WriteWizard - Collaborative Document Editing Tool: Real-Time Multi-functional Platform

(Dynamic visualization for collaborative documents)

TMP-24-25J-146

Project Proposal Report

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B.Sc. (Hons) in Information Technology Specializing in
Software Engineering

Faculty of Computing

Sri Lanka Institute of Information Technology
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Declaration

I declare that this is my own work, and this proposal does not incorporate without acknowledgementany material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously publish or written by another person expect where the acknowledgement is made in the text.

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The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

…………………………..

Signature of the Supervisor:

(Dr. Lakmini Abeywardhana) Date: 23.08.2024

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Abstract

This research focuses on developing a system that generates and customizes mind maps and graphs from document content to enhance collaborative document editing. The system leverages Natural Language Processing (NLP) techniques, including TF-IDF and Named Entity Recognition (NER), to extract key concepts and relationships from documents. It then automatically generates visual representations, such as mind maps and graphs, which users can customize in terms of style, layout, and focus. The system also enables real-time updates, ensuring that changes are synchronized for all users. Additionally, it provides visualization of relationships across multiple documents, helping users understand connections between different pieces of content. This approach aims to improve document analysis and collaboration, making it easier for users to organize, interpret, and share complex information.

Keywords: Collaborative Document Editing, Mind Maps, Graph Generation, Natural Language Processing, Real-Time Updates, Customization, Cross-Document Visualization

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List of Abbreviations

CDE	Collaborative Document Editing
NLP	Natural Language Processing
TF-IDF	Term Frequency-Inverse Document Frequency
NER	Named Entity Recognition
API	Application Programming Interface
LDA	Latent Dirichlet Allocation
CNN	Convolutional Neural Network
RAKE	Rapid Automatic Keyword Extraction

1.0 Introduction

1.1 Background and Literature

New findings indicate that 65% of the population is visual learners [1] while the the human brain processes images 60,000 times faster than text; 90 percent of information transmitted to the brain is visual [2]. According to Burton "Visual aids are those sensory objects or images which initiate or stimulate and support learning". Kinder, S. James; describe visual aids as "Visual aids are any devices which can be used to make the learning experience more real, more accurate and more active". Visual aids are tools that help to make an issue or lesson clearer or easier to understand and know (pictures, models, charts, maps, videos, slides, real objects etc.) [3].

Mind maps and graphs are key tools for visualizing ideas and data. MindMapping is a technique that was developed by Tony Buzan in the 1960s [4]. It is a powerful pictorial technique for representing knowledge, concepts and ideas. Mind maps offer a flexible framework for brainstorming and organizing thoughts systematically. Such forms include tree, circular, flow, simple, professional or detailed ones among others; they rely on shared data like key words for example circular one. Simple mind maps are designed to encompass basic concepts only whereas professional ones give them elaborate appearance appropriate for formal situations. Meanwhile detailed mind maps focus on disaggregating more intricate subjects while engaging designs are present in casual looking map types. In the early days of research or writing (thoughts are flowing), they allow us to pitch ideas freely. Graphs provide organized, pictorial representations of data, using nodes and edges to illustrate relationships and data points, even when it comes down to complicated data sets whose understanding requires much time. Ultimately mind maps and graphs promote better exposition for academic work being pivotal elements of scholarly communication.

Nonetheless, the level of flexibility offered by the existing methods for creating mind maps and graphs is insufficient. As a result, current technologies provide standard visualization features with little flexibility in designing the graphics to meet the needs of the individual user. This restriction disapproves of the use of visual aids in research projects, especially when authorial modification plays a significant role in creating the desired image.

Drawing mind maps and graphs from content of documents needs complete analysis of data, be it from points, headings or entire portions. A few of the methods used in this process are Named Entity Recognition (NER) and topic modeling via Latent Dirichlet Allocation (LDA), which do extract all that is relevant information. Initial visualizations then follow with regards to data processing procedures like Term Frequency-Inverse Document Frequency (TF-IDF). Advanced systems need to also accept user input so that these visuals can be refined further, e.g. by means of clustering or dynamic graphs. This would allow people to customize mind maps made in various styles such as those based on the scope of topics, minimalist style, formal manner or more interactive ones. Additionally, it should be possible for the system itself to show links between several documents, making it easier for users to make comparisons and recognize relationships and patterns in different sources. Such a possibility has more profound meaning when it comes to understanding and discovering how things may relate each other without being so apparent at times.

