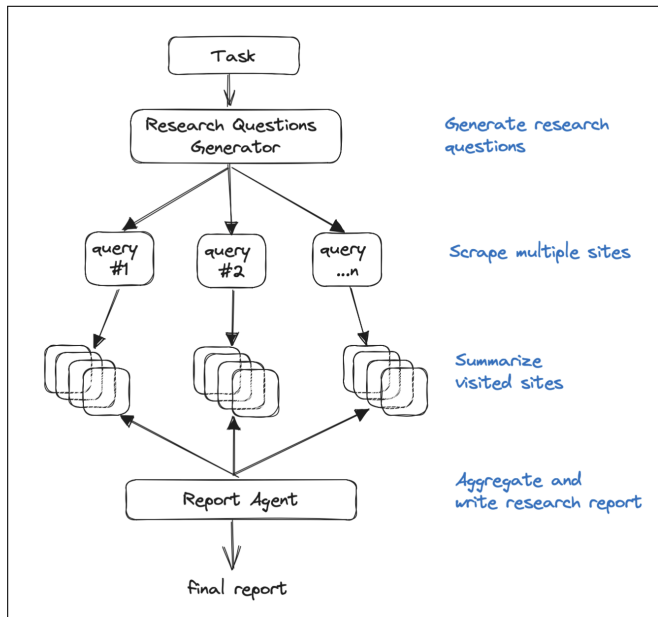


Figure 2: Research Assistant Pipeline[2]

check and evaluate the hidden intermediate steps executed by the pipeline.

After entering the OpenAI API key, the user can start the research assistant by entering a topic, such as: *What happened with Starbucks in 2008 and how Howard Schultz transformed it and saved it from bankruptcy?*

3.2 Generate Research Questions

At this stage, a specific number of *similar and related questions* based on the given topic from the previous stage are generated. These questions form an objective opinion for the given topic. The *total similar questions* at the left sidebar in figure 1 above specifies how many questions are generated. The prompt for this step is:

*Write 4 google search queries to search online that form an objective opinion from the following:
 What happened with Starbucks in 2008 and how Howard Schultz transformed it and save it from bankruptcy?
 You must respond with a list of strings in the following format: ["query 1", "query 2", "query 3", "query 4"].*

After executing the previous prompt, the LLM responded with the following output:

- (1) Starbucks financial crisis 2008,
- (2) Howard Schultz Starbucks transformation,
- (3) How did Howard Schultz save Starbucks from bankruptcy,
- (4) Starbucks success story after 2008.

Answering these newly generated search queries is logically helpful in gaining knowledge about the original task.

3.3 Scrape Multiple Sites

At this stage, the research assistant would search and scrape online resources for each generated new question from the last stage. It uses DuckDuckGo Search.⁴ The *Total answers for each question to be generated* at the left sidebar in figure 1 specifies how many online resources for each question to be scraped. The default is to load five websites for each question.

3.4 Summarize Visited Sites

The content of scraped websites is mostly too long for further steps. Therefore, their contents are summarized separately using the following prompt:

```

    {text}
    ----- Using the above text, answer in short the following question:
    > {question}
    ----- if the question cannot be answered using the text, imply summarize the text. Include all factual information, numbers, stats etc if available.
  
```

The {text} field in the prompt is replaced with the scraped online content and {question} with the desired topic from the first stage, i.e., *What happened with Starbucks in 2008 and how Howard Schultz transformed it and saved it from bankruptcy?*. The possible responses to this prompt are:

- (1) a content summary when it is relevant to the given question:

```

    URL: https://www.linkedin.com/pulse/case-study-starbucks-2008-navigating-challenges-growth-nabeel-shaikh
    SUMMARY: In 2008, Starbucks faced a financial crisis due to market saturation, economic recession, and shifting consumer preferences. This led to a decline in revenue, a notable decline in stock price, and the need for significant employee layoffs. However, the company undertook a strategic shift which involved store closures, menu innovation, brand repositioning, and embracing the digital realm. These actions resulted in financial rejuvenation, elevated customer experience, and global expansion, allowing Starbucks to reclaim its growth trajectory.
  
```

- (2) text hinting that the content isn't relevant:

```

    URL: https://www.reuters.com/legal/government/ex-starbucks-ceo-schultz-illegally-threatened-union-supporter-nlr-judge-rules-2023-10-09/
    SUMMARY: The given text does not provide any information about how Howard Schultz saved Starbucks from bankruptcy. Therefore, I cannot answer the question based on the text.
  
