**Functional Architecture Design Document**

**Version:** 1.0.2  
**Date:** May 7, 2025

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**1. Executive Summary**

This Functional Architecture Design Document details the comprehensive design for a Neural Core Platform with extensible Agentic AI Products. The system is designed as a modular, scalable platform that enables conversation intelligence with advanced capabilities, including user-specific semantic evolution, adaptive communication, multilingual support, empathetic responses, robust memory management, and dynamic workflow orchestration.

The architecture separates core conversation capabilities (Neural Core) from specialized domain functionality (Agentic Products), connected through a Master Control Protocol (MCP) that facilitates orchestration and Agent-to-Agent (A2A) communication. This separation allows for independent development, deployment, and scaling of components while maintaining a cohesive user experience.

The enhanced design introduces a dynamic workflow engine that enables the system to orchestrate complex processes across agents, adapting to changing conditions and user needs in real-time. This allows for sophisticated automated workflows that can be triggered by conversation intents or system events.

The system is designed to provide personalized interactions that adapt to individual users while maintaining organizational knowledge boundaries and privacy requirements. The platform supports multiple deployment configurations across cloud-native, hybrid, and on-premises environments.

**2. Introduction**

The ME.AI Neural Core represents a next-generation architecture for intelligent conversation systems that can understand, adapt to, and assist users through natural language interactions. This document provides a detailed architectural blueprint for implementing this vision.

**Purpose and Goals**

The Neural Core architecture aims to achieve several key objectives:

1. Enable personalized, contextually aware conversations that adapt to individual users
2. Facilitate organization-specific knowledge and capabilities while maintaining privacy
3. Support dynamic orchestration of complex workflows triggered by conversation
4. Provide enterprise-grade integration capabilities for business systems
5. Scale independently across components to optimize resource utilization
6. Support multi-channel interactions including chat and voice
7. Maintain conversation context across sessions and time periods
8. Deliver emotionally intelligent responses based on user state
9. Work effectively across multiple languages and cultural contexts

**Technical Approach**

The architecture follows several key principles:

1. **Modular Design**: Components are designed with clear boundaries and interfaces
2. **Separation of Concerns**: Core conversation intelligence is separate from domain-specific capabilities
3. **Extensibility**: New Agentic Products can be added without modifying the core platform
4. **Scalability**: Components can scale independently based on demand
5. **Adaptability**: The system learns and adapts to users over time
6. **Integration**: Well-defined integration points enable connectivity with enterprise systems
7. **Resilience**: Fault tolerance is built into the design at multiple levels

**Technical Stack Overview**

The implementation leverages modern cloud-native technologies:

| **Category** | **Technologies** |
| --- | --- |
| Frontend | React, Angular, WebSockets, WebRTC |
| Backend | Microservices, Containerization, Kubernetes |
| AI/ML | Transformer Models, Vector Embeddings, Knowledge Graphs |
| Databases | PostgreSQL, Redis, MongoDB, Neo4j, Vector Databases |
| Integration | API Gateways, Event Buses, Webhooks, Adapters |
| Workflow | Temporal.io, Camunda, BPMN |
| Messaging | Kafka, RabbitMQ, gRPC |
| Security | OAuth, OIDC, JWT, mTLS |
| Observability | Prometheus, Grafana, OpenTelemetry |

**3. System Overview**

**3.1 High-Level Architecture**

The system consists of three primary layers: Client Interfaces, Neural Core Platform, and Agentic Products, connected through a Master Control Protocol.

mermaid

flowchart TD

subgraph CLIENT\_INTERFACES["CLIENT INTERFACES"]

CC[Chat Client - React/Angular]

VC[Voice/Telephony - Twilio/Amazon Connect]

ES[Enterprise Systems - REST/GraphQL APIs]

end

subgraph NEURAL\_CORE["NEURAL CORE (CONVERSATION INTELLIGENCE)"]

ASL[Access & Security Layer - OAuth/OIDC]

CPL[Conversation Processing - NLP Pipeline]

MMS[Memory Management System - Redis/MongoDB]

USE[User-Specific Semantic Evolution - Knowledge Graphs]

ACM[Adaptive Communication - Context Adapters]

MLS[Multilingual Support - Translation Services]

ERS[Empathetic Response System - Sentiment Analysis]

DWE[Dynamic Workflow Engine - Temporal.io]

CDB[Core Databases - PostgreSQL/Neo4j/Vector DBs]

end

subgraph MCP["MASTER CONTROL PROTOCOL (MCP)"]

AO[Agent Orchestration - gRPC/Protocol Buffers]

CPC[Cross-Product Communication - Kafka/RabbitMQ]

RR[Request Routing - Envoy/Istio]

WOS[Workflow Orchestration Service - Camunda/Temporal]

end

subgraph PRODUCTS["AGENTIC PRODUCTS"]

AP1[Agentic Product 1 - Domain-Specific Microservices]

AP2[Agentic Product 2 - Domain-Specific Microservices]

AP3[Agentic Product 3 - Domain-Specific Microservices]

FP[Future Products - Extensible API Framework]

end

CC --> NEURAL\_CORE

VC --> NEURAL\_CORE

ES --> NEURAL\_CORE

NEURAL\_CORE --> MCP

MCP --> AP1

MCP --> AP2

MCP --> AP3

MCP --> FP

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class NEURAL\_CORE green

class MCP orange

class PRODUCTS purple

**High-Level Technical Stack**

| **Layer** | **Component** | **Technologies** | **Purpose** |
| --- | --- | --- | --- |
| **Client Interfaces** | Chat Client | React, Angular, Vue.js, WebSockets, Socket.io | Real-time text-based communication interfaces |
|  | Voice/Telephony | Twilio, Amazon Connect, WebRTC, VOIP SIP | Voice channel integration and processing |
|  | Enterprise Systems | REST APIs, GraphQL, SOAP, ESB, Apache Camel | Enterprise system integration points |
| **Neural Core** | Access & Security | OAuth 2.0, OIDC, JWT, SAML, mTLS | Authentication, authorization, and security |
|  | Conversation Processing | NLP Pipeline, Transformers, BERT, GPT models | Natural language understanding and generation |
|  | Memory Management | Redis, MongoDB, Cassandra, Time-series DBs | Short-term, long-term, and cross-session memory |
|  | User-Specific Semantics | Neo4j, TigerGraph, Knowledge Graphs, Word2Vec | Personalized semantic understanding |
|  | Adaptive Communication | Context Adaptation, Fine-tuning, Personality Models | Communication style and preference adaptation |
|  | Multilingual Support | Translation APIs, Language Detection, i18n | Cross-language communication capabilities |
|  | Empathetic Response | Sentiment Analysis, Emotion Detection, NLG | Emotionally intelligent interactions |
|  | Dynamic Workflow | Temporal.io, Camunda, Apache Airflow, BPMN | Orchestration of adaptable processes |
|  | Core Databases | PostgreSQL, MySQL, Neo4j, Vector DBs, Time-series DBs | Structured and unstructured data storage |
| **MCP** | Agent Orchestration | gRPC, Protocol Buffers, Service Registry | Agent discovery and coordination |
|  | Cross-Product Comm. | Kafka, RabbitMQ, NATS, AWS SNS/SQS | Asynchronous messaging between products |
|  | Request Routing | Envoy, Istio, Kong, NGINX, HAProxy | Traffic routing and load balancing |
|  | Workflow Orchestration | Camunda, Temporal.io, Apache Airflow | Cross-product workflow coordination |
| **Agentic Products** | Domain-Specific Agents | Microservices, Domain-Specific ML Models | Specialized functionality for domains |
|  | Storage | PostgreSQL, MongoDB, Specialized Stores | Domain-specific data storage |
|  | Integration | API Gateways, ESB, Message Brokers | External system integration |
|  | Domain Logic | Business Rules Engines, Expert Systems | Domain-specific business logic |

**System Use Case Diagram**

mermaid

graph LR

user((End User))

system((Enterprise System))

admin((Administrator))

subgraph "Neural Core Platform"

UC1[Engage in Natural Conversation]

UC2[Execute Dynamic Workflows]

UC3[Access Enterprise Systems]

UC4[Provide Multilingual Support]

UC5[Deliver Empathetic Responses]

UC6[Maintain User-Specific Semantics]

UC7[Manage Memory Across Sessions]

UC8[Configure System]

end

user --> UC1

user --> UC2

user --> UC4

user --> UC5

system --> UC3

admin --> UC8

UC1 --> UC6

UC1 --> UC7

UC2 --> UC3

**System Data Flow Diagram**

mermaid

flowchart TD

client[Client Interfaces]

core[Neural Core]

mcp[MCP]

products[Agentic Products]

external[External Systems]

client -->|User Inputs| core

core -->|Responses| client

core -->|Agent Requests| mcp

mcp -->|Agent Responses| core

mcp -->|Task Execution| products

products -->|Results| mcp

products -->|Integration Calls| external

external -->|Data & Operations| products

**3.2 Key Components**

The system consists of these primary components:

1. **Neural Core Platform**: The foundation of the system, providing:
   * Authentication and security
   * Conversation processing
   * Memory management
   * User-specific semantic evolution
   * Adaptive communication
   * Multilingual support
   * Empathetic response generation
   * Dynamic workflow engine
2. **Master Control Protocol (MCP)**: Orchestration layer responsible for:
   * Agent discovery and registration
   * Task planning and execution
   * Message routing between agents
   * Cross-product coordination
   * Workflow orchestration service
3. **Agentic Products**: Domain-specific extensions providing:
   * Specialized agent capabilities
   * Domain-specific knowledge
   * Task execution frameworks
   * Product-specific storage
   * Workflow template repository
4. **Database Architecture**: Multi-layered storage strategy for:
   * User profiles and preferences
   * Conversation history
   * Semantic knowledge
   * Memory management
   * Linguistic resources
   * Empathy engine data
   * Workflow state database

**4. Neural Core Platform**

**4.1 User-Specific Semantic Evolution**

The User-Specific Semantic Evolution system builds and maintains personalized semantic understanding for each user.

mermaid

erDiagram

UserProfile ||--o{ UserSemanticProfile : has

UserProfile ||--o{ EntityFamiliarity : tracks

UserProfile ||--o{ UserKnowledgeNode : contains

UserKnowledgeNode ||--o{ UserKnowledgeRelationship : participatesIn

UserProfile ||--o{ ConceptualUnderstanding : measures

UserProfile {

string UserID PK "UUID - Primary Key"

object BasicInfo "JSON - Personal Information"

object CommunicationPrefs "JSON - Communication Settings"

object LanguageProficiency "JSON - Language Capabilities"

object InteractionMetrics "JSON - Usage Statistics"

object LearningProfile "JSON - Learning Patterns"

}

UserSemanticProfile {

string ProfileID PK "UUID - Primary Key"

string UserID FK "User Reference - Foreign Key"

date CreationDate "Timestamp - Creation Time"

date LastUpdated "Timestamp - Last Update"

vector SemanticVector "HNSW/FAISS - 1024-dim Embedding"

boolean DefaultOrganizationProfile "Flag - Default Status"

string ActiveStatus "Enum - Status Values"

string Version "Semantic Version Number"

}

EntityFamiliarity {

string RecordID PK "UUID - Primary Key"

string UserID FK "User Reference - Foreign Key"

string EntityID "UUID - Entity Reference"

float Familiarity "Float - 0.0-1.0 Familiarity Score"

date FirstEncounter "Timestamp - First Seen"

date LastEncounter "Timestamp - Last Seen"

int EncounterCount "Integer - Occurrence Count"

float Importance "Float - Importance Weight"

}

UserKnowledgeNode {

string NodeID PK "UUID - Primary Key"

string UserID FK "User Reference - Foreign Key"

string EntityType "String - Entity Classification"

string EntityName "String - Entity Name"

object EntityProperties "JSON - Entity Attributes"

float PersonalSignificance "Float - User Relevance"

date CreationDate "Timestamp - Creation Time"

date LastReferenced "Timestamp - Last Referenced"

int ReferenceCount "Integer - Reference Count"

string PersonalContext "Text - User Context Notes"

}

UserKnowledgeRelationship {

string RelationshipID PK "UUID - Primary Key"

string UserID FK "User Reference - Foreign Key"

string SourceNodeID FK "Source Node Reference"

string TargetNodeID FK "Target Node Reference"

string RelationType "String - Relationship Type"

float Strength "Float - Relationship Strength"

string Evidence "Text - Supporting Evidence"

date FirstObserved "Timestamp - First Observed"

date LastReinforced "Timestamp - Last Reinforced"

float ConfidenceScore "Float - Confidence Level"

