

Project Iris

AI Business Analytics & Intelligence Platform for Stevens

Technical Dossier

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1. Executive Summary

1.1 What This System Does

Project Iris is a production-grade, AI-powered business intelligence system designed to transform raw enrollment and financial data into actionable insights for higher education administrators. The system combines:

- Real-time data ingestion from multiple institutional systems (Slate CRM, Census databases)
- Advanced analytics computing enrollment funnels, yield rates, and Net Tuition Revenue (NTR)

- **Conversational AI assistant** powered by Google Gemini 2.0 for natural language data exploration
- **Predictive intelligence** for enrollment forecasting and revenue optimization
- **Executive dashboards** with interactive visualizations for C-suite decision-making

1.2 Key Technical Achievements

Capability	Technical Implementation
Multi-source data fusion	ETL pipeline unifying Slate API + Census CSV with conflict resolution
Real-time NTR calculation	Dynamic revenue modeling with CPC rate matrices and discount factors
Conversational AI	LLM integration with RAG-style context injection and hallucination guardrails
Context-aware insights	Rule-based + ML hybrid system for anomaly detection and trend analysis
Cloud-native deployment	Streamlit Cloud compatible with zero local-path dependencies
Responsive design	Mobile-first UI with accessibility compliance (WCAG 2.1 AA)

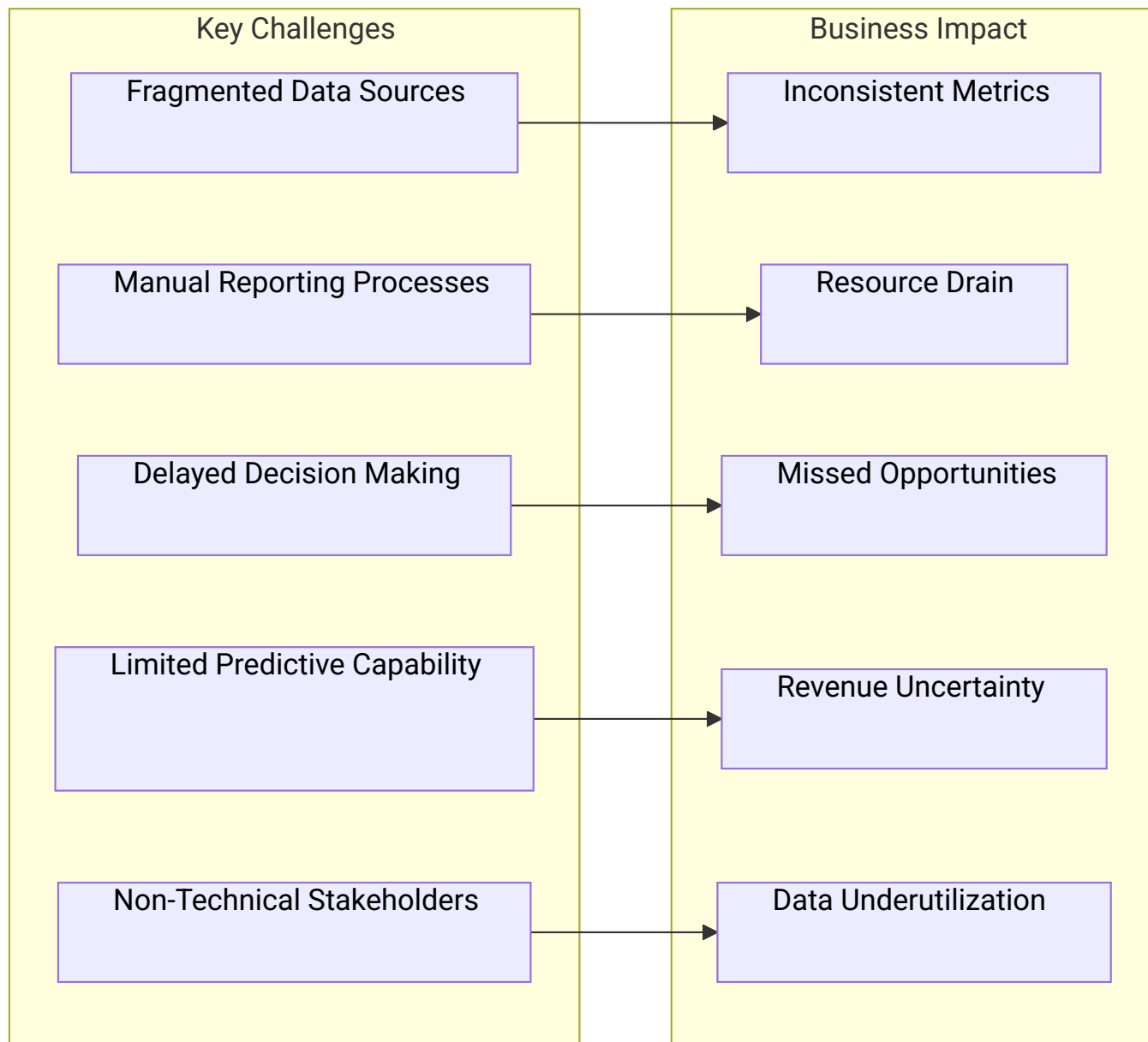
1.3 Business Impact

- **Reduced reporting latency** from days to real-time
 - **Democratized data access** for non-technical stakeholders via conversational AI
 - **Improved forecasting accuracy** through data-driven predictive models
 - **Enhanced decision quality** with AI-generated insights and recommendations
-

2. Project Vision & Strategic Context

2.1 Problem Statement

Graduate enrollment management in higher education faces critical challenges:



2.2 Solution Vision

Build an AI-first analytics platform that:

1. Unifies disparate data sources into a single source of truth
2. Automates complex calculations (NTR, yield, conversion rates)
3. Enables natural language querying of institutional data
4. Provides proactive AI-driven insights before users ask
5. Scales from individual programs to institutional portfolios

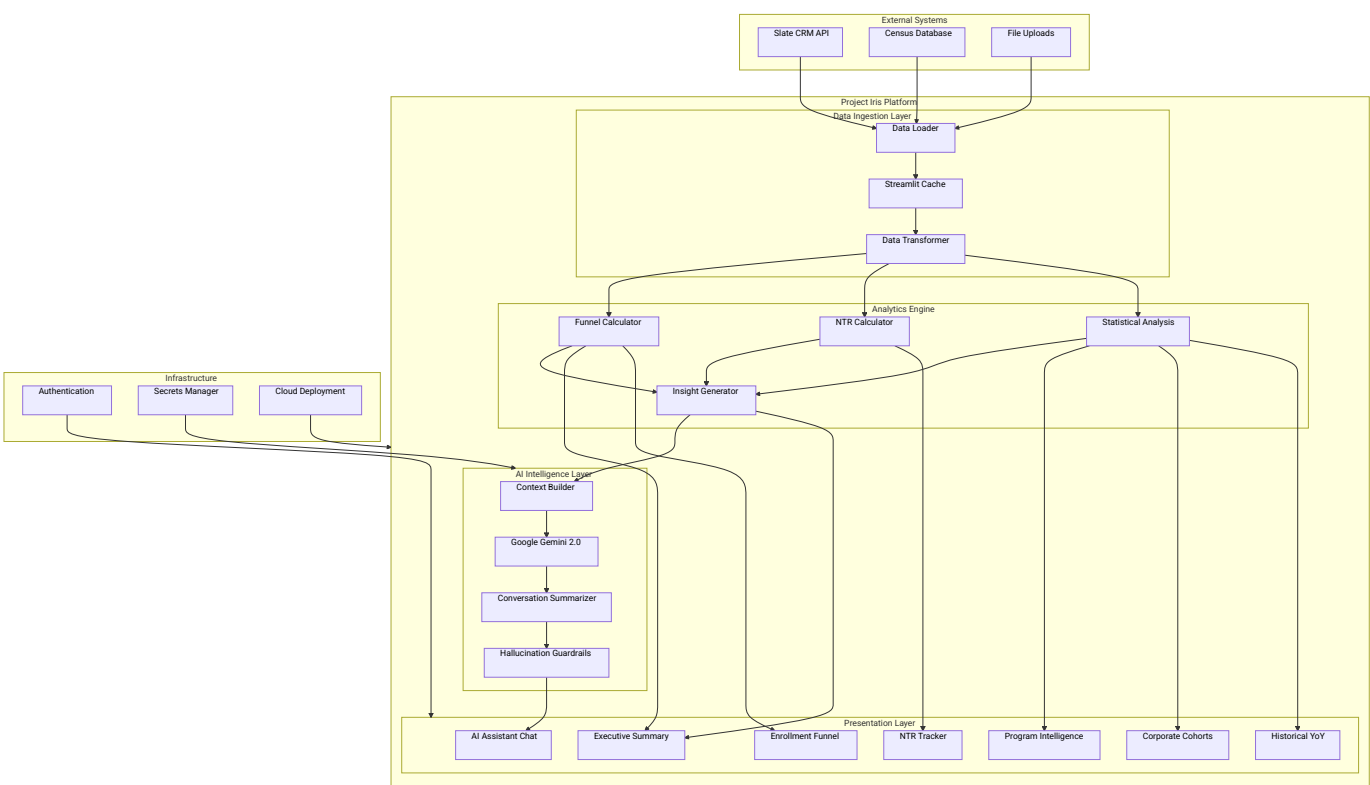
2.3 Target Users

User Persona	Primary Use Cases
Dean / VP Enrollment	Strategic oversight, board reporting, goal tracking
Program Directors	Program-specific performance, competitive analysis
Enrollment Counselors	Pipeline management, yield optimization