```

Using the configuration as in Figure 1, there are, in total, 20 prompt outputs (4 questions X 5 answers) after this stage.

3.5 Aggregate and Write Research Report

The 20 prompt outputs from the previous step are combined in this stage. Based on these combined summaries, a new report is generated using the following prompt:

⁴DuckDuckGo Search integrated into LangChain framework: <https://python.langchain.com/docs/integrations/tools/ddg>

Information:

 {research_summary}

Using the above information, answer the following question or topic: "{question}" in a detailed report – The report should focus on the answer to the question, should be well structured, informative, in depth, with facts and numbers if available and a minimum of 3100 words. You should strive to write the report as long as you can using all relevant and necessary information provided. You must write the report with markdown syntax. You MUST determine your own concrete and valid opinion based on the given information. Do NOT deter to general and meaningless conclusions. Write all used source urls at the end of the report, and make sure to not add duplicated sources, but only one reference for each. You must write the report in apa format. Please do your best, this is very important to my career.

The {research_summary} field in the prompt is replaced with the combined 20 previous outputs and {question} with the original topic from the first stage.

The output is a final report about the given topic from step 1. It contains different sections which differ from one execution to the next. The sections *Introduction*, *Conclusion*, and *Reference* are included. *Abstract* section appears occasionally. Multiple other sections appear between *Introduction* and *Conclusion*.

4 RESULTS

This section describes the generated report and factors influencing the quality.

4.1 Generated Report

The generated final report can be different even though the input topic is the same. The quality of the output is influenced by different factors such as:

Selected Model: Model GPT-4 achieves higher scores in different test exams designed for humans than GPT-3.5 [6]. However, the difference could be very subtle.

Total similar questions: Up to a certain point, setting this parameter as high as possible is desirable. For example, when this parameter is set to 10, some of the generated research questions from step 3.2 are:

- (1) Howard Schultz Starbucks transformation
- (2) Howard Schultz leadership during Starbucks crisis
- (3) Strategies implemented by Howard Schultz to save Starbucks
- (4) Howard Schultz's role in Starbucks' recovery

As can be seen, some of these questions are redundant. Therefore, a higher value only leads to better output if the generated questions are still contributing to the whole report. Furthermore, a large language model also has restrictions, i.e., token limit or maximum number of inputs that an LLM could process in one execution. For GPT3.5, the restriction is 60000 tokens/minute (TPM)[5].

Total answers for each question: Generally, the higher this parameter is, the less biased the final report will be. With higher

values, the research assistant would load more articles from which a report would be generated.

If the preceding two parameters are too high, the research assistant will throw an error when aggregating multiple summaries and generating a final report during step 3.5. This is because the length of combined summaries would exceed the restriction of 60000 TPM.

Temperature: This parameter (between 0 and 1) specifies how creative the LLM could be when generating the output, with the parameter towards 0 for more deterministic output.

Availability of the Topic: The research assistant works best for searchable topics on a search engine. Thus, using it for niche or state-of-the-art research topics is not advisable.

The generated report's word count and its content vary by each execution. The generated report contains multiple sections, i.e., in one instance, it contains 1093 words with the following section:

- (1) Abstract
- (2) Introduction
- (3) Starbucks' Challenges in 2008
 - (a) Financial Crisis Impact
 - (b) Market Saturation and Competition
 - (c) Supply Chain Issues
- (4) Howard Schultz's Transformational Strategies
 - (a) Store Closures and Cost Reduction
 - (b) Reinforced Focus on Core Values
 - (c) Innovation and Digital Initiatives
 - (d) Strategic Restructuring and Menu Innovation
 - (e) Supply Chain Optimization and Sustainability
- (5) Impact of Howard Schultz's Strategies
 - (a) Financial Rejuvenation and Share Recovery
 - (b) Elevated Customer Experience and Global Expansion
 - (c) Operational Efficiency and Cost Savings
- (6) Conclusion
- (7) References

The generated report fulfills the four requirements described in section 2 only partially, i.e.:

- (1) **four pages length or 3100-word counts: not fulfilled.** The generated report has a word count range of 600-1100.
- (2) **in-text citation: partially fulfilled.** Not all summaries, paraphrases, or quotes from external sources are marked with an in-text citation. However, all external sources are present in the reference list.
- (3) **reference list at the end of the document: fulfilled.**
- (4) **factual accuracy: fulfilled with caution.** As described in section 3.3, the research assistant doesn't rely on the knowledge gained from the training data used to develop the LLM. Instead, it uses search engines to gain knowledge about the input topic. This capability minimizes the risk of hallucination. Therefore, it can be used for any searchable topic on a search engine. However, we cannot claim with conviction that the highest search results used to generate the report are factually always correct.

