Seed Specification Language Documentation

Contents

Chapter 1

Seed Specification Language

Seed Spec is an AI-native language that generates production-ready applications from simple specifications. Write what you want, get working software.

Quick Example

Example Specification

```
// core.seed - Domain model
app TodoApp {
  // Core domain model
  entity Task {
    title: string
    done: bool = false
  }
}

// ui.seed - User interface
extend TodoApp {
  // UI definition (implies standard patterns)
  screen Tasks {
    list: [title, done]    // Will imply search, sort, pagination
    actions: [create, done] // Will imply proper handlers
  }
}
```

The extend keyword allows modular app definitions across files, enabling: - Separation of concerns - Team collaboration - Reusable components

This specification will eventually generate a complete application, but the generation tools are still under development.

Key Features

- **AI-First Design**: Optimized for LLM generation and modification
- **Intent-Focused**: Express what you want, not how to build it

- **Smart Defaults**: Production patterns built-in, override only when needed
- **Full Stack**: One specification drives all application layers
- **Tech Independent**: Target any modern technology stack
- **Standard Library**: Rich set of pre-built components and themes
- **Maps Integration**: Built-in support for location-based features and mapping

Smart Defaults

Seed Spec minimizes boilerplate through intelligent defaults:

- `string` fields imply validation, indexing, and proper UI handling
- `list` screens imply pagination, sorting, and search
- `actions` imply proper handlers, validation, and error handling
- All entities get automatic CRUD operations
- Security best practices are automatically applied
- `location` fields imply geocoding, map rendering, and distance calculations
- `map` screens imply clustering, search radius, and interactive controls

Override defaults only when needed:

```
// Use standard library theme with overrides
app MyApp {
  theme: "modern-light" {
    colors: {
      primary: "#0066cc"
      accent: "#ff4081"
    }
  }
}

// Use standard components with customization
entity User {
  // Override string defaults
  name: string {
    min: 3,
    max: 50
  }

  // Use defaults
  email: email  // Implies validation, uniqueness
}

// Maps integration with smart defaults
entity Store {
  location: location  // Implies geocoding, validation, map rendering
}

screen StoreLocator {
  map: [location]     // Implies clustering, search, radius filters
}
```

Generated Stack

Seed Spec generates a complete, production-ready stack:

Frontend

- React + TypeScript
- Responsive UI components
- State management
- Form handling
- API integration
- Maps components

Backend

- FastAPI + SQLAlchemy
- REST endpoints
- Authentication
- Validation
- Error handling

Infrastructure

- Database migrations
- Docker configuration
- API documentation
- Testing setup

Documentation

- **Getting Started**
  - Introduction
  - Installation
  - Quick Start
  - First Application
- **Core Concepts**
  - Type System
  - Business Rules
  - UI Patterns
  - Architecture
- **Examples**
  - Basic CRUD
  - Business App
  - Dashboard
  - SaaS
- **Reference**
  - Types
  - Patterns
  - CLI

Development Status

Seed Spec is in active development (v0.1.0) with a focus on:

1. **Language Evolution**
   - Expanding core patterns
   - Enhancing type system
   - Adding advanced features

    - Improving validation
2. **Generation Pipeline**
    - LLM prompt optimization
    - Code quality improvements
    - Performance tuning
    - Testing automation
3. **Developer Experience**
    - IDE integration
    - Live preview
    - Debug tools
    - Error messages
4. **Enterprise Features**
    - Multi-tenancy
    - Authentication
    - Authorization
    - Audit logging
    - Compliance

🤝 Contributing

We welcome contributions! See CONTRIBUTING.md for: - Development setup - Coding standards - Pull request process - Issue guidelines

📄 License

- **Open Source**: GNU GPL v3.0
    - Free for personal and open source use
    - Modifications must be shared
    - Commercial use requires license
- **Commercial License**
    - Coming soon
    - Priority support
    - Private modifications
    - Enterprise features

📞 Contact & Support

- **Website**: https://noodleseed.com
- **Documentation**: https://docs.noodleseed.com
- **GitHub Issues**: Bug reports & feature requests
- **Discord**: Community chat & support
- **Email**: info@noodleseed.com
- **Twitter**: [@noodleseed](https://twitter.com/noodleseed)

🙏 Acknowledgments

Special thanks to: - Anthropic for Claude API access - Our open source contributors - Early adopters and testers

---

Built with ❤ by Noodle Seed Making software development more natural for humans and machines

Chapter 2

.aider.chat.history.md

Chapter 3

aider chat started at 2024-12-17 21:29:06

> /home/codespace/.python/current/bin/aider
> Aider v0.69.1
> Main model: claude-3-5-sonnet-20241022 with diff edit format, infinite output
> Weak model: claude-3-5-haiku-20241022
> Git repo: .git with 69 files
> Repo-map: using 1024 tokens, auto refresh
> https://aider.chat/HISTORY.html#release-notes
> Would you like to see what's new in this version? (Y)es/(N)o [Yes]: n

give me a summary of this repo, all src code and everything related to themes and examples and tools.

Based on the repository structure, this appears to be a theming/styling framework with the following key components:

1. Core Theme System:

- Located in src/theme/ with ThemeContext.tsx and theme.css
- Standard theme definitions in src/stdlib/themes/ (base.seed, dark.seed, light.seed)

2. Theme Processing Tools:

- tools/compile_react_theme.py: Main compiler that:
  - Generates CSS variables from theme specs
  - Creates theme context for React
  - Handles theme overrides and predefined themes
  - Flattens theme objects

3. Parser:

- src/parser.py: Handles parsing of .seed files which appear to be the theme definition format
- Includes error handling via SeedParseError
- Supports file imports and relative paths

4. Example Applications:

- examples/react-theme/: Complete React application showing theme usage
  - Uses Vite as build tool
  - Includes ThemeContext implementation
  - Shows practical theme application
- examples/app-theme.seed and custom-theme.seed: Theme definition examples

5. Testing:

- Comprehensive test suite under tests/

- Unit tests for imports, parsing, React theme compilation
- Integration tests
- Test fixtures with various .seed files showing different use cases

6. Documentation:

- Extensive markdown docs covering:
  - Core concepts (architecture, theming, type system)
  - Getting started guides
  - Examples and patterns
  - Reference documentation

The system appears to be designed to: 1. Define themes using a custom .seed format 2. Parse and validate these definitions 3. Compile them into CSS variables and React context 4. Provide tools for theme manipulation and override 5. Support modular theme composition through imports

Would you like me to examine any specific component in more detail?

> Tokens: 3.0k sent, 362 received. Cost: $0.01 message, $0.01 session.
> Add examples/app-theme.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: y
> Add examples/custom-theme.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/parser.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/parser.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/stdlib/themes/dark.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/stdlib/themes/dark.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add tools/compile_react_theme.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add tools/compile_react_theme.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Based on the files provided, this appears to be a theming system with the following components:

1. A custom theme definition language called "Seed" (.seed files):

- Custom theme definitions (examples/custom-theme.seed)
- App theme configurations (examples/app-theme.seed)
- Base themes in stdlib (dark.seed, and references to light.seed and base.seed)

2. Parser Infrastructure:

- src/parser.py - Parses .seed files into Python dictionaries
- Handles imports, nested blocks, and various value types
- Prevents circular imports

3. Theme Compilation Tool:

- tools/compile_react_theme.py - Converts Seed themes to React
- Generates CSS variables
- Creates React context/provider components
- Handles theme overrides and inheritance

To get a complete picture, we should also look at:

1. Base theme definitions:

```
src/stdlib/themes/base.seed
src/stdlib/themes/light.seed
```

2. React theme implementation:

```
src/theme/ThemeContext.tsx
src/theme/theme.css
```

3. Any tests:

```
tests/unit/test_theme_spec.py
tests/unit/test_react_theme_compiler.py
```

Would you like me to analyze any of these additional files? Please add them to the chat if you'd like me to propose any changes or improvements to the theming system.

The current implementation supports: - Custom theme definitions - Theme inheritance/extension - App-specific theme overrides - React integration - CSS variable generation

But we might find opportunities for improvement in areas like: - Theme validation - Default fallbacks - Runtime theme switching - Performance optimization - Additional framework support

Let me know which aspects you'd like to explore further!

> Tokens: 5.8k sent, 346 received. Cost: $0.02 message, $0.04 session.
> Add src/stdlib/themes/base.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/stdlib/themes/light.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/stdlib/themes/light.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/theme/ThemeContext.tsx to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/theme/ThemeContext.tsx to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/theme/theme.css to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/theme/theme.css to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add tests/unit/test_react_theme_compiler.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add tests/unit/test_react_theme_compiler.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add tests/unit/test_theme_spec.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add tests/unit/test_theme_spec.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Let me provide a summary of the theming system in this repository:

Core Components: 1. Theme Definition Language (.seed files): - Uses a custom DSL for defining themes - Located in `src/stdlib/themes/` - Has base.seed (default theme), light.seed, and dark.seed variants - Supports inheritance (extends keyword) - Defines colors, typography, spacing, borders, shadows

2. Parser (src/parser.py):

- Parses .seed files into Python dictionaries
- Handles imports, comments, and different value types
- Supports circular import detection
- Error handling with SeedParseError

3. React Theme Compiler (tools/compile_react_theme.py):

- Converts .seed theme definitions to React components
- Generates:
  - CSS variables

    - TypeScript theme context
- Supports theme overrides
- CLI tool with customizable input/output paths

4. React Integration:

- ThemeContext.tsx for React context
- theme.css for CSS variables
- Theme Provider component
- useTheme hook for consuming theme values

5. Examples:

- app-theme.seed: Basic theme usage
- custom-theme.seed: Advanced theme customization
- React theme example showing implementation

6. Tests:

- test_theme_spec.py: Theme parsing tests
- test_react_theme_compiler.py: Compiler tests

The system allows for: - Hierarchical theme definitions - Theme inheritance - Runtime theme overrides - Type-safe theme usage in React - CSS variable generation

All key files appear to be present in the chat. The structure is complete for the theming functionality.

Would you like me to propose any specific improvements or changes to this system?

> Tokens: 8.0k sent, 332 received. Cost: $0.03 message, $0.07 session.

/chat-mode ask

> Aider v0.69.1
> Main model: claude-3-5-sonnet-20241022 with ask edit format, infinite output
> Weak model: claude-3-5-haiku-20241022
> Git repo: .git with 69 files
> Repo-map: using 1024 tokens, auto refresh
> Added examples/app-theme.seed to the chat.
> Added examples/custom-theme.seed to the chat.
> Added src/parser.py to the chat.
> Added src/stdlib/themes/base.seed to the chat.
> Added src/stdlib/themes/dark.seed to the chat.
> Added src/stdlib/themes/light.seed to the chat.
> Added src/theme/ThemeContext.tsx to the chat.
> Added src/theme/theme.css to the chat.
> Added tests/unit/test_react_theme_compiler.py to the chat.
> Added tests/unit/test_theme_spec.py to the chat.
> Added tools/compile_react_theme.py to the chat.

show me an example of defining a theme, compiling it and using it in a react app

I'll show you a complete example from start to finish:

1. First, let's create a custom theme file `my-app-theme.seed`:

```
app MyApp {
  ui {
    theme: "light"  // Extend the light theme

    overrides: {
```

```
      colors.primary: "#0055ff"
      colors.secondary: "#6b2fbc"
      typography.fontFamily.base: "Poppins, sans-serif"
      typography.fontSize.base: "16px"
      spacing.md: "1.25rem"
      borders.radius.md: "8px"
    }
  }
}
```

2. Compile the theme using the provided tool:

```
python tools/compile_react_theme.py my-app-theme.seed --output src/theme
```

This will generate two files: - `src/theme/theme.css` (with CSS variables) - `src/theme/ThemeContext.tsx` (with React context)

3. Create a React app that uses the theme:

```
// App.tsx
import { ThemeProvider } from "./theme/ThemeContext";
import "./theme/theme.css";

function Button({ children }) {
  return (
    <button
      style={{
        backgroundColor: "var(--colors-primary)",
        color: "var(--colors-background)",
        padding: "var(--spacing-md)",
        borderRadius: "var(--borders-radius-md)",
        fontFamily: "var(--typography-fontFamily-base)",
        fontSize: "var(--typography-fontSize-base)",
        border: "none",
        cursor: "pointer"
      }}
    >
      {children}
    </button>
  );
}

// Using the theme with the useTheme hook
import { useTheme } from "./theme/ThemeContext";

function ThemedComponent() {
  const theme = useTheme();

  return (
    <div style={{ color: theme.colors.text }}>
      <h1>Themed Component</h1>
      <p>This text uses the theme's text color</p>
    </div>
  );
}
```

```
// Main App
function App() {
  return (
    <ThemeProvider>
      <div>
        <h1>My Themed App</h1>
        <Button>Click Me</Button>
        <ThemedComponent />
      </div>
    </ThemeProvider>
  );
}

export default App;
```

4. You can also create a styled-components or emotion implementation:

```
// With styled-components
import styled from 'styled-components';

const StyledButton = styled.button`
  background-color: var(--colors-primary);
  color: var(--colors-background);
  padding: var(--spacing-md);
  border-radius: var(--borders-radius-md);
  font-family: var(--typography-fontFamily-base);
  font-size: var(--typography-fontSize-base);
  border: none;
  cursor: pointer;

  &:hover {
    background-color: var(--colors-secondary);
  }
`;
```

5. To switch themes dynamically, you could modify the ThemeProvider:

```
// DynamicThemeProvider.tsx
import { useState } from 'react';
import { ThemeProvider } from './theme/ThemeContext';

const themes = {
  light: lightTheme,
  dark: darkTheme,
};

function DynamicThemeProvider({ children }) {
  const [currentTheme, setCurrentTheme] = useState('light');

  return (
    <ThemeProvider theme={themes[currentTheme]}>
      <button onClick={() => setCurrentTheme(current =>
        current === 'light' ? 'dark' : 'light'
      )}>
        Toggle Theme
      </button>
```

```
      {children}
    </ThemeProvider>
  );
}
```

The benefits of this approach: 1. Type-safe theme usage with TypeScript 2. CSS variables for better performance 3. Centralized theme definition 4. Easy theme switching 5. Support for theme inheritance and overrides 6. Works with any styling solution (CSS-in-JS, CSS Modules, plain CSS)

Would you like me to explain any part in more detail?

Tokens: 6.3k sent, 821 received. Cost: $0.03 message, $0.10 session.

Chapter 4

aider chat started at 2024-12-17 22:32:43

> /home/codespace/.python/current/bin/aider
> Aider v0.69.1
> Main model: claude-3-5-sonnet-20241022 with diff edit format, infinite output
> Weak model: claude-3-5-haiku-20241022
> Git repo: .git with 69 files
> Repo-map: using 1024 tokens, auto refresh

/chat-mode ask

> Aider v0.69.1
> Main model: claude-3-5-sonnet-20241022 with ask edit format, infinite output
> Weak model: claude-3-5-haiku-20241022
> Git repo: .git with 69 files
> Repo-map: using 1024 tokens, auto refresh

tell me about this repo and everything to do with examples, tools and theming system

From analyzing the repository structure, this appears to be a framework or library that has a strong focus on theming capabilities, particularly with React integration. Let me break down the key areas:

Theming System: - There appears to be a core theming system with standard themes in `src/stdlib/themes/` (base, dark, and light variants) - Theme-related React components in `src/theme/ThemeContext.tsx` - Theme-specific CSS in `src/theme/theme.css`

Examples: 1. React Theme Example: - A complete example in `examples/react-theme/` showing theme implementation with React - Includes standard React+Vite setup (vite.config.ts, package.json) - Demonstrates theme context usage (ThemeContext.tsx)

2. Seed Examples:
    - `app-theme.seed`
    - `custom-theme.seed` These appear to be template or configuration files for theming

Tools: The main tool visible is `tools/compile_react_theme.py` which has several key functions: - `generate_css()`: Converts theme specifications into CSS variables - `generate_theme_context()`: Likely creates React context code for themes - `load_predefined_theme()`: Loads built-in themes - `apply_theme_overrides()`: Handles theme customization - `extract_theme_from_app_spec()`: Pulls theme data from application specifications

Documentation: There's extensive documentation about theming in: - `docs/core-concepts/theming.md` - Various examples in the docs showing theme usage

Testing: Theme-related tests are present in: - `tests/unit/test_react_theme_compiler.py` - `tests/unit/test_theme_spec.py`

The system appears to use a custom ".seed" file format (parsed by `src/parser.py`) which might be a configuration or specification format for themes and applications.

