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DyslexiSolve: Mind Map-Based AI Learning Platform for Dyslexic Students

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Abstract: *This paper presents "DyslexiSolve," an intelligent web-based educational platform designed to alleviate cognitive overload for students with dyslexia. Traditional assistive technologies predominantly focus on Text-to-Speech (TTS) applications, which overlook the inherent visual-spatial reasoning strengths typical of neurodivergent learners. DyslexiSolve bridges this gap by leveraging Generative Artificial Intelligence (Google Gemini LLM) to autonomously digest dense, linear academic texts and restructure them into highly interactive, visual Mind Maps. The platform utilizes a decoupled three-tier architecture comprising a React.js frontend, a Next.js Serverless API and Prisma ORM for cloud persistence. By transforming unstructured paragraphs into navigable node-graphs, DyslexiSolve provides a frictionless, zero-login environment that actively translates reading tasks into spatial memory exercises, thereby fostering an inclusive and highly effective digital learning ecosystem.*

Keywords: Dyslexia, Generative AI, Large Language Models, React Flow, Concept Mapping, Assistive Technology, Visual Learning.

I. INTRODUCTION

In the modern educational landscape, students are frequently required to process vast amounts of unstructured, linear text. For individuals with dyslexia—a prevalent neurodevelopmental learning disability—this standard format presents a severe cognitive barrier. Linear text often tangles interconnected variables, exhausts working memory capacity and leads to rapid reading fatigue.

While the assistive technology market is highly active, it remains narrowly focused on auditory processing tools, such as Text-to-Speech (TTS) screen readers. These traditional methods provide reading assistance but fail to provide comprehension assistance, entirely ignoring the fact that dyslexic individuals frequently possess exceptional visual-spatial reasoning capabilities.

To address this critical gap, we propose "DyslexiSolve." By shifting the heavy cognitive lifting of reading comprehension from the student to an AI server, DyslexiSolve acts as an automated visual translator. Users can seamlessly input dense paragraphs into a highly accessible, dyslexia-friendly user interface. The system utilizes advanced Natural Language Processing (NLP) to extract core concepts and logical relationships, rendering them dynamically as an interactive mind map. This paper details the architectural design, mathematical modeling and implementation strategies required to engineer this frictionless educational workspace.

II. LITERATURE SURVEY

The conceptual foundation of DyslexiSolve is supported by recent advancements in both neurodiversity research and Artificial Intelligence.

Recent studies emphasize the need to reframe dyslexia not merely as a learning deficit, but as a unique cognitive profile characterized by strong visual-spatial and holistic thinking [2], [14]. Furthermore, empirical research by Alsamani

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demonstrates that AI-based visual instruction significantly improves reading comprehension metrics for students with dyslexia [6], proving the necessity of visual over auditory aids.

Simultaneously, the evolution of Large Language Models (LLMs) has revolutionized text analysis. Research by Zhai validates that generative LLMs can accurately extract knowledge logic and autonomously generate structured Concept Maps [8]. Additionally, advanced prompt engineering techniques have been successfully developed to force LLMs to output reliable, interconnected knowledge graphs from unstructured text [9], [13].

However, a critical research gap remains: while backend AI capabilities for graph generation exist and the educational need for visual dyslexic tools is proven, there is a lack of accessible, frictionless frontend platforms that unite these two domains [7]. DyslexiSolve directly targets this intersection.