}

ConceptualUnderstanding {

string UnderstandingID PK "UUID - Primary Key"

string UserID FK "User Reference - Foreign Key"

string ConceptID "UUID - Concept Reference"

float UnderstandingLevel "Float - Comprehension Level"

array Misconceptions "Array - Misunderstanding Notes"

object LearningTrajectory "JSON - Learning Path"

array ContextualUsage "Array - Usage Examples"

}

**Semantic Evolution Data Flow Diagram**

mermaid

flowchart LR

UI[User Interaction - Natural Language] --> LE[Language Extraction - NLP Pipeline]

LE --> EG[Entity Generation - Named Entity Recognition]

EG --> VE[Vector Embedding - Sentence Transformers]

VE --> SD[Similarity Detection - FAISS/HNSW]

SD --> KGE[Knowledge Graph Enrichment - Neo4j/TigerGraph]

KGE --> USP[User Semantic Profile Updates - Database Writes]

USP --> FD[Familiarity Detection - Score Calculation]

FD --> AC[Adaptive Communication - Personalization]

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**User-Specific Semantic Evolution Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Knowledge Representation | Neo4j, TigerGraph, Property Graphs | Graph-based knowledge structures with properties |
| Vector Embeddings | BERT, Word2Vec, Sentence Transformers | Entity and concept embeddings in vector space |
| Vector Storage | Pinecone, Weaviate, Milvus, FAISS | Vector databases with similarity search |
| Semantic Matching | HNSW, ANN, cosine similarity | Approximate nearest neighbor algorithms |
| Entity Recognition | NER, BERT-based entity extraction | Identification of entities in conversations |
| Relationship Mining | Dependency parsing, semantic role labeling | Extracting relationships between entities |
| Persistence | PostgreSQL with pgvector, MongoDB | Storage of semantic profiles and relationships |
| Confidence Scoring | Bayesian models, ML confidence scoring | Determining confidence in relationships |
| User Profiling | Collaborative filtering, clustering | Building personalized user profiles |
| Concept Hierarchy | Ontologies, taxonomies, knowledge graphs | Structured concept organization |

**Semantic Evolution Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

subgraph "Semantic Evolution System"

UC1[Create Semantic Profile]

UC2[Update Entity Familiarity]

UC3[Build Knowledge Graph]

UC4[Track Conceptual Understanding]

UC5[Apply Semantic Context]

UC6[Merge Organization/User Semantics]

end

user --> UC1

system --> UC2

system --> UC3

system --> UC4

UC1 --> UC5

UC2 --> UC5

UC3 --> UC5

UC4 --> UC5

UC5 --> UC6

**4.2 Adaptive Communication**

The Adaptive Communication system adjusts communication style to match user preferences and detected proficiency levels.

mermaid

flowchart TD

UIP[User Input Processing - NLP Pipeline/BERT] --> SCR[Session Context Retrieval - Redis/Session Store]

UPL[User Profile Lookup - GraphQL/REST API] --> SCR

SCR --> CSS[Communication Style Selection]

subgraph CSS["COMMUNICATION STYLE SELECTION"]

PDA[Pace Detection & Adjustment - ML Model/LSTM]

DLC[Detail Level Calibration - Context Analysis]

LS[Language Selection - FastText/CLD3]

TLM[Technical Level Matching - Domain Models]

FA[Formality Adjustment - Stylistic Transfer]

CA[Cultural Adaptation - Cultural Models]

end

CSS --> SP[Semantic Personalization - User KG/Vector DB]

CSS --> CG[Content Generation - LLM/Template Engine]

CSS --> LS2[Linguistic Styling - Style Transfer Models]

SP <--> CG

CG <--> LS2

CG --> RD[Response Delivery - API Gateway/Channels]

RD --> URA[User Response Analysis - Sentiment/Feedback]

URA --> LI[Learning Integration - ML Feedback Loop]

LI --> SPE[Semantic Profile Evolution]

subgraph SPE["SEMANTIC PROFILE EVOLUTION"]

PD[Pattern Detection - ML Clustering/Association]

PU[Preference Updates - Bayesian Updates/ML]

KGU[Knowledge Graph Updates - Graph Operations]

end

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class SPE green

**Adaptive Communication Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Input Processing | BERT, RoBERTa, transformer-based NLP | Natural language understanding pipeline |
| Context Retrieval | Redis, DynamoDB, key-value stores | Fast retrieval of conversation context |
| User Profiling | GraphQL, REST APIs, profile databases | Access to comprehensive user profiles |
| Communication Style | ML classifiers, LSTMs, transformers | Detection and selection of communication styles |
| Language Selection | FastText, CLD3, language detection | Identifying and selecting appropriate language |
| Technical Matching | Domain ontologies, expertise models | Matching content to user's technical level |
| Cultural Adaptation | Cultural models, localization | Culturally appropriate communication |
| Content Generation | LLMs, template engines, NLG | Generation of appropriate responses |
| Linguistic Styling | Style transfer models, templates | Applying appropriate linguistic style |
| Response Analysis | Sentiment analysis, feedback collection | Analyzing user reactions to responses |
| Learning Integration | ML feedback loops, reinforcement learning | Learning from user interactions |
| Pattern Detection | Clustering, association rules | Finding patterns in user communications |
| Preference Updates | Bayesian models, ML profiling | Updating user preferences based on feedback |

**Adaptive Communication Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

subgraph "Adaptive Communication System"

UC1[Select Communication Style]

UC2[Adjust Technical Level]

UC3[Apply Cultural Context]

UC4[Generate Personalized Response]

UC5[Learn from Feedback]

UC6[Update User Profile]

end

user --> UC4

system --> UC1

system --> UC2

system --> UC3

UC1 --> UC4

UC2 --> UC4

UC3 --> UC4

user --> UC5

UC5 --> UC6

UC6 --> UC1

**Adaptive Communication Data Flow Diagram**

mermaid

flowchart TD

input[User Input]

context[Context Analysis]

profile[User Profile]

style[Style Selection]

generation[Content Generation]

delivery[Response Delivery]

feedback[Feedback Analysis]

updates[Profile Updates]

input -->|Text/Speech| context

profile -->|Preferences| style

context -->|Context Factors| style

style -->|Style Parameters| generation

generation -->|Response Content| delivery

delivery -->|User Reaction| feedback

feedback -->|Learning Signal| updates

updates -->|Profile Modifications| profile

**4.3 Multilingual Support**

The Multilingual Support system enables natural interactions across different languages with appropriate cultural nuances.

mermaid

flowchart TD

subgraph LPP["LANGUAGE PROCESSING PIPELINE"]

LD[Language Detection - FastText/CLD3]

DI[Dialect Identification - BERT Fine-tuned]

RS[Register Selection - Rule-based System]

end

LPP --> LRS

subgraph LRS["LINGUISTIC RESOURCE SELECTION"]

FS[Filler Selection - Language-specific Corpus]

IR[Idiom Repository - MongoDB Collections]

CR[Cultural References - Knowledge Graph]

FM[Formality Markers - Statistical Models]

TT[Technical Terminology - Domain Ontologies]

EE[Emotional Expressions - Sentiment Lexicons]

end

LRS --> RGA

subgraph RGA["RESPONSE GENERATION & ADAPTATION"]

GS[Grammatical Structure - Language-specific Rules]

NP[Natural Phrasing - Markov Models]

CS[Cultural Sensitivity - Ethics Models]

LCS[Linguistic Code-Switching - ML Detection]

PPI[Pause Pattern Insertion - Prosody Models]

PF[Prosodic Features - Speech Synthesis]

end

RGA --> LPA

subgraph LPA["LANGUAGE PROFICIENCY ADAPTATION"]

CA[Complexity Adjustment - Readability Metrics]

VS[Vocabulary Simplification - Word Frequency]

PC[Pace Control - Sentence Length Analysis]

EI[Explanation Insertion - Context Detection]

VSU[Visual Supplements - Image Generation API]

LLS[Language Learning Support - Pedagogy Models]

end

LPA --> TSI[Translation Services Integration - Google/DeepL APIs]

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class LRS green

class RGA orange

class LPA purple

class LD,DI,TSI tech

**Multilingual Support Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Language Detection | FastText, CLD3, langdetect | Identification of input language |
| Dialect Identification | Fine-tuned BERT models, n-gram analysis | Recognition of regional dialects |
| Translation Services | Google Translate API, DeepL API, MarianMT | Cross-language translation |
| Multilingual Models | XLM-RoBERTa, mBERT, M2M-100 | Unified models for multiple languages |
| Cultural References | Cultural knowledge graphs, cultural ontologies | Culture-specific references and context |
| Idiom Management | Idiom repositories, expression mapping | Translation of non-literal expressions |
| Formality Control | Formality classification, register analysis | Appropriate formality level adaptation |
| Speech Processing | Whisper, Mozilla TTS, eSpeak | Multilingual speech processing |
| Linguistic Resources | WordNet, ConceptNet, BabelNet | Cross-language lexical resources |
| Linguistic Code-Switching | Code-switching detection, bilingual embedding | Managing language mixing |
| Proficiency Adaptation | Readability metrics, vocabulary control | Adapting to user language proficiency |

**Multilingual Support Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

subgraph "Multilingual Support System"

UC1[Detect Input Language]

UC2[Select Response Language]

UC3[Apply Cultural Context]

UC4[Manage Translation]

UC5[Adapt to Proficiency]

UC6[Handle Code-Switching]

end

user --> UC1

system --> UC2

system --> UC3

system --> UC4

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC1 --> UC5

UC5 --> UC4

UC1 --> UC6

UC6 --> UC4

**Multilingual Support Data Flow Diagram**

mermaid

flowchart TD

input[User Input]

detection[Language Detection]

culture[Cultural Context]

translation[Translation Service]

proficiency[Proficiency Analysis]

generation[Response Generation]

localization[Localization]

output[Output Delivery]

input -->|Text/Speech| detection

detection -->|Language/Dialect| culture

detection -->|Language Capability| proficiency

detection -->|Source Language| translation

culture -->|Cultural Parameters| localization

proficiency -->|Complexity Level| generation

translation -->|Translated Content| generation

generation -->|Base Response| localization

localization -->|Localized Response| output

**4.4 Empathetic Response System**

The Empathetic Response System enables emotionally intelligent interactions that recognize and respond appropriately to user emotions.

mermaid

flowchart TD

MI[Multimodal Input - Text/Voice/Visual] --> EDA

subgraph EDA["EMOTION DETECTION & ANALYSIS"]

TSA[Text-based Sentiment Analysis - VADER/TextBlob]

CER[Context-based Emotion Recognition - RoBERTa]

HPA[Historical Pattern Analysis - LSTM Networks]

CEM[Cultural Emotion Mapping - Cross-cultural Models]

SU[Situational Understanding - Contextual AI]

EIE[Emotional Intensity Estimation - ML Regression]

end

EDA --> ERF

subgraph ERF["EMPATHETIC RESPONSE FORMULATION"]

EM[Emotional Mirroring - Neural Matching]

CA[Cultural Appropriateness - Ethics Models]

EV[Empathetic Validation - NLG Templates]

SL[Supportive Language - Therapeutic Language DB]

TC[Tone Calibration - Style Transfer]

PC[Personal Connection - Memory Reference]

end

ERF --> AED

subgraph AED["ADAPTIVE EMPATHY DELIVERY"]

CAD[Cultural Adaptation - Regional Models]

SA[Situational Appropriateness - Context Engine]

PP[Personal Preferences - User Profile]

EI[Emotional Intelligence - EQ Scoring]

LS[Language Sensitivity - Content Filtering]

FA[Follow-up Awareness - Dialogue State Tracking]

end

AED --> RF[Response Feedback - Effectiveness Measurement]

RF --> ERL[Empathy Reinforcement Learning]

