TamilTheni Architecture Document

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Executive Summary

TamilTheni is a Tamil language learning web application designed for the FETNA Tamil Theni Competition. The application is a static single-page application (SPA) hosted on GitHub Pages, featuring five distinct learning modules targeting different Tamil language skills including vocabulary, sentence construction, translation, and word discovery.

Key Architectural Decisions

Decision	Rationale
Vite	Modern, fast build tool with instant HMR and optimized production builds
TypeScript	Static typing for better maintainability and error catching
JSON Data	Structured, interoperable data format separated from logic
CSS Modules	Component-scoped styling (via standard CSS imports)
Python Tooling	Offline data processing pipeline for content generation

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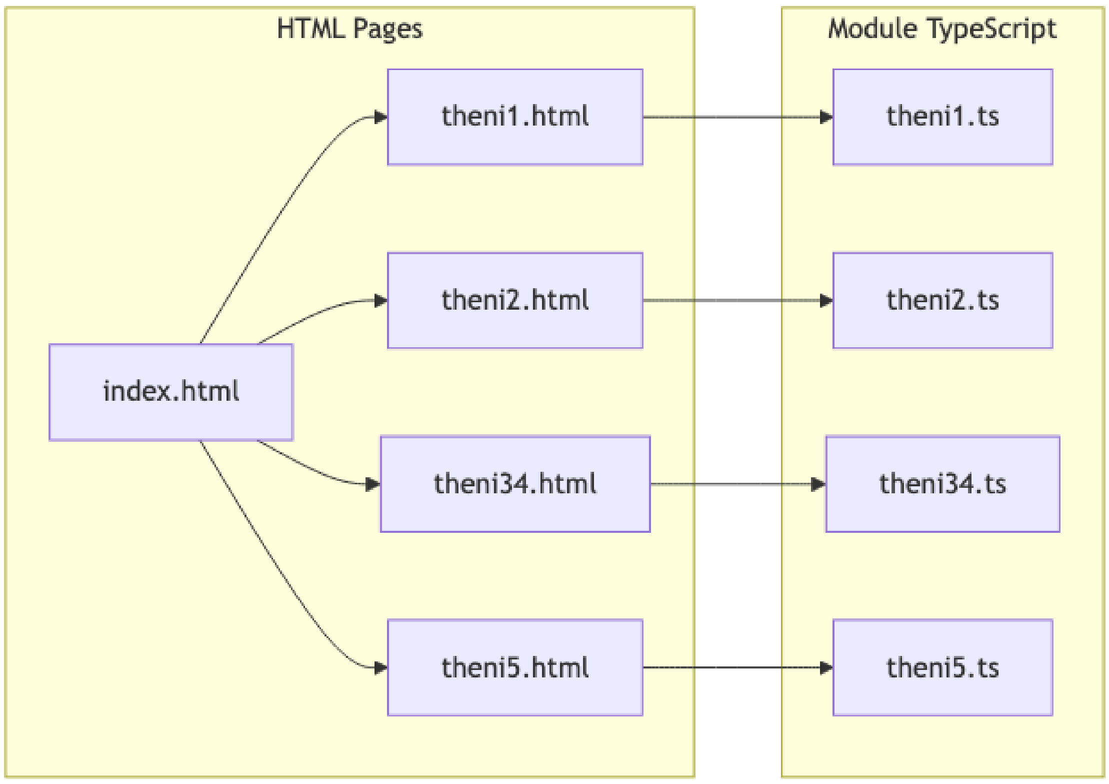
System Overview