5 DISCUSSION

This section addresses our research questions and suggestions for future research.

5.1 RQ1: Is it possible to generate a multi-page report about a specific topic using LLM?

In this application's current state, it is not possible to generate multi-page reports automatically. We tried the following to increase the length of our report:

- (1) We specifically define in our prompt that the generated output report should have a minimum of 3100 words. (Refer to the prompt under section 3.5)
- (2) In our test, we used the GPT-4 model instead of GPT-3.5. We cannot find any significant difference in the output length for both models.
- (3) We set the parameters for *total similar questions* to 4 and *total answers for each question* to 10. These are maximum values before it exceeds the token limit restriction of 60000 tokens/minute. It is sometimes desirable to set higher values for these parameters.
- (4) We applied higher *temperature* value for more creative, i.e., longer output. However, it doesn't seem to lengthen the generated report significantly.

However, we still argue in section 5.3 that it might be possible to generate a longer report automatically.

5.2 RQ2: To what extent can a report writing process be automated?

The research application can be used reliably for the following use cases:

- (1) Before writing a report, it is common to research and gain broad knowledge about the topic. It can be done by using a search engine and reading through a couple of the highest search results. By using this application, it is only necessary to read through a single report generated instead of multiple search result articles.
- (2) If the objective is to write a multi-page report, we could execute the application multiple times for the same topic. Afterward, the generated reports could be combined manually to get a multi-page report. It is possible because the application generates different reports every time. We wrote the preceding report using this application, and 90% of the text is copied from the generated text.

5.3 Future Work

Writing a longer multi-page report requires more writing material or knowledge about the topic. The current state of the research assistant cannot process information that is longer than the token limit of the LLM. Because all writing material must fit into one single input prompt for LLM. Inspired by two pieces of literature about summarizing long text [3, 7], we propose the following workflows:

- (1) Collect the necessary amount of knowledge either by:
 - (a) applying the same workflow described in sections 3.1 - 3.3 or,
 - (b) importing a book with the same topic. E.g., A book authored by Howard Schulz⁵ is a good candidate for the same topic.

⁵Onward: How Starbucks Fought for Its Life: <https://www.goodreads.com/book/show/9151181-onward>

- (2) Split the long documents into multiple chunks,
- (3) Store the chunks as a multi-dimensional vector in a vector store,
- (4) Perform vector clustering, e.g., using the K-Means algorithm,
- (5) Find a representative vector for each cluster,
- (6) Using the representative vectors to generate a report.

The last step might be the most challenging because (unlike the current state of research application, where all knowledge fits into one input prompt) multiple input prompts are necessary for various representative vectors. Furthermore, the LLM must, to some extent, be aware of the content from previous input prompts to generate a well-written report.

Methods which can be applied for the last step are:

- (1) Applying *refine document* method: The model loops over the representative vectors and iteratively updates its answer [3]. This method must be executed with caution due to the cost factor because multiple calls to the LLM are necessary depending on the length of input documents.
- (2) Sorting the representative vectors in the same sequence as in the original document/book [7] and generating a final report from the sorted vectors.

6 CONCLUSION

This report described how we utilized LLM to write a multi-page report. We developed an application that generates a short report for any topics⁶ consisting of sections abstract, introduction, etc. This application doesn't rely on the knowledge gained from the outdated training data of LLM. Instead, it searches the relevant articles using a search engine and summarizes top K search results. Using this method, we could minimize the risk of hallucination. The current limitation of this application is it can only generate a short report consisting of a word count range of 600-1100. The main reason is in the current state of the application, all knowledge or writing material about the topic must fit into a single prompt input for LLM. Furthermore, we propose a method to overcome this limitation. Instead of directly inserting all information into a single input prompt, the information can be stored in a vector store, and the LLM could generate a report using the stored representative vectors.

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⁶Refer to footnote 3