ERL --> EDA

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class EDA blue

class ERF green

class AED orange

class TSA,CER,HPA,ERL tech

**Empathetic Response Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Sentiment Analysis | VADER, TextBlob, IBM Watson Tone Analyzer | Identification of emotional tone in text |
| Emotion Recognition | DeepFace (visual), Librosa (audio), RoBERTa (text) | Multi-modal emotion detection |
| Historical Analysis | LSTM networks, temporal pattern recognition | Detecting emotional patterns over time |
| Cultural Mapping | Cross-cultural emotion models, cultural database | Culture-specific emotional expression |
| Emotional Mirroring | Neural matching, emotional resonance models | Appropriate emotional reflection |
| Response Formulation | Therapeutic language templates, counseling models | Creating empathetic responses |
| Tone Calibration | Style transfer, sentiment-controlled generation | Adjusting tone to emotional context |
| Situational Awareness | Context engines, situation modeling | Understanding emotional context |
| Response Measurement | Effectiveness metrics, emotional impact | Measuring empathetic effectiveness |
| Reinforcement Learning | RL models, human feedback integration | Improving empathetic responses |

**Empathetic Response Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

subgraph "Empathetic Response System"

UC1[Detect User Emotion]

UC2[Analyze Emotional Context]

UC3[Select Empathetic Strategy]

UC4[Generate Supporting Response]

UC5[Adapt to Cultural Context]

UC6[Monitor Emotional Impact]

end

user --> UC1

system --> UC2

system --> UC3

system --> UC4

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC1 --> UC5

UC5 --> UC4

UC4 --> UC6

UC6 --> UC3

**Empathetic Response Data Flow Diagram**

mermaid

flowchart TD

input[User Input]

detection[Emotion Detection]

history[Historical Context]

culture[Cultural Context]

strategy[Response Strategy]

generation[Empathetic Generation]

calibration[Delivery Calibration]

monitoring[Impact Monitoring]

input -->|Text/Voice/Visual| detection

detection -->|Current Emotional State| history

history -->|Emotional Patterns| strategy

culture -->|Cultural Parameters| strategy

strategy -->|Empathetic Approach| generation

generation -->|Base Response| calibration

calibration -->|Empathetic Response| input

input -->|User Reaction| monitoring

monitoring -->|Effectiveness Feedback| strategy

**4.5 Memory Management**

The Memory Management system maintains conversation context across different time spans and interaction sessions.

mermaid

flowchart TD

subgraph STMM["SHORT-TERM MEMORY MANAGEMENT"]

AST[Active Session Tracking - Redis Streams]

RMC[Recent Message Context - In-Memory Cache]

WC[Working Context - Redis JSON]

TDM[Temporal Decay Model - Time-To-Live Settings]

AW[Attention Weighting - Transformer Attention]

RS[Relevance Scoring - BM25/Vector Similarity]

end

subgraph CSMM["CROSS-SESSION MEMORY MANAGEMENT"]

SC[Session Continuity - MongoDB Sessions]

UKP[User Knowledge Persistence - PostgreSQL]

PM[Preference Memory - User Profile Service]

RM[Relationship Memory - Graph Database]

EMT[Event Memory Tracking - Time-series DB]

DH[Dialogue History - Document Store]

end

subgraph SMM["SEMANTIC MEMORY MANAGEMENT"]

PK[Personal Knowledge - Vector Embeddings]

OK[Organizational Knowledge - Knowledge Graph]

CUK[Cultural Knowledge - Ontology Database]

CK[Conceptual Knowledge - Concept Network]

PK2[Procedural Knowledge - Task Graphs]

EH[Episodic Highlights - Summarization Engine]

end

subgraph MOS["MEMORY OPTIMIZATION SERVICES"]

PS[Progressive Summarization - LLM Compression]

MC[Memory Consolidation - Batch Processing]

CP[Context Prediction - Next-Item Prediction]

FM[Forgetting Mechanisms - LRU/TTL Policies]

IW[Importance Weighting - Reinforcement Learning]

MI[Memory Indexing - Inverted/Vector Indices]

end

STMM --> CSMM

CSMM --> SMM

SMM --> MOS

MOS --> RR[Retrieval Routing - RAG Architecture]

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class STMM blue

class CSMM green

class SMM orange

class MOS purple

class AST,RMC,SC,PK,PS,RR tech

**Memory Management Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Short-term Memory | Redis, Memcached, in-memory data structures | Fast access to recent conversation context |
| Cross-session Memory | MongoDB, DynamoDB, Cassandra, session stores | Persistence of context across sessions |
| Semantic Memory | Neo4j, TigerGraph, vector databases | Long-term semantic knowledge storage |
| Vector Storage | Pinecone, Weaviate, Milvus, pgvector | Storage and retrieval of vector embeddings |
| Attentional Mechanisms | Transformer attention, relevance scoring | Focusing on important context elements |
| Memory Indexing | Inverted indices, vector indices, hybrid search | Efficient retrieval of relevant memory |
| Time-series Storage | TimescaleDB, InfluxDB, time-based partitioning | Temporal storage of interaction data |
| Summarization | LLM-based summarization, progressive compression | Condensing verbose information |
| Retrieval | RAG (Retrieval Augmented Generation), hybrid search | Context retrieval for conversations |
| Forgetting | TTL mechanisms, LRU caching, importance-based retention | Managing memory capacity |

**Memory Management Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

subgraph "Memory Management System"

UC1[Maintain Active Context]

UC2[Persist Session State]

UC3[Retrieve Relevant Context]

UC4[Consolidate Memory]

UC5[Optimize Memory Usage]

UC6[Support Semantic Recall]

end

user --> UC1

system --> UC2

system --> UC3

system --> UC4

UC1 --> UC2

UC2 --> UC3

UC3 --> UC1

UC2 --> UC4

UC4 --> UC5

UC5 --> UC3

UC4 --> UC6

UC6 --> UC3

**Memory Management Data Flow Diagram**

mermaid

flowchart TD

input[Conversation Input]

shortterm[Short-term Memory]

crosssession[Cross-session Memory]

semantic[Semantic Memory]

consolidation[Memory Consolidation]

retrieval[Retrieval Service]

assembly[Context Assembly]

generation[Response Generation]

input -->|Current Context| shortterm

shortterm -->|Session Persistence| crosssession

crosssession -->|Long-term Storage| semantic

shortterm -->|Recent Context| retrieval

crosssession -->|Historical Context| retrieval

semantic -->|Semantic Knowledge| retrieval

retrieval -->|Relevant Context| assembly

assembly -->|Assembled Context| generation

shortterm -->|Compression| consolidation

consolidation -->|Compressed Memory| crosssession

**4.6 Dynamic Workflow Engine**

The Dynamic Workflow Engine enables the orchestration of flexible, adaptable processes based on conversation context and user needs.

mermaid

flowchart TD

subgraph DWED["DYNAMIC WORKFLOW ENGINE DESIGN"]

WDD[Workflow Definition Designer - BPMN Editor]

WTP[Workflow Template Parser - YAML/JSON Parser]

WCA[Workflow Context Analyzer - Context Extraction]

WAM[Workflow Activation Manager - Event Triggers]

end

DWED --> WEC

subgraph WEC["WORKFLOW EXECUTION COMPONENTS"]

TSE[Task Sequencing Engine - DAG Scheduler]

CPM[Conditional Path Manager - Rules Engine]

PEM[Parallel Execution Module - Actor Model]

TMM[Task Mapping Module - Service Discovery]

RHM[Rollback & Handling Manager - Saga Pattern]

end

WEC --> WMS

subgraph WMS["WORKFLOW MONITORING SYSTEM"]

WTS[Workflow Tracking Service - OpenTelemetry]

PTS[Progress Tracking Service - State Machine]

NMS[Notification Management Service - Event Bus]

WAS[Workflow Analytics Service - Time Series DB]

end

WMS --> WIS

subgraph WIS["WORKFLOW INTEGRATION SERVICES"]

AIS[Agent Integration Service - API Gateway]

EIS[External System Integration - Adapters/Connectors]

UNI[User Notification Interface - Pub/Sub]

DTW[Data Transformation Workflow - ETL Pipeline]

end

WIS --> DWED

WEC --> FT[Fault Tolerance - Circuit Breaker/Retry]

WEC --> SC[Saga Coordinator - Distributed Transactions]

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class DWED blue

class WEC green

class WMS orange

class WIS purple

class FT,SC tech

**Key Functional Characteristics:**

1. **Workflow Definition Designer**:
   * Visual workflow creation interface
   * Drag-and-drop workflow components
   * Conditional branching definition
   * Parameter configuration
   * Version control for workflow templates
2. **Workflow Execution Components**:
   * Task Sequencing Engine: Manages the order of task execution
   * Conditional Path Manager: Determines execution paths based on conditions
   * Parallel Execution Module: Handles concurrent task execution
   * Task Mapping Module: Maps abstract tasks to concrete agent actions
   * Rollback & Handling Manager: Manages failures and exceptions
3. **Workflow Monitoring System**:
   * Workflow Tracking Service: Monitors active workflows
   * Progress Tracking Service: Tracks completion status
   * Notification Management Service: Sends alerts and updates
   * Workflow Analytics Service: Analyzes performance and patterns
4. **Workflow Integration Services**:
   * Agent Integration Service: Connects workflows to agents
   * External System Integration: Links to external systems
   * User Notification Interface: Communicates with users
   * Data Transformation Workflow: Converts data between formats

**Dynamic Workflow Engine Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Workflow Definition | BPMN 2.0, YAML, JSON Schema, DSL | Defining workflow structure and logic |
| Workflow Designer | Web-based BPMN editors, drag-and-drop interfaces | User interface for workflow creation |
| Workflow Engine | Temporal.io, Camunda, Apache Airflow, Netflix Conductor | Execution of workflow definitions |
| Rules Engine | Drools, CLIPS, native rule implementations | Conditional logic evaluation |
| State Management | Redis, etcd, ZooKeeper, PostgreSQL | Workflow state persistence |
| Event Processing | Kafka, RabbitMQ, NATS | Event-based workflow triggers |
| Task Execution | Actor model, microservices | Distributed task execution |
| Service Discovery | etcd, Consul, Kubernetes Service | Discovering task executors |
| Monitoring | Prometheus, Grafana, OpenTelemetry | Workflow execution monitoring |
| Fault Tolerance | Saga pattern, compensation transactions | Error handling and recovery |
| User Notification | WebSockets, webhook callbacks, email | Informing users of progress |

**Dynamic Workflow Use Case Diagram**

mermaid

graph LR

user((User))

designer((Workflow Designer))

admin((Administrator))

subgraph "Dynamic Workflow Engine"

UC1[Design Workflow Template]

UC2[Instantiate Workflow]

UC3[Execute Workflow Tasks]

UC4[Monitor Workflow Progress]

UC5[Handle Exceptions]

UC6[Analyze Workflow Performance]

end

designer --> UC1

user --> UC2

system --> UC3

admin --> UC4

system --> UC5

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC4 --> UC5

UC5 --> UC3

UC3 --> UC6

**Dynamic Workflow Data Flow Diagram**

mermaid

flowchart TD

trigger[Conversation Trigger]

selection[Workflow Selection]

instantiation[Workflow Instantiation]

execution[Task Execution]

state[State Management]

progress[Progress Tracking]

notification[Notification Service]

error[Error Handling]

trigger -->|Intent/Event| selection

selection -->|Template Selection| instantiation

instantiation -->|Workflow Instance| execution

execution -->|Execution State| state

state -->|State Information| execution

execution -->|Task Completion| progress

progress -->|Progress Updates| notification

execution -->|Exceptions| error

error -->|Recovery Actions| execution

state -->|Historical Data| selection

**5. Master Control Protocol (MCP)**

**5.1 MCP Architecture**

The Master Control Protocol (MCP) provides the orchestration layer between the Neural Core and Agentic Products.

mermaid

flowchart TD

subgraph CC["CORE COMPONENTS"]

ARS[Agent Registry Service - etcd/Consul]

TS[Task Scheduler - Kubernetes Jobs]

RA[Resource Allocator - Kubernetes Resources]

MB[Message Bus - Kafka/RabbitMQ]

EH[Error Handler - Dead Letter Queue]

SM[State Manager - Redis/etcd]

end

CC --> OS

subgraph OS["ORCHESTRATION SERVICES"]

DWE[Dynamic Workflow Engine - Temporal.io]

APS[Adaptive Planning Service - ML Planning]

CRS[Conflict Resolution Service - Rule Engine]

PEM[Parallel Execution Manager - Actor Model]

PMS[Priority Management Service - Priority Queue]

TMS[Timeout Management Service - TTL Management]

end

OS --> MC

subgraph MC["MONITORING & CONTROL"]

PM[Performance Monitoring - Prometheus/Grafana]

SG[Security Gateway - OAuth/mTLS]

OS2[Observability Service - OpenTelemetry]

