Friday AI - Complete Backend Architecture: SIP → LiveKit → Agent

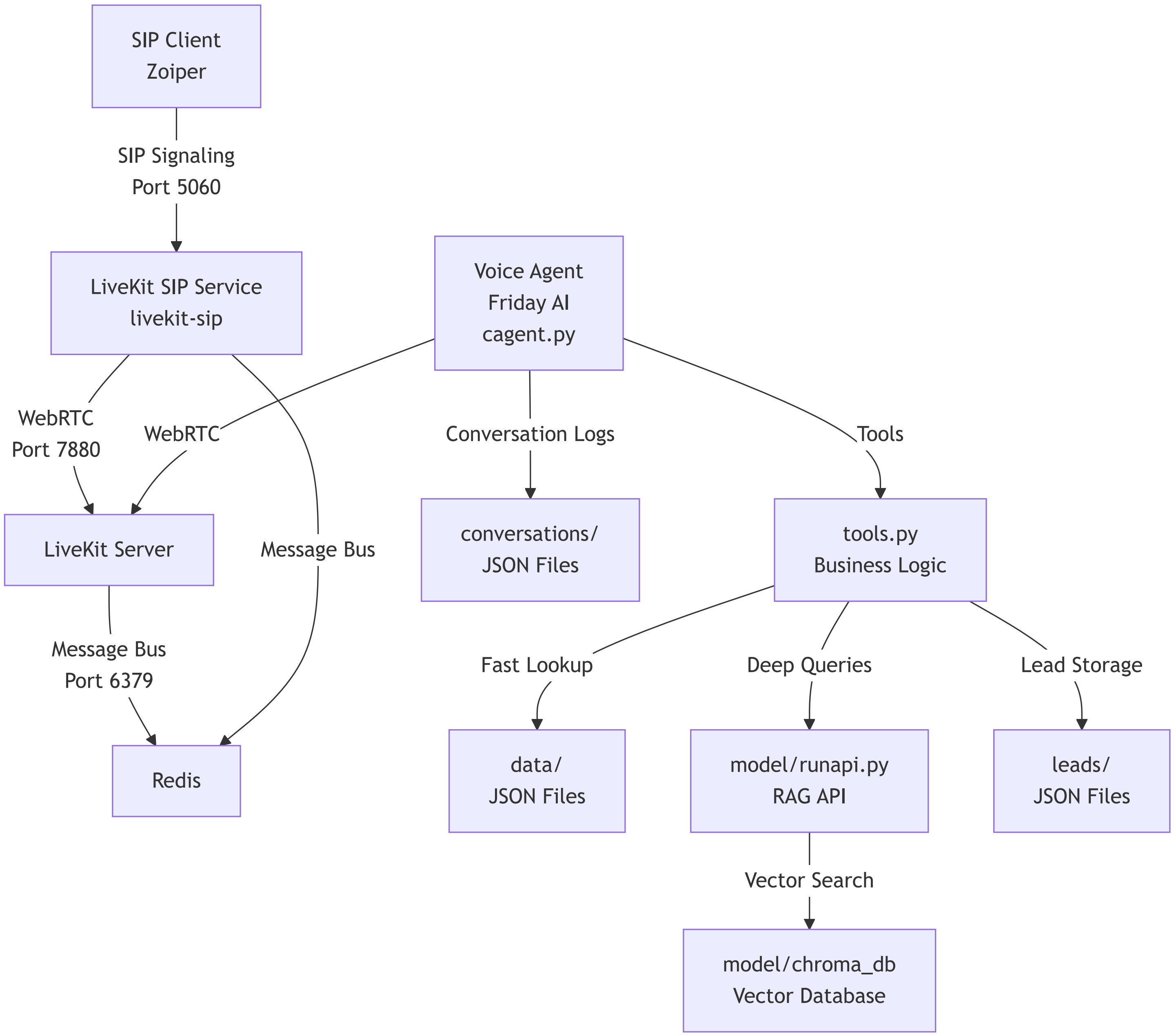
This document describes the complete Friday AI backend architecture including SIP telephony integration, LiveKit real-time communication, voice agent processing, and data flows. It serves as the definitive reference for developers working on the Friday AI system.