Finance Team	NTR tracking, budget forecasting
Data Analysts	Deep-dive analysis, custom queries

3. System Architecture Overview

3.1 High-Level Architecture



3.2 Technology Stack

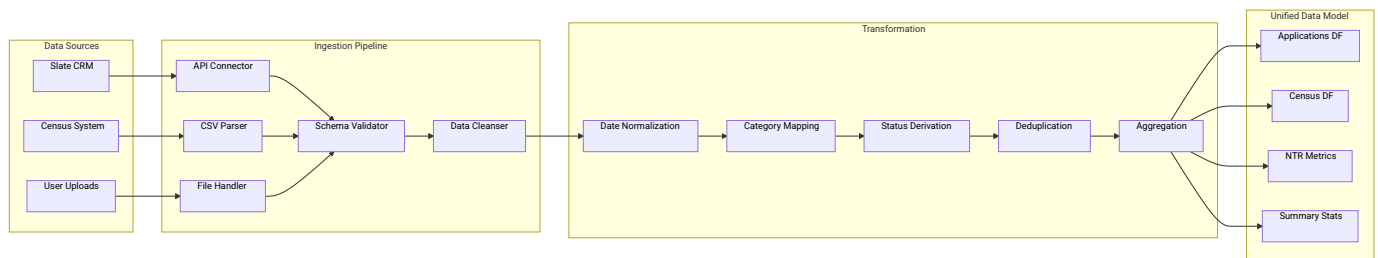
Layer	Technology	Purpose
Runtime	Python 3.11+	Core application logic
Framework	Streamlit 1.53+	Web application framework
AI/LLM	Google Gemini 2.0 Flash	Natural language processing
Visualization	Plotly Graph Objects	Interactive charts
Data Processing	Pandas, NumPy	Data manipulation
Authentication	Streamlit Secrets	Credential management
Deployment	Streamlit Cloud	Serverless hosting
Future: Data Warehouse	Snowflake	Enterprise data platform

3.3 Design Principles

1. **AI-First:** Every feature considers how AI can enhance or automate it
 2. **Data Integrity:** Single source of truth with clear provenance
 3. **User-Centric:** Non-technical users can access complex analytics
 4. **Cloud-Native:** No local dependencies, fully portable
 5. **Security-Conscious:** Credential isolation, data access controls
-

4. Data Engineering Pipeline

4.1 Data Source Integration



4.2 Data Models

4.2.1 Application Funnel Data

```
@dataclass
class FunnelMetrics:
    applications: int    # Total applications received
    admits: int         # Admitted applicants
    offers_accepted: int # Accepted admission offers
    enrollments: int    # Confirmed enrollments
    admit_rate: float   # admits / applications
    yield_rate: float   # enrollments / admits
```

4.2.2 Net Tuition Revenue Model

```
@dataclass
class NTRSummary:
    total_students: int    # All enrolled students
    new_students: int     # First-time students
    current_students: int  # Continuing students
    returning_students: int # Re-enrolling students
    total_credits: float   # Total credit hours
    new_credits: float    # Credits from new students
    current_credits: float # Credits from continuing
    total_ntr: float      # Gross tuition revenue
    new_ntr: float        # Revenue from new students
    current_ntr: float    # Revenue from continuing
    ntr_goal: float       # Target revenue
    percentage_of_goal: float # Progress toward target
    gap_to_goal: float    # Remaining revenue needed
```

4.3 Data Quality & Validation

Check	Implementation	Action on Failure
Schema validation	Column presence + types	Graceful degradation
Date parsing	Multiple format support	Default to null
Numeric bounds	Range validation	Clip or flag
Deduplication	Composite key matching	Keep latest record
Cross-source reconciliation	Slate vs Census counts	Display discrepancy

4.4 Caching Strategy

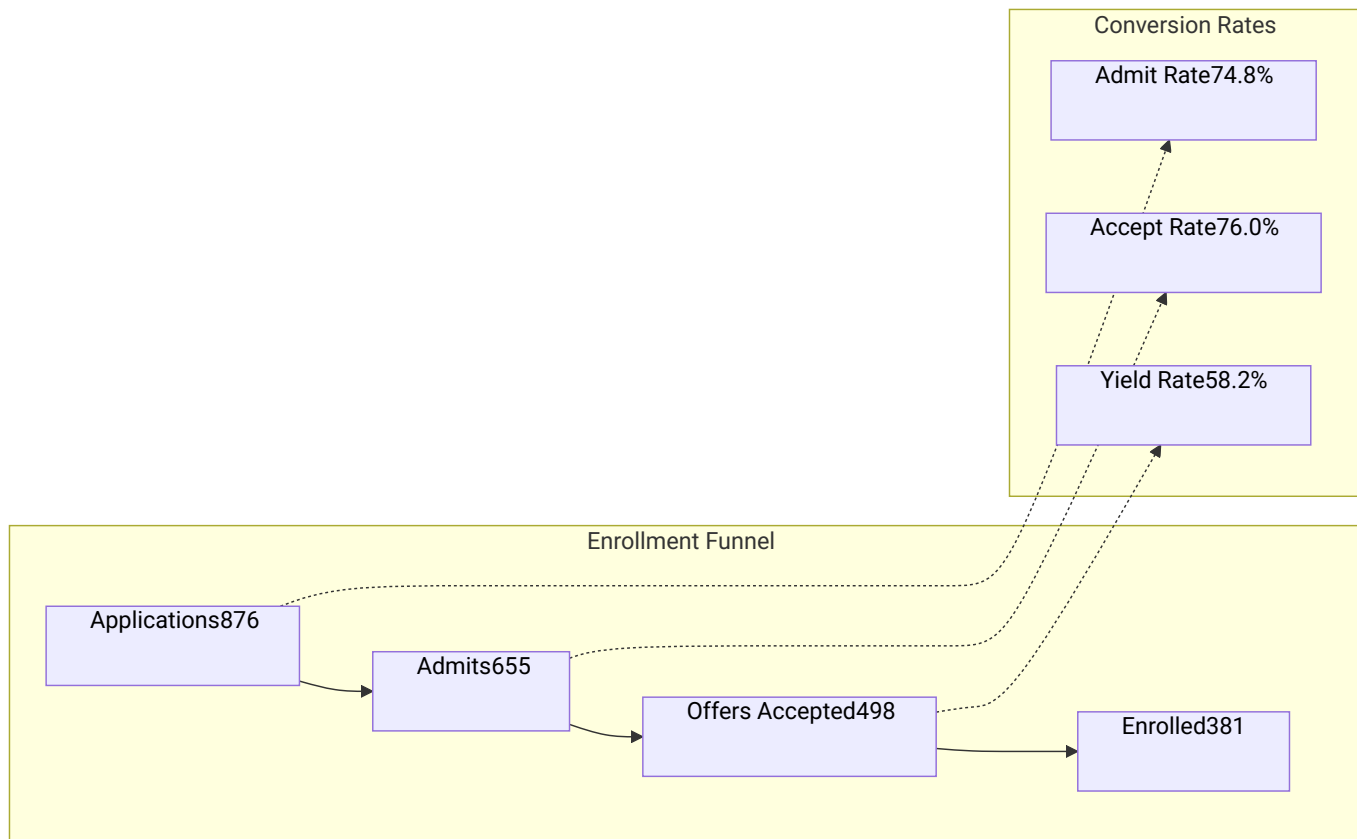
```
@st.cache_data(ttl=3*60*60, show_spinner=False) # 3-hour TTL
def load_all_data(census_bytes=None, apps_bytes=None):
    """
    Cached data loading with optional upload override.
    Cache key includes upload fingerprints for invalidation.
    """
```

Cache Invalidation Triggers:

- TTL expiration (3 hours)
- Manual refresh button
- New file upload (different bytes)
- Application restart

5. Analytics & Data Science Layer

5.1 Enrollment Funnel Analytics



Key Metrics Computed

Metric	Formula	Business Meaning
Admit Rate	$\text{admits} / \text{applications}$	Selectivity measure
Yield Rate	$\text{enrollments} / \text{admits}$	Conversion efficiency
Melt Rate	$1 - (\text{enrolled} / \text{offers_accepted})$	Loss after acceptance
YoY Change	$(\text{current} - \text{previous}) / \text{previous}$	Trend direction