Consequently, the potential of mind maps and graphs is limited by the current absence of complicated differentiation choices, even if they are necessary for academic study. These restrictions can be overcome by using trained models and feedbacks from the users so as to help the researchers in having more robust and more flexible tools for making visual communication. Succeed in research voids and issues to fulfill goals with an accurate method and custom-made visuals.

1.2 Research Gap

The area of document editing tools has developed over the years, and yet, there are some important research areas missing in the literature, mainly real-time work, topic-based work, and adaptations. Automating mind map generation from text can save time and enhance their use [5]. There are solutions that are reliable in handling very large text [6], generalizing mind map visualization for any text and tackling ontology-related problems [7]; however, the accuracy of the system is identified as medium [8]. Some research improves the accuracy of feedback by focusing on distinct technical vocabulary and clear concepts [9]. Many solutions identified have their strengths primarily in one or two directions, and there is no excellent solution that incorporates real-time collaboration with outstanding content targeting and extensive customization.

One such area that does not have such implementation is real-time collaboration with the option to choose what part of it customers want to concentrate on and a variety of options regarding its customization. Although most of the modern applications offer the concepts of side-by-side work and co-authoring, there are no features to highlight the updates and no per-user interface adjustments. Moreover, this poses a challenge to them in an application that requires complicated and advance illustration. Moreover, some of the mentioned tools do not allow synchronizing, at least, connections and references to other documents, which is very meaningful for different research processes since ideas and patterns can be found using data comparison with the help of references from different sources.

There is also another gap that was left, and this was more about the methods of dynamic visualization along with cross document analysis. Most of the said systems may update the results as frequently as possible, however, they do not possess incorporated sophisticated algorithms or dictated by the users' inputs to enhance details and enhancement of the picture connected relevancy. The research should be focused on the determination of the approaches used for real-time collaboration with a set of technologies driven by the combination of Named Entity Recognition, topics modeling, and dynamic graph algorithms.

Also, one should mention the great potential in conducting empirical studies for comparing the efficiency and convenience of the integrated features in reference to real-life scenarios. In many papers, however, complete evaluations on how well these instruments work in these environments, especially on their perceived suitability by users, and their abilities to deal with various kinds of document relations are still lacking.

Tools	Real-Time	Collaborative Editing	Focused Content	Customization	Different Document Relationships
coggle	✓	✓	✗	✗	✗
mind meister	✓	✓	✗	✗	✗
AYOA	✓	✓	✗	✓	✗
MindNode	✗	✗	✓	✓	✗
XMind	✗	✗	✗	✓	✗
Our System	✓	✓	✓	✓	✓

Figure 1: Competitive Analysis

It was assumed that filling these gaps will further develop more varied and reliable CDEs, which will promote the concept of highly effective real-time collaboration, increased focus on content, beyond-measure flexibility, and cross-document analysis.

1.3 Research Problem

In the current research and working context several practical issues concerning with the document visualization and sharing that the users confront frequently. This a major challenge is compounded by challenges in data visualization, specifically different and complex data sets. Scholars and practitioners may require customizable representations of their data to incorporate certain subtleties within their analysis, however, there may be limited ways, for instance, to depict a certain type of mind maps or intricate charts.

A second major concern is the absence of integration in the work of linking between documents at the visual level. When scholars employ large corpora in their studies, it is essential to find a way to link and match the data that is stored in different documents. However, current tools seem to lack in giving integrated solutions for describing these inter-document relationships in a way that can be used to aggregate information and gain insights from various texts.

Real time communication and update pose other challenges All these challenges hinder effective implementation of the framework. Most of the integrated work environments especially in research groups or in institutions require real time display and quick refresh rates. It is in this context that tools are needed by researchers and collaborators to quickly respond to changes, to draw attention on relevant parts and that all the users can rely on the latest information. The lack thereof can cause some work delays, lack of coherency, and in general, inefficiencies will ensue.

In addition, there is a need for highlighting and customization of certain content items in the course of a work to minimize the distraction and make the target topics more visible. If there are no sufficiently effective means to signal the dynamic, essential information then the user is unlikely to flag important changes or alterations, which might compromise the quality of their work and the reliability of data in general.