Would you like me to dive deeper into any particular aspect? To provide more detailed information, I might need to see the contents of some key files.

> Tokens: 823 sent, 401 received. Cost: $0.0085 message, $0.0085 session.
> Add docs/core-concepts/theming.md to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add examples/app-theme.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add examples/app-theme.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add examples/custom-theme.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add examples/custom-theme.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/theme/ThemeContext.tsx to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/theme/ThemeContext.tsx to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/theme/theme.css to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/theme/theme.css to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add tests/unit/test_react_theme_compiler.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add tests/unit/test_react_theme_compiler.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add tests/unit/test_theme_spec.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add tests/unit/test_theme_spec.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add tools/compile_react_theme.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add tools/compile_react_theme.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

This repository appears to contain a theming system implementation with several key components:

1. Theme Definition System:

- Uses a custom "Seed" specification format (.seed files) to define themes
- Supports a hierarchical theme system with inheritance ("extends")
- Has built-in themes (light, dark, etc.) in the standard library
- Allows custom theme definitions and overrides

2. Theme Properties: The theming system covers:

- Colors (primary, secondary, background, etc.)
- Typography (font families, sizes, weights, line heights)
- Spacing scales
- Borders and shadows
- Smart defaults for production-ready styling

3. Tools and Compilation:

- `compile_react_theme.py`: A tool that:
  - Converts Seed theme specs to CSS variables
  - Generates React context for theme consumption

  - Creates necessary theme files for React applications
  - Handles theme overrides and references

4. Examples:

- `app-theme.seed`: Shows basic theme usage with the light theme and overrides
- `custom-theme.seed`: Demonstrates more complex theme definitions including:
  - Creating custom themes from scratch
  - Extending existing themes
  - Detailed theme property configurations

5. React Integration:

- Provides a React context-based theme provider
- Includes TypeScript support
- Generates CSS variables for style application
- Offers a `useTheme` hook for consuming theme values

6. Testing: The system includes comprehensive tests for:

- Theme compilation
- CSS generation
- React context generation
- Theme parsing and extraction
- Override application
- Default theme values

To get a complete picture, it might be helpful to also see: - The contents of `src/stdlib/themes.seed` and the base theme files - Any React component examples using the theme system - Documentation about the Seed specification format itself

Would you like me to elaborate on any of these aspects or should we look at additional files?

> Tokens: 4.8k sent, 387 received. Cost: $0.02 message, $0.03 session.
> Add src/stdlib/themes.seed to the chat? (Y)es/(N)o/(D)on't ask again [Yes]: y

From analyzing the files, this repository appears to have a comprehensive theming system with several key components:

1. Theme Definition System:

- Uses a custom ".seed" file format to define themes
- Supports a hierarchical theme system with inheritance
- Has built-in themes (base, light, dark) in `src/stdlib/themes/`
- Allows custom theme definitions with full customization options

2. Theme Properties: The theming system covers:

- Colors (primary, secondary, background, etc.)
- Typography (font families, sizes, weights, line heights)
- Spacing scales
- Borders and shadows
- Smart defaults with the ability to override

3. Tools and Compilation:

- `tools/compile_react_theme.py`: A Python tool that:
  - Converts .seed theme definitions to CSS variables
  - Generates React context for theme consumption
  - Creates TypeScript types for theme values
  - Supports theme overrides and extensions

4. Examples:

- `examples/app-theme.seed`: Shows basic theme usage with the light theme and overrides
- `examples/custom-theme.seed`: Demonstrates creating custom themes and extending existing ones
- React theme example showing integration with React applications

5. Testing: Comprehensive test coverage including:

- Theme parsing tests
- CSS generation tests
- React context generation tests
- Theme override and extraction tests

6. React Integration:

- Provides a ThemeContext.tsx for React apps
- Includes TypeScript support
- Offers hooks for theme consumption (useTheme)
- CSS variable-based implementation

To get a complete picture, it would be helpful to see: - The actual contents of `src/stdlib/themes/base.seed`, `light.seed`, and `dark.seed` - The full implementation of `src/parser.py` referenced in the tests - Any additional example applications showing theme usage

The system appears to be well-designed for both simplicity and flexibility, allowing both quick starts with default themes and deep customization when needed.

> Tokens: 4.8k sent, 394 received. Cost: $0.02 message, $0.05 session.
> Add src/parser.py to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/stdlib/themes/base.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/stdlib/themes/base.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/stdlib/themes/dark.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/stdlib/themes/dark.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

Add src/stdlib/themes/light.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: all

> Add src/stdlib/themes/light.seed to the chat? (Y)es/(N)o/(A)ll/(S)kip all/(D)on't ask again [Yes]: a

This repository implements a comprehensive theming system with the following key components:

1. Theme Definition System:

- Uses `.seed` files to define themes in a hierarchical structure
- Base theme (`themes/base.seed`) defines default values for all theme properties
- Light (`themes/light.seed`) and Dark (`themes/dark.seed`) themes extend the base theme
- Themes include properties for colors, typography, spacing, borders, and shadows

2. Theme Compilation Tools:

- `tools/compile_react_theme.py` - A Python tool that:
  - Converts `.seed` theme definitions into React context and CSS variables
  - Generates `ThemeContext.tsx` for React theme provider
  - Creates CSS variables in `theme.css`
  - Handles theme inheritance and overrides

3. Examples:

- `examples/app-theme.seed` - Simple example using the light theme with overrides
- `examples/custom-theme.seed` - More complex example showing:
  - Custom theme definition from scratch

- Theme extension (modernLight extends light)
- Theme usage in an app with overrides

4. React Integration:

- Generated `ThemeContext.tsx` provides:
  - Theme context provider
  - useTheme hook for accessing theme values
  - TypeScript types for theme values
- CSS variables for styling components

5. Testing:

- Comprehensive test suite covering:
  - Theme compilation (`test_react_theme_compiler.py`)
  - Theme specification parsing (`test_theme_spec.py`)
  - CSS generation
  - React context generation
  - Theme overrides and inheritance

The system allows for: - Using predefined themes (light/dark) - Creating custom themes - Extending existing themes - Applying theme overrides at the app level - Type-safe theme usage in React applications

Would you like me to elaborate on any specific aspect of the system?

Tokens: 6.8k sent, 372 received. Cost: $0.03 message, $0.08 session.

show me an example of a theme and how to compile and integrate it into a react app

I'll show you a complete example from theme definition to React integration.

1. First, let's create a custom theme file `my-theme.seed`:

```
app MyApp {
  ui {
    // Use light theme as base
    theme: "light"

    // Custom overrides
    overrides: {
      colors.primary: "#0070f3"
      colors.secondary: "#7928ca"
      typography.fontSize.base: "16px"
      typography.fontFamily.base: "Inter, system-ui, sans-serif"
      shadows.lg: "0 20px 25px -5px rgba(0, 0, 0, 0.1)"
    }
  }
}
```

2. Compile the theme using the provided tool:

```
python tools/compile_react_theme.py my-theme.seed --output src/theme
```

This will generate two files:

`theme.css`:

```
:root {
  --colors-primary: #0070f3;
  --colors-secondary: #7928ca;
  --colors-background: #ffffff;
```

```
  --colors-surface: #f8fafc;
  --colors-text: #1e293b;
  /* ... other variables ... */
  --typography-fontSize-base: 16px;
  --typography-fontFamily-base: Inter, system-ui, sans-serif;
  --shadows-lg: 0 20px 25px -5px rgba(0, 0, 0, 0.1);
}
```

ThemeContext.tsx:

```
import { createContext, useContext, ReactNode } from 'react';

export const theme = {
  colors: {
    primary: "#0070f3",
    secondary: "#7928ca",
    background: "#ffffff",
    // ... other colors
  },
  typography: {
    fontSize: {
      base: "16px",
      // ... other sizes
    },
    fontFamily: {
      base: "Inter, system-ui, sans-serif",
      // ... other families
    }
  },
  // ... other theme properties
} as const;

export type Theme = typeof theme;

const ThemeContext = createContext<Theme>(theme);

export function ThemeProvider({ children }: { children: ReactNode }) {
  return (
    <ThemeContext.Provider value={theme}>
      {children}
    </ThemeContext.Provider>
  );
}

export function useTheme() {
  return useContext(ThemeContext);
}
```

3. Use in your React app:

```
// App.tsx
import { ThemeProvider } from './theme/ThemeContext';
import './theme/theme.css';

function App() {
```

```
  return (
    <ThemeProvider>
      <MyComponents />
    </ThemeProvider>
  );
}
```

4. Use the theme in components:

```
// Using CSS variables
const Button = styled.button`
  background-color: var(--colors-primary);
  color: var(--colors-background);
  font-family: var(--typography-fontFamily-base);
  font-size: var(--typography-fontSize-base);
  padding: var(--spacing-md);
  border-radius: var(--borders-radius-md);
  box-shadow: var(--shadows-lg);
`;

// Using React hook
function ThemedComponent() {
  const theme = useTheme();

  return (
    <div style={{
      color: theme.colors.primary,
      fontFamily: theme.typography.fontFamily.base
    }}>
      Themed content
    </div>
  );
}
```

The benefits of this approach:

1. Type-safe theme values in TypeScript
2. CSS variables for better performance
3. Consistent theme values across components
4. Easy theme switching and customization
5. Inheritance from base themes
6. Central theme management

You can also create multiple themes and switch between them, or create responsive themes that change based on media queries or user preferences.

> Tokens: 7.2k sent, 802 received. Cost: $0.03 message, $0.11 session.
> Add examples/react-theme/App.tsx to the chat? (Y)es/(N)o/(D)on't ask again [Yes]: y
> litellm.InternalServerError: AnthropicException - Overloaded. Handle with `litellm.InternalServerError`.
> The API provider's servers are down or overloaded.
> Retrying in 0.2 seconds...

I'll walk you through the complete process using an example:

1. First, define your theme in a `.seed` file (e.g., `app-theme.seed`):

```
app MyApp {
  ui {
```

```
    // Use the light theme as base
    theme: "light"

    // Override some colors and typography
    overrides: {
      colors.primary: "#0070f3"
      colors.secondary: "#7928ca"
      typography.fontSize.base: "16px"
      typography.fontFamily.base: "Inter, system-ui, sans-serif"
    }
  }
}
```

2. Compile the theme using the provided tool:

```
python tools/compile_react_theme.py examples/app-theme.seed --output examples/react-theme
```

This generates two files: - `theme.css` with CSS variables - `ThemeContext.tsx` with React context and types

3. In your React app, use the theme like in the example `App.tsx`:

```
import { ThemeProvider, useTheme } from "./ThemeContext";
import "./theme.css";

// Example component using the theme
function DemoCard({ title, children }) {
  const theme = useTheme();
  return (
    <div style={{
      backgroundColor: theme.colors.surface,
      padding: theme.spacing.lg,
      borderRadius: theme.borders.radius.lg,
      boxShadow: theme.shadows.md,
    }}>
      <h2 style={{
        color: theme.colors.text,
        fontSize: theme.typography.fontSize.xl,
      }}>{title}</h2>
      {children}
    </div>
  );
}

// Wrap your app with ThemeProvider
function App() {
  return (
    <ThemeProvider>
      <DemoCard title="Theme Demo">
        <Button primary>Primary Button</Button>
        <Button>Secondary Button</Button>
      </DemoCard>
    </ThemeProvider>
  );
}
```

The example `App.tsx` shows several ways to use the theme:

1. Direct style properties:

```
style={{
  backgroundColor: theme.colors.background,
  padding: theme.spacing.xl,
  fontFamily: theme.typography.fontFamily.base
}}
```

2. Compound components like `DemoCard` and `Button` that use theme values

3. Responsive design using theme values:

```
style={{
  display: "flex",
  gap: theme.spacing.md,
  flexWrap: "wrap"
}}
```

Key benefits: - Type-safe theme access via `useTheme` hook - Consistent styling across components - Easy theme switching (light/dark) - CSS variables for performance - Customizable via theme overrides

The system supports both direct style usage and CSS variables, allowing you to choose the most appropriate approach for each use case.

Would you like me to explain any specific aspect in more detail?

Tokens: 8.0k sent, 580 received. Cost: $0.03 message, $0.14 session.

can this be changed to make the theming system more like tailwind css?

Yes, the theming system could be modified to be more Tailwind-like in several ways:

1. Modify the base theme (`src/stdlib/themes/base.seed`) to match Tailwind's design system:

```
theme default {
  colors {
    // Tailwind-style color scales
    gray-50: "#f9fafb"
    gray-100: "#f3f4f6"
    gray-200: "#e5e7eb"
    // ... etc

    blue-500: "#3b82f6"
    blue-600: "#2563eb"
    // ... etc
  }

  spacing {
    // Tailwind-style spacing scale
    0: "0"
    0.5: "0.125rem"
    1: "0.25rem"
    1.5: "0.375rem"
    2: "0.5rem"
    // ... etc
  }

  fontSize {
    // Tailwind-style sizes
```

```
    xs: ["0.75rem", "1rem"]
    sm: ["0.875rem", "1.25rem"]
    base: ["1rem", "1.5rem"]
    // ... etc
  }
}
```

2. Modify the theme compiler (`tools/compile_react_theme.py`) to generate utility classes:

```python
def generate_utility_classes(theme_spec: dict) -> str:
    """Generate Tailwind-style utility classes"""
    css = []

    # Generate color utilities
    for color_name, value in theme_spec['colors'].items():
        css.append(f".bg-{color_name} {{ background-color: {value}; }}")
        css.append(f".text-{color_name} {{ color: {value}; }}")

    # Generate spacing utilities
    for space_name, value in theme_spec['spacing'].items():
        css.append(f".p-{space_name} {{ padding: {value}; }}")
        css.append(f".m-{space_name} {{ margin: {value}; }}")
        css.append(f".gap-{space_name} {{ gap: {value}; }}")

    # Generate typography utilities
    for size_name, [size, line_height] in theme_spec['fontSize'].items():
        css.append(f".text-{size_name} {{ font-size: {size}; line-height: {line_height}; }}")

    return "\n".join(css)
```

3. Update the React components to use utility classes instead of inline styles:

```
// Before:
function DemoCard({ title, children }) {
  const theme = useTheme();
  return (
    <div style={{
      backgroundColor: theme.colors.surface,
      padding: theme.spacing.lg,
      borderRadius: theme.borders.radius.lg,
    }}>
      {children}
    </div>
  );
}

// After:
function DemoCard({ title, children }) {
  return (
    <div className="bg-surface p-4 rounded-lg shadow-md">
      {children}
    </div>
  );
}
```

4. Add a class composition system:

```
// src/theme/classNames.ts
export function cn(...classes: string[]) {
  return classes.filter(Boolean).join(' ');
}

// Usage
function Button({ primary, className, children }) {
  return (
    <button
      className={cn(
        "px-4 py-2 rounded-md",
        primary ? "bg-blue-500 text-white" : "bg-gray-100 text-gray-900",
        className
      )}
    >
      {children}
    </button>
  );
}
```

5. Add responsive and state variants:

```
@media (min-width: 640px) {
  .sm\:text-lg { font-size: 1.125rem; }
}

.hover\:bg-blue-600:hover {
  background-color: #2563eb;
}
```

6. Update the parser to support Tailwind-style configuration:

```
theme config {
  screens {
    sm: "640px"
    md: "768px"
    lg: "1024px"
  }

  variants {
    extend {
      backgroundColor: ["active", "disabled"]
      opacity: ["hover", "focus"]
    }
  }
}
```

Example usage with the new system:

```
function App() {
  return (
    <div className="min-h-screen bg-gray-50 p-6">
      <div className="max-w-md mx-auto space-y-4">
        <Card className="bg-white p-6 rounded-lg shadow-md">
          <h2 className="text-xl font-semibold text-gray-900 mb-4">
            Welcome
```

```
          </h2>
          <Button className="w-full hover:bg-blue-600 transition-colors">
            Get Started
          </Button>
        </Card>
      </div>
    </div>
  );
}
```

This would require: 1. Updating the theme specification format 2. Modifying the compiler to generate utility classes 3. Adding a build step to generate the CSS 4. Creating helper functions for class composition 5. Adding support for responsive and state variants 6. Updating documentation and examples

Would you like me to elaborate on any of these aspects?