AS[Audit Service - Immutable Log]

RLS[Rate Limiting Service - Redis/Token Bucket]

CB[Circuit Breaker - Resilience4j/Hystrix]

end

MC --> SM2[Service Mesh - Istio/Linkerd]

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class CC blue

class OS green

class MC orange

class ARS,MB,DWE,PM,SG,SM2 tech

**MCP Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Service Registry | etcd, Consul, Kubernetes Service | Agent and service discovery |
| Messaging | Kafka, RabbitMQ, NATS | Asynchronous messaging between components |
| Task Scheduling | Kubernetes Jobs, Quartz, cron systems | Scheduling of tasks and workflows |
| Resource Management | Kubernetes Resources, custom allocators | Allocation of compute and memory resources |
| State Management | Redis, etcd, ZooKeeper | Distributed state management |
| Workflow Engine | Temporal.io, Camunda, Apache Airflow | Orchestration of workflow execution |
| Planning | ML-based planning systems, heuristic planners | Determining optimal task sequences |
| Conflict Resolution | Rule engines, constraint solvers | Resolving resource and logic conflicts |
| Service Mesh | Istio, Linkerd, Consul Connect | Network-layer service communication |
| Security | OAuth 2.0, mTLS, JWT, OPA | Authentication and authorization |
| Observability | Prometheus, Grafana, Jaeger, OpenTelemetry | Monitoring and tracing |
| Resilience | Circuit breaker, bulkhead, retry patterns | Service resilience and fault tolerance |

**MCP Use Case Diagram**

mermaid

graph LR

core((Neural Core))

product((Agentic Product))

admin((Administrator))

subgraph "Master Control Protocol"

UC1[Discover Agents]

UC2[Route Messages]

UC3[Coordinate Workflows]

UC4[Monitor Performance]

UC5[Manage Resources]

UC6[Enforce Security]

end

core --> UC1

core --> UC2

core --> UC3

product --> UC1

product --> UC2

admin --> UC4

admin --> UC5

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC5 --> UC3

UC6 --> UC2

**MCP Data Flow Diagram**

mermaid

flowchart TD

core[Neural Core]

registry[Agent Registry]

router[Message Router]

scheduler[Task Scheduler]

workflow[Workflow Engine]

allocator[Resource Allocator]

products[Agentic Products]

core -->|Agent Discovery| registry

core -->|Message Sending| router

registry -->|Agent Location| router

router -->|Message Delivery| products

core -->|Task Scheduling| scheduler

scheduler -->|Task Orchestration| workflow

workflow -->|Resource Requests| allocator

allocator -->|Resource Allocation| products

products -->|Result Messages| router

router -->|Response Routing| core

**5.2 Agent-to-Agent Communication**

The Agent-to-Agent (A2A) Communication architecture enables secure, standardized communication between agents across products.

mermaid

flowchart TD

subgraph MCP["MASTER CONTROL PROTOCOL"]

AR[Agent Registry - Service Registry]

MR[Message Router - Event Router]

PE[Protocol Enforcement - Schema Validation]

SD[Service Discovery - DNS/Kubernetes Service]

SA[Security & Authentication - JWT/mTLS]

ML[Monitoring & Logging - Distributed Tracing]

end

MCP --> CC

subgraph CC["COMMUNICATION CHANNELS"]

SC[Synchronous Communication - gRPC/REST]

AC[Asynchronous Communication - Kafka/SQS]

PS[Publish-Subscribe - MQTT/NATS]

end

CC --> MF

subgraph MF["MESSAGE FORMATS"]

SMF[Standard Message Format - Protocol Buffers/Avro]

SMT[Specialized Message Types - Domain-specific Schemas]

end

MF --> SI[Serialization/Deserialization - JSON/Binary]

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class MCP blue

class CC green

class MF orange

class SC,AC,PS,SMF,SI tech

**Agent-to-Agent Communication Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Service Registry | etcd, Consul, Kubernetes Service | Registration and discovery of agents |
| Message Routing | Event routers, message brokers | Routing messages between agents |
| Protocol Enforcement | Schema validation, API gateways | Ensuring message format compliance |
| Service Discovery | DNS-SD, Kubernetes Services, Consul | Finding available agents |
| Security | JWT, mTLS, API Keys, OAuth 2.0 | Secure agent communication |
| Synchronous Comm | gRPC, REST, GraphQL | Request-response communication |
| Asynchronous Comm | Kafka, RabbitMQ, AWS SQS, Google Pub/Sub | Event-based communication |
| Pub/Sub | MQTT, NATS, Redis Pub/Sub, Kafka topics | Topic-based communication |
| Message Formats | Protocol Buffers, Avro, JSON Schema | Message structure definition |
| Serialization | JSON, Binary formats, MessagePack | Message encoding/decoding |
| Monitoring | OpenTelemetry, Jaeger, Zipkin | Tracing communication flows |
| Resilience | Acknowledgments, Dead Letter Queues, Idempotency | Reliable message delivery |

**Agent-to-Agent Communication Use Case Diagram**

mermaid

graph LR

agent1((Agent 1))

agent2((Agent 2))

admin((Administrator))

subgraph "Agent-to-Agent Communication"

UC1[Register Capabilities]

UC2[Discover Agents]

UC3[Send Synchronous Request]

UC4[Publish Event]

UC5[Subscribe to Topic]

UC6[Monitor Communication]

end

agent1 --> UC1

agent1 --> UC2

agent1 --> UC3

agent1 --> UC4

agent2 --> UC1

agent2 --> UC2

agent2 --> UC3

agent2 --> UC5

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC2 --> UC4

UC5 --> UC4

**Agent-to-Agent Communication Data Flow Diagram**

mermaid

flowchart TD

agent1[Agent 1]

registry[Agent Registry]

router[Message Router]

broker[Message Broker]

security[Security Gateway]

agent2[Agent 2]

agent1 -->|Register Capabilities| registry

agent1 -->|Discover Agents| registry

registry -->|Agent Information| agent1

agent1 -->|Authentication| security

security -->|Authorized Message| router

router -->|Synchronous Request| agent2

agent2 -->|Synchronous Response| router

router -->|Response Delivery| agent1

agent1 -->|Publish Event| broker

broker -->|Event Notification| agent2

**5.3 Workflow Orchestration Service**

The Workflow Orchestration Service coordinates the execution of workflows across agents and products.

mermaid

flowchart TD

subgraph WOS["WORKFLOW ORCHESTRATION SERVICE"]

WRM[Workflow Registry Manager - Workflow Catalog]

WIM[Workflow Instance Manager - Instance Tracker]

WTM[Workflow Template Manager - Version Control]

WEM[Workflow Execution Monitor - Status Tracking]

end

WOS --> SCL

subgraph SCL["STATE COORDINATION LAYER"]

SSM[Shared State Manager - Distributed Cache]

TLM[Transaction Lock Manager - Distributed Locks]

SHM[State History Manager - Append-Only Log]

DCM[Distributed Consistency Manager - Consensus Protocol]

end

SCL --> EHL

subgraph EHL["EVENT HANDLING LAYER"]

EPM[Event Processing Manager - Event Processor]

ERM[Event Routing Manager - Event Router]

EHM[Event History Manager - Event Store]

CSE[Complex Event Processor - CEP Engine]

end

EHL --> AGL

subgraph AGL["AGENT COORDINATION LAYER"]

ACM[Agent Capability Matcher - Capability Registry]

ATD[Agent Task Dispatcher - Task Distribution]

ARS[Agent Response Synchronizer - Response Aggregator]

AFH[Agent Failure Handler - Failure Recovery]

end

AGL --> DTRM[Distributed Transaction - Saga/2PC]

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class WOS blue

class SCL green

class EHL orange

class AGL purple

class SSM,TLM,EPM,CSE,DTRM tech

**Key Functional Characteristics:**

1. **Workflow Orchestration Service**:
   * Workflow Registry Manager: Maintains catalog of available workflows
   * Workflow Instance Manager: Tracks active workflow instances
   * Workflow Template Manager: Manages workflow templates and versions
   * Workflow Execution Monitor: Monitors workflow execution status
2. **State Coordination Layer**:
   * Shared State Manager: Manages workflow state across components
   * Transaction Lock Manager: Ensures data consistency during execution
   * State History Manager: Maintains history of state changes
   * Distributed Consistency Manager: Ensures state consistency across nodes
3. **Event Handling Layer**:
   * Event Processing Manager: Processes workflow events
   * Event Routing Manager: Routes events to appropriate handlers
   * Event History Manager: Maintains event history
   * Complex Event Processor: Identifies patterns in event streams
4. **Agent Coordination Layer**:
   * Agent Capability Matcher: Matches tasks to agent capabilities
   * Agent Task Dispatcher: Dispatches tasks to agents
   * Agent Response Synchronizer: Synchronizes agent responses
   * Agent Failure Handler: Handles agent failures and retries

**Workflow Orchestration Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Workflow Registry | Workflow catalog services, template registry | Maintaining workflow definitions |
| Instance Tracking | Instance databases, state tracking services | Tracking active workflow instances |
| Template Management | Version control, Git-based systems | Managing workflow template versions |
| State Management | Redis, etcd, ZooKeeper | Distributed state management |
| Distributed Locking | Redis locks, etcd locks, database locks | Ensuring exclusive access |
| State History | Append-only logs, event sourcing | Maintaining execution history |
| Consistency | Consensus algorithms (Raft, Paxos), CRDTs | Ensuring state consistency |
| Event Processing | Kafka, RabbitMQ, event processors | Processing workflow events |
| Event Routing | Event routers, topic-based routing | Routing events to handlers |
| Event History | EventStoreDB, event logs | Storing event history |
| Complex Event Processing | Esper, Flink CEP, custom CEP engines | Detecting event patterns |
| Capability Matching | Capability registries, matching algorithms | Matching tasks to capabilities |
| Distributed Transactions | Saga pattern, 2-phase commit, outbox pattern | Ensuring transactional integrity |

**Workflow Orchestration Use Case Diagram**

mermaid

graph LR

core((Neural Core))

product((Agentic Product))

admin((Administrator))

subgraph "Workflow Orchestration Service"

UC1[Register Workflow Template]

UC2[Instantiate Workflow]

UC3[Coordinate Task Execution]

UC4[Manage Workflow State]

UC5[Handle Workflow Events]

UC6[Monitor Workflow Execution]

end

product --> UC1

core --> UC2

core --> UC3

product --> UC3

system --> UC4

system --> UC5

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC4 --> UC5

UC5 --> UC3

UC3 --> UC6

**Workflow Orchestration Data Flow Diagram**

mermaid

flowchart TD

template[Workflow Template]

instance[Workflow Instance]

state[State Manager]

events[Event Bus]

dispatcher[Task Dispatcher]

agents[Agent Pool]

collector[Response Collector]

monitoring[Monitoring Service]

template -->|Instantiation| instance

instance -->|State Updates| state

instance -->|Event Publication| events

events -->|Task Events| dispatcher

dispatcher -->|Task Assignment| agents

agents -->|Task Completion| collector

collector -->|State Updates| state

state -->|State Information| instance

state -->|Execution Metrics| monitoring

events -->|Event Metrics| monitoring

**6. Agentic Products Architecture**

**6.1 Product Isolation**

Each Agentic Product operates in isolation with its own domain-specific capabilities and databases.

mermaid

flowchart TD

subgraph AOL["AGENT ORCHESTRATION LAYER"]

TP[Task Planner - Planning Algorithm]

AS[Agent Selector - Capability Matching]

EC[Execution Coordinator - Workflow Engine]

end

AOL --> SA

subgraph SA["SPECIALIZED AGENTS"]

IRA[Information Retrieval Agents - Vector Search]

TPA[Transaction Processing Agents - ACID Compliance]

IA[Integration Agents - API Adapters]

DSA[Domain-Specific Agents - Expert Systems]

DMA[Decision-Making Agents - Logic/Rules Engine]

NA[Notification Agents - Message Dispatchers]

end

SA --> AC

subgraph AC["AGENT CAPABILITIES"]

BAI[Backend API Integration - API Gateway]

DQE[Database Query Execution - Query Processor]

ESI[External Service Integration - Service Connectors]

DG[Document Generation - Template Engine]

WA[Workflow Automation - Process Automation]

LA[Learning & Adaptation - Reinforcement Learning]

end

AC --> AO

subgraph AO["AGENT OVERSIGHT"]