Solving these real-life issues is crucial to improving the state of the art of document visualization coordination tools. With such solutions in place, the researchers and professionals can advance the application's effectiveness of interpreting and sharing of such information by incorporating the best solutions to these challenges.

2.0 Objectives

2.1 Main Objective

Development of a dynamic visualization system for collaborative document editing that generates and customizes mind maps and graphs.

2.2 Specific Objectives

- Provide real time updates to mind maps and graphs while working together in the application.
- Allow users to display and arrange the mind map and graphs according to their desire and requirement.
- Design features which can be used to point out and draw attention to specific content or information within the document.
- Create links and associations among multiple documents.
- Increase usability and user satisfaction of designed interfaces with natural and versatile graphical user interfaces.

3.0 Methodology

3.1 Requirement Gathering

Requirement gathering was carried out through an extensive analysis of past research, identification of existing systems, and exploration of real-world scenarios relevant to the development of a dynamic visualization system for collaborative document editing. This process ensured a thorough understanding of the needs and challenges associated with the proposed system.

3.1.1 Past Research Analysis

The Past Research Analysis involved a deep dive into previous studies related to document visualization, mind mapping, and collaborative editing. Key areas of focus included:

- NLP Techniques and Visualization Approaches: Analyzing methodologies like TF-IDF, NER, and graph algorithms to understand their application in document content analysis and visualization.
- Limitations of Existing Studies: Identifying gaps in current research, particularly in real-time collaboration, customization, and cross-document visualization.
- Review of Relevant Publications: Engaging with academic papers and industry reports to gather insights on successful implementations and identify potential areas for innovation.

3.1.2 Identifying Existing Systems

An assessment of existing systems that offer document visualization and collaborative editing was conducted to benchmark features and functionalities. This phase included:

- Feature Comparison: Examining the capabilities of systems like Miro, Lucidchart, and MindMeister, focusing on their mind map generation, customization options, and handling of cross-document relationships.

- User Experience Evaluation: Collecting user feedback through online reviews, surveys, and interviews to understand the strengths and weaknesses of current systems.

- Technical Capabilities: Evaluating the technical infrastructure of these systems to inform the development of a more robust and scalable solution.

3.1.3 Real-World Scenarios

To ensure the practical applicability of the system, real-world scenarios were considered:

- Case Studies: Analyzing how professionals in research, education, and corporate settings currently use visualization tools and identifying their unmet needs.
- User Surveys and Interviews: Conducting surveys and interviews with potential users to gather detailed requirements and preferences.
- Scenario-Based Testing: Exploring hypothetical scenarios to predict system performance and identify potential challenges in real-world applications.

3.2 Feasibility Study

A feasibility study was conducted to evaluate the technical, economic, and schedule feasibility of developing the proposed system. This study ensures that the project can be successfully executed within the given constraints.

3.2.1 Technical Feasibility

3.2.1.1 Knowledge on Technologies

The development of the system will require expertise in several key technologies:

- Natural Language Processing (NLP): Techniques like TF-IDF, BERT embeddings, and Named Entity Recognition (NER) will be used for content analysis, keyword extraction and relationship mapping.
- Real-Time Communication Protocols: WebSocket or similar protocols will be implemented to enable real-time updates and synchronization during collaborative editing.
- Graph Algorithms: Advanced graph algorithms will be used to visualize relationships across documents, ensuring accurate and meaningful connections are displayed.
- Web Development: Front-end frameworks like React.js and back-end frameworks like Node.js will be utilized for the development of the user interface and server-side logic.

3.2.1.2 Knowledge on Tools

The development of this system will require a deep understanding of various technologies and methodologies relevant to natural language processing, real-time communication, and web development. The team will leverage their expertise in these areas to ensure that the system is both robust and scalable. This includes a strong foundation in front-end and back-end development practices, machine learning algorithms, and data visualization techniques.

3.2.1.3 Data Collection and Preprocessing

For the proposed system, data collection will focus on gathering various types of mind maps from sources like academic papers, existing tools, and user-generated content. These mind maps will be pre-processed to ensure they are in a consistent format, making them ready for analysis and model training.