> Tokens: 8.6k sent, 1.1k received. Cost: $0.04 message, $0.18 session.

i would like to change it so that the seed spec is semantic with a fixed schema for most if not all business applications (web based) and it should compile to something that can provide classNames for all the elements in an app.

I understand - you want to create a semantic schema that maps business application UI elements to consistent classNames. Here's how we could modify the system:

1. First, let's define a semantic schema in the base theme:

```
// src/stdlib/themes/base.seed
theme default {
  // Semantic layout components
  layout {
    page {
      container: true
      header: true
      main: true
      sidebar: true
      footer: true
    }

    section {
      container: true
      header: true
      content: true
      footer: true
    }

    grid {
      container: true
      item: true
    }
  }

  // Semantic components for business apps
  components {
    // Data display
    table {
      container: true
```

```
    header: true
    row: true
    cell: true
    pagination: true
    sortable: true
    filterable: true
  }

  dataGrid {
    container: true
    header: true
    toolbar: true
    content: true
    footer: true
  }

  card {
    container: true
    header: true
    content: true
    footer: true
    actionArea: true
  }

  // Forms
  form {
    container: true
    section: true
    field: true
    label: true
    input: true
    error: true
    help: true
  }

  // Navigation
  nav {
    container: true
    item: true
    active: true
    group: true
  }

  // Actions
  button {
    base: true
    primary: true
    secondary: true
    danger: true
    success: true
    disabled: true
  }
```

```
    // Feedback
    alert {
      info: true
      success: true
      warning: true
      error: true
    }

    // Status indicators
    badge {
      default: true
      success: true
      warning: true
      error: true
    }

    // Modals and dialogs
    dialog {
      overlay: true
      container: true
      header: true
      content: true
      footer: true
    }
  }
}
```

2. Modify the theme compiler to generate semantic classNames:

```python
def generate_semantic_classes(theme_spec: dict) -> str:
    """Generate semantic utility classes"""
    css = []

    def process_component(prefix: str, config: dict):
        for key, value in config.items():
            if isinstance(value, dict):
                process_component(f"{prefix}-{key}", value)
            elif value is True:
                class_name = f".{prefix}-{key}"
                css.append(f"""
                    {class_name} {{
                        /* Base styles */
                        @apply {get_base_styles(prefix, key)};
                        /* Theme-specific styles */
                        {get_theme_styles(prefix, key)}
                    }}
                """)

    # Process layout components
    process_component("layout", theme_spec["layout"])

    # Process semantic components
    process_component("component", theme_spec["components"])
```

```
    return "\n".join(css)

def get_base_styles(prefix: str, key: str) -> str:
    """Get base styles for a semantic component"""
    # Define standard styles for common patterns
    patterns = {
        "layout-page-container": "min-h-screen w-full",
        "layout-section-container": "w-full py-6",
        "component-table-container": "w-full overflow-x-auto",
        "component-form-container": "space-y-4",
        # ... etc
    }
    return patterns.get(f"{prefix}-{key}", "")

def get_theme_styles(prefix: str, key: str) -> str:
    """Get theme-specific styles for a semantic component"""
    # These would come from the active theme
    return ""
```

3. Example usage in React components:

```
// Components/DataTable.tsx
function DataTable({ data, columns }) {
  return (
    <div className="component-table-container">
      <div className="component-table-header">
        <div className="component-table-toolbar">
          <SearchField />
          <FilterDropdown />
        </div>
      </div>
      <table className="component-table">
        <thead className="component-table-header">
          {/* ... */}
        </thead>
        <tbody>
          {data.map(row => (
            <tr className="component-table-row">
              {/* ... */}
            </tr>
          ))}
        </tbody>
      </table>
      <div className="component-table-pagination">
        {/* ... */}
      </div>
    </div>
  );
}

// Components/Form.tsx
function BusinessForm({ onSubmit }) {
  return (
    <form className="component-form-container">
```

```
      <div className="component-form-section">
        <div className="component-form-field">
          <label className="component-form-label">
            Name
          </label>
          <input className="component-form-input" />
          <span className="component-form-error">
            {/* error message */}
          </span>
        </div>
      </div>

      <div className="component-form-footer">
        <button className="component-button-secondary">
          Cancel
        </button>
        <button className="component-button-primary">
          Submit
        </button>
      </div>
    </form>
  );
}

// Pages/Dashboard.tsx
function DashboardPage() {
  return (
    <div className="layout-page-container">
      <header className="layout-page-header">
        {/* ... */}
      </header>

      <main className="layout-page-main">
        <section className="layout-section-container">
          <div className="layout-grid-container">
            <div className="layout-grid-item">
              <div className="component-card-container">
                {/* ... */}
              </div>
            </div>
          </div>
        </section>
      </main>
    </div>
  );
}
```

4. Add a helper to compose classNames with variants:

```
// theme/classNames.ts
export function getComponentClass(
  component: string,
  element: string,
  variants?: {
    size?: 'sm' | 'md' | 'lg',
```

```
    state?: 'active' | 'disabled' | 'loading',
    intent?: 'primary' | 'secondary' | 'danger'
  }
) {
  const base = `component-${component}-${element}`;
  const variantClasses = variants ?
    Object.entries(variants)
      .map(([key, value]) => `${base}--${key}-${value}`)
      .join(' ')
    : '';

  return `${base} ${variantClasses}`.trim();
}

// Usage
<button className={getComponentClass('button', 'base', {
  size: 'lg',
  intent: 'primary',
  state: 'loading'
})}>
  Submit
</button>
```

This approach provides: - Semantic, predictable classNames - Consistent styling across the application - Type-safe component variants - Easy theme switching - Standard layouts and components for business apps

Would you like me to elaborate on any part of this approach?

> Tokens: 9.8k sent, 1.5k received. Cost: $0.05 message, $0.24 session.

the idea is to be able to generate theme separate from the rest of the application. if the theme is updated, the rest of the app shouldn't have to be updated. and vice versa.

Ah, I understand better now. We want to decouple the theme generation from the application code, where:

1. The theme system defines semantic structures (like "data-table", "form-field", etc.)
2. Theme changes only require updating theme files and regenerating CSS
3. Application code remains stable using semantic classNames

Here's how we could restructure this:

```
# themes/business-app.seed
theme business-app {
  // Semantic definitions that map to any business app
  components {
    data-table {
      wrapper: {
        base: true
        bordered: true
        compact: true
      }
      header: {
        cell: true
        sortable: true
      }
      body: {
        row: true
```

```
        cell: true
        striped: true
        hoverable: true
      }
      footer: {
        pagination: true
      }
    }

    form {
      group: {
        base: true
        inline: true
        stacked: true
      }
      label: {
        base: true
        required: true
      }
      input: {
        base: true
        invalid: true
        disabled: true
      }
    }

    // ... other semantic components
  }
}
```

The theme compiler would generate two key outputs:

1. CSS Variables and Classes:

```
/* Generated theme.css */
:root {
  /* Theme variables */
  --data-table-border-color: #e2e8f0;
  --form-input-border: 1px solid #cbd5e1;
  /* ... */
}

/* Semantic classes */
.data-table-wrapper {
  /* Base styles that won't change with theme */
  display: table;
  width: 100%;
}

.data-table-wrapper--bordered {
  border: var(--data-table-border-color);
}

.form-input {
  border: var(--form-input-border);
```

```
}

/* ... */
```

2. TypeScript Types:

```
// Generated theme.d.ts
export type SemanticComponent =
  | 'data-table'
  | 'form'
  | 'button'
  // ...

export type ComponentVariant = {
  'data-table': {
    wrapper: ['base', 'bordered', 'compact']
    header: ['cell', 'sortable']
    // ...
  }
  'form': {
    group: ['base', 'inline', 'stacked']
    // ...
  }
  // ...
}
```

Then the application code would use stable semantic classNames:

```
// Application code that doesn't change with theme updates
function DataTable({ data, bordered = true }) {
  return (
    <div className="data-table-wrapper data-table-wrapper--bordered">
      <div className="data-table-header">
        {/* ... */}
      </div>
    </div>
  );
}

function FormField({ label, required }) {
  return (
    <div className="form-group">
      <label className={`form-label ${required ? 'form-label--required' : ''}`}>
        {label}
      </label>
      <input className="form-input" />
    </div>
  );
}
```

The workflow would be:

1. Update theme:

```
# Update theme files
vim themes/business-app.seed
```

```
# Regenerate theme assets
seed-theme compile themes/business-app.seed --output src/theme
```

2. The generated files update, but application code stays the same because it uses semantic classNames that don't change.

This provides: - Complete separation of theme and application code - Semantic classNames that represent business UI concepts - Type safety for component variants - Ability to switch themes without touching application code - Standard patterns for common business UI elements

Would you like me to elaborate on any part of this approach or show more examples?

> Tokens: 11k sent, 772 received. Cost: $0.05 message, $0.28 session.

Chapter 5

CONTRIBUTING.md

Chapter 6

Contributing to SeedML

Thank you for your interest in contributing to SeedML! This document provides guidelines and information for contributors.

Getting Started

1. Fork the repository
2. Clone your fork
3. Create a new branch for your work
4. Make your changes
5. Submit a pull request

Development Setup

```
# Install from source
git clone https://github.com/seedml/seedml.git
cd seedml
pip install -e .

# Set your API key
export ANTHROPIC_API_KEY='your-api-key'

# Run tests
python -m pytest

# Build documentation
mkdocs build
```

CLI Development

The SeedML CLI tool generates applications from specifications:

```
# Generate application from spec
seedml myapp.seed

# Show help
seedml --help
```

```
# Show version
seedml --version
```

Options:

```
--api-key KEY      Anthropic API key (or use ANTHROPIC_API_KEY env var)
--output DIR       Output directory (default: ./generated)
--verbose          Show detailed output
```

Contribution Areas

We welcome contributions in these areas:

1. Language Design
    - Syntax improvements
    - New features
    - Pattern recognition
2. Compiler Development
    - Parser improvements
    - Code generation
    - Optimization
3. Documentation
    - Examples
    - Tutorials
    - API documentation
4. Tools
    - IDE plugins
    - Development tools
    - Testing utilities

Code Style

- Follow existing patterns
- Add tests for new features
- Document your changes
- Keep commits focused

Pull Request Process

1. Update documentation
2. Add tests if needed
3. Ensure all tests pass
4. Update CHANGELOG.md
5. Submit PR with clear description

Questions?

- Open an issue for bugs
- Discussions for features
- Discord for community chat

License

By contributing, you agree to license your work under our project’s license terms.

Chapter 7

LICENSE-GPL.md

```
                GNU GENERAL PUBLIC LICENSE
                   Version 3, 29 June 2007
```

Copyright (C) 2007 Free Software Foundation, Inc. https://fsf.org/ Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

```
                        Preamble
```

The GNU General Public License is a free, copyleft license for software and other kinds of works.

[... Full GPL v3 text would go here ...]

The precise terms and conditions for copying, distribution and modification follow.

```
                    TERMS AND CONDITIONS
```

[... Full terms and conditions would go here ...]

END OF TERMS AND CONDITIONS

```
        How to Apply These Terms to Your Programs
```

[... Application instructions would go here ...]

Chapter 8

docs/getting-started.md

Chapter 9

Getting Started with SeedML

Installation

```
pip install -e .
```

Quick Start

1. Create a new project:

```
seedml new my-app
cd my-app
```

2. Edit your app.seed file:

```
app MyApp {
  entity User {
    name: string
    email: email
    active: bool = true
  }

  screen Users {
    list: [name, email, active]
    actions: [create, edit]
  }
}
```

3. Generate and run:

```
seedml generate
seedml run
```

Next Steps

- Read the Core Concepts
- Try the Examples
- Learn about Patterns

Learning Path

1. Start Here:
    - Quick Start Guide
    - First Application
2. Core Concepts:
    - Architecture
    - Type System
    - Business Rules
    - UI Patterns
3. Examples:
    - Basic CRUD
    - Business App
    - Dashboard
    - SaaS
4. Reference:
    - Types
    - Patterns
    - CLI

Chapter 10

docs/getting-started/basic-concepts.md

Chapter 11

Basic Concepts

Learn the core concepts of SeedML development.

Application Structure

SeedML applications can be organized in multiple files using the `extend` keyword:

```
# core.seed - Core app definition
app MyApp {
  # Data models
  entity Task {
    title: string
    done: bool
  }
}

# ui.seed - UI components
extend MyApp {
  # Theme configuration
  ui {
    theme: "light"  # Use built-in theme
  }

  # Screens
  screen Tasks {
    list: [title, done]
    actions: [create, complete]
  }
}
```

Every SeedML application has these main parts:

1. Data Models (Entities)

Define your data structure:

```
entity Task {
  title: string           # Text fields
  done: bool = false      # Boolean with default
  due: date              # Date field
```

```
  assigned: User         # Reference another entity
  items: [Item]          # Simple list
}
```

2. User Interface (Screens)

Define your views:

```
screen TaskList {
  # List view
  list: [title, done, due]
  actions: [create, edit, delete]
}

screen TaskForm {
  # Form view
  form: [title, due, assigned]
  actions: [save]
}
```

3. Business Rules

Define basic validation and logic:

```
rules {
  # Validation
  validate: due > today
  require: title != null

  # Simple actions
  then: notify_assigned
}
```

Key Principles

1. Keep It Simple

- Focus on core features
- Use basic types
- Minimal configuration

2. Smart Defaults

- Common patterns built-in
- Sensible behaviors
- Easy to get started

3. Full Stack

- One specification
- Generates complete app
- Ready to run

Basic Types

```
# Available field types
string              # Text
number              # Numbers
bool                # True/False
date                # Dates
[Type]              # Lists
Reference           # Entity references
```

Common Patterns

1. Fields

```
fields {
  required: string         # Required field
  optional: string?        # Optional field
  default: bool = false    # Default value
}
```

2. Views

```
screens {
  list: [field1, field2]   # List view
  form: [field1, field2]   # Form view
}
```

3. Actions

```
actions: [
  create,                  # Create new
  edit,                    # Edit existing
  delete                   # Delete item
]
```

Next Steps

1. Try the Quick Start Guide
2. Build your First Application
3. See Examples

Chapter 12

docs/getting-started/first-app.md

Chapter 13

Building Your First Application

This tutorial walks through creating a complete task management application with SeedML.