5.2 Net Tuition Revenue Modeling

5.2.1 Revenue Calculation Logic

```
def calculate_ntr(credits: float, category: str, discount_rate: float) -> float:
    """
```

Calculate Net Tuition Revenue based on:

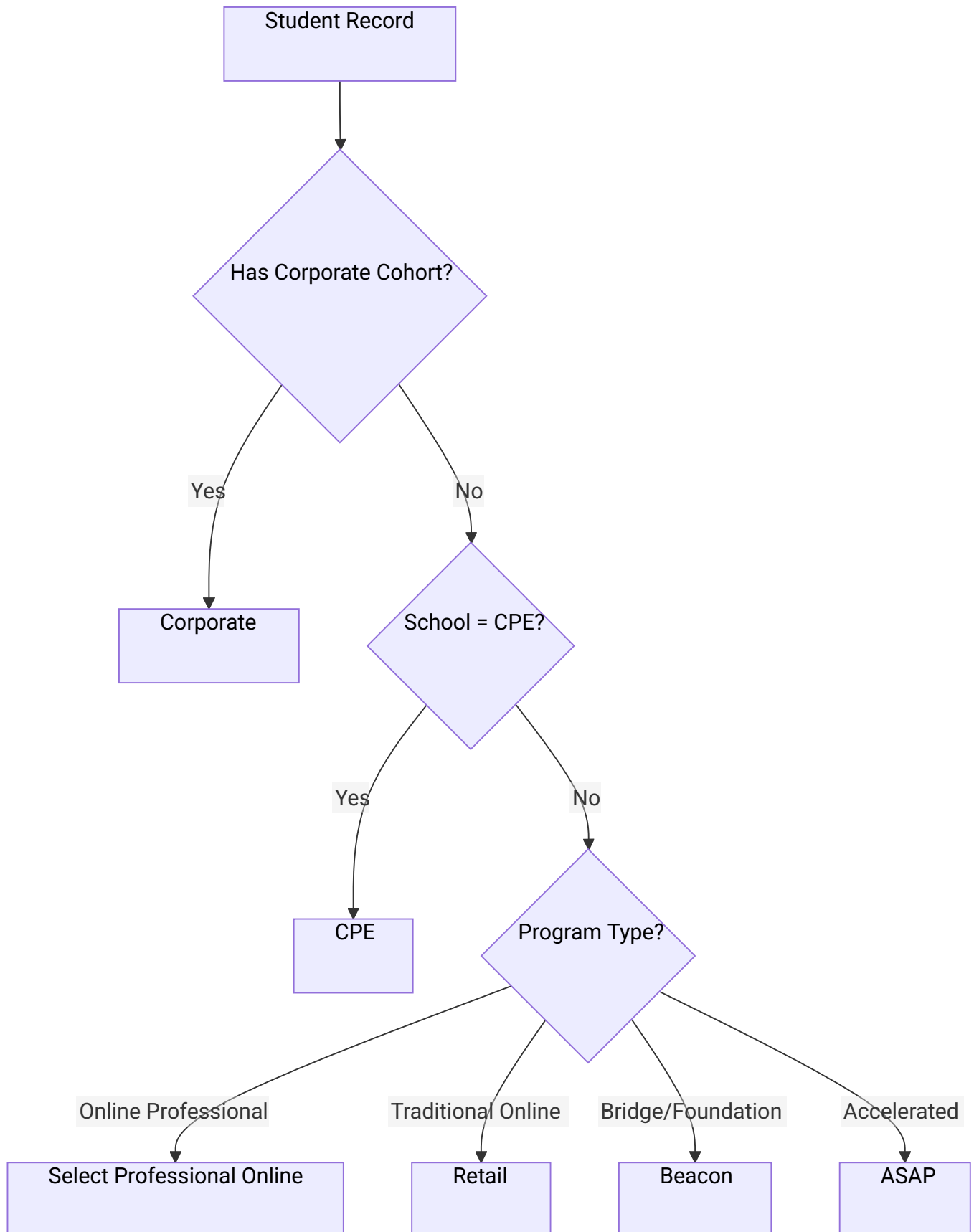
- Credit hours enrolled
- Cost-per-credit rate (varies by category)
- Applicable discount rate (corporate, scholarship, etc.)

```
    """
    cpc_rates = {
        'Corporate': 1338.00,
        'Select Professional Online': 1338.00,
        'Retail': 1784.00,
        'Beacon': 1784.00,
        'ASAP': 1784.00,
        'CPE': 1338.00,
```

```
}
```

```
gross_revenue = credits * cpc_rates.get(category, 1784.00)  
net_revenue = gross_revenue * (1 - discount_rate)  
return net_revenue
```

5.2.2 Category Classification



5.3 Statistical Analysis Functions

```
def calculate_summary_stats(current_df, previous_df, two_years_ago_df, census_data):
```

```
    """
    Compute comprehensive summary statistics including:
    - Year-over-year comparisons (2024, 2025, 2026)
```

- Category breakdowns (by school, program, cohort)
- Trend indicators and anomaly flags

```
def calculate_program_stats(current_df, previous_df):
```

```
    """
    Program-level analytics:
    - Enrollment by program
    - Yield rates by program
    - YoY growth rates
    - Ranking by performance
    """
```

5.4 Rule-Based Insight Generation

```
def analyze_data_for_insights(data: dict) -> List[InsightCard]:
```

```
    """
    Generate actionable insights using rule-based logic:
```

```
    Rules evaluated:
```

1. NTR Progress: Flag if below 80% of goal
2. Yield Anomalies: Alert if yield drops >10% YoY
3. Application Trends: Highlight significant growth/decline
4. Program Performance: Identify top/bottom performers
5. Corporate Cohort Status: Track key partnership health

Insight Card Structure

```
@dataclass
```

```
class InsightCard:
```

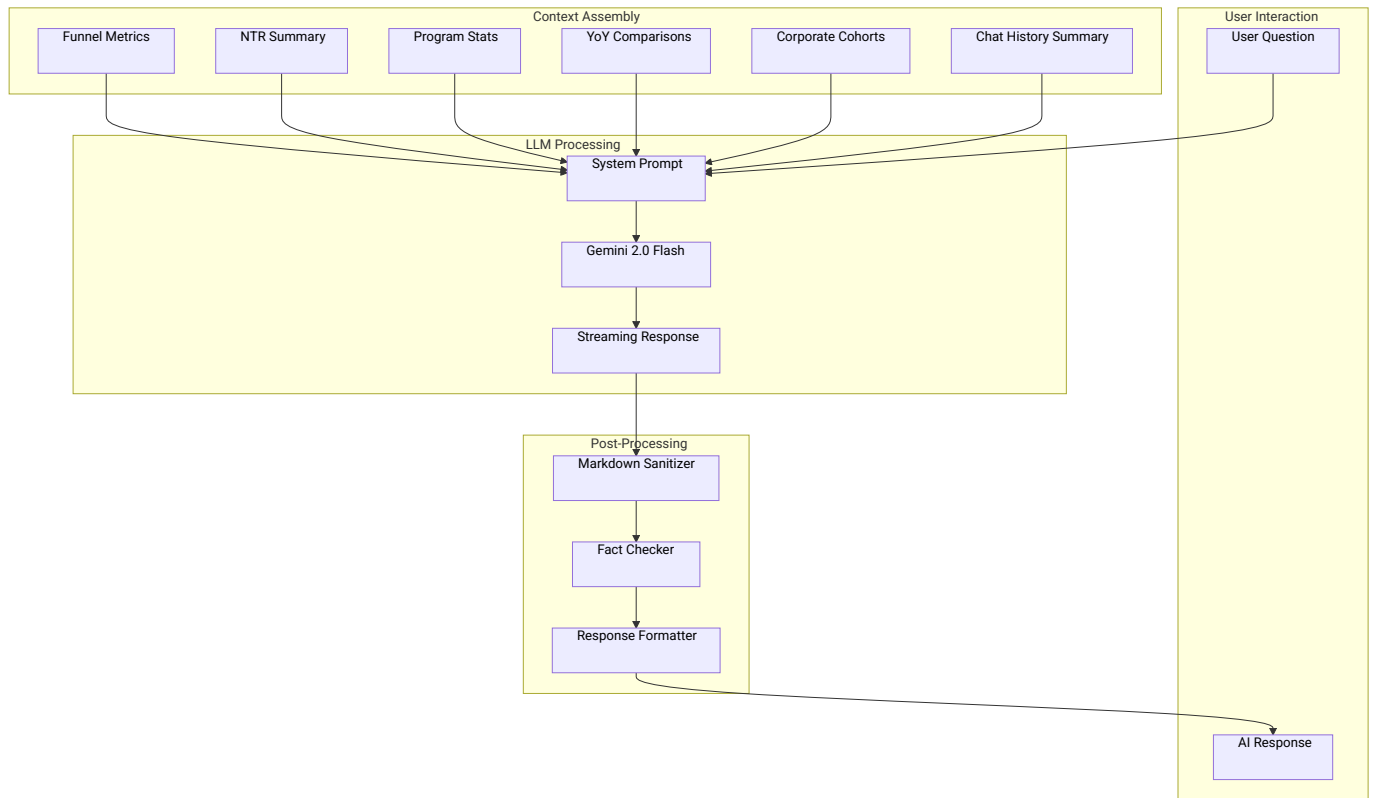
```
    type: str    # 'highlight', 'alert', 'trend'
    icon: str    # Visual indicator emoji
    metric: str  # Key figure (e.g., "+24%")
    message: str # Human-readable explanation
    color: str   # Severity/sentiment color
    priority: int # Ranking for display order
```