3.2.2 Schedule Feasibility

A detailed project timeline was created, outlining key milestones and deliverables. This includes phases such as requirement analysis, system design, development, testing, and deployment. The timeline ensures that the project can be completed within the allocated time frame, with buffer periods for unexpected challenges.

3.2.3 Economic Feasibility

The economic feasibility assesses the cost-effectiveness of the project. The focus will be on:

- Development Costs: Estimating costs for development tools, technology licenses, and human resources.
- Maintenance Costs: Projecting costs for ongoing maintenance, updates, and support.
- Potential Savings: Evaluating the cost savings from using open-source tools and minimizing unnecessary expenses.
- Budget Plan: Creating a detailed budget to track expenses and ensure the project stays within financial limits. Adjustments will be made based on the project's financial status to ensure it remains economically viable.

3.3 Requirement Analysis

Requirement analysis involves translating the gathered requirements into specific functionalities and features for the system. This step ensures that the system is designed to meet user needs and project objectives effectively.

A detailed analysis was conducted to define the specific requirements for content analysis, mind map generation, real-time visualization, and customization. This involved creating user stories, defining use cases, and mapping out the system architecture to align with the identified needs.

3.4 System Analysis

System analysis involves a comprehensive examination of how the system will function, focusing on the integration of various components, data flow, and interaction between users and the system.

3.4.1 Software Solution Approach

The software solution approach is structured into specific tasks, each contributing to the overall functionality of the system. Below are the steps involved in developing the solution:

- Data Collection:
    - Mind Maps: Collect a variety of mind maps (simple, professional, detailed, friendly) from datasets or user contributions, ensuring they cover different document types and contexts.
    - Document Content: Gather documents, including academic papers and technical reports, for mind map generation.
- Content Analysis:
    - Use TF-IDF and Named Entity Recognition (NER) to extract key concepts, entities, and relationships from the collected documents.
    - Focus on the most relevant sections for generating mind maps.
- Initial Mind Map Generation:
    - Implement an API to generate initial mind maps based on content analysis, allowing for different styles like minimalist, formal, or engaging, as needed.
- Model Training:

   - Train models on the collected mind maps to improve customization. The models will learn to recognize different styles and structures, enabling accurate, user-specific adjustments.
- Customization of Mind Maps:
   - Use trained models to customize the initial mind maps, adjusting style, layout, and focus according to user preferences and document requirements.
- Cross-Document Visualization:
   - Apply graph algorithms and topic modelling to visualize relationships between documents, helping users identify connections across different sources.
- Evaluation and Testing:
   - Assess system performance with metrics like content accuracy, visualization relevance, and user satisfaction. Test the system across various document types to ensure it meets collaborative editing needs.