1. Project Setup

Create a new directory and file:

```
mkdir task-manager
cd task-manager
touch app.seed
```

2. Basic Structure

Add this initial structure to `app.seed`:

```
app TaskManager {
  # We'll add components here
}
```

3. Adding Data Models

Expand your app with data models:

```
app TaskManager {
  entity Task {
    title: string!
    description: text
    status: todo->doing->done
    priority: low/medium/high = medium
    due?: date
    assigned?: User
  }

  entity User {
    name: string!
    email: email!
    role: member/admin = member
```

```
  }
}
```

4. Creating Screens

Add user interface screens:

```
app TaskManager {
  # ... previous code ...

  screen TaskBoard {
    list: [title, assigned, priority, due]
    view: kanban(status)
    actions: [create, edit, assign]
    search: [title, assigned]
  }

  screen TaskDetail {
    layout: split
    left: [title, description, status]
    right: [assigned, due, priority]
    actions: [save, delete]
  }
}
```

5. Adding Business Rules

Implement task management logic:

```
app TaskManager {
  # ... previous code ...

  rules {
    assign_task: {
      require: role.member
      validate: assigned != null
      then: notify@assigned
    }

    complete_task: {
      require: [
        status == doing,
        assigned == current_user
      ]
      then: [
        update_status(done),
        notify@created_by
      ]
    }
  }
}
```

6. Running Your App

Generate and run the application:

```
seedml generate app.seed
cd task-manager-app
seedml run
```

What You've Learned

- Basic SeedML project structure
- Entity definition and relationships
- Screen layouts and components
- Business rules and validation
- Application generation and deployment

Next Steps

1. Add more features:
    - Comments on tasks
    - File attachments
    - Time tracking
    - Reports
2. Learn about:
    - Advanced Patterns
    - Integration
    - Security

Chapter 14

docs/getting-started/installation.md

Chapter 15

Installing Seed Spec

Prerequisites

Before installing Seed Spec, ensure you have: - Python 3.8 or higher - pip package manager - Anthropic API key (for Claude access) - Node.js 16+ (for frontend implementations) - Docker (optional, for containerized builds)

Installation

```
# Install from source
git clone https://github.com/fahd-noodleseed/seed-spec.git
cd seed-spec
pip install -e .
```

Configuration

Set your Anthropic API key:

```
export ANTHROPIC_API_KEY='your-api-key'
```

Verify Installation

```
# Should show available commands
seedspec --help

# Should show version number
seedspec --version
```

Current Status

Seed Spec is in early development (v0.1.0). Current features: - Basic application generation from .seed files - Cross-compilation to multiple implementations: - React + FastAPI stack - Vue + Express stack - Angular + NestJS stack - Simple CRUD operations - Template customization support

Many planned features are still in development.

Next Steps

- Follow the Quick Start Guide
- Try the First Application Tutorial
- Read about Core Concepts

Chapter 16

docs/getting-started/introduction.md

Chapter 17

Introduction to SeedML

Why SeedML?

Modern software development faces several key challenges: - Business requirements get lost in translation across multiple technical layers - Changes require updates across numerous disconnected components - Different teams (business, frontend, backend) speak different languages - Development requires constant context switching between technologies

SeedML solves these challenges by providing: - A single source of truth for entire applications - Natural language-like syntax that maps directly to implementation - AI-native design that works seamlessly with LLMs - Technology-independent specifications that can target any modern stack

---

Chapter 18

docs/getting-started/quick-start.md

Chapter 19

Quick Start Guide

Prerequisites

1. Install SeedML following the installation guide
2. Set up your Anthropic API key:

```
export ANTHROPIC_API_KEY='your-api-key'
```

3. Set up your Google Maps API key (optional):

```
export GOOGLE_MAPS_KEY='your-maps-key'
```

Your First SeedML App

1. Create a new file `todo.seed`:

```
// core.seed - Core domain model
app TodoList {
  entity Task {
    title: string
    done: bool = false
    due?: date
    location?: location    // Optional location
  }
}

// ui.seed - UI components
extend TodoList {
  // UI definition with theme
  ui {
    theme: "light"  // Use built-in light theme
  }

  screen Tasks {
    // List view with location awareness
    list: [title, done, due, location]
    actions: [create, toggle-done]

    // Optional map view
```

```
    map?: {
      markers: incomplete_tasks
      cluster: true
    }
  }
}
```

2. Generate the application:

```
seedml todo.seed
```

This will create a basic application with: - React + TypeScript frontend (alpha) - FastAPI backend (alpha) - MySQL database schema - Basic API documentation - Interactive maps (when location fields are used) - Geocoding support

Note: SeedML is currently in early alpha. Many features are still under development and the generated code should be reviewed carefully before use in production.

Note: Location features require a Google Maps API key. Without the key, the application will still work but location features will be disabled. Features can be enabled later by adding the API key to your environment.

Next Steps

1. Add more features to your todo app
2. Learn about Core Concepts
3. Try the First Application Tutorial

Chapter 20

docs/core-concepts/architecture.md

Chapter 21

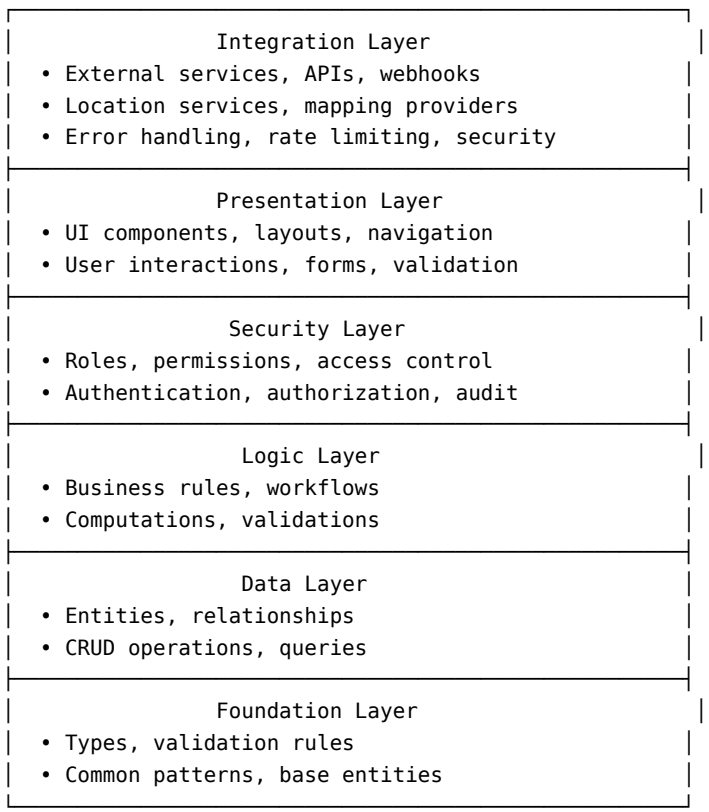
Architecture & Design

The Seed Specification Language transforms specifications into working applications through a carefully designed pipeline architecture.

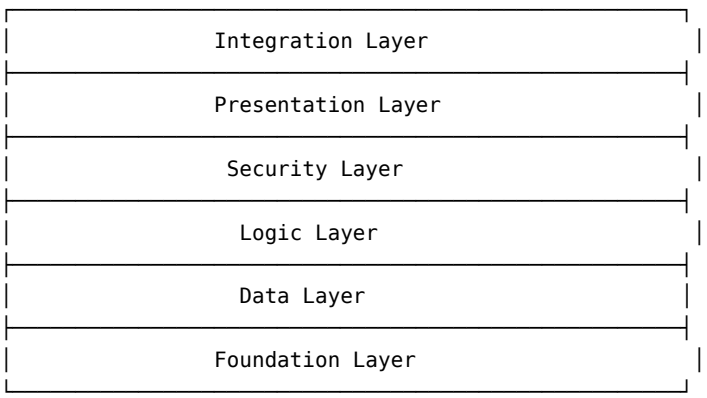
System Architecture

The Seed Specification Language follows a strict layered architecture pattern where each layer has clear responsibilities and boundaries:

Layer Dependencies



The Seed Specification Language enforces these architectural boundaries:



Each layer builds upon lower layers:

1. **Foundation Layer**
   - Type system
   - Validation rules
   - Computed fields
2. **Data Layer**
   - Independent entities
   - Dependent entities
   - Relationships
3. **Logic Layer**
   - Business rules
   - Workflows
   - Computations
4. **Security Layer**
   - Permissions
   - Roles
   - Access control
5. **Presentation Layer**
   - Screens
   - Components
   - Layouts
6. **Integration Layer**
   - External services
   - APIs
   - Events

Core Components

1. Parser & Validator

The validation pipeline ensures specifications are correct before generation:

```
class Validator:
    def validate_syntax(self, spec):
        """Check YAML syntax and structure"""
        # Verify basic YAML format
        # Check required sections
        # Validate section structure

    def validate_semantics(self, spec):
```

```
        """Verify semantic correctness"""
        # Check entity relationships
        # Validate type usage
        # Verify rule logic

    def resolve_references(self, spec):
        """Resolve all references"""
        # Link entity relationships
        # Resolve type references
        # Connect rule dependencies
```

2. Generation Engine

The generation engine handles interaction with Claude:

```
class Generator:
    def prepare_prompt(self, spec):
        """Transform spec into prompt"""
        # Break into logical chunks
        # Add context and instructions
        # Format for Claude

    def generate_code(self, prompt):
        """Generate via Claude API"""
        # Send prompt to Claude
        # Handle response streaming
        # Manage rate limits
        # Retry on failures

    def process_response(self, response):
        """Process Claude's response"""
        # Parse response format
        # Extract file content
        # Validate output
```

3. Output Processor

The output processor handles file system operations:

```
class OutputProcessor:
    def create_structure(self):
        """Create directory structure"""
        # Make directories
        # Set up config files
        # Initialize git repo

    def write_files(self, files):
        """Write files atomically"""
        # Write to temp location
        # Validate content
        # Move to final location

    def setup_project(self):
        """Configure project"""
```

```
        # Install dependencies
        # Set up tooling
        # Initialize services
```

4. Location Services

```
class LocationServices:
    def geocode(self, address):
        """Convert address to coordinates"""
        # Validate address format
        # Call geocoding service
        # Cache results

    def reverse_geocode(self, lat, lng):
        """Convert coordinates to address"""
        # Validate coordinates
        # Call reverse geocoding
        # Format response

    def validate_region(self, points):
        """Validate geographic region"""
        # Check boundary validity
        # Compute area
        # Verify constraints
```

Design Principles

1. Separation of Concerns

Each component has clear responsibilities: - **Parser**: Understanding specifications - **Generator**: Code generation - **Output**: File system management

2. Reliability

Multiple layers ensure reliable operation: - Validation before generation - Atomic file operations - Error recovery - Output verification

3. Extensibility

The system is designed for extension: - Custom validators - Template overrides - Output adapters - Plugin system

Implementation Details

1. Validation Pipeline

```
def validate_specification(spec):
    # 1. Basic syntax
    validate_yaml_syntax(spec)

    # 2. Schema validation
    validate_against_schema(spec)
```

```
    # 3. Semantic checks
    validate_semantics(spec)

    # 4. Reference resolution
    resolve_all_references(spec)
```

2. Generation Process

```
def generate_application(spec):
    # 1. Prepare context
    context = prepare_generation_context(spec)

    # 2. Generate components
    components = []
    for component in spec.components:
        result = generate_component(component, context)
        components.append(result)

    # 3. Post-process
    post_process_components(components)
```

```
# Maps Component Generation
def generate_maps_components(spec):
    # 1. Analyze location usage
    location_fields = find_location_fields(spec)

    # 2. Generate components
    for field in location_fields:
        # Generate picker component
        # Generate view component
        # Generate search component

    # 3. Generate services
    generate_location_services()
    generate_geocoding_pipeline()

    # 4. Setup integration
    configure_maps_provider()
    setup_caching()
```

3. File Management

```
def manage_output(components):
    # 1. Prepare directories
    setup_directory_structure()

    # 2. Write files
    with atomic_writer() as writer:
        for component in components:
            writer.write_component(component)

    # 3. Verify output
    verify_written_files()
```

```python
def handle_location_data(location):
    # 1. Validation
    validate_coordinates(location)

    # 2. Geocoding
    with geocoding_client() as client:
        result = client.geocode(location)

    # 3. Data enhancement
    enhance_location_data(result)

    # 4. Storage preparation
    prepare_for_storage(result)
```

Error Handling

The system uses a comprehensive error handling approach:

1. **Validation Errors**
    - Syntax errors
    - Semantic errors
    - Reference errors
2. **Generation Errors**
    - API failures
    - Context limits
    - Invalid output
3. **Output Errors**
    - File system errors
    - Permission issues
    - Verification failures

Cross-Compilation Architecture

The Seed Specification Language uses a sophisticated cross-compilation pipeline to transform declarative specifications into implementation-specific code:

Cross-Compiler Components

```
┌─────────────────────────────────────────────────────┐
│              Specification Parser                   │
│  • YAML/JSON parsing                                │
│  • Schema validation                                │
│  • Intermediate representation                      │
├─────────────────────────────────────────────────────┤
│               Template Engine                       │
│  • Implementation-specific templates                │
│  • Component generation                             │
│  • Layout processing                                │
├─────────────────────────────────────────────────────┤
│               Code Generator                        │
│  • Target platform adaptation                       │
│  • Project structure generation                     │
│  • Dependency management                            │
```

└──┘

The cross-compiler follows these key principles:

1. **Clean Separation**
   - Parser independent of implementation
   - Template system isolation
   - Generator modularity
2. **Implementation Support**
   - Multiple frontend frameworks (React, Vue, Angular)
   - Backend technology options
   - Database flexibility
3. **Template Organization**
   - Component templates
   - Layout patterns
   - Style definitions
   - Configuration templates

Cross-Compilation Process

```
class CrossCompiler:
    def compile(self, spec):
        """Transform spec to implementation"""
        # 1. Parse and validate
        ir = self.parser.parse(spec)

        # 2. Load templates
        templates = self.template_engine.load()

        # 3. Generate code
        self.generator.generate(ir, templates)
```

Future Directions

1. Near-term Improvements

- **Deterministic Generation**
  - Local generation options
  - Template-based generation
  - Hybrid approaches
- **Enhanced Validation**
  - Deep semantic analysis
  - Cross-reference checking
  - Custom rule validation

2. UI Patterns & Components

```
# Standard Screen Types
screen List {
  list: [field1, field2]        # Fields to display
  actions: [create, edit]       # Basic actions
}

screen Form {
```

```
  form: [field1, field2]        # Form fields
  actions: [save, cancel]       # Form actions
}

screen Detail {
  content: [field1, field2]     # Content fields
  actions: [edit, delete]       # Item actions
}

screen Dashboard {
  summary: [metric1, metric2]   # Key metrics
  lists: [recent, popular]      # Data lists
}

# Layout Patterns
screen OrderDetail {
  layout: split
  left: [customer, items]
  right: [summary, actions]
}

# Built-in Features
features: {
  search: true        # Search functionality
  sort: true         # Column sorting
  pagination: true   # Page navigation
}
```

3. Research Areas

- **Prompt Engineering**
  - Context optimization
  - Output consistency
  - Token efficiency
- **Code Quality**
  - Style consistency
  - Best practice enforcement
  - Security patterns
- **Location Optimization**
  - Smart geocoding caching
  - Efficient region calculations
  - Clustering algorithms
  - Distance matrix optimization

3. Tooling

- **Development Tools**
  - IDE integration
  - Live preview
  - Debug tools
- **Deployment**
  - CI/CD integration
  - Container support
  - Cloud deployment

Contributing

The architecture is designed for contribution in these areas:

1. **Core Components**
   - Validators
   - Generators
   - Processors
2. **Extensions**
   - Templates
   - Plugins
   - Tools
3. **Documentation**
   - Examples
   - Tutorials
   - Reference # Architecture

SeedML generates scalable architectures through intent-focused patterns that automatically implement proven practices.