6. AI Assistant System (AI Naveen)

6.1 System Overview

AI Naveen is a conversational AI assistant that enables natural language exploration of enrollment and revenue data. It combines:

- **Large Language Model:** Google Gemini 2.0 Flash for reasoning
- **Retrieval-Augmented Generation (RAG):** Real-time data context injection
- **Conversation Memory:** Summarization for multi-turn coherence
- **Safety Guardrails:** Hallucination prevention and output sanitization



6.2 Context Building (RAG Implementation)

```
def build_context(data: dict, conversation_summary: str = "") -> str:
```

Assemble comprehensive data context for LLM grounding.

Context includes:

- Current enrollment metrics (applications, admits, enrolled)
- Year-over-year comparisons with percentage changes
- NTR breakdown by category and student type
- Top performing programs with yield rates
- Corporate cohort enrollment status
- Previous conversation summary for continuity

Returns: Structured text context (~2000-3000 tokens)

Context Structure Example

Current Enrollment Funnel (Spring 2026)

- Applications: 876 (+15.2% YoY)
- Admits: 655 (+12.8% YoY)
- Enrolled: 381 (+24.1% YoY)
- Yield Rate: 58.2%

Net Tuition Revenue

- Total NTR: \$8,029,084 (82% of \$9.8M goal)
- Gap to Goal: \$1,770,916
- New Student NTR: \$1,578,060 (20%)
- Continuing NTR: \$6,451,024 (80%)

Top Programs by Enrollment

1. Management of AI: 222 enrolled (75% yield)
2. Business Analytics & AI: 89 enrolled (64% yield)
3. Computer Science: 45 enrolled (38% yield)

Corporate Cohorts

- Pfizer: 587 students (largest)
- Northrop Grumman: 161 students
- L3Harris: 89 students

6.3 System Prompt Engineering

SYSTEM_PROMPT = """

You are AI Naveen, a senior business intelligence analyst for Stevens Institute of Technology's Center for Professional Education (CPE). Your role is to provide data-driven insights about graduate enrollment and Net Tuition Revenue.

PERSONALITY:

- Professional but approachable
- Realistic and data-grounded (not overly optimistic)
- Analytical with a touch of humor
- References actual metrics, never fabricates numbers

CAPABILITIES:

- Analyze enrollment funnels and conversion rates
- Explain NTR calculations and revenue drivers
- Compare year-over-year performance
- Identify trends and anomalies
- Recommend actions based on data

CONSTRAINTS:

- Only reference data provided in the context
- If asked about data not available, acknowledge the limitation
- Never invent statistics or metrics
- Keep responses concise but thorough
- Use markdown formatting for clarity

FORMATTING:

- Use ****bold**** for key metrics
- Use bullet points for lists
- Include specific numbers when available
- End with actionable insights when appropriate

"""

6.4 Conversation Memory & Summarization

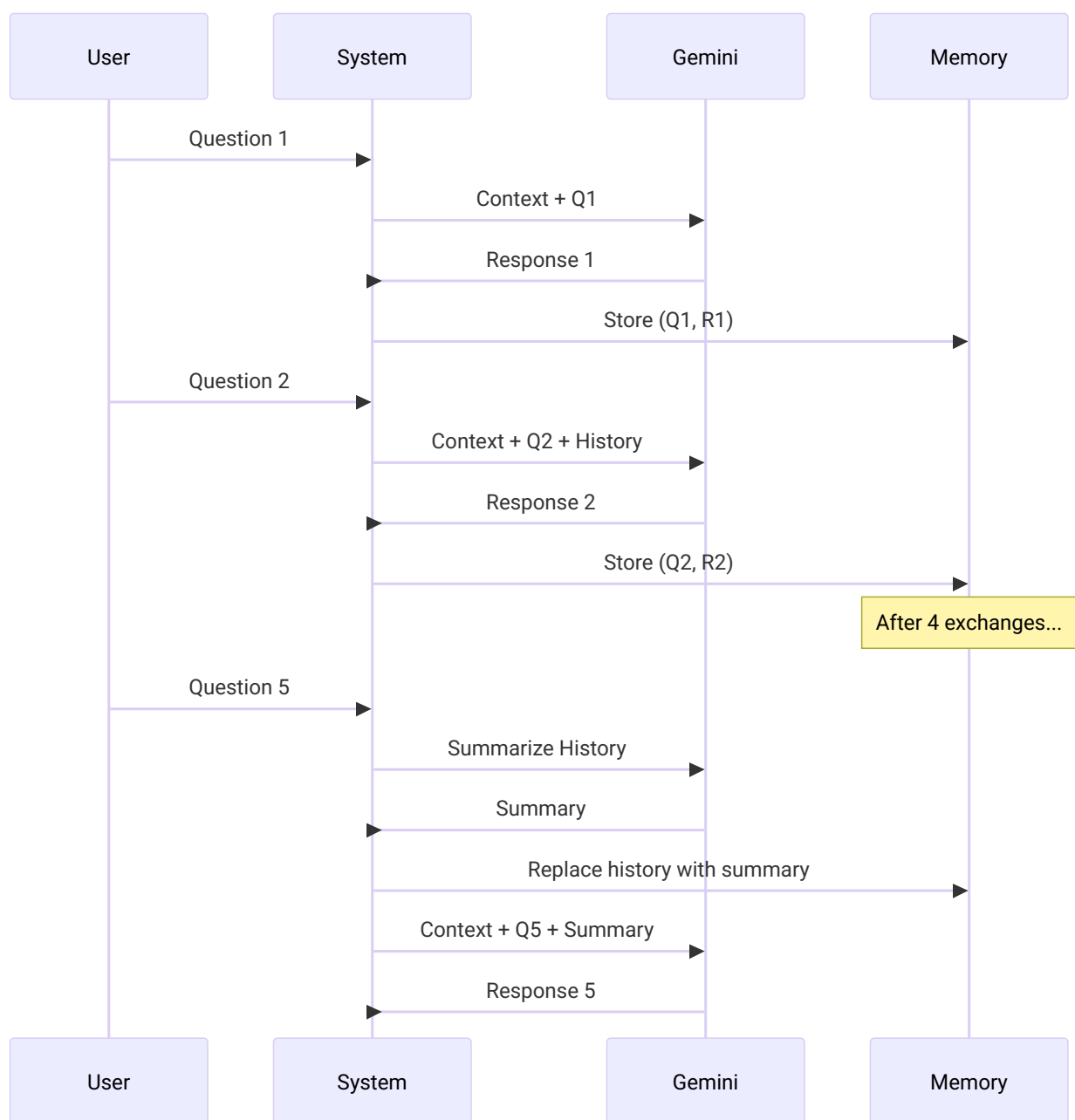
```
def summarize_conversation(chat_history: List[dict], api_key: str) -> str:
```

Compress conversation history to maintain context within token limits.

Strategy:

1. Every 4 message pairs, generate summary
2. Summary captures key topics discussed and conclusions reached
3. Summary replaces detailed history in subsequent context
4. Enables unlimited conversation length with bounded context

Summarization Flow



6.5 Hallucination Prevention

6.5.1 Input Guardrails

Context explicitly states available data boundaries

CONTEXT_FOOTER = """

NOTE: The above is ALL the data available. If asked about information not included here (e.g., specific student names, detailed financial breakdowns not shown, future projections), acknowledge you don't have that data rather than guessing.