SC[Security Controls - Policy Enforcement]

CR[Compliance Rules - Regulatory Framework]

PM[Performance Monitoring - Metrics Collection]

LA2[Logging & Auditing - Audit Trail]

ET[Explainability Tools - Explanation Generation]

HS[Human Supervision - Human-in-the-loop]

end

AC --> NSB[Namespace Boundary - Kubernetes Namespace]

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class AOL blue

class SA green

class AC orange

class AO purple

class IRA,BAI,SC,NSB tech

**Product Isolation Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Task Planning | Planning algorithms, task schedulers | Planning agent activities |
| Agent Selection | Capability matching, load balancing | Selecting appropriate agents |
| Execution Coordination | Workflow engines, orchestration services | Coordinating agent execution |
| Information Retrieval | Vector search, semantic search, RAG | Retrieving relevant information |
| Transaction Processing | ACID transactions, transaction managers | Processing business transactions |
| Integration | API adapters, message transformers | Integrating with external systems |
| API Integration | API gateways, API clients | Connecting to backend APIs |
| Database Access | Query processors, ORM, data access layers | Accessing databases |
| Document Generation | Template engines, document generators | Creating documents and reports |
| Security Controls | Policy enforcement, access control | Implementing security measures |
| Compliance | Regulatory frameworks, compliance rules | Ensuring regulatory compliance |
| Monitoring | Metrics collection, alerting systems | Monitoring performance and health |
| Containerization | Docker, Kubernetes, namespace isolation | Isolating product resources |

**Product Isolation Use Case Diagram**

mermaid

graph LR

mcp((MCP))

external((External System))

admin((Administrator))

subgraph "Agentic Product"

UC1[Receive Task]

UC2[Select Agent]

UC3[Execute Capability]

UC4[Access Domain Knowledge]

UC5[Integrate External System]

UC6[Monitor Performance]

end

mcp --> UC1

system --> UC2

system --> UC3

system --> UC4

external --> UC5

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC3 --> UC5

UC3 --> UC6

**Product Isolation Data Flow Diagram**

mermaid

flowchart TD

mcp[MCP]

planner[Task Planner]

selector[Agent Selector]

agents[Agent Pool]

knowledge[Domain Knowledge]

database[Product Database]

external[External Systems]

monitoring[Monitoring Service]

mcp -->|Task Request| planner

planner -->|Task Plan| selector

selector -->|Agent Selection| agents

agents -->|Knowledge Query| knowledge

agents -->|Data Operations| database

agents -->|Integration Calls| external

agents -->|Task Results| mcp

agents -->|Performance Metrics| monitoring

monitoring -->|Status Reports| mcp

**6.2 Product Integration**

Each Agentic Product integrates with the Neural Core and other products through standardized interfaces.

mermaid

flowchart TD

subgraph II["INTEGRATION INTERFACES"]

SI[Semantic Interface - Knowledge API]

CI[Conversation Interface - Conversation API]

CTI[Context Interface - Context API]

AI[Authentication Interface - Auth API]

PI[Product Interface - Product API]

UI[User Interface - UI Components]

end

II --> DS

subgraph DS["DATA SYNCHRONIZATION"]

CDC[Change Data Capture - Debezium/Kafka Connect]

ES[Event Streaming - Kafka/Kinesis]

PS[Periodic Synchronization - Batch Processing]

CR[Conflict Resolution - CRDT/OT]

TM[Transaction Management - Distributed Transactions]

CI2[Cache Invalidation - Cache Invalidation Patterns]

end

DS --> SI2

subgraph SI2["SERVICE INTEGRATION"]

AG[API Gateway - Kong/Ambassador]

SM[Service Mesh - Istio/Linkerd]

SP[Sidecar Proxies - Envoy]

CB[Circuit Breaker - Hystrix/Resilience4j]

LB[Load Balancing - Client-side/Server-side]

RM[Retry Mechanisms - Exponential Backoff]

end

SI2 --> APV[API Versioning - Semantic Versioning]

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class CDC,ES,AG,SM,APV tech

**Product Integration Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Semantic Interface | Knowledge APIs, semantic APIs | Accessing semantic knowledge |
| Conversation Interface | Conversation APIs, dialog managers | Integrating with conversations |
| Context Interface | Context APIs, context managers | Accessing conversation context |
| Authentication Interface | Auth APIs, identity providers | Managing authentication |
| Change Data Capture | Debezium, Kafka Connect, database triggers | Capturing data changes |
| Event Streaming | Kafka, Kinesis, event buses | Streaming events between systems |
| Synchronization | Batch processing, ETL jobs | Periodic data synchronization |
| Conflict Resolution | CRDTs, OT (Operational Transformation) | Resolving data conflicts |
| API Gateway | Kong, Ambassador, AWS API Gateway | Managing API traffic |
| Service Mesh | Istio, Linkerd, Consul Connect | Service-to-service communication |
| Circuit Breaker | Hystrix, Resilience4j | Preventing cascading failures |
| Load Balancing | Client-side/server-side load balancers | Distributing traffic |
| API Versioning | Semantic versioning, version negotiation | Managing API changes |

**Product Integration Use Case Diagram**

mermaid

graph LR

core((Neural Core))

productA((Product A))

productB((Product B))

admin((Administrator))

subgraph "Product Integration"

UC1[Exchange Semantic Knowledge]

UC2[Share Conversation Context]

UC3[Authenticate Request]

UC4[Synchronize Data]

UC5[Exchange Events]

UC6[Monitor Integration Health]

end

core --> UC1

core --> UC2

core --> UC3

productA --> UC1

productA --> UC3

productA --> UC4

productA --> UC5

productB --> UC1

productB --> UC3

productB --> UC4

productB --> UC5

admin --> UC6

UC3 --> UC1

UC3 --> UC2

UC3 --> UC4

UC3 --> UC5

**Product Integration Data Flow Diagram**

mermaid

flowchart TD

core[Neural Core]

interfaces[Integration Interfaces]

gateway[API Gateway]

events[Event Bus]

mesh[Service Mesh]

sync[Data Sync Service]

productA[Product A]

productB[Product B]

core -->|API Calls| interfaces

interfaces -->|Routed Requests| gateway

gateway -->|Service Routing| mesh

mesh -->|Service Request| productA

mesh -->|Service Request| productB

productA -->|Event Publication| events

events -->|Event Consumption| productB

productA -->|Data Changes| sync

sync -->|Synchronized Data| productB

productA -->|Response Data| core

productB -->|Response Data| core

**6.3 Workflow Template Repository**

The Workflow Template Repository provides reusable workflow templates for common business processes.

mermaid

flowchart TD

subgraph WTR["WORKFLOW TEMPLATE REPOSITORY"]

WTC[Workflow Template Catalog - Template Registry]

WVM[Workflow Version Manager - Git/Version Control]

WTL[Workflow Template Library - Template Store]

DWB[Domain Workflow Builder - Workflow Composer]

end

WTR --> TMF

subgraph TMF["TEMPLATE METADATA FRAMEWORK"]

PD[Parameter Definitions - Schema Definitions]

ID[Integration Descriptors - Integration Specs]

CD[Compatibility Descriptors - Compatibility Matrix]

RM[Resource Manifests - Resource Requirements]

end

TMF --> WTE

subgraph WTE["WORKFLOW TESTING ENVIRONMENT"]

WVT[Workflow Validation Tests - Test Suites]

WST[Workflow Simulation Tool - Simulation Engine]

WDT[Workflow Debugging Tools - Debug Tooling]

WPT[Workflow Performance Tests - Performance Testing]

end

WTE --> WCT

subgraph WCT["WORKFLOW CUSTOMIZATION TOOLS"]

WCD[Workflow Cloning & Derivation - Template Forking]

WEW[Workflow Extension Wizard - Extension Framework]

WPS[Workflow Parameter Settings - Parameter Configuration]

WTI[Workflow Trigger Integration - Trigger Framework]

end

WCT --> CIP[CI/CD Pipeline - Jenkins/GitHub Actions]

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class WTR blue

class TMF green

class WTE orange

class WCT purple

class WVM,WST,WCD,CIP tech

**Key Functional Characteristics:**

1. **Workflow Template Repository**:
   * Workflow Template Catalog: Indexed library of available templates
   * Workflow Version Manager: Tracks template versions and changes
   * Workflow Template Library: Stores template definitions
   * Domain Workflow Builder: Creates domain-specific workflow templates
2. **Template Metadata Framework**:
   * Parameter Definitions: Defines configurable workflow parameters
   * Integration Descriptors: Specifies integration requirements
   * Compatibility Descriptors: Defines compatibility constraints
   * Resource Manifests: Specifies resource requirements
3. **Workflow Testing Environment**:
   * Workflow Validation Tests: Verifies workflow correctness
   * Workflow Simulation Tool: Simulates workflow execution
   * Workflow Debugging Tools: Helps diagnose workflow issues
   * Workflow Performance Tests: Measures workflow efficiency
4. **Workflow Customization Tools**:
   * Workflow Cloning & Derivation: Creates variations of templates
   * Workflow Extension Wizard: Adds capabilities to workflows
   * Workflow Parameter Settings: Configures workflow parameters
   * Workflow Trigger Integration: Defines workflow activation triggers

**Workflow Template Repository Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Template Catalog | Catalog services, search systems | Organizing workflow templates |
| Version Manager | Git, version control systems | Managing template versions |
| Template Library | Template storage, databases | Storing workflow templates |
| Workflow Builder | Workflow composers, DSLs | Creating workflow templates |
| Parameter Definitions | JSON Schema, parameter validators | Defining workflow parameters |
| Integration Descriptors | API specifications, connector definitions | Specifying integration points |
| Compatibility | Compatibility matrices, version compatibility | Managing template compatibility |
| Validation Tests | Test frameworks, test runners | Validating workflow correctness |
| Simulation | Workflow simulators, mock engines | Simulating workflow execution |
| Debugging Tools | Debuggers, step-through tools | Troubleshooting workflows |
| Performance Tests | Load generators, performance metrics | Testing workflow performance |
| Customization | Template inheritance, composition | Customizing workflow templates |
| CI/CD Pipeline | Jenkins, GitHub Actions, GitLab CI | Automating template deployment |

**Workflow Template Repository Use Case Diagram**

mermaid

graph LR

designer((Workflow Designer))

developer((Product Developer))

admin((Administrator))

subgraph "Workflow Template Repository"

UC1[Create Workflow Template]

UC2[Version Workflow Template]

UC3[Test Workflow Template]

UC4[Search for Templates]

UC5[Customize Template]

UC6[Deploy Template]

end

designer --> UC1

designer --> UC2

designer --> UC3

developer --> UC4

developer --> UC5

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC6

UC4 --> UC5

UC5 --> UC6

**Workflow Template Repository Data Flow Diagram**

mermaid

flowchart TD

designer[Workflow Designer]

catalog[Template Catalog]

version[Version Manager]

library[Template Library]

testing[Testing Environment]

customization[Customization Tools]

cicd[CI/CD Pipeline]

deployment[Deployment Target]

designer -->|Template Registration| catalog

designer -->|Version Management| version

version -->|Template Storage| library

library -->|Template Validation| testing

testing -->|Test Results| version

library -->|Template Retrieval| customization

customization -->|Customized Template| version

version -->|Deployment Request| cicd

cicd -->|Template Deployment| deployment

catalog -->|Template Search| designer

**7. Database Architecture**

**7.1 Workflow State Database**

The Workflow State Database maintains the state of active and historical workflows.

mermaid

erDiagram

WorkflowDefinition ||--o{ WorkflowInstance : instantiates

WorkflowInstance ||--o{ WorkflowTaskExecution : contains

WorkflowInstance ||--o{ WorkflowStateTransition : records

WorkflowInstance ||--o{ WorkflowVariable : uses

WorkflowInstance ||--o{ WorkflowEvent : generates

WorkflowDefinition {

string DefinitionID PK "UUID - Primary Key"

string Name "Indexed"

string Version "Semantic version"

json Definition "JSONB"

date CreatedDate "Timestamp with timezone"

string CreatedBy "User reference"

boolean IsActive "Indexed"

array Tags "String array"

string Description "Text"

}

WorkflowInstance {

string InstanceID PK "UUID - Primary Key"

string DefinitionID FK "Indexed"

string Status "Enum, Indexed"

date StartTime "Timestamp with timezone"

date EndTime "Timestamp with timezone, Nullable"

string InitiatedBy "User reference"

string Priority "Enum, Indexed"

json Context "JSONB"

string ConversationID "Conversation reference, Indexed"