1. High-level Architecture Overview

Friday AI is a complete voice assistant system with SIP telephony integration, featuring:

- **SIP Telephony**: Zoiper/softphone → LiveKit SIP bridge → LiveKit server → Voice agent
- **Hybrid Knowledge**: Fast JSON lookup + RAG-powered vector database for complex queries
- **Lead Capture**: Automatic lead detection, validation, and storage in Hinglish conversations
- **Real-time Voice**: STT → Agent processing → TTS with LiveKit WebRTC infrastructure
- **Conversation Logging**: Persistent conversation history with timestamps and lead tracking

Core Components

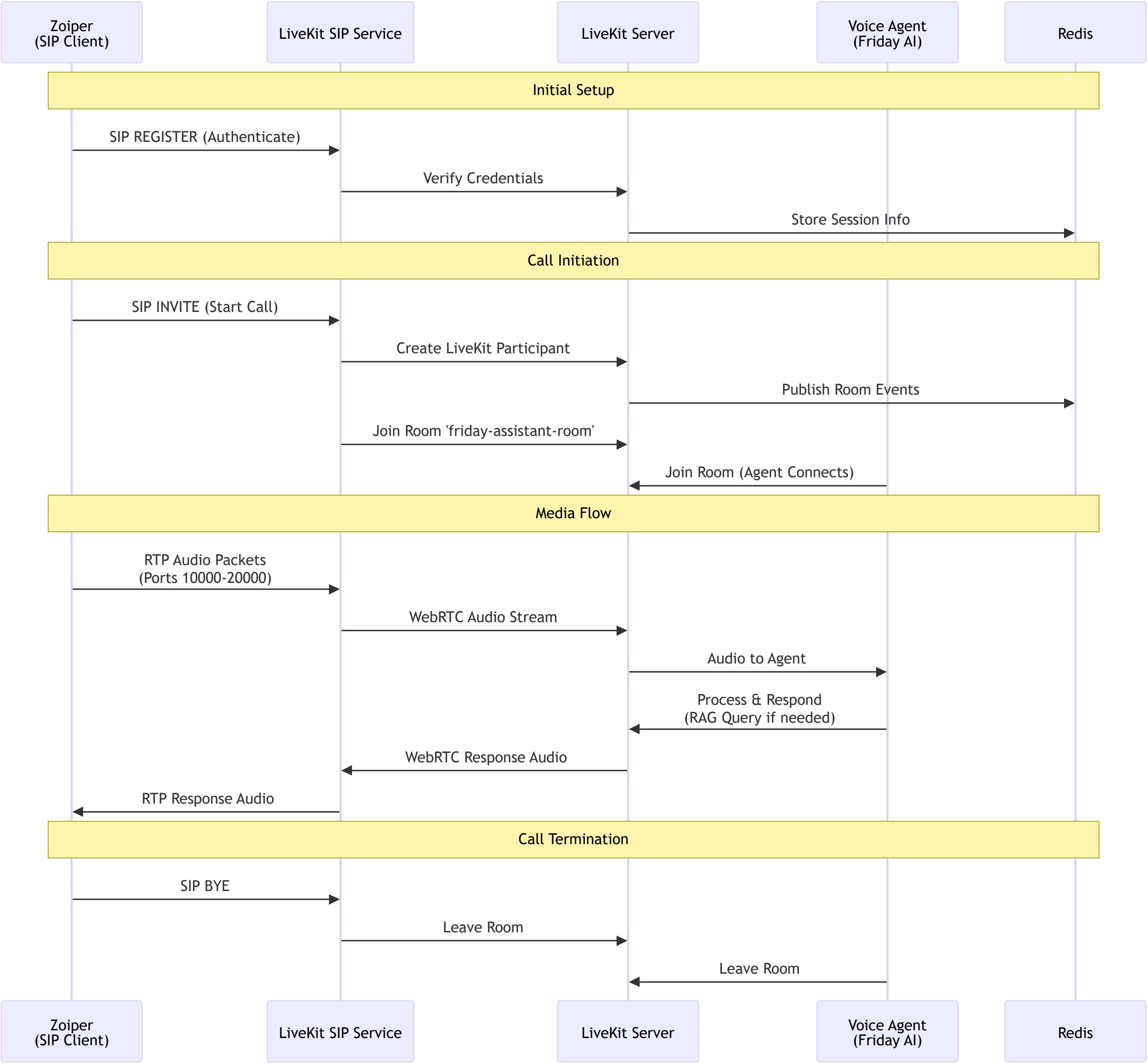


Service Architecture

- **LiveKit Server**: Core WebRTC service managing rooms, participants, and media tracks
- **LiveKit SIP Service**: SIP-to-WebRTC bridge handling phone call signaling and RTP conversion
- **Redis**: Message bus enabling communication between LiveKit server and SIP service
- **Voice Agent**: Python agent (`cagent.py`) joining LiveKit rooms for conversation processing
- **RAG System**: Vector database with embeddings for knowledge retrieval
- **Lead Management**: Automatic lead detection and JSON storage system

2. SIP Telephony Integration

SIP Call Flow



Configuration Requirements

LiveKit Server (`livekit.yaml`):

```
port: 7880
bind_addresses:
  - 0.0.0.0
keys:
  APIntavBoHTqApw: pRkd16t4uYVUs9nSlNeMawSE1qmUzfV2ZkSrMT2aiFM
redis:
  address: '192.168.109.66:6379'
  db: 0
```

SIP Service (`sip-setup/config.yaml`):

```
api_key: APIntavBoHTqApw
api_secret: pRkd16t4uYVUs9nSlNeMawSE1qmUzfV2ZkSrMT2aiFM