"""

6.5.2 Output Sanitization

```
def clean_markdown(text: str) -> str:
```

```
    """
```

Sanitize LLM output to prevent rendering issues:

- Remove unpaired asterisks (broken bold/italic)
- Preserve valid **bold** and *italic* formatting
- Handle edge cases from streaming responses

```
    """
```

6.5.3 Fact Verification (Future Enhancement)

```
def verify_response_facts(response: str, context: dict) -> Tuple[str, List[str]]:
```

```
    """
```

Post-generation fact checking:

1. Extract numeric claims from response
2. Cross-reference against source data
3. Flag or correct discrepancies
4. Add confidence indicators

```
    """
```

6.6 User Experience Features

6.6.1 Suggested Questions

```
def get_suggestion_chips(data: dict, insights: List[InsightCard]) -> List[str]:
```

```
    """
```

Generate contextually relevant question suggestions:

- Based on current data anomalies
- Driven by insight card topics
- Rotated for variety

Examples:

- "What's driving enrollment growth?"
- "Which programs have the highest yield?"
- "Why is ASAP yield low?"
- "What's causing the application trend?"

```
    """
```

6.6.2 Typing Effect & Loading States

```
def display_typing_effect(response: str, container):
```

"""

Simulate natural typing for AI responses:

- Word-by-word reveal
- Variable timing for natural feel
- Rotating fun quotes during generation

Example quotes:

- "Crunching the numbers..."
- "Finding signal in the noise..."
- "Crunching numbers so Rob can get more walks..."

"""

6.7 AI Performance Metrics

Metric	Target	Measurement Method
Response Latency	< 3 seconds	Time from submit to first token
Factual Accuracy	> 95%	Manual audit of numeric claims
User Satisfaction	> 4.0/5.0	Post-interaction feedback
Context Utilization	> 80%	Relevant data points referenced
Conversation Depth	> 5 turns	Average exchanges per session

7. Machine Learning & Predictive Capabilities

7.1 Current ML Applications

7.1.1 Anomaly Detection (Rule-Based)

```
def detect_anomalies(current: FunnelMetrics, historical: List[FunnelMetrics]) -> List[Anomaly]:  
    """
```

- Identify statistically significant deviations:
- Yield rate changes > 2 standard deviations
 - Application volume outside historical range
 - NTR tracking significantly off-pace

"""

7.1.2 Trend Classification

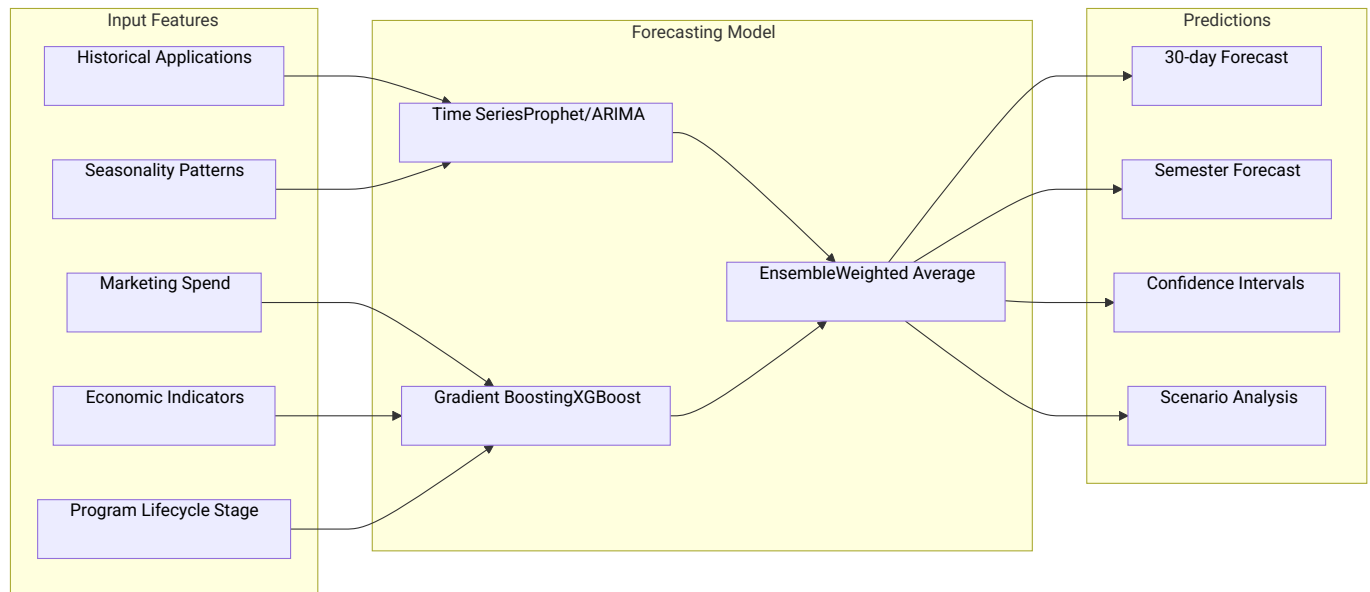
```
def classify_trend(metric_series: List[float]) -> TrendType:  
    """
```

- Categorize metric trajectories:
- ACCELERATING_GROWTH
 - STABLE_GROWTH
 - PLATEAU
 - DECLINING
 - VOLATILE

#####

7.2 Planned ML Enhancements

7.2.1 Enrollment Forecasting Model



7.2.2 Yield Prediction Model

Planned implementation

```
def predict_yield(applicant_features: dict) -> Tuple[float, float]:
```

#####

Predict probability of enrollment for admitted students.

Features:

- Program of interest
- Application timing
- Geographic location
- Previous engagement score
- Financial aid status

Returns:

- yield_probability: float (0-1)
- confidence: float (0-1)

#####

7.2.3 NTR Forecasting

Planned implementation

```
def forecast_ntr(
    current_enrollment: int,
    pipeline_data: dict,
    historical_patterns: dict
) -> NTRForecast:
```

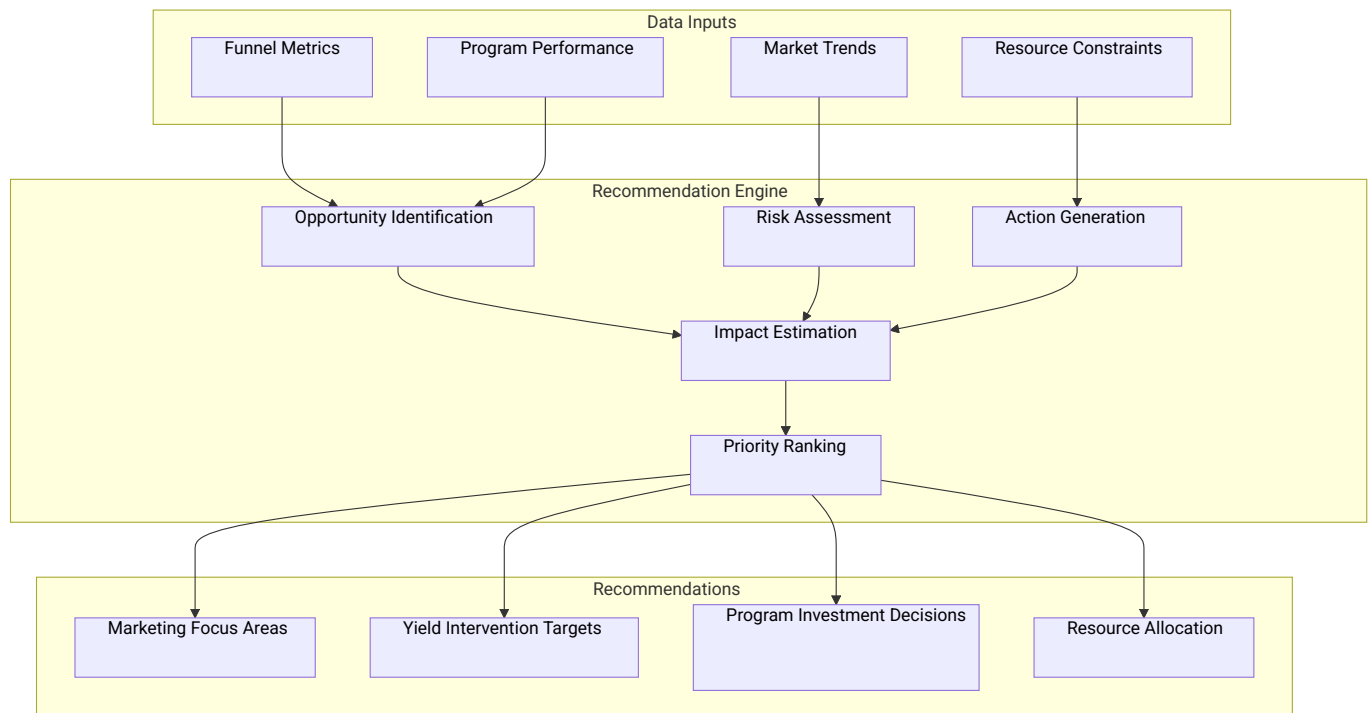
#####

Project end-of-semester NTR based on:

- Current confirmed enrollments

- Pipeline conversion probabilities
- Historical melt rates
- Credit load distributions