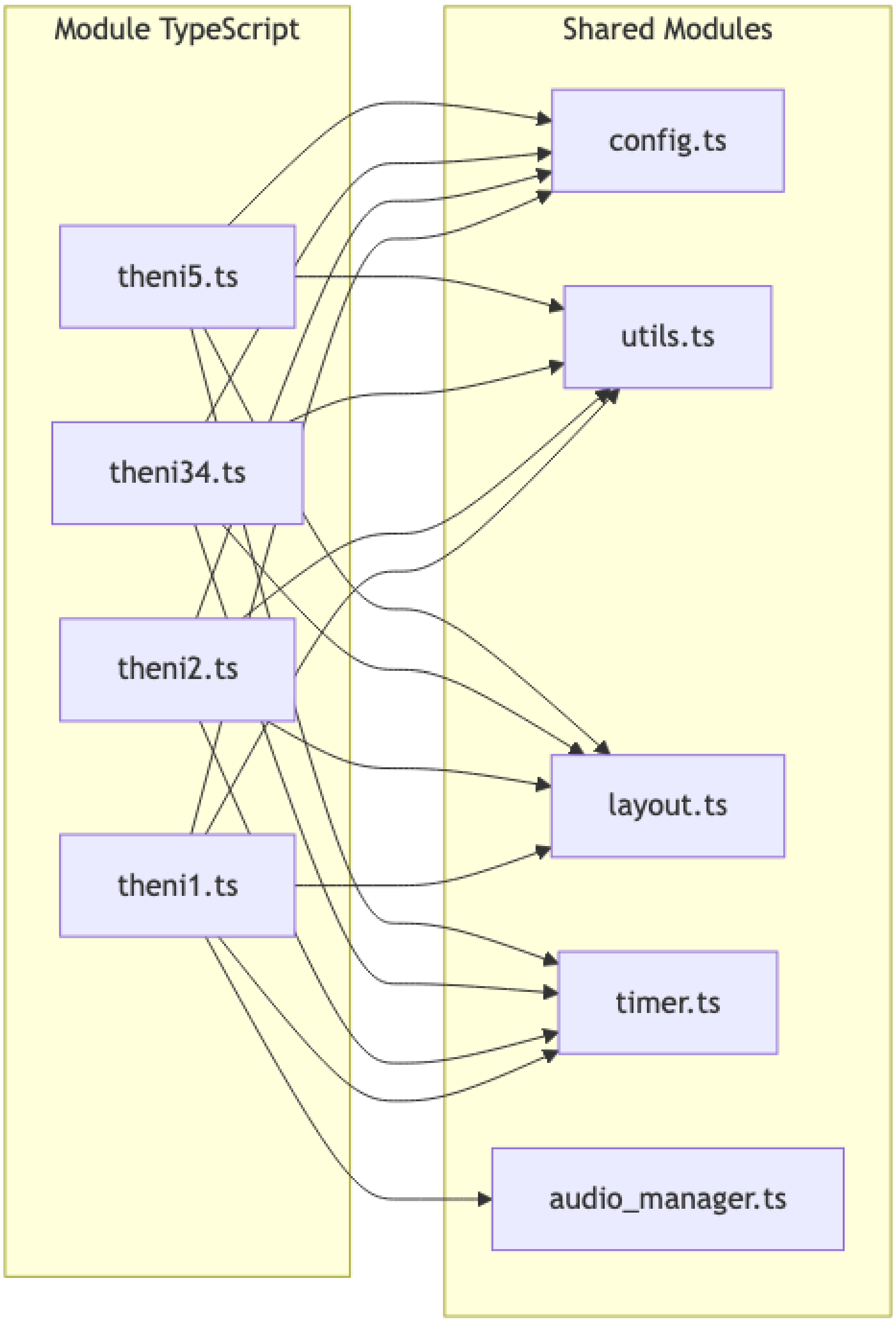
```
┌─────────────────────────────────────────────────────────────────────┐
│                         TamilTheni System                             │
├─────────────────────────────────────────────────────────────────────┤
│                                                                       │
│  ┌───────────────────┐    ┌───────────────────┐    ┌────────────────┐ │
│  │  Content Pipeline  │───▶│    Vite Build     │───▶│  GitHub Pages  │  │
│  │  (Python Scripts)  │    │ (TS -> JS Bundle) │    │  (Deployment)  │  │
│  └────────────────────┘    └───────────────────┘    └────────────────┘  │
│             │                        │                                   │
│             ▼                        ▼                                   │
│  ┌────────────────────┐    ┌───────────────────┐                        │
│  │  JSON Data Files   │    │  External APIs    │                        │
│  │ (src/data/*.json)  │    │ (Wikipedia, AI)   │                        │
│  └────────────────────┘    └───────────────────┘                        │
│                                                                          │
└──────────────────────────────────────────────────────────────────────────┘
```