}

WorkflowTaskExecution {

string ExecutionID PK "UUID - Primary Key"

string InstanceID FK "Indexed"

string TaskName "Task reference"

string TaskType "Enum"

string Status "Enum, Indexed"

date StartTime "Timestamp with timezone"

date EndTime "Timestamp with timezone, Nullable"

string AssignedAgent "Agent reference"

json Parameters "JSONB"

json Result "JSONB, Nullable"

string ErrorDetails "Text, Nullable"

}

WorkflowStateTransition {

string TransitionID PK "UUID - Primary Key"

string InstanceID FK "Indexed"

string FromState "State reference"

string ToState "State reference"

date TransitionTime "Timestamp with timezone, Indexed"

string Trigger "Trigger reference"

json ContextSnapshot "JSONB"

}

WorkflowVariable {

string VariableID PK "UUID - Primary Key"

string InstanceID FK "Indexed"

string Name "Variable name, Indexed"

string DataType "Data type enum"

json Value "JSONB"

date LastUpdated "Timestamp with timezone"

string Scope "Variable scope"

}

WorkflowEvent {

string EventID PK "UUID - Primary Key"

string InstanceID FK "Indexed"

string EventType "Event type enum, Indexed"

date Timestamp "Timestamp with timezone, Indexed"

json Payload "JSONB"

boolean Processed "Indexed"

string SourceComponent "Component reference"

}

**Key Functional Characteristics:**

1. **Workflow Definition**:
   * Stores the blueprint for workflows
   * Supports versioning for workflow evolution
   * Includes metadata for discovery and management
   * Maintains active/inactive status
2. **Workflow Instance**:
   * Represents a running or completed workflow
   * Tracks overall status and execution times
   * Maintains execution context
   * Links to conversation context
3. **Workflow Task Execution**:
   * Records individual task executions
   * Tracks task status, timing, and assignment
   * Stores task parameters and results
   * Captures error details for troubleshooting
4. **Workflow State Transition**:
   * Tracks workflow state changes
   * Records transition triggers
   * Maintains state history for auditing
   * Captures context snapshots at transition points
5. **Workflow Variable**:
   * Stores workflow execution variables
   * Supports different data types
   * Tracks value changes over time
   * Maintains variable scope information
6. **Workflow Event**:
   * Records significant workflow events
   * Supports event-based integration
   * Tracks event processing status
   * Identifies event sources

**Workflow State Database Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Primary Database | PostgreSQL with JSONB, TimescaleDB, MongoDB | Storage of workflow state |
| Indexing | B-tree indices, GIN indices for JSONB | Efficient data retrieval |
| Archival Storage | Amazon S3, Google Cloud Storage, Azure Blob Storage | Long-term storage of historical data |
| Caching | Redis, Memcached | Fast access to active workflow state |
| Search | Elasticsearch, OpenSearch | Full-text search of workflow data |
| Event Store | EventStoreDB, Apache Kafka with compacted topics | Event storage and retrieval |
| Partitioning | Time-based partitioning, tenant-based sharding | Scaling database capacity |
| High Availability | Database replication, read replicas | Ensuring system availability |
| Backup | Point-in-time recovery, continuous backups | Data protection |
| Query Optimization | Execution plans, index tuning | Performance optimization |

**Workflow State Database Use Case Diagram**

mermaid

graph LR

engine((Workflow Engine))

monitoring((Monitoring System))

admin((Administrator))

subgraph "Workflow State Database"

UC1[Store Workflow Definition]

UC2[Track Workflow Instance]

UC3[Record Task Execution]

UC4[Manage State Transitions]

UC5[Store Workflow Variables]

UC6[Analyze Workflow Patterns]

end

engine --> UC1

engine --> UC2

engine --> UC3

engine --> UC4

engine --> UC5

monitoring --> UC2

monitoring --> UC3

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC2 --> UC4

UC2 --> UC5

UC4 --> UC6

UC3 --> UC6

**Workflow State Database Data Flow Diagram**

mermaid

flowchart TD

engine[Workflow Engine]

definition[Definition Store]

instance[Instance Store]

task[Task Store]

state[State Store]

variable[Variable Store]

event[Event Store]

monitoring[Monitoring System]

analytics[Analytics System]

engine -->|Store Definition| definition

engine -->|Create/Update Instance| instance

engine -->|Record Task Execution| task

engine -->|Record State Transition| state

engine -->|Store/Update Variables| variable

engine -->|Record Events| event

definition -->|Definition Reference| instance

instance -->|Instance Reference| task

instance -->|Instance Reference| state

instance -->|Instance Reference| variable

instance -->|Instance Reference| event

monitoring -->|Query Status| instance

monitoring -->|Query Execution| task

monitoring -->|Query Transitions| state

analytics -->|Historical Data| instance

analytics -->|Performance Data| task

analytics -->|Transition Patterns| state

**8. Key Functional Flows**

**8.1 Conversation Processing Flow**

The complete flow from user input to response generation.

mermaid

flowchart TD

CI[Conversation Input - User Interface] --> AAA[Authentication & Authorization - OAuth/OIDC]

AAA --> PPF

subgraph PPF["PRE-PROCESSING FLOW"]

STT[Speech-to-Text - Whisper/Google STT]

LD[Language Detection - FastText/CLD3]

ICP[Initial Context Preparation - Context Builder]

STT --> LD --> ICP

end

PPF --> PF

subgraph PF["PARALLEL PROCESSING FLOW"]

subgraph UEB["USER EXPERIENCE BRANCH"]

IE[Information Extraction - NER/Entity Recognition]

SE[Semantic Enrichment - Knowledge Graph]

UNS[UX Negotiation Service - User Preferences]

IE --> SE --> UNS

end

subgraph AEB["AGENT EXECUTION BRANCH"]

TP[Task Planning - Planning Algorithm]

AE[Action Execution - Agent Framework]

ST[Status Tracking - Status Monitor]

TP --> AE --> ST

end

end

PF --> MMF

subgraph MMF["MEMORY MANAGEMENT FLOW"]

MR[Memory Router - Memory Dispatcher]

WM[Working Memory - Redis/In-Memory]

TD[Transactional Database - PostgreSQL]

EM[Episodic Memory - MongoDB/Document Store]

SM[Semantic Memory - Vector Database]

PD[Proprietary Database - Tenant DB]

MR --> WM & TD

TD --> EM & SM & PD

end

MMF --> RGF

subgraph RGF["RESPONSE GENERATION FLOW"]

CA[Context Assembly - Context Builder]

RG[Response Generation - LLM/NLG]

CSF[Channel-specific Formatting - Response Formatters]

CA --> RG --> CSF

end

RGF --> CC

subgraph CC["CONVERSATION CONTINUITY"]

CSP[Conversation State Persistence - State Store]

CM[Context Maintenance - Context Manager]

AI[Analytics & Improvement - Analytics Pipeline]

FB[Feedback - Feedback System]

CSP --> CM --> AI --> FB

end

CC --> DWF

subgraph DWF["DYNAMIC WORKFLOW FLOW"]

ITA[Intent Analysis - Intent Classifier]

WTS[Workflow Template Selection - Template Matcher]

WI[Workflow Instantiation - Instance Creator]

WE[Workflow Execution - Workflow Engine]

ITA --> WTS --> WI --> WE

end

DWF --> UO[User Output - Response Delivery]

RGF --> EH[Error Handling - Error Management]

EH --> FR[Fallback Responses - Degraded Service]

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classDef tech fill:#f9f,stroke:#333,stroke-width:1px

class PPF blue

class UEB green

class AEB orange

class MMF purple

class RGF orange

class CC green

class DWF red

class STT,LD,IE,SE,WM,SM,RG,ITA tech

**Conversation Processing Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Authentication | OAuth 2.0, OIDC, JWT | User authentication and authorization |
| Speech-to-Text | Whisper, Google STT, Azure Speech | Converting voice to text |
| Language Detection | FastText, CLD3, language detection models | Identifying input language |
| Context Preparation | Context builders, context managers | Preparing conversation context |
| Information Extraction | NER, entity recognition, information extraction | Extracting entities and information |
| Semantic Enrichment | Knowledge graphs, semantic networks | Enriching with semantic information |
| Task Planning | Planning algorithms, task schedulers | Planning agent activities |
| Action Execution | Agent frameworks, action executors | Executing agent actions |
| Memory Management | Memory routers, memory systems | Managing conversation memory |
| Response Generation | LLMs, NLG, template engines | Generating responses |
| Channel Formatting | Response formatters, channel adapters | Formatting for delivery channels |
| State Persistence | State stores, persistence layers | Maintaining conversation state |
| Intent Analysis | Intent classifiers, intent detection | Identifying user intents |
| Workflow Management | Workflow engines, process automation | Managing business workflows |
| Error Handling | Error managers, recovery mechanisms | Handling system errors |

**Conversation Processing Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

subgraph "Conversation Processing"

UC1[Process User Input]

UC2[Extract Information]

UC3[Execute Agent Actions]

UC4[Manage Memory]

UC5[Generate Response]

UC6[Trigger Workflows]

end

user --> UC1

system --> UC2

system --> UC3

system --> UC4

system --> UC5

system --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC4 --> UC5

UC2 --> UC6

UC5 --> user

**Conversation Processing Data Flow Diagram**

mermaid

flowchart TD

input[User Input]

auth[Authentication]

preprocess[Preprocessing]

extract[Information Extraction]

agent[Agent Execution]

memory[Memory Management]

response[Response Generation]

workflow[Workflow Engine]

output[User Output]

input -->|User Input| auth

auth -->|Authenticated Input| preprocess

preprocess -->|Processed Input| extract

extract -->|Extracted Information| agent

extract -->|Intent/Trigger| workflow

agent -->|Execution Results| memory

memory -->|Context/Memory| response

workflow -->|Workflow Status| response

response -->|Formatted Response| output

output -->|Continuous Conversation| input

**8.2 User-Organization Semantic Fallback Flow**

The flow for determining when to use user-specific semantic data versus organization defaults.

mermaid

flowchart TD

UR[User Request - Natural Language] & CA[Context Analysis - Context Analyzer] --> SKRL

subgraph SKRL["SEMANTIC KNOWLEDGE RETRIEVAL"]

USS[User-Specific Semantics - User Knowledge Base] --> MA[Match Available? - Matching Algorithm]

OS[Organization Semantics - Org Knowledge Base] --> MA

MA -->|Yes| YB[YES BRANCH]

MA -->|No| NB[NO BRANCH]

YB --> UUS[Use User Semantics - User-Specific Knowledge]

NB --> UOS[Use Org Semantics - Organization Knowledge]

UUS & UOS --> CK[Combined Knowledge - Knowledge Integration]

end

SKRL --> SLP

subgraph SLP["SEMANTIC LEARNING PROCESS"]

DNSO[Detect New Semantics Opportunity - Learning Trigger]

CUSR[Create User Semantic Records - Knowledge Creation]

UUSP[Update User Semantic Profile - Profile Update]

DNSO --> CUSR --> UUSP

end

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class SKRL blue

class SLP green

class USS,OS,MA,DNSO tech

**Semantic Fallback Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Context Analysis | Context analyzers, context extraction | Analyzing conversation context |
| User Semantics | User knowledge bases, personal knowledge | User-specific semantic information |
| Organization Semantics | Organizational knowledge bases, shared knowledge | Organization-wide semantic information |
| Matching Algorithm | Semantic matching, vector similarity | Finding semantic matches |
| Knowledge Integration | Knowledge integrators, knowledge fusion | Combining knowledge sources |
| Learning Trigger | Learning opportunity detection | Identifying learning opportunities |
| Knowledge Creation | Knowledge creation pipelines | Creating new semantic knowledge |
| Profile Update | Profile update mechanisms | Updating user semantic profiles |

**Semantic Fallback Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

subgraph "Semantic Fallback System"

UC1[Analyze Request Context]

UC2[Search User Semantics]

UC3[Search Organization Semantics]

UC4[Decide Knowledge Source]

UC5[Combine Knowledge]