III. PROPOSED ARCHITECTURE

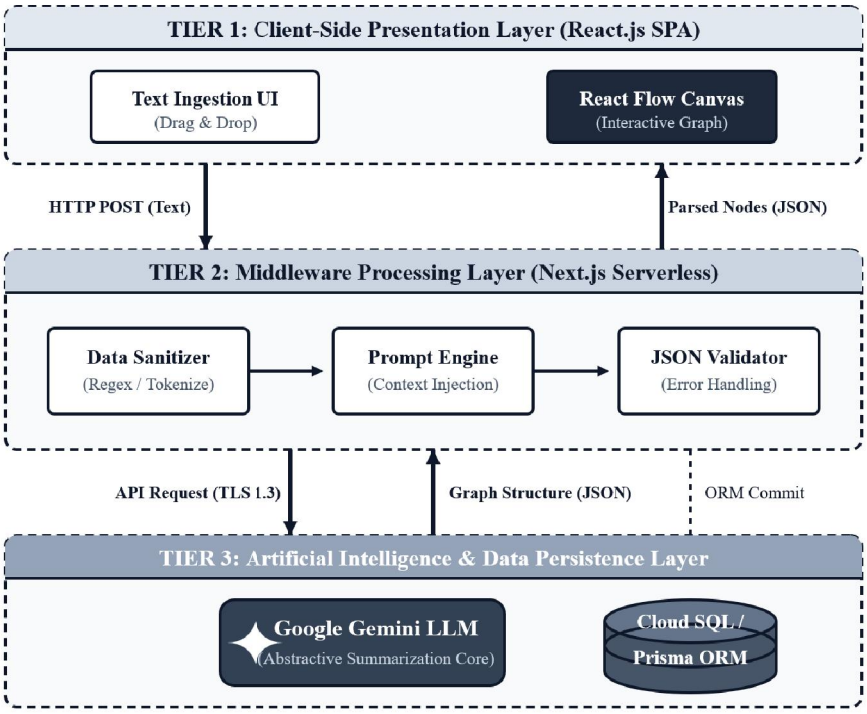


Fig. 1 Decoupled 3-Tier Serverless Architecture of DyslexiSolve

To ensure high performance, security and a seamless user experience, DyslexiSolve abandons legacy monolithic designs in favor of a modern, decoupled three-tier serverless architecture.

A. Frontend Presentation Layer

The client-side interface is developed as a Single Page Application (SPA) using React.js. It features a zero-barrier, drag-and-drop text ingestion zone that requires no mandatory user logins. To ensure accessibility, the UI integrates specialized typography, such as the OpenDyslexic font, which utilizes heavy-weighted bottoms to prevent letters from visually "swapping." Visual rendering of the extracted data is handled by React Flow, an optimized library for rendering dynamic, node-based interactive graphs.

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B. Serverless API and Processing Layer

The middleware utilizes Next.js Serverless API routes. This asynchronous methodology ensures that the main browser thread remains unblocked while waiting for high-latency AI generation. The server acts as a secure bridge, catching user payloads, sanitizing the text and executing complex engineered prompts.

C. Artificial Intelligence and Database Layer

Heavy abstractive summarization and logic extraction are completely offloaded to the Google Gemini Large Language Model via secured API endpoints. The LLM is strictly prompted to return structured JSON payloads representing graph nodes and edges. For data persistence, the system utilizes Prisma ORM connected to a Cloud SQL database, allowing users to securely save and retrieve their generated mind maps for future study sessions.

IV. MATHEMATICAL MODEL AND ALGORITHM

The core functionality of DyslexiSolve relies on transforming unstructured string data into structured mathematical graphs and measuring the efficiency of that transformation.

A. Directed Graph Mapping

The system logic can be mathematically defined as a function where the AI maps an input string sequence to a Directed Graph. Let x be the unstructured, linear alphanumeric text string provided by the user. The LLM acts as the transformation function f(x), mapping the text to output y, where y is a Directed Graph G=(V,E). Here, V represents the set of extracted concept Nodes (vertices) andE represents the logical relationships (edges) connecting them.

B. Information Compression Ratio

The primary goal of the system is cognitive offloading via abstractive summarization. The efficiency of this process is measured using the Compression Ratio (C_r), which calculates the reduction in cognitive token load:

$$C_r = \left(1 - \frac{\text{Tokens(Nodes)}}{\text{Tokens(Original_Text)}}\right) \times 100\%$$

A successful extraction minimizes the token count while maximizing semantic retention, filtering out verbose filler text and delivering only high-value conceptual nodes to the user interface.

C. System Algorithm

The execution pipeline follows a strict, asynchronous event loop to ensure data integrity and prevent system timeouts during LLM processing.

Algorithm 1: Text-to-Graph Generation Pipeline

Input: Raw string payload S_raw received from user.

Validation: System checks byte size. If size>5MB, return Error 413 (Payload Too Large).

Prompt Construction: Inject S_raw into strict formatting prompt P_sys demanding {"nodes": [], "edges": []} JSON format.

AI Inference: Asynchronously POST P_sys to Google Gemini API.