7.3 AI-Driven Recommendations Engine



8. User Interface & Experience Design

8.1 Design System

8.1.1 Color Palette

/* Brand Colors */

```

--stevens-red: #A41034;
--stevens-white: #FAFAFA;
--stevens-gray-light: #8892A0;
--stevens-gray-dark: #4A5568;
  
```

/* Semantic Colors */

```

--chart-success: #2E7D32;
--chart-warning: #F57C00;
--chart-danger: #C62828;
  
```

/* Background Colors */

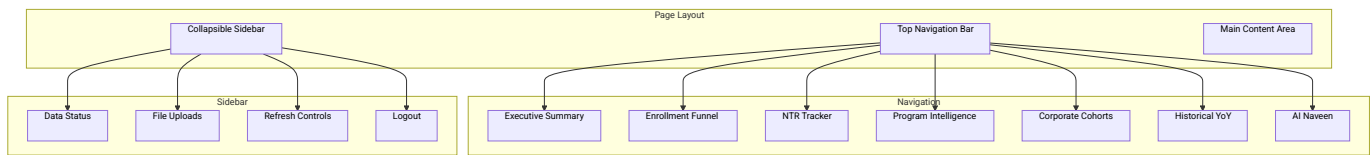
```

--background-main: #0E1117;
--background-card: #1A1F2E;
--background-glass: rgba(26, 31, 46, 0.85);
  
```

8.1.2 Component Library

Component	Purpose	Accessibility
cpe-card	Container with glass effect	Focus visible, high contrast
cpe-button	Primary actions	44px min touch target
cpe-chip	Suggestion pills	Keyboard navigable
cpe-gauge	Progress visualization	ARIA labels
cpe-chat	AI conversation	Screen reader compatible

8.2 Dashboard Layout



8.3 Responsive Design

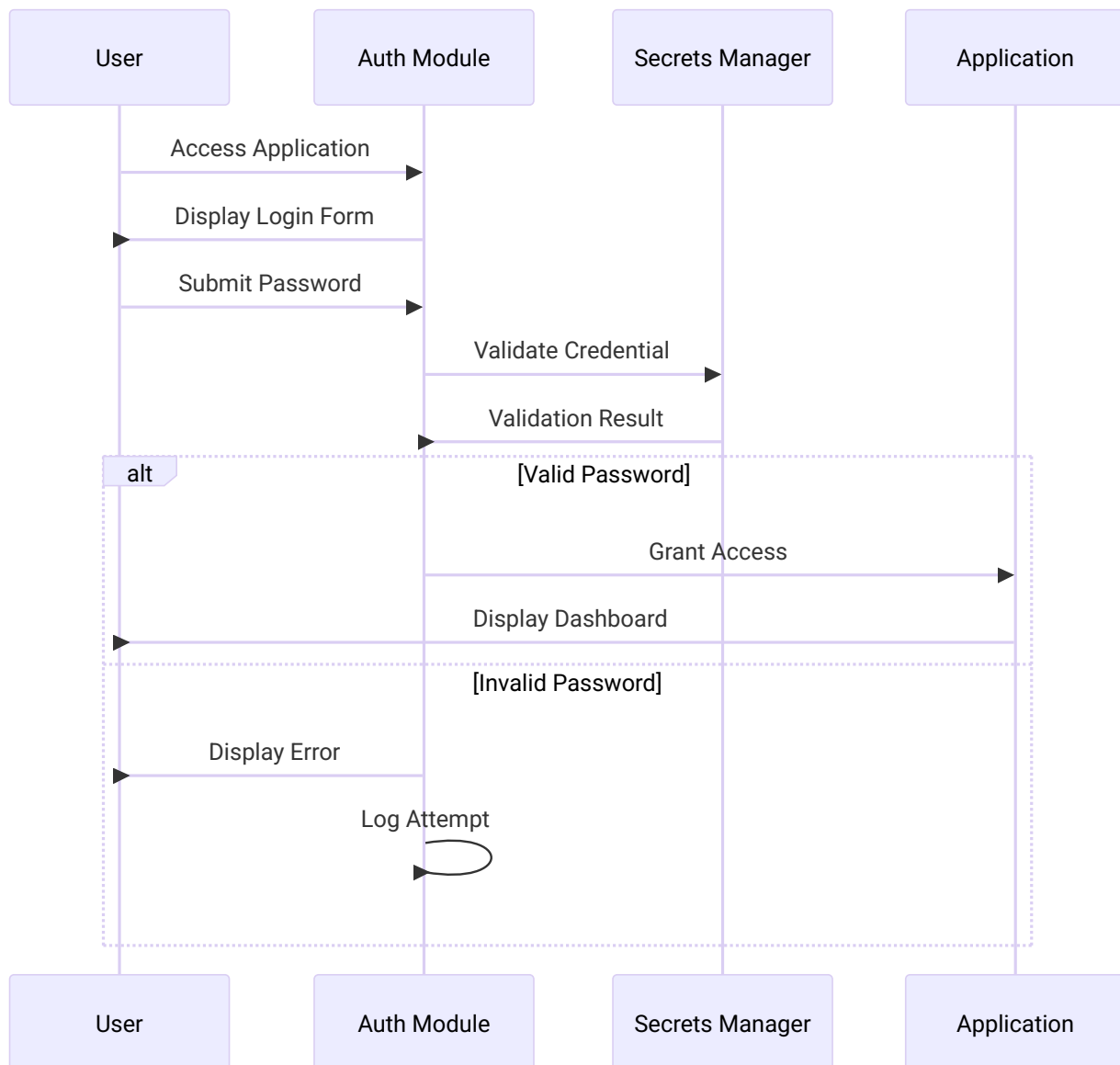
Breakpoint	Layout Adaptation
Desktop (>1024px)	Full top nav, expanded charts
Tablet (768-1024px)	Compressed nav, 2-column grids
Mobile (<768px)	Hamburger menu, single column, touch-optimized

8.4 Accessibility Compliance

- WCAG 2.1 AA target compliance
- Minimum 4.5:1 contrast ratio for text
- Focus indicators for keyboard navigation
- ARIA labels for interactive elements
- Screen reader compatible chart descriptions

9. Security, Authentication & Compliance

9.1 Authentication Flow



9.2 Credential Management

Secrets stored in .streamlit/secrets.toml (gitignored)
 # Accessed via st.secrets["key_name"]

Required secrets:
 # - password: Application access password
 # - gemini_api_key: Google AI API key
 # - slate_api_key: CRM API credentials (if applicable)

9.3 Data Security Measures

Layer	Protection
Transport	HTTPS enforced
Authentication	Password-protected access
API Keys	Server-side secrets, never exposed to client
Session	Streamlit session isolation
Logging	No PII in logs

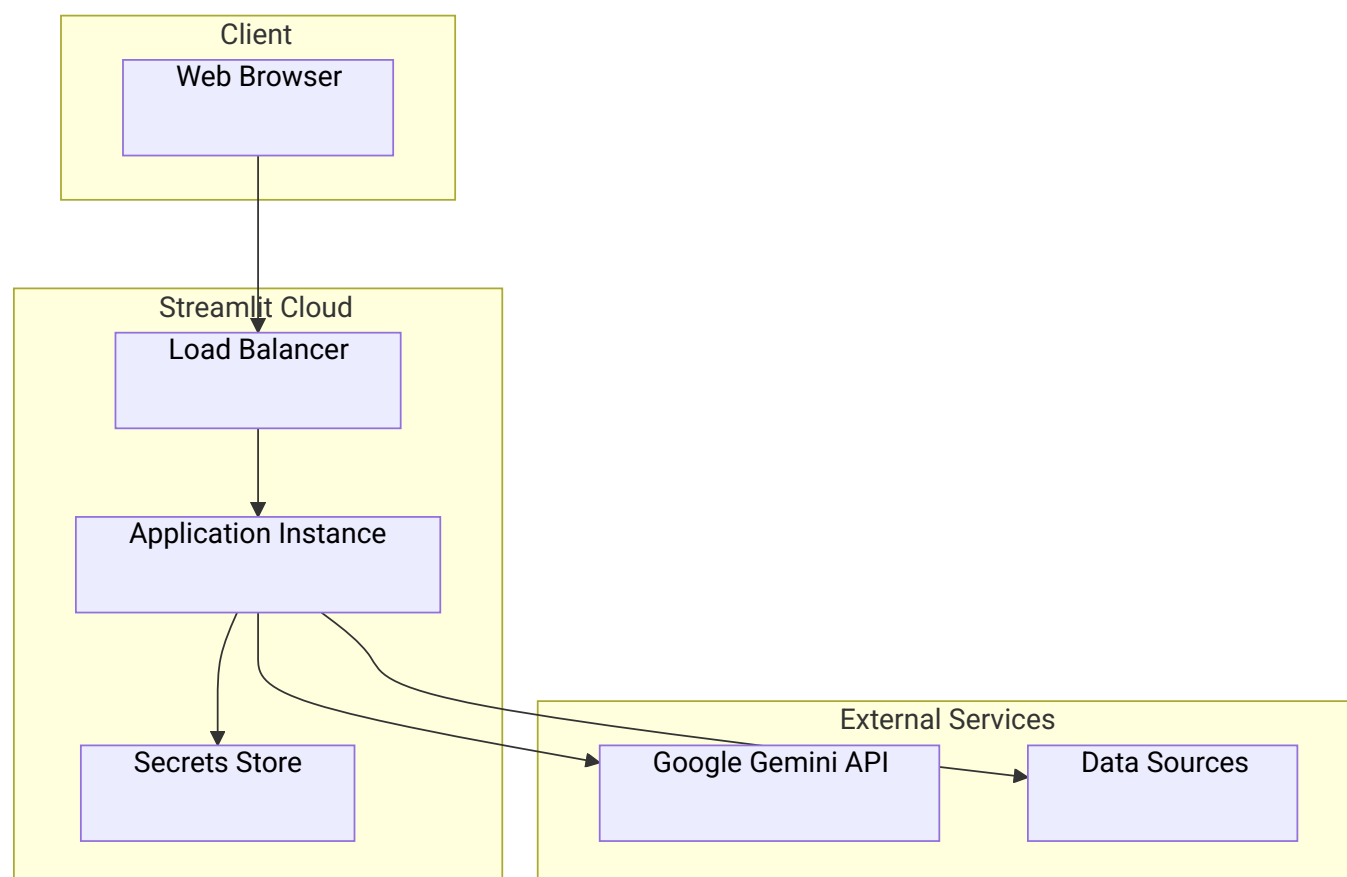
Uploads	In-memory processing, not persisted
---------	-------------------------------------