UC6[Learn New Semantics]

end

user --> UC1

system --> UC2

system --> UC3

system --> UC4

UC1 --> UC2

UC1 --> UC3

UC2 --> UC4

UC3 --> UC4

UC4 --> UC5

UC5 --> user

UC1 --> UC6

UC6 --> UC2

**Semantic Fallback Data Flow Diagram**

mermaid

flowchart TD

request[User Request]

context[Context Analysis]

user[User Semantics]

org[Organization Semantics]

decision[Matching Decision]

integration[Knowledge Integration]

response[Response Generation]

learning[Learning Process]

request -->|Request Content| context

context -->|Context Information| user

context -->|Context Information| org

user -->|User Matches| decision

org -->|Org Matches| decision

decision -->|Knowledge Selection| integration

integration -->|Integrated Knowledge| response

context -->|Learning Opportunities| learning

learning -->|Knowledge Updates| user

**8.3 Memory Management Flow**

The detailed flow for managing conversation memory across different time spans.

mermaid

flowchart TD

subgraph MR["MEMORY ROUTER"]

PBR[Priority-based Routing - Routing Algorithm]

TTLM[TTL Management & Expiration - TTL Policies]

SP[Storage Policy - Policy Engine]

end

MR --> IP

subgraph IP["INPUT PROCESSING"]

MTC[Memory Type Classification - Type Classifier]

DP[Data Preparation - Data Processor]

CL[Context Linking - Context Linker]

end

IP --> MO

subgraph MO["MEMORY OPERATIONS"]

WO[Write Operations - Write Handler]

RO[Read Operations - Read Handler]

UO[Update Operations - Update Handler]

DO[Delete Operations - Delete Handler]

CO[Compression Operations - Compression Engine]

IO[Index Operations - Index Manager]

end

MO --> MD

subgraph MD["MEMORY DESTINATIONS"]

WM[Working Memory - Redis/In-Memory]

STM[Short-term Memory - Cache Layer]

LTM[Long-term Memory - Persistent Storage]

EM[Episodic Memory - Time-series Storage]

SM[Semantic Memory - Knowledge Graph]

USM[User-Specific Memory - User Database]

end

MD --> MOP

subgraph MOP["MEMORY OPTIMIZATION"]

PS[Progressive Summarization - Summarizer]

MC[Memory Consolidation - Consolidation Engine]

GC[Garbage Collection - Resource Reclaimer]

end

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classDef red fill:#e74c3c,stroke:#000,stroke-width:1px,color:#fff

classDef tech fill:#f9f,stroke:#333,stroke-width:1px

class MR blue

class IP green

class MO orange

class MD purple

class MOP red

class PBR,TTLM,MTC,WO,WM,PS tech

**Memory Management Flow Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Memory Router | Routing algorithms, policy engines | Routing memory operations |
| TTL Management | TTL policies, expiration mechanisms | Managing memory lifetime |
| Storage Policy | Policy engines, rule systems | Determining storage locations |
| Type Classification | Type classifiers, type detection | Classifying memory types |
| Data Preparation | Data processors, data transformers | Preparing data for storage |
| Memory Operations | CRUD handlers, operation managers | Performing memory operations |
| Working Memory | Redis, in-memory data structures | Very short-term memory |
| Short-term Memory | Cache layers, fast storage | Short-term memory |
| Long-term Memory | Persistent storage, databases | Long-term memory |
| Memory Optimization | Summarizers, consolidation engines | Optimizing memory usage |
| Garbage Collection | Resource reclaimers, cleanup processes | Reclaiming unused memory |

**Memory Management Flow Use Case Diagram**

mermaid

graph LR

system((Conversation System))

consumer((Memory Consumer))

admin((Administrator))

subgraph "Memory Management Flow"

UC1[Route Memory Operation]

UC2[Process Memory Input]

UC3[Execute Memory Operation]

UC4[Store in Appropriate Destination]

UC5[Optimize Memory Usage]

UC6[Monitor Memory Health]

end

system --> UC1

system --> UC2

system --> UC3

consumer --> UC4

admin --> UC5

admin --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC4 --> UC5

UC5 --> UC6

**Memory Management Flow Data Flow Diagram**

mermaid

flowchart TD

system[Conversation System]

router[Memory Router]

processor[Input Processor]

operation[Operation Handler]

storage[Memory Storage]

optimization[Optimization Engine]

monitoring[Monitoring System]

system -->|Memory Request| router

router -->|Routed Request| processor

processor -->|Processed Data| operation

operation -->|Storage Operation| storage

storage -->|Operation Result| operation

operation -->|Operation Response| system

storage -->|Storage Metrics| optimization

optimization -->|Optimization Actions| storage

storage -->|Health Metrics| monitoring

monitoring -->|Policy Updates| router

**8.4 Dynamic Workflow Execution Flow**

The flow for executing dynamic workflows based on conversation context and user needs.

mermaid

flowchart TD

UT[User Trigger - Conversation Intent] & ST[System Trigger - System Event] --> WIF

subgraph WIF["WORKFLOW INITIATION FLOW"]

TP[Trigger Processing - Event Processor]

CA[Context Analysis - Context Analyzer]

WS[Workflow Selection - Template Matcher]

PS[Parameter Setting - Parameter Configuration]

TP --> CA --> WS --> PS

end

WIF --> WEF

subgraph WEF["WORKFLOW EXECUTION FLOW"]

WI[Workflow Instantiation - Instance Creator]

TS[Task Scheduling - Task Scheduler]

TR[Task Routing - Task Router]

TE[Task Execution - Task Executor]

SR[Status Reporting - Status Reporter]

WI --> TS --> TR --> TE --> SR

end

WEF --> BCF

subgraph BCF["BRANCHING & CONTROL FLOW"]

CD[Condition Determination - Condition Evaluator]

BP[Branch Processing - Branch Handler]

EP[Error Processing - Error Handler]

CR[Compensation Routing - Compensation Manager]

CD --> BP

CD --> EP --> CR

end

BCF --> PIF

subgraph PIF["PROGRESS & INTEGRATION FLOW"]

PM[Progress Monitoring - Progress Monitor]

NM[Notification Management - Notification Manager]

DC[Data Collection - Data Collector]

SI[System Integration - Integration Service]

PM --> NM

PM --> DC --> SI

end

PIF --> WCF

subgraph WCF["WORKFLOW COMPLETION FLOW"]

FC[Final Cleanup - Cleanup Service]

SR2[State Recording - State Recorder]

AR[Analytics Recording - Analytics Service]

NS[Next Steps Determination - Next Steps Planner]

FC --> SR2 --> AR --> NS

end

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class WIF blue

class WEF green

class BCF orange

class PIF purple

class WCF red

class TP,CA,WI,TS,CD,PM,FC tech

**Key Functional Characteristics:**

1. **Workflow Initiation Flow**:
   * Trigger Processing: Handles user and system workflow triggers
   * Context Analysis: Analyzes conversation context for workflow selection
   * Workflow Selection: Selects appropriate workflow templates
   * Parameter Setting: Configures workflow parameters based on context
2. **Workflow Execution Flow**:
   * Workflow Instantiation: Creates workflow instances from templates
   * Task Scheduling: Schedules tasks for execution
   * Task Routing: Routes tasks to appropriate agents
   * Task Execution: Executes individual workflow tasks
   * Status Reporting: Reports task and workflow status
3. **Branching & Control Flow**:
   * Condition Determination: Evaluates conditions for branching
   * Branch Processing: Manages workflow branches
   * Error Processing: Handles workflow errors
   * Compensation Routing: Manages compensating actions for failures
4. **Progress & Integration Flow**:
   * Progress Monitoring: Tracks workflow progress
   * Notification Management: Manages notifications to users and systems
   * Data Collection: Collects data from workflow execution
   * System Integration: Integrates with external systems
5. **Workflow Completion Flow**:
   * Final Cleanup: Performs cleanup actions
   * State Recording: Records final workflow state
   * Analytics Recording: Captures workflow analytics
   * Next Steps Determination: Identifies follow-up actions

**Dynamic Workflow Execution Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Trigger Processing | Event processors, event handlers | Processing workflow triggers |
| Context Analysis | Context analyzers, context extraction | Analyzing conversation context |
| Workflow Selection | Template matchers, selection algorithms | Selecting appropriate workflows |
| Parameter Setting | Parameter configurators, parameter validators | Setting workflow parameters |
| Workflow Instantiation | Instance creators, instance managers | Creating workflow instances |
| Task Scheduling | Task schedulers, job schedulers | Scheduling workflow tasks |
| Task Routing | Task routers, routing algorithms | Routing tasks to agents |
| Task Execution | Task executors, execution engines | Executing workflow tasks |
| Condition Evaluation | Condition evaluators, rule engines | Evaluating branching conditions |
| Error Handling | Error handlers, error recovery | Handling execution errors |
| Compensation | Compensation managers, compensation actions | Managing compensating transactions |
| Progress Monitoring | Progress monitors, monitoring services | Tracking workflow progress |
| Notification | Notification managers, notification services | Managing user notifications |
| Integration | Integration services, system connectors | Integrating with external systems |
| Completion | Cleanup services, completion handlers | Completing workflows |

**Dynamic Workflow Execution Use Case Diagram**

mermaid

graph LR

user((User))

system((System))

external((External System))

subgraph "Dynamic Workflow Execution"

UC1[Process Workflow Trigger]

UC2[Select Workflow Template]

UC3[Execute Workflow Tasks]

UC4[Handle Branching Logic]

UC5[Monitor Progress]

UC6[Complete Workflow]

end

user --> UC1

system --> UC1

system --> UC2

system --> UC3

system --> UC4

system --> UC5

external --> UC3

system --> UC6

UC1 --> UC2

UC2 --> UC3

UC3 --> UC4

UC4 --> UC3

UC3 --> UC5

UC5 --> UC6

UC6 --> user

UC6 --> external

**Dynamic Workflow Execution Data Flow Diagram**

mermaid

flowchart TD

trigger[Trigger Source]

context[Context Analyzer]

selector[Template Selector]

parameter[Parameter Configurator]

engine[Workflow Engine]

router[Task Router]

agents[Agent Pool]

condition[Condition Evaluator]

monitor[Progress Monitor]

notification[Notification Service]

external[External Systems]

completion[Completion Handler]

trigger -->|Trigger Event| context

context -->|Context Information| selector

selector -->|Selected Template| parameter

parameter -->|Configured Workflow| engine

engine -->|Task Assignment| router

router -->|Routed Tasks| agents

agents -->|Task Results| engine

engine -->|Execution State| condition

condition -->|Branch Decision| engine

engine -->|Execution Progress| monitor

monitor -->|Progress Updates| notification

engine -->|Integration Calls| external

external -->|External Results| engine

engine -->|Workflow Completion| completion

completion -->|Completion Notification| notification

**9. Integration Architecture**

The system integrates with external systems through well-defined integration points.

mermaid

flowchart TD

subgraph IP["INTEGRATION PATTERNS"]

ABI[API-based Integration - REST/GraphQL/SOAP]

EDI[Event-driven Integration - Kafka/EventBridge]

FBI[File-based Integration - SFTP/S3]

MBI[Message-based Integration - JMS/AMQP]

DBI[Database Integration - JDBC/ODBC]

WI[Webhook Integration - HTTP Callbacks]

end

IP --> IE

subgraph IE["INTEGRATION ENDPOINTS"]

CRMS[External CRM Systems - Salesforce/Dynamics]

AS[Authentication Systems - AD/LDAP/SAML]

KBS[Knowledge Base Systems - Confluence/SharePoint]

ERPS[ERP Systems - SAP/Oracle]

TS[Ticketing Systems - JIRA/ServiceNow]

TES[Telephony Systems - Twilio/Asterisk]

end

IE --> IS

subgraph IS["INTEGRATION SERVICES"]

AG[API Gateway - Kong/Apigee]

MB[Message Broker - Kafka/RabbitMQ]

EB[Event Bus - EventBridge/Event Grid]

DI[Data Integration - ETL/CDC]

AS2[Authentication Service - Auth Server]

TS2[Transformation Service - Mapping Service]

end

IS --> ISEC

subgraph ISEC["INTEGRATION SECURITY"]

ASG[API Security Gateway - WAF/Gateway]

DE[Data Encryption - TLS/Encryption]

AA[Authentication & Authorization - OAuth/OIDC]

AT[Audit Trail - Audit Service]

RL[Rate Limiting - Rate Limiter]