ws_url: ws://192.168.109.66:7880
redis:
  address: 192.168.109.66:6379
sip_port: 5060
rtp_port: 10000-20000
use_external_ip: false
logging:
  level: debug
```

Critical Setup Commands:

```
# Start services in order
redis-cli ping                                    # verify Redis
livekit-server --config livekit.yaml            # start main server
cd sip-setup && ./livekit-sip --config config.yaml    # start SIP bridge

# Setup SIP trunk and dispatch
lk project add friday --url ws://192.168.109.66:7880 --api-key APIntavBoHTqApw --api-secret pRkd16t4
lk sip inbound create --project friday inbound_trunk.json
lk sip dispatch create --project friday sip_dispatch.json

# Start voice agent
python cagent.py
```

Automating SIP Trunk & Dispatch creation

To avoid manual copy/paste when creating SIP trunks and dispatch rules, use the `lk` CLI and parse its JSON output with `jq` . Example (run from repository root where `sip-setup/` lives):

```
# Create inbound trunk and capture its ID
TRUNK_ID=$(lk sip inbound create --project friday sip-setup/inbound_trunk.json | jq -r '.sip_trunk_i

# Replace placeholder in dispatch JSON and create the dispatch rule
sed -i "s/REPLACE_WITH_TRUNK_ID/$TRUNK_ID/g" sip-setup/sip_dispatch.json
lk sip dispatch create --project friday sip-setup/sip_dispatch.json
```

This follows the canonical pattern in `README.md` and prevents human error during provisioning.

Start services (development)

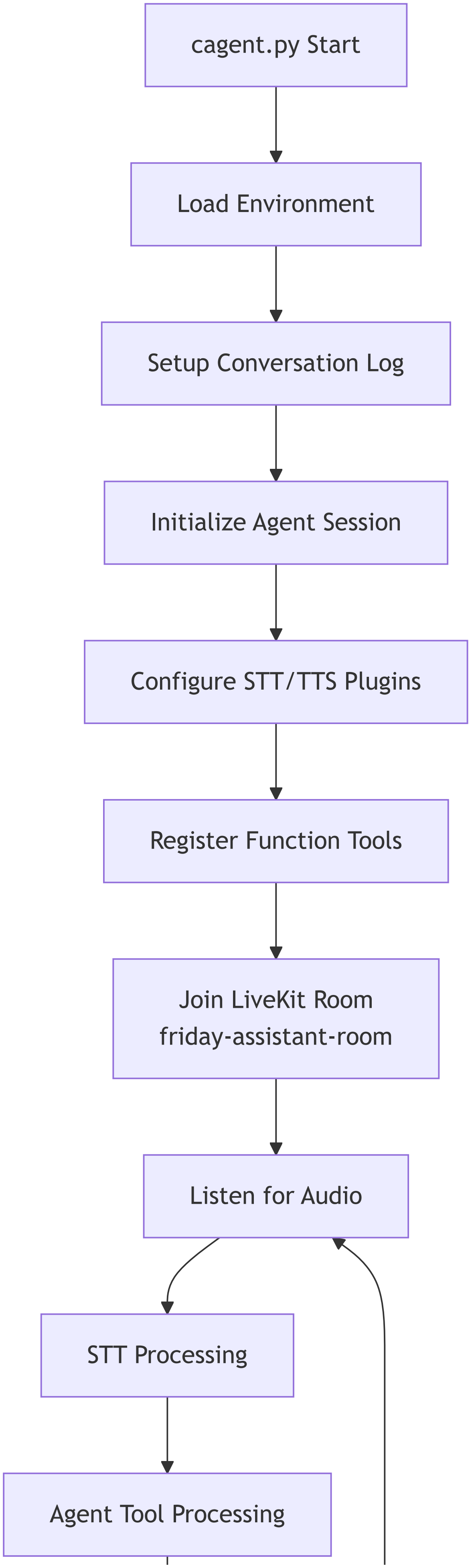
For local development, use `screen` to run services detached. For production prefer systemd or container orchestration.