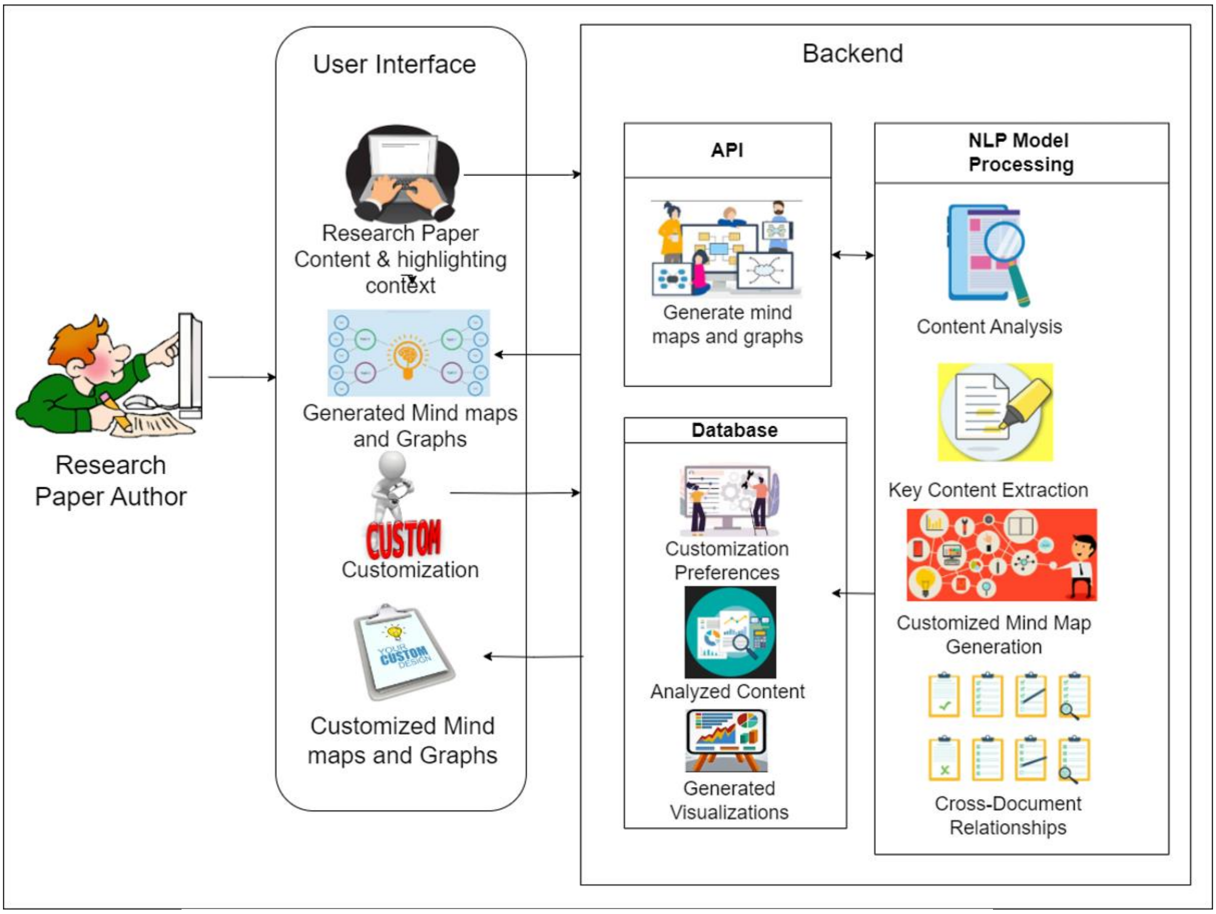

Figure 2: System Diagram

3.4.2 Tools & Technology

The following tools and technologies will be employed to implement the system:

- Programming Languages:
  - Python: Backend development and machine learning model implementation.
  - JavaScript: Frontend development and interactive visualization.
- Frameworks & Libraries:
  - TensorFlow/PyTorch: For machine learning model development.
  - D3.js: For creating interactive and dynamic visualizations.
  - spaCy/NLTK: For natural language processing and content analysis.
- Database Systems:
  - MongoDB: For storing document data, user preferences, and generated mind maps.
- Web Development Frameworks:
  - React JS: For developing the frontend user interface.
  - Node.js/Express: For handling backend API requests.
- UI Design Tools:
  - Figma: For designing user interfaces and visual components.
- Version Control System (VCS):
  - Git: For tracking changes in the source code and collaboration through platforms like GitHub or GitLab.
- Collaboration Tools
  - Microsoft Teams/Slack: For team communication and project management.
- Testing Tools:
  - Jest: For JavaScript unit testing.
  - Postman: For API testing.
  - Unit test: For Python-based testing.
- Deployment Tools:
  - Docker: For containerization of the application.
  - Kubernetes: For orchestration and management of containers.
- Project Management:
  - MS Planner/Jira: For tracking tasks, milestones, and deadlines throughout the project lifecycle.