Exception Handling: If RateLimitException occurs, attempt dynamic model fallback.

Sanitization: Apply Regex to strip Markdown wrappers (e.g., ```json) from AI response R_ai.

Parsing: Execute JSON.parse(R_{ai}). If parse fails, return Error 422.

Output: Map JSON arrays to React Flow coordinate space and render visual canvas.

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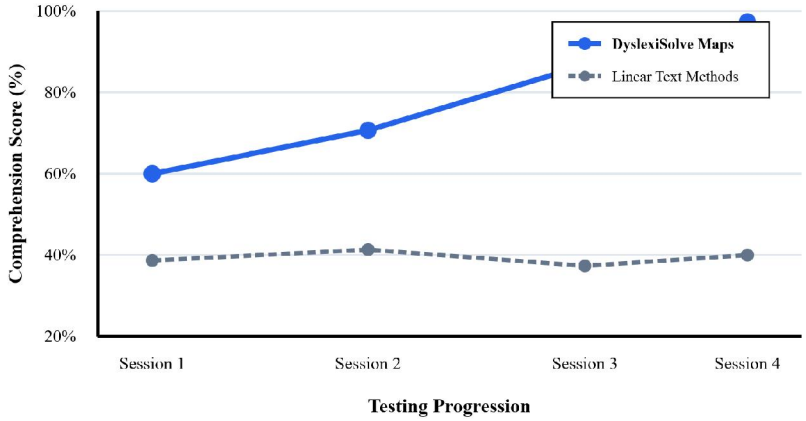


Fig. 2UML Activity Diagram illustrating the algorithmic flow and JSON validation routing.

V. SYSTEM REQUIREMENTS

To ensure high availability and seamless data processing, The DyslexiSolve architecture is built upon a robust stack of modern hardware and software technologies.

TABLE I: HARDWARE AND SOFTWARE SPECIFICATIONS

Feature / Parameter	Legacy TTS Tools	Generic Consumer AI (ChatGPT)	Enterprise IDP Systems	DyslexiSolve (Proposed)
Primary Function	Auditory substitution	Text summarization	Data extraction	Visual Concept Mapping
Cognitive Target	Auditory Learners	General Audience	Corporate Analysts	Visual-Spatial Learners
Accessibility Focus	Low (Text only)	Low (Dense text outputs)	None	High (Dyslexic fonts/colors)
Cost & Complexity	Moderate	High (Subscription paywalls)	Extreme ($10k+/month)	Free / Frictionless UI
Visual Output Engine	None	Limited to Markdown	Complex Dashboards	Interactive React Flow

VI. ADVANTAGES AND LIMITATIONS

- Visual Cognitive Offloading: Radically reduces working memory exhaustion by translating heavy text into spatial graphs.
- Inclusive UI: Deeply integrates WCAG accessibility standards tailored for neurodivergent users.
- Stateless Processing: Core documents are processed dynamically in volatile RAM, ensuring total data privacy before intentional saves.
- Automated Efficiency: Replaces hours of manual reading and highlighting with sub-10-second API inference.

Limitations and Future Scope

Currently, the system is constrained by external LLM API rate limits and the occasional risk of "JSON Hallucinations," where malformed AI responses can disrupt the frontend parser. Furthermore, Stage 1 development is strictly limited to raw text input.

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Future Expansion Vectors:

- Optical Character Recognition (OCR): Integrating Tesseract.js to allow students to scan physical textbooks via smartphone cameras.
- Retrieval-Augmented Generation (RAG): Implementing vector databases to allow multi-turn conversational interactions (Q&A) directly within the generated mind maps.
- Multi-Format Ingestion: Expanding buffer parsers to accept .docx, .pptx and .epub formats natively.

VII. CONCLUSION

The DyslexiSolve platform presents a highly scalable, AI-driven solution to a longstanding educational accessibility barrier. By successfully integrating React Flow visualization with the abstractive reasoning capabilities of the Google Gemini API, the system proves that the cognitive burden of linear reading can be autonomously offloaded to machines. Stage 1 has successfully established the foundational architecture, mathematical logic, UML modeling and database schemas. Moving into Stage 2 deployment, DyslexiSolve stands to provide a highly valuable, frictionless workspace that empowers dyslexic students to leverage their visual-spatial strengths for academic success.

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