Core Concepts

```
app ScalableApp {
  # Declare architecture needs
  architecture {
    style: microservices    # Application pattern
    scale: auto             # Infrastructure
    regions: [us, eu]       # Distribution
    resilience: high        # Reliability
  }

  # Intent-focused services
  service Orders {
    type: core          # Service classification
    scale: high         # Resource allocation
    storage: dedicated  # Data patterns
  }
}
```

Key Features

1. Application Patterns

```
architecture {
  # Smart architectural choices
  style: microservices
  patterns: [
    cqrs,              # Command/Query
    event_sourcing,    # State management
    api_gateway        # Access control
  ]
}
```

2. Scalability

```
scale {
  # Automatic scaling
  compute: auto       # Resources
  storage: replicated # Data
  cache: distributed  # Performance

  limits: {
    cpu: 80%         # Thresholds
    memory: 70%      # Monitoring
  }
}
```

3. Resilience

```
resilience {
  # Built-in reliability
  failover: automatic    # Recovery
  backup: continuous     # Data protection
  monitoring: complete   # Observability

  sla: {
    uptime: 99.9%       # Availability
    latency: 100ms      # Performance
  }
}
```

4. Distribution

```
regions {
  # Global deployment
  primary: us-east
  replicas: [eu, asia]

  routing: {
    strategy: latency    # Smart routing
    failover: nearest    # Reliability
  }
}
```

Best Practices

1. **Cloud Native**
   - Container based
   - Auto scaling
   - Service mesh
2. **Reliability First**
   - High availability
   - Disaster recovery
   - Performance monitoring
3. **Future Ready**

- Modular design
- Easy scaling
- Tech flexibility

Chapter 22

docs/core-concepts/business-rules.md

Chapter 23

Business Rules

The Seed Specification Language provides a simplified approach to business rules focused on common use cases and rapid prototyping.

Core Concepts

1. Basic Validation

```
entity User {
  email: email
  password: string

  rules {
    validate: {
      email: required,
      password: length >= 8
    }
  }
}
```

2. Simple State Transitions

```
entity Task {
  status: string = "todo"

  rules {
    start: {
      validate: status == "todo"
      then: updateStatus("in-progress")
    }

    complete: {
      validate: status == "in-progress"
      then: updateStatus("done")
    }
  }
}
```

3. Basic Computations

```
entity Invoice {
  items: [InvoiceItem]

  rules {
    calculate: {
      then: [
        updateSubtotal(sum(items.amount)),
        updateTotal(subtotal + tax)
      ]
    }
  }
}
```

Common Patterns

1. Field Validation

```
entity Product {
  rules {
    validate: {
      name: required,
      price: positive,
      stock: minimum(0)
    }
  }
}
```

2. Cross-field Validation

```
entity Booking {
  rules {
    validate: {
      endDate: after(startDate),
      capacity: lessThan(maxCapacity)
    }
  }
}
```

3. Simple Workflows

```
entity Leave {
  status: string = "requested"

  rules {
    approve: {
      validate: status == "requested"
      then: [
        updateStatus("approved"),
        notifyEmployee
      ]
```

```
    }

    reject: {
      validate: status == "requested"
      then: [
        updateStatus("rejected"),
        notifyEmployee
      ]
    }
  }
}
```

Best Practices

1. Keep Validations Simple

```
# DO - Use simple validations
entity Order {
  rules {
    submit: {
      validate: [
        items.length > 0,
        total > 0
      ]
    }
  }
}
```

2. Use Clear State Transitions

```
# DO - Simple state changes
entity Task {
  rules {
    complete: {
      validate: status == "active"
      then: updateStatus("completed")
    }
  }
}
```

3. Minimize Complexity

- Focus on common use cases
- Avoid complex validation chains
- Keep workflows linear
- Use simple state machines

4. Prefer Convention

- Use standard validation patterns
- Follow common state transitions
- Apply consistent naming

- Leverage built-in behaviors

Key Benefits

1. **Rapid Development**
   - Quick to implement
   - Easy to understand
   - Fast to modify
2. **Reduced Errors**
   - Simple validation
   - Clear state flow
   - Standard patterns
3. **Better Maintenance**
   - Less complexity
   - Standard approaches
   - Clear intent

Chapter 24

docs/core-concepts/core-qualities.md

Chapter 25

Core Qualities

SeedML is built on four fundamental qualities that make it uniquely suited for AI-native development:

1. AI-First Design

```
# Clear patterns that map to natural language
entity Order {
  # AI understands these concepts naturally
  status: enum(draft, submitted, approved)
  total: money
  customer: reference

  # Intent is clear to both AI and humans
  validate: {
    total: positive
    customer: verified
  }
}
```

Key Aspects: - Designed for AI generation and modification - Natural language mapping - Context-preserving structure - Minimal but unambiguous syntax

2. Intent Over Implementation

```
# Express what you want, not how to build it
screen Orders {
  # High-level patterns imply implementation
  list: [date, customer, total, status]
  actions: [create, approve]
  features: [search, filter, export]
}
```

Key Aspects: - Focus on business goals - Hide technical complexity - Smart pattern recognition - Progressive disclosure

3. Single Source of Truth

```
# One file describes everything
app OrderSystem {
  # All aspects in one place
  data: {
    entities: [Order, Customer]
    storage: cloud
  }

  ui: {
    screens: [dashboard, orders]
    theme: modern
  }

  rules: {
    workflow: [approve, fulfill]
    security: role_based
  }
}
```

Key Aspects: - Complete system specification - No redundancy - Automatic consistency - Clear dependencies

4. Smart Defaults

```
# Best practices built-in
entity User {
  # These imply proper handling
  email: email        # Validation included
  password: secure    # Hashing automatic
  role: admin        # Permissions set

  # Override only when needed
  name: string {
    min: 2,
    max: 50
  }
}
```

Key Aspects: - Production patterns included - Override when needed - Progressive complexity - Secure by default

Why These Matter

1. **Faster Development**
   - AI generates more accurately
   - Less boilerplate
   - Fewer decisions needed
2. **Better Quality**
   - Consistent patterns
   - Built-in best practices
   - Reduced errors
3. **Future Ready**
   - AI-native architecture

- Technology independent
- Easy to evolve # Core Qualities

SeedML ensures essential software qualities through intent-focused patterns that automatically implement best practices.

Core Concepts

```
app QualityApp {
  # Declare quality needs
  qualities {
    performance: high      # Speed focus
    reliability: 99.9%     # Uptime target
    maintainable: true     # Code quality
    testable: complete     # Coverage
  }

  # Quality-focused features
  api Orders {
    cache: smart          # Performance
    retry: automatic      # Reliability
    docs: generated       # Maintainability
    tests: integration    # Quality
  }
}
```

Key Features

1. Performance

```
performance {
  # Automatic optimization
  cache: {
    strategy: smart      # Caching
    invalidate: auto     # Freshness
  }

  optimize: {
    queries: true       # Database
    assets: true        # Frontend
    api: true          # Backend
  }
}
```

2. Reliability

```
reliability {
  # Built-in stability
  errors: {
    handling: complete    # Error management
    recovery: automatic   # Self-healing
    reporting: detailed   # Monitoring
```

```
  }

  testing: {
    unit: required       # Code quality
    integration: auto    # System health
    performance: load    # Capacity
  }
}
```

3. Maintainability

```
maintainable {
  # Code quality focus
  structure: {
    modular: true        # Organization
    documented: auto     # Understanding
    consistent: true     # Standards
  }

  practices: {
    clean: true         # Code quality
    tested: true        # Verification
    reviewed: true      # Quality control
  }
}
```

4. Testability

```
testing {
  # Comprehensive testing
  coverage: {
    unit: 80%           # Code tests
    integration: 90%    # System tests
    e2e: critical       # User flows
  }

  automation: {
    ci: full            # Integration
    deployment: safe    # Release
    monitoring: live    # Production
  }
}
```

Best Practices

1. **Quality by Design**
   - Built into patterns
   - Automated checks
   - Continuous verification
2. **Performance First**
   - Smart optimization
   - Efficient patterns

- Regular monitoring

3. **Future Ready**
   - Clean architecture
   - Full testing
   - Easy maintenance

Chapter 26

docs/core-concepts/integration.md

Chapter 27

Integration & Location Services

The Seed Specification Language simplifies external service integration and location-based features through intent-focused patterns that handle authentication, data flow, mapping, and error cases automatically.

Core Concepts

```
app MyApp {
  integrate {
    # Authentication services
    auth: {
      provider: oauth2
      features: {
        mfa: required      # Multi-factor auth
        sso: optional      # Single sign-on
        session: {
          duration: 24h    # Session length
          refresh: true    # Enable refresh
        }
      }
    }

    # Storage services
    storage: {
      provider: s3
      features: {
        cdn: enabled       # Content delivery
        sync: enabled      # File syncing
        backup: daily      # Backup schedule
      }
    }

    # Communication services
    email: {
      provider: sendgrid
      features: {
        templates: true    # Email templates
        tracking: true     # Email tracking
        analytics: basic   # Basic analytics
```

```
    }
  }

  # Payment processing
  payment: {
    provider: stripe
    features: {
      subscriptions: true  # Recurring billing
      refunds: automated   # Automated refunds
      disputes: managed    # Dispute handling
    }
  }
}

# Intent-focused usage
entity Order {
  on create {
    notify: email     # Automatic handling
    track: analytics  # Built-in integration
  }
}

# Maps Integration
integrate {
  maps: google {
    key: env.GOOGLE_MAPS_KEY
    features: [
      maps,      # Basic mapping
      places,    # Places API
      geocoding  # Address lookup
    ]
  }
}

# Intent-focused location usage
entity Store {
  location: location
  on save {
    geocode: address    # Automatic geocoding
    validate: region    # Location validation
  }
}
}
```

Key Features

1. Smart Authentication

```
auth {
  # Complete auth patterns
  type: oauth
  providers: [google, github]
  features: [mfa, sso]     # Security included
```

```
}
```

2. Data Integration

```
storage {
  # Automatic data handling
  files: s3          # Cloud storage
  cache: redis       # Performance
  search: elastic    # Advanced features
}
```

3. Service Communication

```
services {
  # Intent-based integration
  weather: {
    provider: openweather
    cache: 30min          # Smart caching
    retry: automatic      # Error handling
  }
}
```

4. Location Services

```
class LocationServices {
    def geocode(self, address):
        """Convert address to coordinates"""
        # Validate address format
        # Call geocoding service
        # Cache results

    def reverse_geocode(self, lat, lng):
        """Convert coordinates to address"""
        # Validate coordinates
        # Call reverse geocoding
        # Format response

    def validate_region(self, points):
        """Validate geographic region"""
        # Check boundary validity
        # Compute area
        # Verify constraints
}
```

5. Event Handling

```
events {
  # Declarative event processing
  'order.created': [
    notify@customer,
    update@inventory,
    track@analytics
```

```
  ]

  'payment.failed': {
    retry: 3,
    notify: [customer, support],
    timeout: 1h
  }
}
```

6. Maps Integration

```
maps {
  # Complete mapping patterns
  features: {
    view: {
      clustering: auto     # Smart clustering
      bounds: dynamic     # Auto-fitting
      controls: standard  # Default controls
    }
    search: {
      radius: 5km        # Search radius
      filters: [type]    # Place filtering
    }
    interaction: {
      select: single     # Selection mode
      draw: polygon      # Drawing tools
    }
  }
}

# Usage patterns
screen StoreLocator {
  map: {
    markers: Store.all
    cluster: true
    search: {
      radius: 10km
      types: [retail]
    }
  }
}
```

6. Location Services

```
# Location-based Integration
entity DeliveryZone {
  region: region
  rules {
    validate: {
      location: within(region)
      distance: <= max_range
    }
    compute: {
```

```
      coverage: area(region)
      stores: find_in(region)
    }
  }
}

# Maps Customization
maps {
  style: {
    theme: light/dark
    colors: custom
    features: [poi, transit]
  }
  controls: {
    position: top_left
    types: [zoom, search]
  }
  behavior: {
    zoom: [min, max]
    scroll: disabled
    gesture: enabled
  }
}
```

events { # Declarative event processing ‘order.created’: [notify@customer, update@inventory, track@analytics]

‘payment.failed’: { retry: 3, notify: [customer, support], timeout: 1h } } “‘

Best Practices

1. **Express Intent**
   - Declare service needs
   - Focus on business logic
   - Trust smart handling
2. **Security First**
   - Automatic encryption
   - Credential management
   - Access control
3. **Reliability**
   - Smart retries
   - Error handling
   - Monitoring included
4. **Maps Integration**
   - Use appropriate clustering for large datasets
   - Implement proper error handling for geocoding
   - Consider mobile-friendly controls
   - Cache geocoding results
   - Optimize marker rendering
   - Handle offline scenarios

Chapter 28

docs/core-concepts/language-structure.md

Chapter 29

Intent-Focused Language Structure

The Seed Specification Language lets you express what you want to build, not how to build it.

Core Principles

1. Express Intent, Not Implementation

```
// Just describe what you want
app TodoList {
  // Core data
  entity Task {
    title: string
    done: bool
    due?: date
  }

  // User interface
  screen Tasks {
    list: [title, done, due]
    actions: [create, complete]
  }
}

// SeedML infers the rest:
// - Database schema
// - API endpoints
// - UI components
// - Business logic
// - Validation
// - Error handling
```

2. Progressive Complexity

Start simple, add detail only when needed:

```
// Minimal version
entity User {
  name: string
```

```
  email: email
}

// Add validation when needed
entity User {
  name: string {
    min: 2
    max: 50
  }
  email: email {
    unique: true
    domain: company.com
  }
}

// Add behavior when needed
entity User {
  name: string
  email: email

  rules {
    on_create: send_welcome_email
    on_delete: archive_data
  }

  compute {
    full_name: name + " " + surname
    age: birthday.years_since()
  }
}
```

3. Smart Composition

Combine patterns to express complex intent:

```
app OrderSystem {
  // Core domain
  entity Order {
    status: draft->submitted->approved
    items: [OrderItem]
    total: money
  }

  // Business rules
  rules {
    submit: {
      require: [
        items.length > 0,
        total > 0
      ]
      then: notify@customer
    }
  }
```

```
  // User interface
  screen Orders {
    list: [id, customer, total, status]
    actions: [create, submit, approve]
  }

  // Integration
  integrate {
    payment: stripe {
      on: order.submit
      charge: total
    }
  }
}
```

Key Components

1. Domain Model

Define your core business entities:

```
entity Product {
  name: string
  price: money
  category: electronics/books/clothing

  # Relations
  vendor: Vendor
  reviews: [Review]
}
```

2. Business Rules

Express logic and workflows:

```
rules {
  approve_order: {
    when: status -> approved
    require: [
      total < 10000,
      items.all(in_stock)
    ]
    then: [
      notify@customer,
      update@inventory
    ]
  }
}
```

3. User Interface

Define screens and interactions:

```
screen Products {
  # Layout
```

```
  layout: grid(3)

  # Data display
  show: [image, name, price]

  # User actions
  actions: [
    create: button,
    edit: menu,
    delete: confirm
  ]

  # Behavior
  search: [name, category]
  sort: price
  filter: category
}
```

4. Integration

Connect external services:

```
integrate {
  # Authentication
  auth: {
    provider: google
    roles: [user, admin]
  }

  # Storage
  files: s3 {
    bucket: uploads
    types: [image, pdf]
  }

  # Notifications
  notify: {
    email: sendgrid
    sms: twilio
  }
}
```

Best Practices

1. **Start Simple**
   - Begin with core entities
   - Add complexity gradually
   - Let defaults work for you
2. **Focus on Intent**
   - Describe what, not how
   - Use business terminology
   - Express natural workflows
3. **Leverage Patterns**

- Use built-in components
- Combine existing patterns
- Stay consistent

4. **Think in Domains**
   - Model business concepts
   - Group related features
   - Maintain boundaries

Chapter 30

docs/core-concepts/modular-apps.md

Chapter 31

Modular App Specifications

The Seed language supports splitting app definitions across multiple files using the `extend` keyword. This enables better organization, team collaboration, and reuse of components.