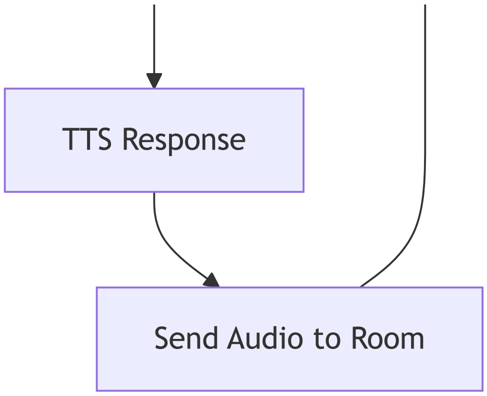
```
screen -dmS livekit-server livekit-server --config sip-setup/livekit.yaml
screen -dmS sip-bridge livekit-sip --config sip-setup/config.yaml
screen -dmS friday-agent bash -c "source ainvenv/bin/activate && python cagent.py"
```

3. Voice Agent Core (cagent.py)

The voice agent is the central component that connects to LiveKit rooms and processes conversations.

Agent Session Flow


cagent.py Start
Load Environment
Setup Conversation Log
Initialize Agent Session
Configure STT/TTS Plugins
Register Function Tools
Join LiveKit Room
friday-assistant-room
Listen for Audio
STT Processing
Agent Tool Processing



Key Components

- **Agent Session**: Manages LiveKit connection, room participation, and audio processing
- **STT/TTS Plugins**: Deepgram for speech-to-text, Cartesia for text-to-speech (Hindi voice)
- **Function Tools**: Business logic tools registered with `@function_tool()` decorator
- **Conversation Logging**: Realtime events are appended to `conversations/transcripts.jsonl` , and a final session snapshot is written to `conversations/transcript_session_<timestamp>.json`

Agent Configuration

```
# Agent initialization in cagent.py
session = AgentSession(
    stt=deepgram.STT(model="nova-3", language="multi"),
    llm=google.LLM(model="gemini-2.5-flash", temperature=0.8),
    tts=cartesia.TTS(
        model="sonic-2",
        language="hi",
        voice="f91ab3e6-5071-4e15-b016-cde6f2bcd222",
    ),
    vad=silero.VAD.load(),
)
```

4. Business Logic Tools (tools.py)

Core business logic functions exposed to the agent via `@function_tool()` decorator pattern.

Tool Functions

triotech_info(query: str) → str

- **Purpose**: Handles product and company information queries
- **Flow**: Fast JSON lookup in `data/` → RAG fallback for complex queries

- **Implementation**:
  - Check keywords: "features", "how to", "api", "integrate" → use RAG
  - Simple product queries → return JSON snippet
  - Fallback → call `model/runapi.py` for vector search