3.5 Work Breakdown

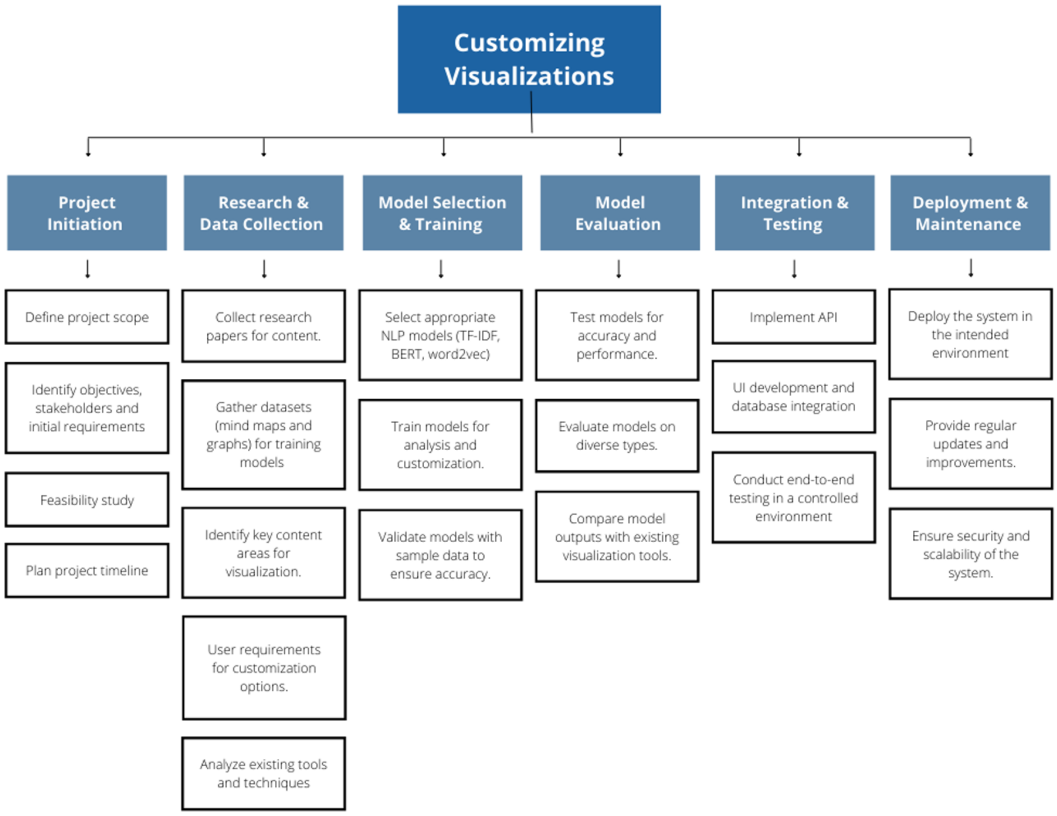

Figure 3: Work Breakdown Structure

3.6 Timeline

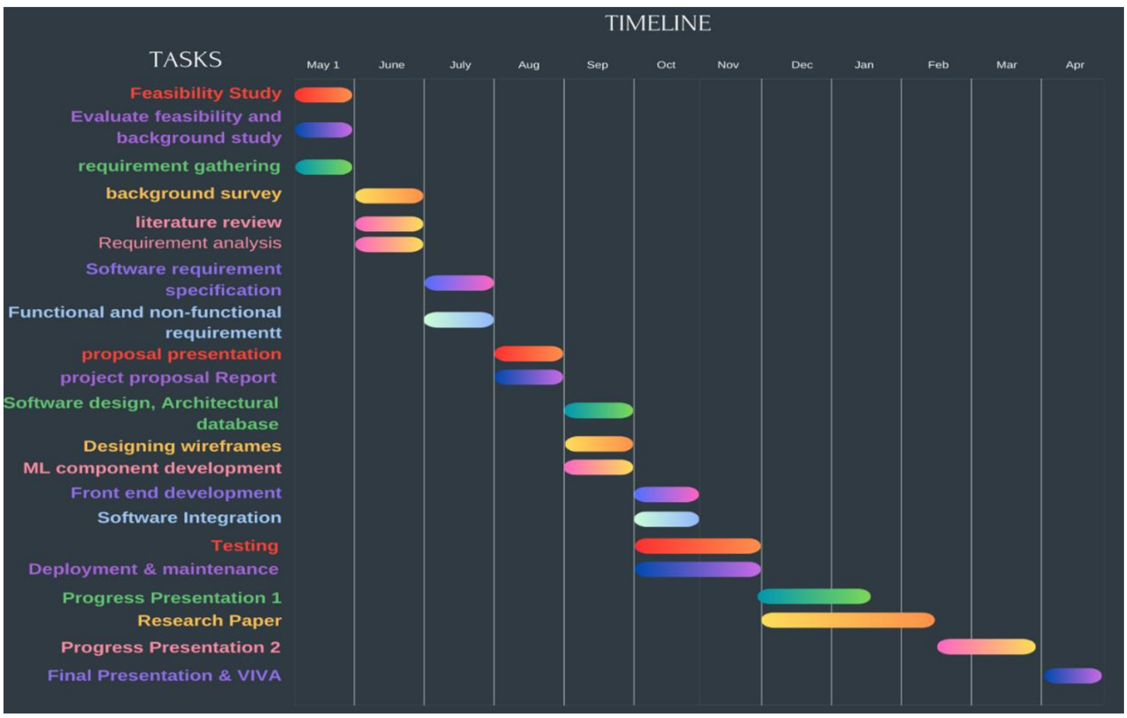

Figure 4: Gannt Chart

3.7 Risk Management Plan

This plan identifies potential risks in the dynamic visualization system for collaborative document editing and outlines strategies to manage them.

1. Key Risks:

Technical Risks:

- Model inaccuracies in mind map generation and customization.
- API integration issues.
- Failures in real-time synchronization.

Data Risks:

- Insufficient or low-quality mind map data.
- Data security breaches.

Project Management Risks:

- Timeline delays.
- Resource allocation problems.

2. Mitigation Strategies:
    - Conduct thorough testing and integration processes.
    - Ensure diverse, high-quality data collection and strong data security.
    - Develop a detailed project timeline and regularly review resource allocation.

3. Monitoring:
    - Regular reviews will be conducted to update the plan and address new risks.

3.8 Communication Management Plan

This plan ensures clear communication among all team members and stakeholders throughout the project.

1. Communication Goals:
    - Keep stakeholders informed about project progress.
    - Facilitate feedback and collaboration.

2. Key Channels:
   - Meetings: Regular team and progress review meetings.
   - Email: Bi-weekly updates on progress and challenges.
   - Collaboration Tools: Use of Microsoft Teams, MS Planner for communication and document sharing.
3. Monitoring:
   - Regular reviews will be conducted to update the plan and address new risks.

4.0 Project Requirements

4.1 Functional Requirements

- Document Content Analysis: Extract key concepts, entities, and relationships from document content.
- Mind Map and Graph Generation: Automatically generate mind maps and graphs from analyzed content.
- Real-Time Updates and Synchronization: Ensure that updates to mind maps and graphs are reflected in real-time for all users.
- Customization of Mind Maps and Graphs: Allow users to customize the style, layout, and focus of generated mind maps and graphs.
- Key Content Highlighting: Highlight important sections of the document within the visualizations.
- Visualize Document Connections: Show relationships between different documents through visualizations.