9.4 Compliance Considerations

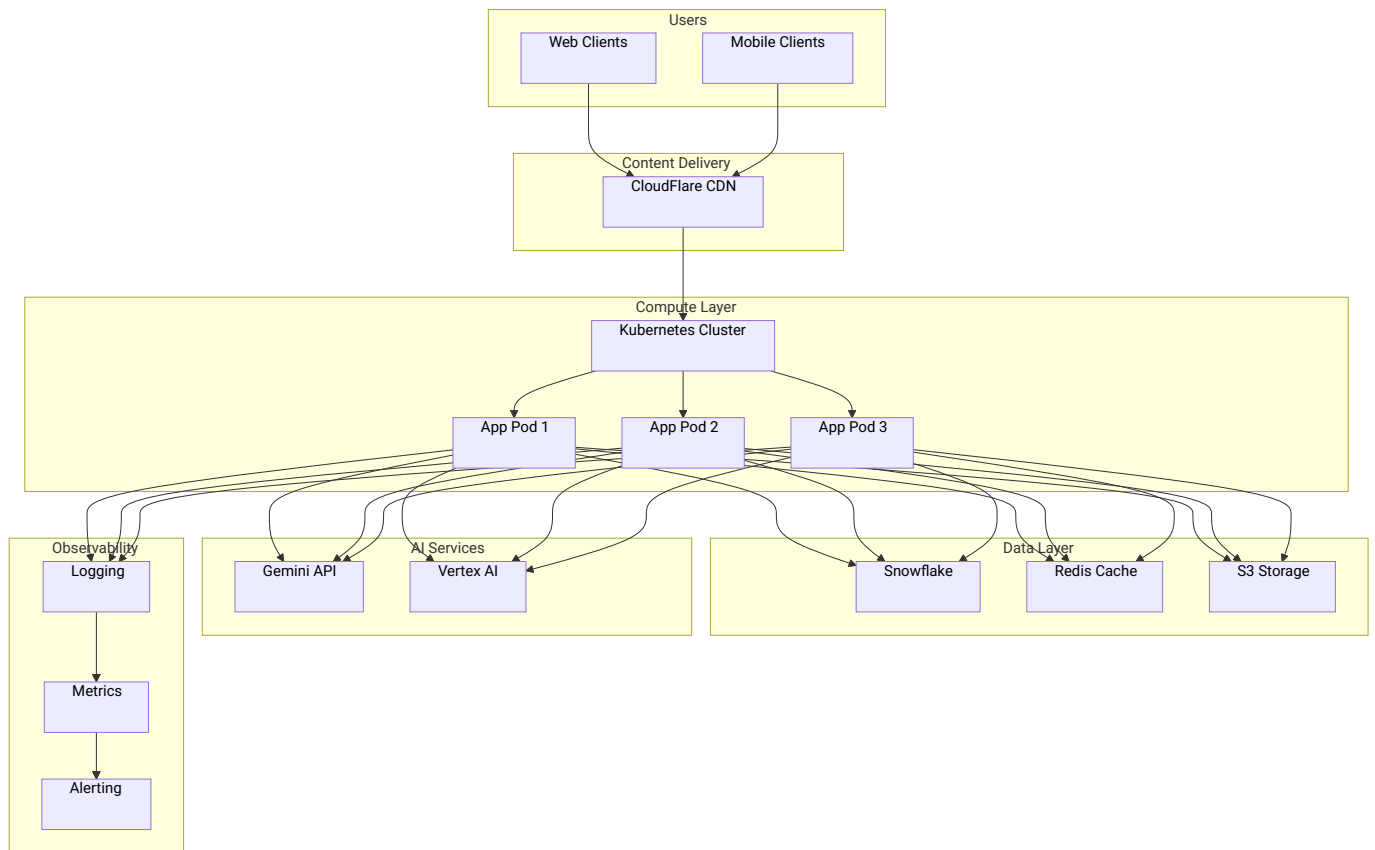
- **FERPA:** No individual student PII displayed
 - **Data Minimization:** Only aggregate metrics shown
 - **Access Control:** Role-based access (future enhancement)
 - **Audit Trail:** Authentication events logged
-

10. Cloud Deployment Architecture

10.1 Current Deployment (Streamlit Cloud)



10.2 Production Deployment (Future)



10.3 Deployment Configuration

```
# streamlit cloud deployment
# .streamlit/config.toml
```

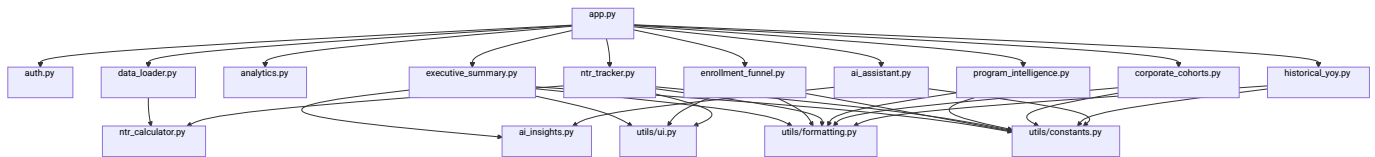
```
[server]
headless = true
enableCORS = true
enableXsrfProtection = false
runOnSave = true
```

```
[theme]
primaryColor = "#A41034"
backgroundColor = "#0E1117"
secondaryBackgroundColor = "#1A1F2E"
textColor = "#FAFAFA"
```

```
[browser]
gatherUsageStats = false
```

11. Technical Implementation Details

11.1 Module Dependency Graph



11.2 Key Implementation Patterns

11.2.1 Data Loading with Upload Override

```
@st.cache_data(ttl=3*60*60, show_spinner=False)
```

```
def load_all_data(
    census_uploaded_bytes: Optional[bytes] = None,
    census_uploaded_name: str = "",
    apps_uploaded_bytes: Optional[bytes] = None,
    apps_uploaded_name: str = "",
) -> Tuple[Dict, datetime]:
    """
```

Priority order for data sources:

1. User-uploaded files (highest priority)
2. Local file system (development)
3. API endpoints (production fallback)

```
Cache key includes upload fingerprints for proper invalidation.
"""
```

11.2.2 Multipage Navigation

```
def main():
    # Define pages as functions
    p_exec = st.Page(page_executive_summary, title="Executive Summary")
    p_funnel = st.Page(page_enrollment_funnel, title="Enrollment Funnel")
    # ... additional pages

    # Group pages for navigation
    pages = {
        "": [p_exec, p_funnel, p_ntr],
        "More": [p_prog, p_cohorts, p_yoy],
        "AI": [p_ai],
    }

    # Native Streamlit navigation
    current = st.navigation(pages, position="top", expanded=False)
    current.run()
```

11.2.3 AI Response Streaming

```
def process_message(prompt: str, data: dict, api_key: str):
    # Build context from current data
    context = build_context(data, st.session_state.chat_summary)

    # Generate response with Gemini
    client = genai.Client(api_key=api_key)
    response = client.models.generate_content(
```

```

model="gemini-2.0-flash",
contents=f"{SYSTEM_PROMPT}\n\nCONTEXT:\n{context}\n\nUSER: {prompt}"
)

# Display with typing effect
display_typing_effect(response.text, response_container)

# Update conversation history
st.session_state.chat_history.append({"role": "user", "content": prompt})
st.session_state.chat_history.append({"role": "assistant", "content": response.text})

# Summarize if history is long
if len(st.session_state.chat_history) >= 8:
    st.session_state.chat_summary = summarize_conversation(
        st.session_state.chat_history, api_key
    )