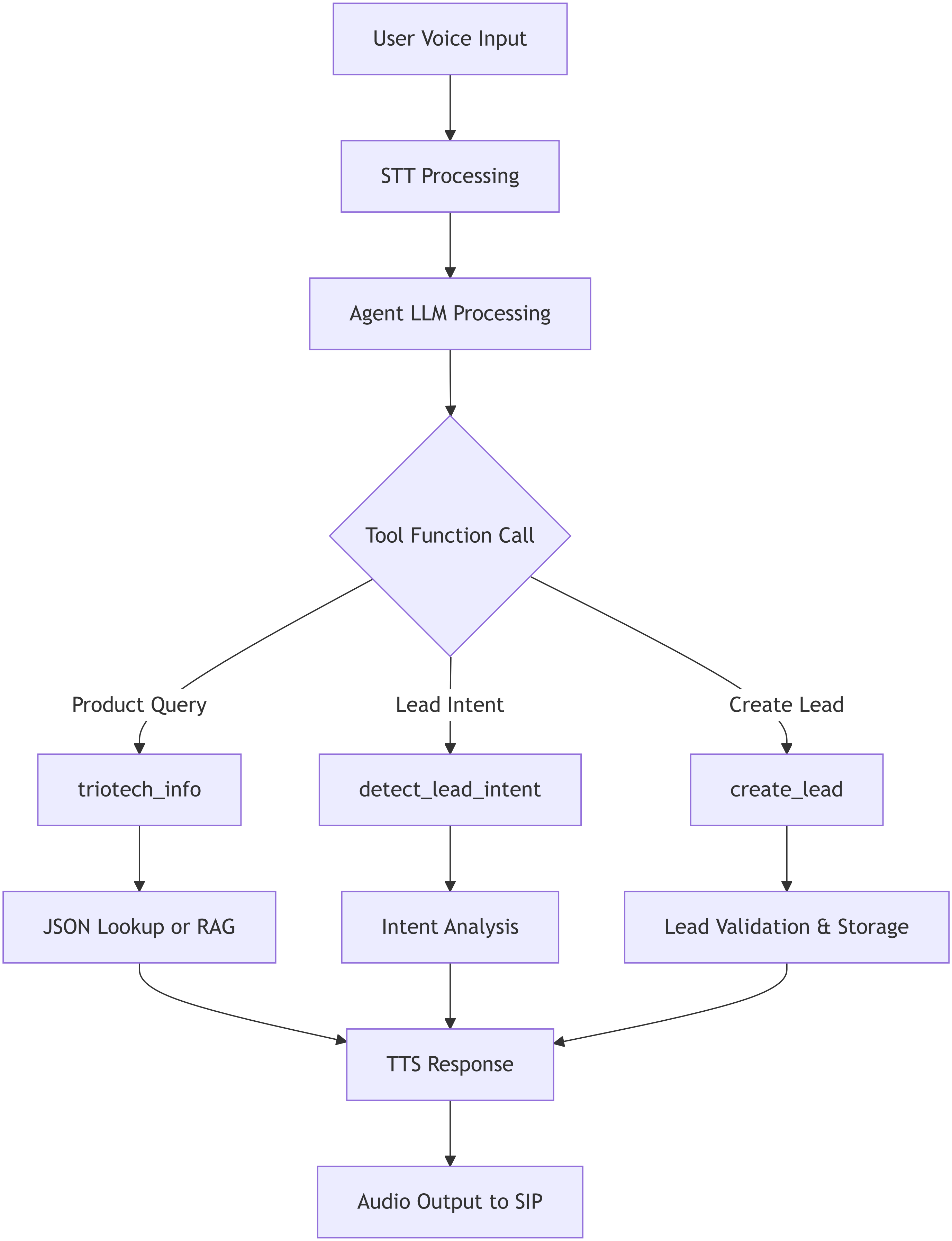
detect_lead_intent(text: str) → dict

- **Purpose**: Detects if user message indicates sales interest
- **Output**: `{is_lead: bool, confidence: float, extracted_fields: dict}`
- **Triggers**: Keywords like "interested", "price", "demo", "sales team"

create_lead(name, email, company, interest, phone=None, budget=None) → str

- **Purpose**: Validates and stores lead information
- **Validation**: Required fields present, email format check
- **Storage**: `leads/lead_YYYYMMDD_HHMMSS.json` with English keys
- **Response**: Hinglish confirmation message

Tool Integration Flow



5. RAG System Architecture (model/)

Hybrid knowledge retrieval system combining fast JSON lookups with vector database search.