4.2 Non-Functional Requirements

- Performance: The system must generate and update visualizations quickly and efficiently.
- Scalability: The system should handle an increasing amount of data and users without performance degradation.
- Usability: The interface should be intuitive, allowing users to easily interact with and customize visualizations.
- Reliability: The system must be dependable, with minimal downtime and error rates.
- Security: Ensure that user data and document content are securely processed and stored.
- Accessibility: The system should be accessible to users with varying levels of technical expertise and should comply with accessibility standards.

4.3 User Requirements

- Intuitive Interface: Users should be able to easily interact with the system, generate mind maps, and customize them without extensive technical knowledge.
- Real-Time Collaboration: Multiple users should be able to work on the same document

simultaneously, with changes visible in real-time.

- Customization Options: Users should have the ability to tailor mind maps and graphs according to their specific needs, including altering styles and layouts.

4.4 System Requirements

- Backend Processing: The system must have a robust backend to handle NLP processing, model training, and API calls for mind map generation.
- Data Storage: A secure and scalable database is required to store user data, document content, and generated visualizations.
- API Integration: The system should integrate with external APIs to enhance functionality, such as initial mind map generation and real-time updates.
- Cross-Platform Compatibility: The system should be accessible across various devices and platforms, ensuring a consistent user experience.

4.5 Use Cases

- Generating a Mind Map from a Document: A user uploads a document, and the system generates a mind map based on the content.
- Customizing a Mind Map: After generating a mind map, the user adjusts the layout, style, and focus according to their preferences.
- Collaborative Editing: Multiple users edit a document simultaneously, with real-time updates reflected in the mind map.
- Visualizing Document Connections: A user views connections between multiple documents through a cross-document visualization feature.

