Echo — Design Documentation

Private AI Journaling Companion

Built for Palo Alto Networks Software Engineering Case Study

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1 Overview

1.1 What Echo Is

Echo is a privacy-first, AI-powered journaling application designed to reduce blank-page anxiety, surface emotional patterns over time, and encourage consistent self-reflection without compromising user privacy. The system combines zero-knowledge encryption with carefully scoped AI interactions, making sure that sensitive personal content stays private while still enabling meaningful, contextual guidance.

1.2 Who It's For

Echo is designed for individuals who:

- Struggle to start journaling due to blank-page anxiety
- Want to understand emotional patterns across time
- Value strong privacy guarantees for personal writing
- Prefer reflective guidance over prescriptive advice

1.3 Core Problem

Most journaling tools force users to trade off between three competing needs:

1. **Getting started**: Generic prompts fail to reduce friction
2. **Pattern recognition**: Insights are buried across entries
3. **Privacy**: AI-powered tools require full access to sensitive content

Echo addresses this by providing AI-driven prompts and pattern detection while preserving zero-knowledge guarantees and minimizing data exposure.

2 Design Principles

2.1 Privacy-First Architecture

- Zero-knowledge encryption with all cryptography performed client-side
- Journal content is encrypted before storage and never accessible server-side
- AI receives only aggregated or purpose-limited data
- No cloud sync or server-side persistence of user content

2.2 Minimal, Non-Judgmental UX

- Calm visual design with neutral colors and generous spacing
- Streaks and metrics inform but do not pressure behavior
- AI features degrade gracefully when unavailable
- Users can lock and unlock entries at will

2.3 AI as a Reflective Companion

- AI generates questions, not answers
- Reflective prompts only appear when grounded in real data
- Silence is preferred over low-confidence or fabricated insights
- AI limitations are explicit and enforced

3 Technical Architecture

3.1 Frontend Stack

- React 18.2 with functional components and hooks
- JavaScript with TypeScript type checking
- Tailwind CSS with a custom theme system
- Vite for development and production builds
- Lucide React for iconography

3.2 Client-Side Encryption Model

Echo implements a zero-knowledge encryption model using the Web Crypto API.

Key Properties:

- AES-256-GCM for authenticated encryption
- PBKDF2 (SHA-256, 100,000 iterations) for key derivation
- Unique salt and IV per entry
- Passphrase never stored; hash used only for verification

Encrypted entries are stored in browser `localStorage` as Base64-encoded payloads. Decrypted content exists only in memory during active viewing and is cleared immediately on lock.

3.3 AI Integration via Serverless Proxy

All AI interactions occur through serverless functions acting as secure proxies:

```
Client → Serverless Function → AI Provider → Response
```

- API keys stored as environment variables
- No plaintext journaling content logged or retained server-side
- All AI processing is ephemeral

4 AI Application and User Engagement

4.1 Client-Side NLP and Insight Generation

Echo uses lightweight, client-side NLP to help users reflect safely:

- Tokenizes journal text, removes stop words, and counts keyword frequency — all locally
- Sends only aggregated statistics to AI (e.g., "mood: stressed 2x, recurring theme: work"), never raw entries
- Generates empathetic, personalized prompts grounded in user data
- Highlights recurring emotional patterns and trends through visualizations like mood distribution and journaling times

4.2 Emotion-to-Question Prompting

- Triggered by user-selected mood
- Produces a single reflective question under 60 words
- Fallback prompts are used if AI unavailable

4.3 Reflective Contrast Prompts

Reflective contrast prompts are generated only when sufficient historical data exists:

- Minimum 3 entries within 14 days
- Detect dominant moods or recurring keyword patterns
- Only aggregated summaries are sent to AI
- Prompts validated to ensure they reference real past data

4.4 User Engagement and Consistency

Echo encourages consistent journaling through subtle, non-intrusive features:

- Streak tracking and peak time highlights gently nudge users to maintain habits
- AI prompts are optional and appear only when contextually relevant
- Focus Mode disables prompts for distraction-free writing
- Metrics are informative, not coercive — encouraging reflection without guilt

4.5 Responsible AI Constraints

- No diagnosis or medical advice
- No fabricated past experiences
- Token limits enforce brevity
- Validation layer rejects low-confidence output

5 Security and Privacy Considerations

- Data minimization ensures only essential information is sent to AI
- AI requests processed immediately and discarded
- Locking clears decrypted state from memory; app-level lock clears passphrase
- Client-side architecture prevents server-side exposure of journal content

6 Limitations and Tradeoffs

Echo intentionally avoids:

- Cloud sync
- Sharing or collaboration
- Clinical mental health intervention
- Multimedia journaling

These tradeoffs prioritize privacy and simplicity over feature breadth.

7 Future Enhancements

- On-device sentiment analysis for richer insights without sending data to AI
- Deeper local pattern detection and trend visualization
- Optional habit reminders to support daily journaling, given user enables reminders
- Encrypted export and portability across devices
- Progressive Web App (PWA) features for offline support and notifications

8 Summary

Echo demonstrates that intelligent reflection and strong privacy guarantees are not mutually exclusive. By combining client-side encryption, serverless AI proxies, and conservative AI design, Echo delivers meaningful guidance while respecting user autonomy and trust. User engagement is supported through gentle nudges, optional AI prompts, and Focus Mode, while insights are grounded in actual historical data using privacy-preserving NLP techniques.