Architecture Diagram

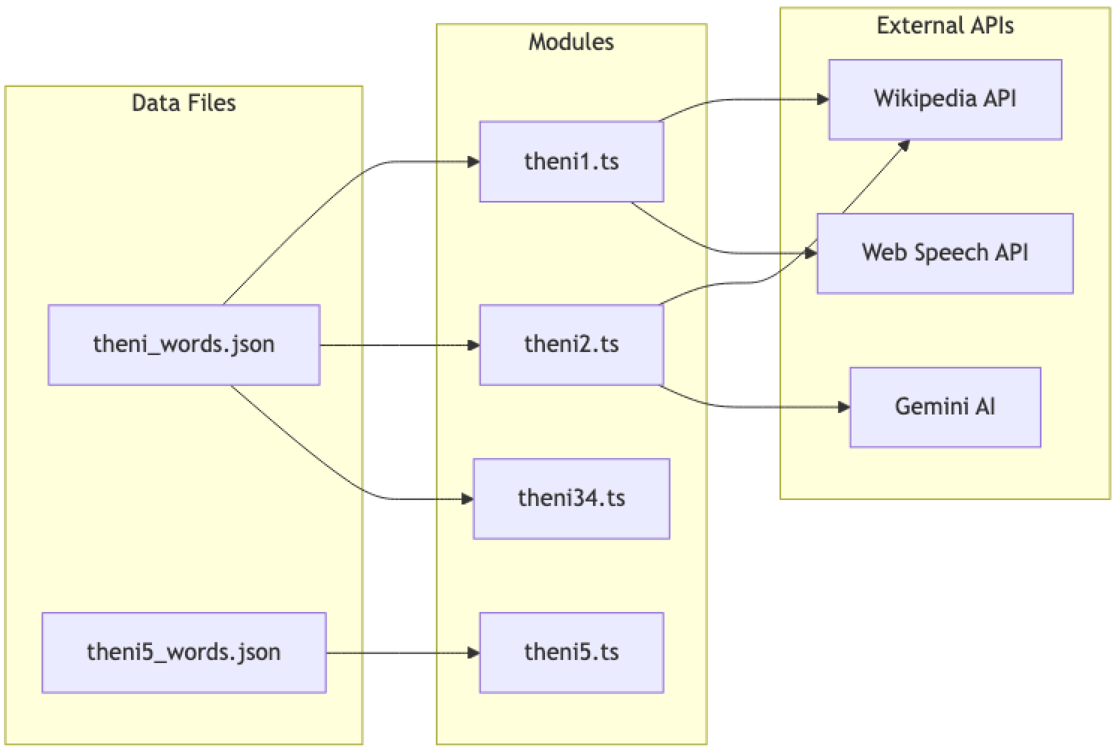
Application Layer



Shared Infrastructure


Module TypeScript
Shared Modules
config.ts
theni5.ts
utils.ts
theni34.ts
theni2.ts
layout.ts
theni1.ts
timer.ts
audio_manager.ts

Data Flow



Frontend Architecture

Directory Structure

```
tamiltheni/
├── public/                 # Static assets (images, fonts) served efficiently
├── src/                    # Source code
│   ├── css/                # Stylesheets modularized by page
│   ├── js/                 # TypeScript logic files
│   ├── data/               # JSON data files (Single Source of Truth)
│   └── types/              # TypeScript interface definitions
├── html/                   # HTML entry points for each module
├── test/                   # Test files
│   ├── bat/                # Build Acceptance Tests
│   └── unit/               # Unit tests
├── documentation/          # Project documentation
│   ├── ARCHITECTURE.md     # This file
│   └── REQUIREMENTS.md     # Product requirements
├── index.html              # Main entry point
├── docs/                   # Production build output (GitHub Pages root)
```

TypeScript Strategy

We use TypeScript to enforce data contracts and reduce runtime errors. Key interfaces include:

```
// Word Data Structure
interface Word {
    id: number;
    category: string;
    word_en: string;
    word_ta: string;
    difficulty: 'D1' | 'D2';
    // ...other fields
}
```

The build process (`tsc && vite build`) transpiles this to optimized JavaScript bundles.