```

11.3 Error Handling Strategy

```

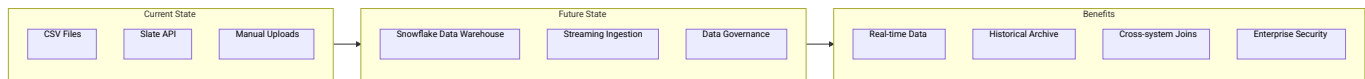
# Graceful degradation pattern used throughout
try:
    data = load_critical_data()
except DataSourceError as e:
    st.warning(f"Primary data source unavailable: {e}")
    data = load_fallback_data()
except Exception as e:
    st.error(f"Data loading failed: {e}")
    data = get_empty_data_structure()

# Continue with partial data rather than crashing
render_dashboard(data)

```

12. Future Roadmap & AI Enhancements

12.1 Phase 1: Snowflake Integration (Q2 2026)



Implementation Plan

- Snowflake Connector Integration**

```
python from snowflake.connector import connect
@st.cache_resource def get_snowflake_connection():
    return
connect(
        account=st.secrets["snowflake_account"],
        user=st.secrets["snowflake_user"],      password=st.secrets["snowflake_password"],
        warehouse="CPE_ANALYTICS_WH",      database="ENROLLMENT",
        schema="FUNNEL"
    )
```
- Data Model Migration**
 - Applications fact table

- Census dimension table
- NTR aggregation views
- Historical snapshots

3. Query Optimization

- Materialized views for common aggregations
- Incremental refresh for real-time updates

12.2 Phase 2: Advanced AI Features (Q3 2026)

12.2.1 Predictive Enrollment Forecasting

```
class EnrollmentForecaster:
    """
```

Multi-model ensemble for enrollment prediction.

Models:

- Prophet: Seasonality and trend decomposition
- XGBoost: Feature-based gradient boosting
- LSTM: Sequential pattern recognition

Output:

- Point forecasts with confidence intervals
 - Scenario analysis (optimistic/pessimistic)
 - Feature importance for interpretability
- ```
 """
```

### 12.2.2 Automated Insight Generation

```
class InsightEngine:
 """
```

AI-powered insight generation pipeline.

Capabilities:

- Anomaly detection with root cause analysis
- Trend identification and projection
- Comparative analysis across segments
- Natural language insight narratives

Integration:

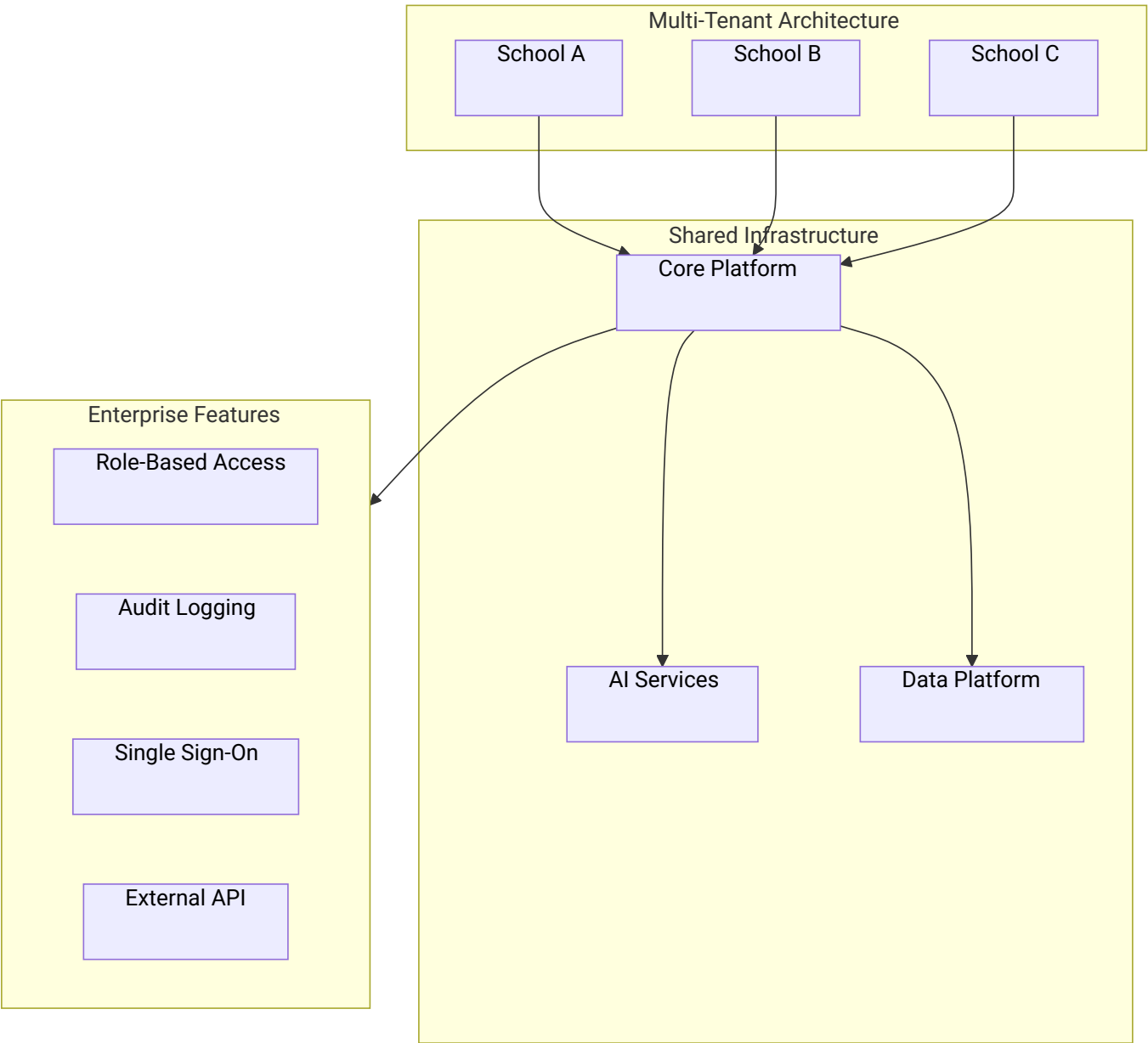
- Proactive alerts via email/Slack
  - Dashboard widget updates
  - AI Naveen knowledge augmentation
- ```
    """
```

12.2.3 Conversational Analytics Expansion

- **Voice Interface:** Speech-to-text for hands-free querying
- **Chart Generation:** AI creates visualizations from natural language

- **Report Automation:** Scheduled AI-generated summaries
- **Multi-modal Responses:** Charts embedded in chat responses

12.3 Phase 3: Enterprise Scale (Q4 2026)



Planned Capabilities

Feature	Description	Priority
Multi-tenant	Support multiple schools/departments	High
Role-based access	Granular permission control	High
SSO integration	SAML/OAuth2 authentication	Medium
External API	Programmatic data access	Medium
Custom dashboards	User-defined views	Low
Mobile app	Native iOS/Android	Low

12.4 AI Research Directions

1. Fine-tuned Domain Models

- Train on higher education enrollment data
- Improve accuracy for sector-specific queries

2. Retrieval-Augmented Generation (RAG) Enhancement

- Vector database for semantic search
- Dynamic context selection
- Citation linking in responses

3. Agentic AI Capabilities

- Autonomous data exploration
- Self-improving prompt engineering
- Multi-step reasoning chains

4. Explainable AI (XAI)

- Model decision transparency
- Confidence scoring
- Uncertainty quantification

Appendix: Code Architecture

A.1 Directory Structure

```
CPE Funnel Dashboard/  
├── app.py           # Main application entry point  
├── auth.py          # Authentication module  
├── data_loader.py    # Data ingestion and caching  
├── analytics.py      # Statistical calculations  
├── ntr_calculator.py # Revenue modeling  
├── naveen-headshot.png # AI assistant avatar  
├──   
├── components/  
│   ├── ai_assistant.py # AI Naveen chat interface  
│   ├── ai_insights.py  # Insight generation engine  
│   ├── executive_summary.py # KPI dashboard  
│   ├── enrollment_funnel.py # Funnel visualization  
│   ├── ntr_tracker.py   # Revenue tracking  
│   ├── program_intelligence.py # Program analytics  
│   └── corporate_cohorts.py # Partner analysis
```


This document describes Project Iris as of January 2026. The project requires functions as a systems engineering, data science, and enterprise level software and AI development.