Basic Usage

```
# core.seed - Core app definition
app MyApp {
  entity User {
    name: string
    email: email
  }
}

# ui.seed - UI components
extend MyApp {
  screen Users {
    list: [name, email]
    actions: [create, edit]
  }
}

# rules.seed - Business rules
extend MyApp {
  rules {
    validateEmail: {
      when: email.changed
      validate: email.format
    }
  }
}
```

Key Benefits

1. **Separation of Concerns**
   - Split specifications by feature
   - Organize by team responsibility

    - Maintain focus in each file
2. **Team Collaboration**
    - UI team works on screens
    - Backend team handles data model
    - Rules team manages business logic
3. **Reusability**
    - Share common components
    - Create feature libraries
    - Mix and match modules

File Organization

Recommended file organization:

```
myapp/
  ├── core.seed      # Core app definition
  ├── ui/
  │   ├── admin.seed    # Admin screens
  │   └── public.seed   # Public screens
  ├── rules/
  │   ├── auth.seed     # Auth rules
  │   └── billing.seed  # Billing rules
  └── api/
      └── external.seed # External APIs
```

Loading Order

Files are loaded in this order:

1. Core app definition (app keyword)
2. Extensions (`extend` keyword) in alphabetical order
3. Feature modules
4. Component libraries
5. Integration modules

Validation

The system ensures:

1. **Consistency**
    - No conflicting definitions
    - Valid references
    - Complete dependencies
2. **Uniqueness**
    - No duplicate entities
    - Unique component names
    - Distinct rule names
3. **Dependencies**
    - Core app exists
    - Required modules present
    - Valid references

Best Practices

1. **File Naming**
   - Use descriptive names
   - Group related files
   - Follow consistent patterns
2. **Module Size**
   - Keep files focused
   - Split large modules
   - Group related features
3. **Dependencies**
   - Minimize coupling
   - Clear dependencies
   - Explicit imports

Chapter 32

docs/core-concepts/overview.md

Chapter 33

Core Concepts

SeedML is built on simple but powerful concepts that work together:

Modular Apps

Split app definitions across multiple files for better organization and team collaboration. See Modular Apps for details.

Key Ideas

```
# Everything in one place
app TodoList {
  # Data model
  entity Task {
    title: string
    done: bool
  }

  # Business rules
  rules {
    complete: {
      validate: !done
      then: done = true
    }
  }

  # User interface
  screen Tasks {
    list: [title, done]
    actions: [create, complete]
  }
}
```

Core Features

1. **Smart Defaults**
    - Production patterns built-in

    - Override only when needed
    - Progressive enhancement
2. **Clear Intent**
    - Express what you want
    - Not how to build it
    - Natural language
3. **Full Stack**
    - One specification
    - Complete application
    - Modern tech stack

Learn More

1. Type System
    - Basic types
    - Validation
    - Relationships
2. Business Rules
    - Simple validation
    - Clear workflows
    - Computed fields
3. UI Patterns
    - Standard layouts
    - Common components
    - Best practices
4. Theming
    - Hierarchical themes
    - Simple overrides
    - Visual consistency

Chapter 34

docs/core-concepts/security.md

Chapter 35

Security

The Seed Specification Language implements comprehensive security patterns to protect applications and data.

Access Control

1. Role-Based Access

```
app SecureApp {
  # Define roles
  roles: {
    admin: full_access,
    manager: [read_all, write_own],
    user: read_own
  }

  entity Document {
    access: {
      view: authenticated
      edit: role.manager
      delete: role.admin
    }

    fields: {
      total: view@finance,
      notes: edit@owner
    }
  }
}
```

2. Data-Level Security

```
entity Order {
  # Row-level security
  access: {
    view: owner or role.manager
    edit: owner and status == draft
  }
```

```
  # Field-level security
  fields: {
    total: view@finance,
    notes: edit@owner
  }
}
```

Authentication

1. Configuration

```
auth {
  providers: [
    oauth: [google, github],
    saml: corporate,
    mfa: optional
  ]

  session: {
    duration: 24h
    refresh: true
    secure: true
  }
}
```

2. User Management

```
entity User {
  auth: {
    password: {
      min_length: 12
      require: [letter, number, special]
      expire: 90d
    }

    mfa: {
      methods: [app, sms]
      required: role.admin
    }
  }
}
```

Data Protection

1. Encryption

```
entity Customer {
  # Field encryption
  fields: {
    ssn: encrypted,
    card: encrypted(PCI)
```

```
  }

  # Data classification
  classify: {
    pii: [name, email, phone],
    sensitive: [ssn, card]
  }
}
```

2. Audit Trails

```
audit {
  # What to track
  track: [
    data_access,
    changes,
    auth_events
  ]

  # How to store
  store: {
    retention: 1y
    tamper_proof: true
  }
}
```

3. Location Privacy

```
entity UserLocation {
  # Location privacy controls
  location: location {
    precision: reduced     # Reduce coordinate precision
    mask: radius(1km)     # Area-based masking
    share: opt_in         # Explicit sharing consent
  }

  # Data classification
  classify: {
    location: sensitive,
    history: restricted,
    patterns: protected
  }

  # Access controls
  access: {
    exact: role.admin,
    approximate: authenticated,
    history: owner
  }
}

# Location data lifecycle
location_data {
```

```
  retention: {
    live: 30d,            # Live data retention
    history: 90d,         # Historical data
    analytics: 1y         # Aggregated data
  }

  disposal: {
    method: secure_erase,
    schedule: automatic,
    audit: required
  }
}
```

Best Practices

1. **Authentication**
   - Strong password policies
   - Multi-factor authentication
   - Secure session management
   - Regular credential rotation

Chapter 36

Maps API security

maps_api { keys: { rotation: 90d, # Key rotation period restrict: { domains: [list], # Domain restrictions usage: rate_limit, # Usage limits features: minimal # Minimal permissions } }

requests: { sign: required, # Request signing encrypt: transit, # Transport encryption validate: origin # Origin validation } }

Chapter 37

Location audit

audit { track: [location.access, # Location data access location.changes, # Location updates boundary.cross, # Region transitions pattern.detect # Movement patterns]

location_events: { precision: city, # Audit trail precision retain: 1y, # Retention period encrypt: always # Encryption requirement } }

2. **Authorization**
    - Principle of least privilege
    - Granular permissions
    - Context-aware access
    - Regular access review
3. **Data Security**
    - Encryption at rest
    - Encryption in transit
    - Secure key management
    - Data classification
4. **Operational Security**
    - Security logging
    - Intrusion detection
    - Regular audits
    - Incident response
5. **Location Data Security**
    - Data Collection • Collect minimum necessary data • Clear consent requirements • Purpose specification • Retention limits
    - Data Access • Role-based access control • Location data masking • Audit trail requirement • Privacy by default
    - Data Storage • Encrypted at rest • Secure transmission • Geographic restrictions • Backup controls
    - Data Usage • Purpose limitations • Usage transparency • Access notifications • Pattern detection alerts # Security

SeedML provides comprehensive security through intent-focused patterns that automatically implement industry best practices.

Core Concepts

```
app SecureApp {
  # Declare security needs
  security {
```

```
    auth: [oauth2, mfa]     # Authentication
    roles: [admin, user]    # Authorization
    audit: all              # Logging
    encrypt: sensitive      # Data protection
  }

  # Intent-focused usage
  entity Payment {
    amount: money
    card: encrypted     # Automatic protection
    access: admin      # Role-based control
  }
}
```

Key Features

1. Authentication

```
auth {
  # Complete auth patterns
  type: oauth2
  providers: [google, github]
  features: [
    mfa,              # Multi-factor
    sso,              # Single sign-on
    passwordless      # Modern auth
  ]
}
```

2. Authorization

```
roles {
  # Declarative permissions
  admin: {
    access: all
    except: [audit.delete]
  }

  manager: {
    create: [orders, reports]
    approve: expenses
  }
}
```

3. Data Protection

```
protect {
  # Automatic encryption
  fields: {
    pii: encrypted       # Personal data
    card: tokenized      # Payment info
    notes: redacted      # Sensitive text
```

```
  }

  backup: encrypted      # Data at rest
  transit: tls          # Data in motion
}
```

4. Audit Logging

```
audit {
  # Comprehensive tracking
  track: [
    auth.login,          # Access events
    data.modify,         # Changes
    api.access           # Usage
  ]

  retain: 1year          # Compliance
  alert: suspicious      # Monitoring
}
```

Best Practices

1. **Security by Default**
   - Everything private unless exposed
   - Encryption always on
   - Least privilege access
2. **Compliance Ready**
   - GDPR patterns built-in
   - Audit trails automatic
   - Data protection standard
3. **Modern Standards**
   - Zero trust architecture
   - Defense in depth
   - Regular updates

Chapter 38

docs/core-concepts/smart-defaults.md

Chapter 39

Smart Defaults

SeedML reduces boilerplate through intelligent defaults while maintaining flexibility for custom configurations.

Core Principles

1. Convention Over Configuration

SeedML follows established patterns and best practices by default:

```
entity User {
  name: string      # Implies: required, indexed
  email: email      # Implies: unique, validated
  created: timestamp  # Implies: auto-set, immutable
}
```

2. Progressive Complexity

Start simple and add complexity only when needed:

```
# Simple case - uses all defaults
entity Product {
  name: string
  price: money
}

# Complex case - custom configuration
entity Product {
  name: string {
    min: 3
    max: 100
    format: title_case
  }
  price: money {
    min: 0
    precision: 2
    currency: USD
  }
}
```

3. Contextual Awareness

Defaults change based on context:

```
entity Order {
  status: draft->submitted->approved
  # Implies:
  # - State machine behavior
  # - Status validation
  # - Transition hooks
  # - Audit logging
  # - UI status indicators
}
```

Common Default Patterns

1. Type-Based Defaults

Each type comes with sensible defaults:

- `string`: Required, trimmed, max length
- `email`: Unique, validated format
- `money`: Non-negative, precision(2)
- `date`: Valid range, proper formatting
- `phone`: Format validation, optional
- `location`: Validated coordinates, geocoding, map display
- `region`: Boundary validation, area calculation
- `distance`: Unit conversion, formatting

```
# Location type implications
location: {
  validation: coordinates
  geocoding: automatic
  reverse: on_save
  format: address
}

region: {
  validation: boundary
  calculation: area
  contains: points
}

distance: {
  conversion: automatic
  display: localized
}
```

2. UI Patterns

Standard UI components with smart defaults:

```
screen Products {
  list: [name, price]  # Implies:
  # - Pagination
  # - Sorting
```

```
  # - Search
  # - Responsive layout
}

# Map components with smart defaults
screen Locations {
  map: [location] # Implies:
  # - Marker clustering
  # - Bounds fitting
  # - Zoom controls
  # - Mobile gestures
  # - Location search
  # - Responsive layout
}

# Progressive map enhancement
map: {
  basic: location        # Single marker
  multiple: [location]   # Clustered markers
  interactive: selector  # Location picker
  advanced: {           # Full features
    cluster: true
    search: radius
    draw: regions
  }
}
```

3. Business Logic

Common business patterns are built-in:

```
entity Invoice {
  status: draft->submitted->approved
  # Implies:
  # - State transitions
  # - Validation rules
  # - Notifications
  # - Audit trails
}

entity Store {
  location: location
  # Implies:
  # - Distance calculations
  # - Geocoding pipeline
  # - Region validation
  # - Location indexing
  # - Search optimization
}

# Location-aware rules
rules {
  within_region: true    # Region containment
  distance_calc: auto    # Distance computation
```

```
  geo_index: enabled     # Spatial indexing
}
```

4. Security

Security best practices by default:

```
entity Document {
  access: role.manager
  # Implies:
  # - Role-based access control
  # - Permission checking
  # - Audit logging
  # - Data filtering
}

location_data {
  access: restricted
  # Implies:
  # - Coordinate precision control
  # - Address masking
  # - Usage tracking
  # - API key management
}
```

Overriding Defaults

When defaults don't fit, explicit configuration takes precedence:

```
entity CustomProduct {
  # Override string defaults
  name: string {
    required: false
    max: 500
    format: custom_regex("[A-Z].*")
  }

  # Override money defaults
  price: money {
    min: -1000  # Allow negative
    precision: 4  # 4 decimal places
  }

  # Override timestamp defaults
  created: timestamp {
    auto: false
    mutable: true
  }
}
```

Benefits

1. Faster Development

    - Less boilerplate code
    - Fewer decisions needed
    - Quick prototyping
2. Consistency
    - Standard patterns
    - Best practices built-in
    - Uniform behavior
3. Maintainability
    - Clear override points
    - Documented defaults
    - Centralized configuration
4. Security
    - Secure by default
    - Best practices enforced
    - Explicit overrides needed

Chapter 40

docs/core-concepts/theming.md

Chapter 41

Theming

Seed Spec provides themes through its standard library (`src/stdlib/themes.seed`) that controls all visual aspects of your application. These themes are part of the standard library and provide a simple hierarchical theming system.

Basic Usage

```
app MyApp {
  ui {
    theme: "light"  # Use built-in light theme
  }
}
```

Theme Properties

Seed Spec includes a standard library of production-ready themes. The built-in themes include:

- modern-light
- modern-dark
- classic-light
- classic-dark
- minimal
- corporate

Each theme controls these visual aspects:

Colors

```
colors:
  primary: "#0066cc"
  secondary: "#6c757d"
  background: "#ffffff"
  surface: "#f8f9fa"
  text: "#212529"
  error: "#dc3545"
  warning: "#ffc107"
  success: "#28a745"
```

Typography

```yaml
typography:
  fontFamily:
    base: "Inter, system-ui, sans-serif"
    heading: "Poppins, sans-serif"
  fontSize:
    xs: "0.75rem"
    sm: "0.875rem"
    base: "1rem"
    lg: "1.125rem"
    xl: "1.25rem"
  fontWeight:
    normal: "400"
    medium: "500"
    bold: "700"
  lineHeight:
    tight: "1.25"
    normal: "1.5"
    relaxed: "1.75"
```

Spacing

```yaml
spacing:
  xs: "0.25rem"
  sm: "0.5rem"
  md: "1rem"
  lg: "1.5rem"
  xl: "2rem"
  xxl: "3rem"
```

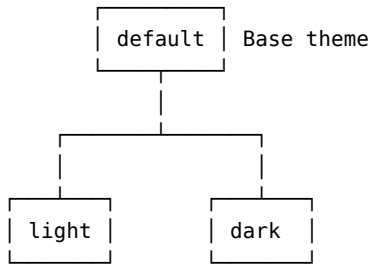
Borders & Shadows

```yaml
borders:
  radius:
    sm: "0.25rem"
    md: "0.5rem"
    lg: "1rem"
    full: "9999px"
  width:
    thin: "1px"
    medium: "2px"
    thick: "4px"

shadows:
  sm: "0 1px 2px rgba(0,0,0,0.05)"
  md: "0 4px 6px rgba(0,0,0,0.1)"
  lg: "0 10px 15px rgba(0,0,0,0.1)"
```

Theme Hierarchy

Themes inherit from parent themes:



Theme Usage

Use a standard theme with optional overrides:

```
app MyApp {
  // Use a standard theme
  theme: "modern-light"
}

// Or with overrides
app CustomApp {
  theme: "modern-light" {
    colors: {
      primary: "#0066cc"
      accent: "#ff4081"
    }
    typography: {
      fontFamily: {
        base: "Roboto, sans-serif"
      }
    }
  }
}

// Or create a custom theme extending a base
theme CustomTheme {
  extends: "modern-light"
  colors: {
    primary: "#0066cc"
    // ... other overrides
  }
}
```

Smart Defaults

The theme system follows Seed’s smart defaults principle: - Built-in themes provide production-ready styling - Override only what needs to be different - Maintain consistent visual patterns

---

Chapter 42

docs/core-concepts/type-system.md

Chapter 43

Type System

The Seed Specification Language's type system combines simplicity with power.