TP[Threat Protection - Security Service]

end

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class IP blue

class IE green

class IS orange

class ISEC purple

class ABI,EDI,CRMS,AG,MB,ASG,DE tech

**Integration Architecture Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| API Integration | REST, GraphQL, SOAP, gRPC | API-based integration |
| Event Integration | Kafka, AWS EventBridge, Azure Event Grid | Event-driven integration |
| File Integration | SFTP, S3, file shares | File-based integration |
| Message Integration | JMS, AMQP, messaging protocols | Message-based integration |
| Database Integration | JDBC, ODBC, database connectors | Direct database integration |
| Webhook Integration | HTTP callbacks, webhook receivers | Webhook-based integration |
| CRM Integration | Salesforce, Dynamics, HubSpot | CRM system integration |
| ERP Integration | SAP, Oracle, Microsoft Dynamics | ERP system integration |
| API Gateway | Kong, Apigee, AWS API Gateway | API traffic management |
| Message Broker | Kafka, RabbitMQ, ActiveMQ | Message routing and delivery |
| Data Integration | ETL tools, CDC tools, data pipelines | Data transformation and integration |
| Security Gateway | WAF, API security gateways | API security protection |
| Authentication | OAuth 2.0, OIDC, SAML | Authentication and authorization |
| Encryption | TLS, encryption libraries | Data protection |

**Integration Architecture Use Case Diagram**

mermaid

graph LR

core((Neural Core))

product((Agentic Product))

external((External System))

admin((Administrator))

subgraph "Integration Architecture"

UC1[Connect via API]

UC2[Exchange Events]

UC3[Transfer Files]

UC4[Send/Receive Messages]

UC5[Secure Communications]

UC6[Monitor Integration Health]

end

core --> UC1

core --> UC2

product --> UC1

product --> UC3

product --> UC4

external --> UC1

external --> UC2

external --> UC3

external --> UC4

admin --> UC5

admin --> UC6

UC1 --> UC5

UC2 --> UC5

UC3 --> UC5

UC4 --> UC5

UC5 --> UC6

**Integration Architecture Data Flow Diagram**

mermaid

flowchart TD

core[Neural Core]

products[Agentic Products]

gateway[API Gateway]

broker[Message Broker]

file[File Transfer]

data[Data Integration]

security[Security Layer]

external[External Systems]

monitoring[Monitoring]

core -->|API Requests| gateway

products -->|API Requests| gateway

core -->|Event Publication| broker

products -->|Event Publication| broker

products -->|File Transfer| file

gateway -->|Security Validation| security

broker -->|Security Validation| security

file -->|Security Validation| security

security -->|Secure Communication| external

external -->|Response/Events| security

security -->|Validated Responses| gateway

security -->|Validated Events| broker

security -->|Validated Files| file

gateway -->|API Responses| core

gateway -->|API Responses| products

broker -->|Event Notifications| core

broker -->|Event Notifications| products

file -->|Received Files| products

gateway -->|Gateway Metrics| monitoring

broker -->|Broker Metrics| monitoring

file -->|Transfer Metrics| monitoring

security -->|Security Metrics| monitoring

**10. Deployment Architecture**

The system supports multiple deployment models across cloud and on-premises environments.

mermaid

flowchart TD

subgraph MED["MULTI-ENVIRONMENT DEPLOYMENT"]

DE[Development Environment - Dev Cluster]

TE[Testing Environment - Test Cluster]

SE[Staging Environment - Staging Cluster]

PE[Production Environment - Production Cluster]

end

MED --> KCP

subgraph KCP["KUBERNETES CLUSTER (PRODUCTION)"]

subgraph IL["INGRESS LAYER"]

LB[Load Balancer - NGINX/HAProxy]

AG[API Gateway - Kong/Ambassador]

DP[DDoS Protection - CloudFlare/AWS Shield]

end

subgraph SM["SERVICE MESH"]

SM1[Service Mesh Components - Istio/Linkerd]

end

subgraph AS["APPLICATION SERVICES"]

ASM[Authentication Microservice - Auth Service]

CP[Conversation Processing - NLP Service]

AAO[AI Agent Orchestration - Agent Service]

SES[Semantic Enrichment Service - Knowledge Service]

UNS[UX Negotiation Service - UX Service]

MRS[Memory Router Service - Memory Service]

DWE[Dynamic Workflow Engine - Workflow Service]

end

subgraph DS["DATA SERVICES"]

RC[Redis Cluster - In-Memory Cache]

PG[PostgreSQL - Relational Database]

N4J[Neo4j Cluster - Graph Database]

ES[Elasticsearch - Search Engine]

VDB[Vector DB - Pinecone/Weaviate]

ODB[Organization-specific DB - Tenant Database]

end

subgraph PS["PLATFORM SERVICES"]

MON[Monitoring - Prometheus/Grafana]

LOG[Logging - ELK/Loki]

CICD[CI/CD Pipeline - Jenkins/GitHub Actions]

end

IL --> SM --> AS

AS --> DS

PS -.- AS

end

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class MED blue

class IL green

class SM orange

class AS purple

class DS red

class PS orange

class LB,SM1,ASM,RC,PG,MON tech

**Deployment Architecture Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Container Orchestration | Kubernetes, Docker Swarm | Managing containerized workloads |
| Container Runtime | Docker, containerd, CRI-O | Running containers |
| Ingress Control | NGINX, HAProxy, Traefik | Managing inbound traffic |
| API Gateway | Kong, Ambassador, AWS API Gateway | API traffic management |
| DDoS Protection | CloudFlare, AWS Shield, Azure DDoS Protection | Protection against DDoS attacks |
| Service Mesh | Istio, Linkerd, Consul Connect | Service-to-service communication |
| In-Memory Cache | Redis, Memcached | Fast data access |
| Relational Database | PostgreSQL, MySQL, Aurora | Structured data storage |
| Graph Database | Neo4j, TigerGraph, Amazon Neptune | Graph data storage |
| Search Engine | Elasticsearch, OpenSearch, Solr | Full-text search |
| Vector Database | Pinecone, Weaviate, Milvus, Qdrant | Vector data storage |
| Monitoring | Prometheus, Grafana, Datadog | System monitoring |
| Logging | ELK Stack, Loki, Graylog | Log management |
| CI/CD | Jenkins, GitHub Actions, GitLab CI | Continuous integration and deployment |
| Infrastructure as Code | Terraform, Pulumi, CloudFormation | Infrastructure provisioning |
| Configuration Management | Ansible, Puppet, Chef | Configuration management |

**Deployment Architecture Use Case Diagram**

mermaid

graph LR

devops((DevOps Engineer))

platform((Platform Engineer))

admin((Administrator))

user((End User))

subgraph "Deployment Architecture"

UC1[Deploy Environment]

UC2[Manage Kubernetes Cluster]

UC3[Scale Services]

UC4[Monitor System Health]

UC5[Manage Data Services]

UC6[Access Application]

end

devops --> UC1

platform --> UC2

platform --> UC3

admin --> UC4

admin --> UC5

user --> UC6

UC1 --> UC2

UC2 --> UC3

UC2 --> UC4

UC2 --> UC5

UC5 --> UC6

UC3 --> UC4

**Deployment Architecture Data Flow Diagram**

mermaid

flowchart TD

traffic[User Traffic]

loadbalancer[Load Balancer]

gateway[API Gateway]

mesh[Service Mesh]

services[Application Services]

data[Data Services]

monitoring[Monitoring System]

cicd[CI/CD Pipeline]

iac[Infrastructure as Code]

traffic -->|User Requests| loadbalancer

loadbalancer -->|Routed Traffic| gateway

gateway -->|API Requests| mesh

mesh -->|Service Requests| services

services -->|Data Operations| data

services -->|Service Responses| mesh

mesh -->|API Responses| gateway

gateway -->|Response Traffic| loadbalancer

loadbalancer -->|User Responses| traffic

services -->|Metrics/Logs| monitoring

data -->|Metrics/Logs| monitoring

mesh -->|Metrics/Logs| monitoring

gateway -->|Metrics/Logs| monitoring

cicd -->|Deployment Triggers| iac

iac -->|Service Deployment| services

iac -->|Data Service Deployment| data

iac -->|Mesh Configuration| mesh

iac -->|Gateway Configuration| gateway

**11. Testing Architecture**

The system includes a comprehensive testing framework to ensure quality and performance.

mermaid

flowchart TD

subgraph UT["UNIT TESTING"]

ST[Service Tests - JUnit/pytest]

CT[Component Tests - Component Testing]

UFT[Utility Function Tests - Function Testing]

end

UT --> IT

subgraph IT["INTEGRATION TESTING"]

APT[API Tests - Postman/REST Assured]

SIT[Service Integration Tests - Integration Testing]

DIT[Database Integration Tests - DB Testing]

WFT[Workflow Integration Tests - Workflow Testing]

end

IT --> E2E

subgraph E2E["E2E TESTING"]

CS[Conversation Scenarios - Conversation Flows]

UFT2[User Flow Tests - User Journeys]

CIT[Chat/Voice Interface Tests - Interface Testing]

WET[Workflow E2E Tests - End-to-End Flows]

end

E2E --> PT

subgraph PT["PERFORMANCE TESTING"]

LT[Load Tests - JMeter/Gatling]

ST2[Stress Tests - Stress Testing]

SCT[Scalability Tests - Scalability Testing]

WPT[Workflow Performance Tests - Workflow Performance]

end

PT --> SPT

subgraph SPT["SPECIALIZED TESTING"]

SET[Security Tests - OWASP/Penetration Testing]

COT[Compliance Tests - Regulatory Testing]

FTT[Fault Tolerance Tests - Chaos Engineering]

WVT[Workflow Validation Tests - Validation Suite]

end

SPT --> CICD

subgraph CICD["CI/CD PIPELINE"]

BV[Build & Validation - Build Pipeline]

ATS[Automated Test Suite - Test Automation]

DT[Deployment Tests - Deployment Validation]

end

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class UT blue

class IT green

class E2E orange

class PT purple

class SPT red

class CICD yellow

class ST,APT,CS,LT,SET,BV tech

**Testing Architecture Technical Stack**

| **Component** | **Technologies** | **Implementation Details** |
| --- | --- | --- |
| Unit Testing | JUnit, pytest, Mocha | Testing individual units |
| Component Testing | Component test frameworks | Testing individual components |
| API Testing | Postman, REST Assured, Karate | Testing APIs |
| Integration Testing | Integration test frameworks | Testing component integration |
| Database Testing | Database test frameworks | Testing database interactions |
| Workflow Testing | Workflow test frameworks | Testing workflow processes |
| E2E Testing | Selenium, Cypress, Playwright | End-to-end testing |
| User Flow Testing | User journey testing frameworks | Testing user flows |
| Interface Testing | UI/UX testing frameworks | Testing interfaces |
| Load Testing | JMeter, Gatling, k6 | Testing under load |
| Stress Testing | Stress testing tools | Testing system limits |
| Scalability Testing | Scalability test frameworks | Testing scaling behavior |
| Security Testing | OWASP tools, penetration testing | Testing security |
| Compliance Testing | Regulatory compliance tools | Testing compliance |
| Fault Tolerance | Chaos engineering tools | Testing fault tolerance |
| CI/CD | Jenkins, GitHub Actions, GitLab CI | Continuous integration and deployment |
| Test Automation | Test automation frameworks | Automating test execution |

**Testing Architecture Use Case Diagram**

mermaid

graph LR

developer((Developer))

qa((QA Engineer))

security((Security Engineer))

devops((DevOps Engineer))

subgraph "Testing Architecture"

UC1[Run Unit Tests]

UC2[Perform Integration Testing]

UC3[Execute E2E Testing]

UC4[Conduct Performance Testing]

UC5[Validate Security]

UC6[Automate Testing Pipeline]

end

developer --> UC1

developer --> UC2

qa --> UC2

qa --> UC3

qa --> UC4

security --> UC5

devops --> UC6

UC1 --> UC6

UC2 --> UC6

UC3 --> UC6

UC4 --> UC6

UC5 --> UC6

**Testing Architecture Data Flow Diagram**

mermaid

flowchart TD

developer[Developer]

cicd[CI/CD Pipeline]

unit[Unit Testing]

integration[Integration Testing]

e2e[E2E Testing]

performance[Performance Testing]

security[Security Testing]

results[Test Results]

reporting[Reporting System]

decision[Deployment Decision]

developer -->|Code Commit| cicd

cicd -->|Run Unit Tests| unit

unit -->|Unit Tests Pass| integration

integration -->|Integration Tests Pass| e2e

e2e -->|E2E Tests Pass| performance

performance -->|Performance Tests Pass| security

security -->|Security Tests