4.6 Testing

The initial phase will involve testing the system among team members and close associates. This will function as unit testing and system testing, where individual components, such as mind map generation and content analysis, will be thoroughly evaluated. Internal functions and assertions will be used to verify that each part of the system operates as expected.

In the final phase, the solution will undergo acceptance testing in a real-world environment. A selected group of users, such as students and researchers, will interact with the system in both local and deployed environments. This will include Alpha testing (internal testing with a limited user group) and Beta testing (wider user group testing) to gather feedback on system usability, performance, and effectiveness.

Expected Test Cases:

- Mind Map Generation: Test the accuracy and relevance of generated mind maps based on different types of document content.
- Customization Features: Evaluate how well the system allows users to customize mind maps and graphs, including style and layout adjustments.
- Real-Time Synchronization: Verify that updates made by one user are immediately reflected for other users in real-time.
- Cross-Document Visualization: Test the system's ability to visualize and highlight connections between multiple documents accurately.
- Performance Testing: Assess the system's ability to handle large datasets and multiple simultaneous users without significant delays or crashes.
- Security Testing: Ensure that all user data and document content are securely processed, transmitted, and stored, protecting against unauthorized access or breaches.
- Accessibility Testing: Validate that the system meets accessibility standards and is usable by individuals with varying levels of technical expertise and those with disabilities.

5.0 Commercialization

The commercialization of this project centers on the development of a dynamic visualization platform tailored for academic and professional users, particularly those involved in research and collaborative writing. The platform will leverage advanced NLP techniques and real-time collaborative editing tools to provide unique features that differentiate it from existing solutions in the market.

Unique Selling Points:

- Dynamic Mind Maps and Graphs: Automatically generated and customizable visualizations based on document content, enhancing the writing and research process.
- Real-Time Collaboration: Simultaneous editing and updates with real-time synchronization across multiple users.
- Cross-Document Visualization: Ability to visualize relationships and connections across various documents, providing deeper insights into research data.
- Customizable Visualization Styles: Users can tailor the appearance of mind maps and graphs to meet specific needs, improving user experience and engagement.

Target Market:

- Academic Institutions: Universities, research centers, and academic publishers who require efficient tools for collaborative research and writing.
- Professional Researchers: Professionals in R&D departments, think tanks, and consultancy firms who rely on detailed and interconnected document analysis.
- Education Sector: E-learning platforms and educational content creators who can benefit from the visual learning tools provided by the platform.

Revenue Streams:

- Subscription Model: Offering tiered subscription plans with different levels of access and features, including basic, professional, and enterprise levels.
- Licensing: Licensing the platform to educational institutions and corporations as part of their internal research and development tools.
- Custom Solutions: Providing tailored solutions and integrations for large organizations with specific visualization and collaborative editing needs.

6.0 Budget

The budget for developing and launching the dynamic visualization platform is outlined below in Table 1. The costs include cloud services, software licensing, development tools, and model training.

Cost Type	Cost Amount
Internet Use & web hosting	20,000
Publication cost	45,000
Model Training	40,000
Total	**105,000**

Table 1: Cost Management Plan

Budget Justification:

- Cloud Services: Necessary for hosting the platform and supporting real-time data processing. Ensures scalability and reliability.
- Software Licenses: Essential for development, ensuring access to the latest tools and libraries required for effective implementation.
- Internet and Hosting: Required for platform accessibility and maintenance of online services.
- Marketing: Critical for reaching potential users and establishing market presence.
- Miscellaneous: Provides flexibility for unforeseen expenses and necessary operational supplies.

7.0 Summary

This research proposes the development of an advanced dynamic visualization platform designed to enhance collaborative document editing and analysis. By leveraging state-of-the-art Natural Language Processing (NLP) and machine learning (ML) techniques, the system aims to automatically generate and customize mind maps and graphs from document content. Key features include real-time updates and synchronization, customizable visualization styles, and the ability to visualize relationships across multiple documents. This platform will support users in creating detailed visual representations of their research, facilitating better content understanding and collaboration.

The implementation of this tool addresses critical needs in document analysis and collaborative research. It will provide a comprehensive solution for generating contextually relevant visualizations, improving the efficiency and effectiveness of research processes. With its focus on real-time collaboration, customization, and cross-document insights, the proposed system aims to significantly enhance the productivity of research teams and academic institutions.

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