Core Types

```
// Basic Types
string              // Text
number              // Numbers
bool                // True/False
date                // Dates
time                // Time
datetime            // Date+Time
money               // Currency
email               // Email
phone               // Phone
url                 // URLs

// Complex Types
[Type]              // Lists
Type?               // Optional
Type!               // Required
map<Key,Value>      // Maps
enum(v1,v2)         // Enums

// Special Types
id                  // Unique IDs
timestamp           // Timestamps
file                // Files
image               // Images

// Location Types
location            // Geographic coordinates with address
place               // Place details with metadata
region              // Geographic boundary
distance            // Distance with units
```

Type Usage

```
// Validation
age: number {
  min: 0
  max: 150
}

// Collections
tags: [string]
metadata: map<string,any>

// Inference
entity Product {
  price: 0.00      // money
  created: now()    // timestamp
  active: true     // bool
}
```

Location Type System

```
# Location Types
location {
  lat: number        # Latitude
  lng: number        # Longitude
  address?: string   # Optional formatted address
  placeId?: string   # Optional place identifier
}

place {
  location: location
  name: string
  type: string
  metadata: map<string, any>
}

region {
  type: circle/polygon/bounds
  center?: location   # For circle
  radius?: distance   # For circle
  points?: [location] # For polygon
  bounds?: {          # For bounds
    ne: location
    sw: location
  }
}

distance {
  value: number
  unit: km/mi/m
}
```

```
# Location Validation
location {
  within: region          # Must be within region
  near: location, radius  # Must be near point
  type: business/postal   # Place type constraints
}

# Location Formatting
location {
  format: full/short     # Address format
  components: [street, city, country]
  language: string       # Localization
}

# Usage Examples
stores: [location]           # List of locations
coverage: region            # Service area
distance: number as km      # Distance in kilometers

entity Store {
  location: location {
    within: service_area
    type: commercial
  }
  compute {
    distance: from(user.location)
    nearby: stores.within(5km)
    region: coverage_area()
  }
}
```

Custom & Composite Types

```
# Custom Types
types {
  Currency: money {
    precision: 2
    positive: true
  }
  Status: enum(active, pending)
}

# Composition
entity Order {
  items: [{
    product: Product
    quantity: number > 0
    price: Currency
  }]
  shipping: {
    address: Address
    method: standard/express
```

```
  }
}
```

Benefits

- Type Safety: Compile-time & runtime validation
- Clear Modeling: Self-documenting schemas
- Code Generation: DB, API, UI components
- IDE Support: Completion, validation, docs

Chapter 44

docs/patterns/advanced-patterns.md

Chapter 45

Advanced SeedML Patterns

This guide covers advanced patterns and techniques for building sophisticated applications with SeedML.

Multi-Tenant Architecture

```
app MultiTenantSaaS {
  # Tenant configuration
  tenant {
    isolation: schema  # or: database, row
    routing: subdomain
    customization: {
      branding: true
      fields: true
    }
  }

  # Tenant-aware entity
  entity Document {
    tenant: Tenant
    name: string
    content: text

    access: tenant.users
  }
}
```

Complex Workflows

```
app ApprovalSystem {
  # State machine with parallel tracks
  entity Request {
    status: {
      main: draft->submitted->approved,
      finance: pending->reviewed->cleared,
      legal: waiting->checked->signed
    }
```

```
    rules {
      approve: {
        require: [
          finance.cleared,
          legal.signed,
          role.manager
        ]
      }
    }
  }
}
```

Plugin Architecture

```
app PluggableSystem {
  # Plugin system
  plugins {
    types: [ui, logic, data]
    isolation: process
    permissions: restricted
  }

  # Plugin hooks
  hooks {
    beforeCreate: [validate, enrich]
    afterUpdate: [notify, sync]
    onError: [log, retry]
  }
}
```

Event Sourcing

```
app EventSourced {
  # Event definitions
  events {
    OrderCreated: {
      order_id: id
      items: [Product]
      total: money
    }

    OrderShipped: {
      order_id: id
      tracking: string
      carrier: enum
    }
  }

  events {
    order.created: [
      notify@customer,
```

```
      update@inventory,
      track@analytics
    ]

    order.shipped: {
      handler: [
        update@status,
        send@tracking,
        notify@customer
      ]
      retry: {
        attempts: 3
        backoff: exponential
      }
    }
  }
}
```

AI Integration

```
app AIEnhanced {
  # AI field types
  entity Content {
    text: ai.text {
      analyze: sentiment
      extract: [topics, entities]
      suggest: tags
    }

    image: ai.image {
      detect: [objects, faces, text]
      moderate: inappropriate
      enhance: quality
    }
  }

  # AI-powered rules
  rules {
    categorize: {
      using: ai.classifier
      model: content-type
      threshold: 0.8
    }
  }
}
```

Time-Based Patterns

```
app TimeAware {
  # Scheduling
  schedule {
```

```
    daily: [
      cleanupTemp,
      updateStats
    ]
    weekly: generateReport
    custom: "0 9 * * 1-5"  # Cron
  }

  # Temporal rules
  entity Contract {
    valid: daterange

    rules {
      approve: {
        require: within@businessHours
        deadline: 2@businessDays
      }
    }
  }
}
```

Best Practices

1. **Plugin Design**
   - Use clear interfaces
   - Implement security boundaries
   - Handle failures gracefully
   - Version plugin APIs
2. **Event Sourcing**
   - Keep events immutable
   - Use meaningful event names
   - Include all relevant data
   - Handle idempotency
3. **AI Integration**
   - Set confidence thresholds
   - Handle AI failures
   - Respect privacy concerns
   - Monitor AI performance
4. **Time Management**
   - Consider timezones
   - Handle business calendars
   - Plan for failures
   - Monitor long-running tasks

Chapter 46

docs/reference/cli.md

Chapter 47

Command Line Interface

SeedML CLI focuses on simplicity with smart defaults. Most commands require minimal configuration.

Quick Start

```
// Generate app from spec (uses all smart defaults)
seedml create myapp.seed

// Run the generated app
cd myapp
seedml run
```

Essential Commands

```
seedml create <spec>     # Generate new app from spec(s)
seedml extend <app>      # Add components to existing app
seedml run              # Run the app locally
seedml deploy           # Deploy to production
seedml test             # Run all tests
```

Location Commands

```
seedml geocode <file>    # Batch geocode addresses
seedml regions verify    # Verify region definitions
seedml maps cache clear  # Clear geocoding cache
seedml maps config test  # Test maps configuration
```

Maps Configuration

Configure maps features through command line options or environment variables:

```
// Provider Selection
--maps-provider google|mapbox|osm  // Select maps provider
--maps-version latest|legacy       // API version
```

```
// Geocoding Options
--geocoding-cache true|false       // Enable caching
--geocoding-precision high|normal  // Coordinate precision
--geocoding-regions [codes]        // Restrict to regions

// Performance
--maps-clustering auto|manual      // Clustering strategy
--maps-cache-size 100MB           // Cache size limit
--maps-rate-limit 100/min         // API rate limit
```

Configuration

Configuration uses smart defaults - override only when needed:

```
// Environment (optional)
export SEEDML_ENV=dev              // dev/staging/prod
export ANTHROPIC_API_KEY=xxx       // For AI features
export GOOGLE_MAPS_KEY=xxx         // For maps features
export MAPS_CACHE_DIR=./cache      // For geocoding cache

// Command options (all optional)
seedml create myapp.seed \
  --stack modern                   // Use latest tech stack
  --db postgres                    // Override default DB
  --port 3000                      // Override default port
  --maps-provider google           // Maps provider
  --geocoding-strategy cached      // Geocoding approach
```

Generated Stack

The CLI generates a complete, production-ready application with:

- Modern frontend (React + TypeScript)
- API backend (FastAPI)
- Database (PostgreSQL)
- Authentication
- Testing
- Documentation
- Deployment configs
- Maps components and services
- Geocoding pipeline
- Location caching system

All components use battle-tested patterns and best practices by default.

Learn More

- Quick Start Guide
- Configuration Guide
- Deployment Guide

Chapter 48

docs/reference/patterns.md

Chapter 49

Application Patterns

SeedML provides built-in patterns organized by architectural layer. These patterns ensure consistency and best practices across applications.

Foundation Layer Patterns

```
# Base entity pattern
entity BaseEntity {
  id: uuid
  created_at: timestamp = now()
  created_by: User
  updated_at: timestamp
  updated_by: User
  version: int = 1
}

# Common validation patterns
validation {
  required: field != null
  format: matches(pattern)
  range: between(min, max)
  money: positive and precision(2)
  quantity: positive and <= stock
}

# Error handling patterns
error_handling {
  retry: {
    attempts: 3
    backoff: exponential
    notify: on_final_failure
  }
  validation: {
    collect_all: true
    format: standard_error
  }
}
```

1. Foundation Patterns

```
# Type patterns
types {
  Email: string { format: email }
  Money: number { precision: 2 }
  Status: enum(active, inactive)
}

# Validation patterns
validate {
  required: field != null
  format: matches(pattern)
  range: between(min, max)
}
```

2. Data Patterns

```
# Entity patterns
entity Base {
  id: uuid
  created: timestamp
  updated: timestamp
}

# Relationship patterns
relationships {
  one_to_many: [parent->children]
  many_to_many: [products<->categories]
}
```

3. Logic Patterns

```
# Business rule patterns
rules {
  validation: require(condition)
  workflow: state->next_state
  computation: derived = formula
}
```

4. Security Patterns

```
# Permission patterns
permissions {
  entity_level: {
    entity: Type
    actions: [create, read, update]
  }
}
```

```
# Role patterns
roles {
  hierarchical: [admin->manager->user]
  functional: [billing, support, sales]
}
```

5. Presentation Patterns

```
# UI patterns
screens {
  layouts: [list, detail, dashboard]
  components: [table, form, chart]
  navigation: [menu, tabs, breadcrumbs]
}
```

6. Integration Patterns

```
# External service patterns
integrate {
  apis: [rest, graphql]
  events: [webhook, queue]
  sync: [batch, realtime]
}
```

CRUD Operations

```
# Basic CRUD pattern
entity Product {
  name: string
  price: money
  status: active/inactive = active
}

screen Products {
  list: [name, price, status]
  search: [name, status]
  actions: [create, edit, delete]
}
```

Workflow Management

```
# State machine workflow
entity Order {
  status: draft->submitted->approved->shipped

  rules {
    submit: {
      require: [items.valid, total > 0]
      then: notify@manager
```

```
    }
    approve: {
      require: role.manager
      then: [create@invoice, notify@customer]
    }
  }
}
```

Dashboard Layouts

```
screen Dashboard {
  layout: grid(2x2)

  widgets: [
    {
      type: counter
      data: Orders.count(today)
      compare: yesterday
    },
    {
      type: chart
      data: Sales.by(month)
      range: last_6_months
    }
  ]
}
```

Form Handling

```
screen OrderForm {
  form: {
    sections: [
      customer: [name!, email!, phone?],
      items: editable_table,
      notes: textarea
    ]

    validation: inline
    actions: [save_draft, submit]
  }
}
```

Search and Filter

```
screen Products {
  search: {
    quick: [name, sku]
    filters: {
      category: select,
      price: range,
```

```
      status: multiple
    }
    sort: [name, -created]
  }
}
```

Access Control

```
app Portal {
  roles: [admin, manager, user]

  entity Document {
    access: {
      view: authenticated
      edit: role.manager
      delete: role.admin
    }
  }
}
```

Integration Patterns

```
integrate {
  # Event-driven integration
  stripe: {
    on: payment.success
    then: [approve@order, notify@customer]
  }

  # API integration
  weather: {
    url: "https://api.weather.com"
    cache: 30min
    retry: 3
  }
}
```

Multi-tenant Patterns

```
app SaaS {
  tenant {
    isolation: schema  # or: database, row
    routing: subdomain

    customize: {
      branding: true
      fields: true
    }
  }
```

```
  entity Document {
    tenant: Tenant
    access: tenant.users
  }
}
```

Best Practices

1. **Pattern Selection**
   - Use built-in patterns when possible
   - Customize only when needed
   - Maintain consistency across app
2. **Pattern Composition**
   - Combine patterns effectively
   - Keep patterns focused
   - Document custom patterns
3. **Pattern Evolution**
   - Start simple
   - Add complexity gradually
   - Refactor when needed

Chapter 50

docs/reference/types.md

Chapter 51

Type System Reference

Core Types

```
# Simplified primitive types
types {
  string              # Text values
  number              # Numeric values
  bool                # True/false values
  date                # Simple dates
}

# Common domain types
types {
  email               # Email addresses
  phone               # Phone numbers
  money               # Currency values
}

# Simple collections
[Type]                # Lists of values
Type                  # References to entities

# Optional/Required modifiers
Type?                 # Optional value
Type = default        # Default value
```

Basic Validation

```
# Simple validation rules
string {
  validate: {
    required: bool     # Field is required
    unique: bool       # Values must be unique
    min: number        # Minimum length
    max: number        # Maximum length
  }
}
```

```
number {
  min: number       # Minimum value
  max: number       # Maximum value
}

# Format validation
email: string       # Validates email format
phone: string       # Validates phone format
money: number       # Validates currency format
```

Type Inference

SeedML automatically infers types in many contexts:

```
entity Product {
  price: 0.00      # Inferred: money
  created: now()    # Inferred: timestamp
  active: true     # Inferred: boolean
  tags: []         # Inferred: [string]
}
```

Custom Types

Define reusable custom types:

```
types {
  # Simple custom type
  Currency: money {
    precision: 2
    positive: true
  }

  # Complex custom type
  Address: {
    street: string!
    city: string!
    state: enum(...)
    zip: string {
      pattern: "\\d{5}"
    }
  }

  # Enum type
  Status: enum(
    active: "Active",
    inactive: "Inactive",
    pending: "Pending Review"
  )
}
```

Type Composition

Build complex types through composition:

```
entity Order {
  # Nested structure
  shipping: {
    address: Address
    method: ShippingMethod
    tracking?: string
  }

  # List of complex items
  items: [{
    product: Product
    quantity: int > 0
    price: Currency
  }]
}
```

Best Practices

1. **Type Selection**
   - Use specific types over generic ones
   - Consider validation requirements
   - Think about UI rendering
   - Plan for future needs
2. **Validation**
   - Add constraints appropriately
   - Use built-in validations
   - Create reusable types
   - Document custom types
3. **Performance**
   - Consider database implications
   - Plan indexes carefully
   - Use appropriate list types
   - Monitor complex types
4. **Maintenance**
   - Document custom types
   - Use consistent patterns
   - Plan for versioning
   - Consider migrations

Basic Structure

Every SeedML application follows this structure:

```
app [AppName] {
  # Global Configuration
  meta: { ... }

  # Data Models
  entity [EntityName] { ... }
```

```
  # Business Rules
  rules { ... }

  # User Interface
  screens { ... }

  # Integrations
  integrate { ... }
}
```

Entity Syntax

```
entity [EntityName] {
  # Basic fields
  name: string
  age: number
  active: bool = true

  # Field modifiers
  required: string!
  optional: string?
  defaulted: string = "default"

  # Complex types
  items: [Item]
  metadata: map<string,any>
  status: draft->submitted->approved
}
```

Chapter 52

docs/examples/basic-crud.md

Chapter 53

Basic CRUD Example

The simplest possible SeedML application showing smart defaults in action.

```
// core.seed - Core domain model
app Contacts {
  entity Contact {
    // Required fields
    name: string!         // Full name
    email: email!        // Email with validation

    // Optional fields with validation
    phone?: phone {      // Phone number
      format: international
    }
  }
}

// ui.seed - UI components
extend Contacts {
  // Theme configuration
  ui {
    theme: "light"  // Use built-in theme
  }
    location?: location { // Location with defaults
      validate: {
        region: service_area
      }
    }

    // Metadata
    created: timestamp = now()
    updated: timestamp
    version: int = 1
  }

  // Complete UI with maps
  screen Contacts {
    views: {
      list: {
```

```
        fields: [name, email, phone],
        actions: [create, edit, delete],
        search: [name, email],
        sort: name
      },
      map: {
        source: location,
        cluster: true,
        search: {
          radius: 10km,
          filters: [type, status]
        }
      }
    }
  }
}
```

What You Get

This minimal specification automatically generates:

Data Layer

- Database schema with proper types and indexes
- Input validation for all fields
- API endpoints for CRUD operations
- Search and filter capabilities

User Interface

- Responsive list/grid view
- Create and edit forms
- Search functionality
- Sort and filter options
- Mobile friendly layout

Features

- Authentication and authorization
- Error handling
- Success messages
- Audit logging
- API documentation

Map Features

- Interactive map view
- Location picker for editing
- Address autocomplete
- Distance calculations
- Clustering for multiple contacts
- Mobile-friendly controls

All of these features come from smart defaults - no additional configuration needed.