Shared Modules

Module	Purpose	Key Exports
`config.ts`	Centralized configuration	`config` object
`utils.ts`	Utility functions	`Utils` class
`layout.ts`	UI component injection	`Layout` class
`timer.ts`	Countdown timer engine	`Timer` class
`audio_manager.ts`	Text-to-Speech wrapper	`AudioManager` class
`gemini_service.ts`	AI API Integration	`GeminiService` class

Data Architecture

JSON Data Files (`src/data/`)

Data is stored in standard JSON format, allowing easy manipulation by Python scripts and straightforward import by TypeScript.

- `theni_words.json` : Contains the main dataset of ~800 words.
- `theni5_words.json` : Contains the clue-based dataset for Theni 5.

Word Data Schema (`theni_words.json`)

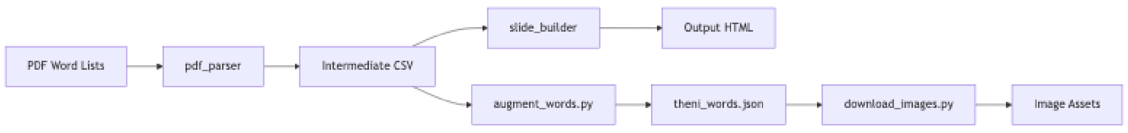
```
[
    {
        "id": 1,
        "category": "Body Parts",
        "category_ta": "உடல் பகுதிகள்",
        "difficulty": "D1",
        "word_en": "ear",
        "word_ta": "காது",
        "image_word": "ear",
        "sentence_en": "I have an <b>ear</b> infection.",
        "sentence_ta": "எனக்கு காதில் தொற்று உள்ளது.",
        "complexity": 2
    }
]
```

Image Storage Strategy

- **Location:** `public/assets/images/theni12/`
- **Naming:** `{word_en}.jpg` (e.g., `ear.jpg`)
- **Fallback:** Wikipedia API fetch if local image missing

Python Tooling Pipeline

Pipeline Overview



Deployment Architecture

GitHub Pages Configuration

```
# Deployment: docs/ folder on publish branch
Source: docs/
Branch: publish (primary)
```

Build Process

1. **Development**: `npm run dev` serves files from memory with hot replacement.
2. **Production**: `npm run build` runs `tsc` (type check) then `vite build` .
3. **Artifacts**: Minified JS/CSS and assets are output to `docs/` .

Module Deep Dives

Timer Module (`timer.ts`)

Configurable countdown timer with visual pie-chart representation and audio feedback.

Layout Module (`layout.ts`)

Injects common UI elements (headers, navigation, sidebars) into each HTML page at runtime, ensuring consistency. It also manages the **Control Panel toggle** and **Global Keyboard Shortcuts** (including the Help Modal).

Agentic Architecture

To provide intelligent feedback without a backend, we use **Client-Side Micro-Agents**. These are TypeScript classes that wrap the Gemini API with specific roles, prompts, and behaviors.

Infrastructure (`src/js/agents/`)

- **BaseAgent**: Abstract class handling API communication, error handling, and JSON parsing.
- **Specific Agents**: Subclasses like `SentenceConstructorAgent` that implement specific learning logic (prompt engineering, caching, context).

Workflow

1. **User Action**: User interacts with UI (e.g., clicks "Generate Sentence").
2. **UI Delegation**: View layer calls the specific Agent.
3. **Agent Processing**: Agent constructs prompt, checks local cache, calls `GeminiService`.
4. **Response**: Agent parses JSON response and returns typed data to UI.

Security Considerations

API Key Management

The Theni 2 module uses the Gemini AI API. Keys are stored in `localStorage` by the user.

> *[!WARNING] Client-side API key storage is inherently insecure.*

Future Considerations

1. **Backend**: Optional backend for user progress tracking.

This document is maintained alongside the codebase.