Progressive Enhancement

When you need customization:

```
app Contacts {
  // Override specific defaults
  entity Contact {
    name: string {
      min: 2,            # Min length
      max: 50,           # Max length
      case: title        # Title case
    }
    email: email         # Keep email defaults
    phone: phone?        # Keep phone defaults
    location: location {
      required: true
      validate: {
        region: service_area
        type: business
      }
    }
  }

  // Customize UI
  screen Contacts {
    // Enhanced list view
    list {
      show: [name, email, location]
      group: region
      sort: distance(current_location)
    }

    // Enhanced map view
    map {
      cluster: true
      search: {
        radius: 10km
        filters: [region, type]
      }
      interactions: [
        select: show_details,
        route: get_directions
      ]
    }
  }
}
```

Key Principles Demonstrated

1. **Minimal Valid Specification**: Express only what's unique about your application
2. **Smart Defaults**: Production patterns included automatically
3. **Progressive Enhancement**: Add complexity only when needed
4. **Intent-Focused**: Express what you want, not how to build it
5. **Location-Aware**: Seamless integration of mapping features

Chapter 54

docs/examples/business-app.md

Chapter 55

Business Application Example

A complete order management system showing how intent-focused patterns scale to larger applications.

```
# core.seed - Core domain model
app OrderSystem {
  # Theme configuration
  ui {
    theme: "modern"  # Use modern theme
  }

  # 1. Domain Model
  entity Customer {
    # Basic information
    name: string!
    email: email!
    phone: phone?
    status: active/inactive = active

    # Financial & verification
    verified: boolean = false
    creditLimit: money = 1000.00

    # Validation rules
    validate: {
      email: required if status == active
      creditLimit: positive
    }

    # Customer verification process
    rules {
      verify: {
        require: [
          email != null,
          status == active
        ]
        then: [
          set(verified, true),
          notify@customer
        ]
```

```
    }
  }
}

entity Product {
  name: string!
  description: text
  price: money!
  inStock: boolean = true
  stockQuantity: int > 0

  validate: {
    price: positive
    stockQuantity: positive
  }
}

# Dependent entities
entity OrderItem {
  product: Product!
  quantity: int > 0
  price: money!
  total: quantity * price

  validate: {
    quantity: <= product.stockQuantity
    price: == product.price
  }
}

entity Order {
  # Basic fields
  customer: Customer!
  items: [OrderItem]
  status: draft->submitted->approved->shipped

  # Computed fields
  subtotal: sum(items.total)
  tax: subtotal * 0.2
  total: subtotal + tax

  # Business rules
  rules {
    submit: {
      require: [
        items.length > 0,
        customer.verified,
        total <= customer.creditLimit
      ]
      error: {
        items.length: "Order must contain at least one item"
        customer.verified: "Customer must be verified before placing orders"
        creditLimit: "Order total exceeds customer credit limit"
      }
```

```
      then: notify@sales
    }

    approve: {
      require: role.manager
      check: items.all(product.inStock)
      error: {
        role: "Only managers can approve orders"
        stock: "Some items are out of stock"
      }
      then: [
        create@invoice,
        notify@warehouse
      ]
    }

    ship: {
      require: status == approved
      error: {
        status: "Order must be approved before shipping"
      }
      then: [
        update@inventory,
        notify@customer,
        notify@shipping
      ]
    }
  }
}

entity Invoice {
  order: Order!
  issueDate: datetime = now()
  dueDate: datetime = issueDate + 30.days
  status: pending/paid/overdue = pending
  amount: money = order.total
}

# Permissions (now can reference known entities)
permissions {
  # Customer-related permissions
  view_all_customers: {
    entity: Customer
    access: read
    filter: all
  }
  view_active_customers: {
    entity: Customer
    access: read
    filter: status == active
  }
  set_credit_limits: {
    entity: Customer
    access: [read, update]
```

```
    fields: [creditLimit]
    validate: {
      creditLimit: <= 50000
    }
  }

  # Order-related permissions
  create_orders: {
    entity: Order
    access: create
    fields: [customer, items]
  }
  view_own_orders: {
    entity: Order
    access: read
    filter: created_by == current_user
  }
  view_customer_orders: {
    entity: Order
    access: read
    filter: customer.id == current_user.id
  }
  approve_orders: {
    entity: Order
    access: [read, update]
    filter: status == submitted
    allow: [approve]
  }
  submit_orders: {
    entity: Order
    access: [read, update]
    filter: created_by == current_user
    allow: [submit]
  }

  # Product-related permissions
  manage_products: {
    entity: Product
    access: [create, read, update]
    filter: all
  }
}

# Roles now reference permissions
roles {
  admin: {
    permissions: [all]
  }

  manager: {
    permissions: [
      view_all_customers,
      approve_orders,
      manage_products,
```

```
      set_credit_limits
    ]
  }

  sales: {
    permissions: [
      view_active_customers,
      create_orders,
      submit_orders,
      view_own_orders
    ]
  }

  customer: {
    permissions: [
      view_customer_orders,
      create_orders
    ]
  }
}
# Customer entity definition
entity Customer {
  # Basic information
  name: string!
  email: email!
  phone: phone?
  status: active/inactive = active

  # Financial & verification
  verified: boolean = false
  creditLimit: money = 1000.00

  # Validation rules
  validate: {
    email: required if status == active
    creditLimit: positive
  }

  # Customer verification process
  rules {
    verify: {
      require: [
        email != null,
        status == active
      ]
      then: [
        set(verified, true),
        notify@customer
      ]
    }
  }
}

# Product entity definition
```

```
entity Product {
  name: string!
  description: text
  price: money!
  inStock: boolean = true
  stockQuantity: int > 0

  validate: {
    price: positive
    stockQuantity: positive
  }
}

# Order entity definition
entity Order {
  # Basic fields
  customer: Customer!
  items: [OrderItem]
  status: draft->submitted->approved->shipped

  # Computed fields
  subtotal: sum(items.total)
  tax: subtotal * 0.2
  total: subtotal + tax

  # Business rules
  rules {
    submit: {
      require: [
        items.length > 0,
        customer.verified,
        total <= customer.creditLimit
      ]
      error: {
        items.length: "Order must contain at least one item"
        customer.verified: "Customer must be verified before placing orders"
        creditLimit: "Order total exceeds customer credit limit"
      }
      then: notify@sales
    }

    approve: {
      require: role.manager
      check: items.all(product.inStock)
      error: {
        role: "Only managers can approve orders"
        stock: "Some items are out of stock"
      }
      then: [
        create@invoice,
        notify@warehouse
      ]
    }
```

```
    ship: {
      require: status == approved
      error: {
        status: "Order must be approved before shipping"
      }
      then: [
        update@inventory,
        notify@customer,
        notify@shipping
      ]
    }
  }
}

entity OrderItem {
  product: Product!
  quantity: int > 0
  price: money!
  total: quantity * price

  validate: {
    quantity: <= product.stockQuantity
    price: == product.price
  }
}

entity Invoice {
  order: Order!
  issueDate: datetime = now()
  dueDate: datetime = issueDate + 30.days
  status: pending/paid/overdue = pending
  amount: money = order.total
}

# UI Screens (reference entities and roles)
screen Products {
  list {
    view: table
    show: [name, price, inStock, stockQuantity]
    actions: [create, edit]
  }
}

screen Customers {
  list {
    view: table
    show: [name, email, status, verified, creditLimit]
    actions: [create, edit, verify]
  }

  detail {
    layout: tabs
    info: [name, email, phone, status]
    orders: related-list(Order)
```

```
      invoices: related-list(Invoice)
    }
  }

  screen Orders {
    list {
      view: table
      show: [id, customer.name, total, status]
      group: status
      actions: [
        submit if draft,
        approve if submitted and role.manager,
        ship if approved
      ]
    }

    detail {
      layout: split
      left {
        customer: card {
          show: [name, email, creditLimit, verified]
        }
        items: editable-table {
          columns: [product.name, quantity, price, total]
          validate: onEdit
        }
      }
      right {
        summary: [subtotal, tax, total]
        status: timeline
        actions: panel
      }
    }
  }

  # External integrations (last since they may reference entities and actions)
  integrate {
    payment: stripe      # Payment processing
    shipping: fedex      # Shipping integration
    email: sendgrid     # Email service

    config {
      stripe_key: env.STRIPE_KEY
      fedex_account: env.FEDEX_ACCOUNT
      templates: {
        order: "d-123456"
        shipping: "d-789012"
      }
    }
  }
}
```

This example demonstrates: - Complete entity definitions with relationships - Comprehensive business rules and validation - Computed fields and dependencies - Multi-step workflows with proper states - Rich UI components and layouts -

Detailed external integrations - Role-based permissions - Inventory management

Chapter 56

docs/examples/dashboard.md

Chapter 57

Analytics Dashboard Example

```
// Real-time analytics dashboard with location intelligence
app Analytics {
  // Data models
  entity Metric {
    name: string
    value: number
    timestamp: datetime
    category: string
    location?: location    // Optional location data
  }

  entity LocationMetric {
    location: location
    metrics: map<string, number>
    timestamp: datetime
    region: reference
  }

  # Dashboard screen
  screen Dashboard {
    layout: grid(2x2)

    // Multiple visualization types
    widgets: [
      {
        type: map
        data: LocationMetric
        view: {
          type: heatmap
          cluster: {
            enabled: true
            threshold: 100
            radius: 50
            colors: gradient
          }
          controls: {
            zoom: true
```

```
          pan: true
          search: {
            radius: 10km
            filters: [type, status]
          }
        }
      }
      value: {
        field: metrics.value
        range: last-7-days
        aggregation: sum
      }
    },
    {
      type: region-map
      data: Metric.by(region)
      color: value
      legend: true
      interact: drill_down
    },
    {
      type: line-chart
      data: Metric
      x: timestamp
      y: value
      group: category
      range: last-7-days
    },
    {
      type: cluster-map
      data: EventMetric
      cluster: category
      size: value
      tooltip: details
    }
  ]

  // Interactive features
  features: [
    time-range-selector,
    region-filter,
    category-filter,
    export-data
  ]

  # Real-time updates
  refresh: 5min
  realtime: websocket
}

# Location analytics
analytics {
  spatial: {
```

```
      hotspots: {
        method: kernel_density
        threshold: significant
        timeframe: hourly
      },
      patterns: {
        type: movement
        window: 24h
        detect: [clusters, flows]
      }
    }

    metrics: {
      density: per_km2
      distribution: by_region
      concentration: gini_index
    }
  }

  # Map controls
  controls {
    view: {
      type: [heat, cluster, region]
      switch: animated
      sync: linked
    },

    analysis: {
      tools: [
        area_selection,
        pattern_detection
      ],
      export: [
        geojson,
        csv,
        image
      ]
    }
  }
}
```

This example demonstrates: - Location-based analytics - Spatial visualization - Real-time updates - Interactive mapping - Multiple chart types - Pattern detection - Integrated dashboard layout

---

Chapter 58

docs/examples/integration.md

Chapter 59

Integration Examples

This guide shows how to integrate external services using SeedML's simplified patterns.

Basic Integration

```
app Store {
  # Simple integrations
  integrate {
    auth: {
      provider: google    # Basic auth
      features: default
    }
    email: {
      provider: sendgrid  # Email service
      features: default
    }
    storage: {
      provider: s3       # File storage
      features: default
    }
  }

  # Use integrations naturally
  entity Order {
    status: Draft -> Paid -> Shipped
    attachment: file    # Uses storage

    rules {
      create: {
        then: notify@customer  # Uses email
      }
    }
  }
}
```

Common Patterns

1. Authentication

```
integrate {
  auth: {
    provider: google    # Single provider
    redirect: "/home"   # After login
  }
}
```

2. File Storage

```
integrate {
  storage: {
    provider: s3
    bucket: "app-files"  # Single bucket
  }
}
```

3. Email Service

```
integrate {
  email: {
    provider: sendgrid
    from: "app@example.com"
  }
}
```

Best Practices

1. **Keep It Simple**
   - Use single providers
   - Minimal configuration
   - Default behaviors
2. **Security First**
   - Environment variables for keys
   - HTTPS connections
   - Basic access control
3. **Handle Errors**
   - Basic retry logic
   - Simple error states
   - Clear messages

Smart Defaults

Every integration includes: - Basic error handling - Simple retry logic - Standard logging - Essential security

---

Chapter 60

docs/examples/saas.md

Chapter 61

SaaS Application Example

```
# Multi-tenant SaaS platform
app SaaSPlatform {
  # Tenant configuration
  tenant {
    isolation: schema  # database, schema, or row
    routing: subdomain

    customize: {
      branding: {
        logo: image
        colors: theme
        domain: url?
      }
      features: {
        enabled: [module]
        limits: map<feature, limit>
      }
    }
  }

  # Subscription management
  subscription {
    plans: {
      basic: {
        price: 10/month
        limits: {
          users: 5
          storage: 5gb
          api: 1000/day
        }
      }

      pro: {
        price: 50/month
        limits: {
          users: 50
          storage: 50gb
```

```
        api: 10000/day
      }
    }

    enterprise: {
      price: custom
      limits: custom
    }
  }

  features: {
    basic: [core, support],
    pro: [api, advanced, priority],
    enterprise: [custom, sla, training]
  }
}

# Cross-tenant features
cross_tenant {
  sharing: {
    content: {
      access: explicit
      audit: true
    }

    marketplace: {
      publish: verified
      install: compatible
    }
  }

  analytics: {
    usage: aggregate
    trends: anonymous
  }
}

# Tenant management
admin {
  dashboard: {
    metrics: [
      active_tenants,
      total_users,
      storage_used,
      api_usage
    ]

    actions: [
      provision,
      suspend,
      migrate,
      backup
    ]
```

```
    }

    monitoring: {
      health: [status, performance],
      alerts: [limits, errors],
      audit: [access, changes]
    }
  }

  # Tenant-aware entities
  entity Document {
    tenant: Tenant
    sharing: private/shared/public

    # Tenant isolation
    access: tenant.users
    storage: tenant.bucket
    audit: tenant.log
  }

  # Tenant-specific UI
  screen Dashboard {
    branding: tenant.theme
    modules: tenant.enabled
    limits: tenant.quotas

    widgets: [
      usage: tenant.metrics,
      users: tenant.members,
      activity: tenant.events
    ]
  }
}
```

This example demonstrates: - Multi-tenant architecture - Tenant isolation - Custom branding - Feature management - Usage tracking - Cross-tenant features

---