RAG Components

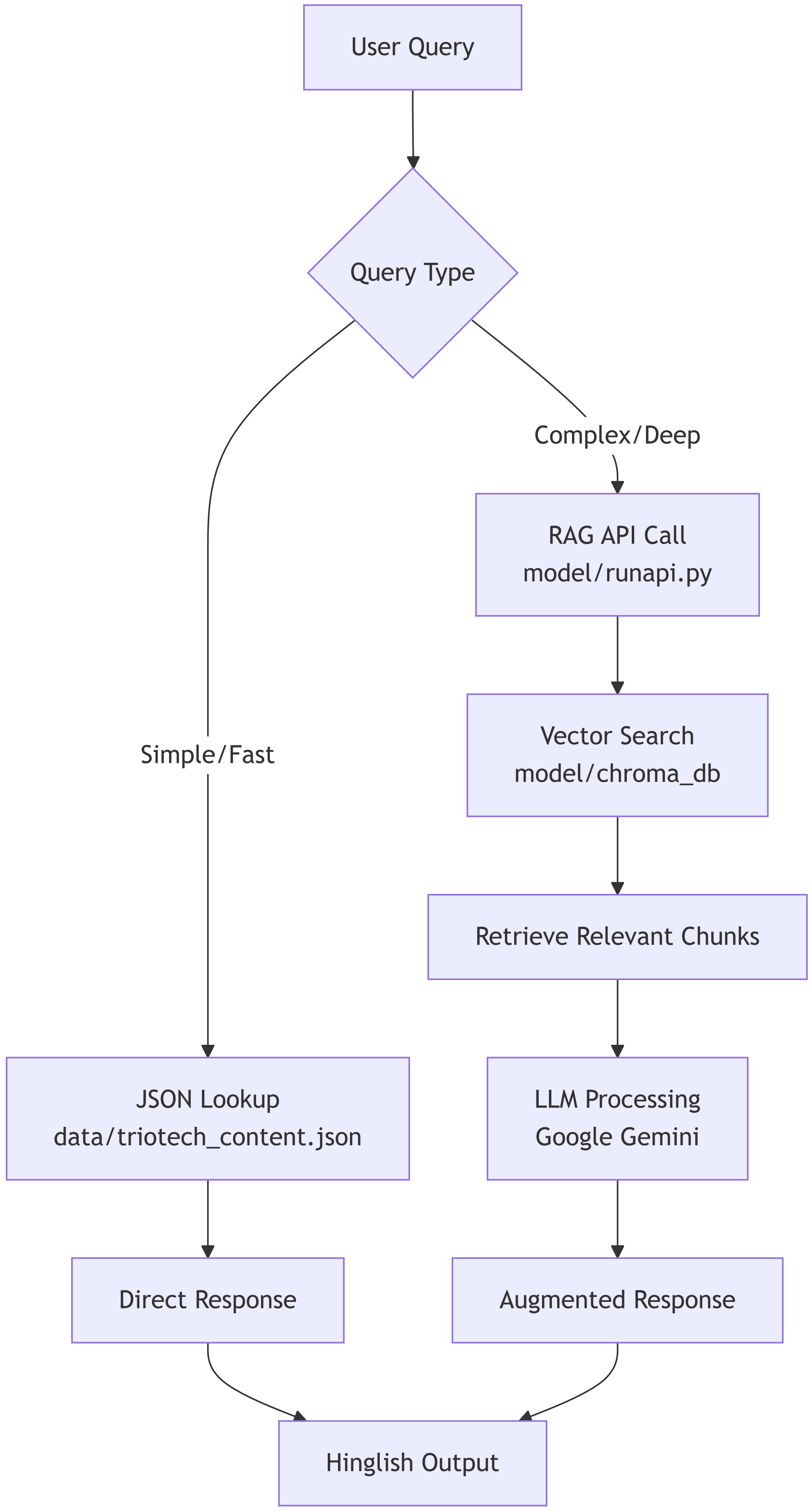
Vector Database Build (`model/build_db.py`):

- Chunks knowledge documents (chunk_size=1500, overlap=200)
- Uses HuggingFace embeddings for vector generation
- Builds persistent Chroma DB at `model/chroma_db/`
- Sources: `data/triotech_knowledge.txt` and other knowledge files

RAG API Runtime (`model/runapi.py`):

- Flask API server for RAG queries (port 5000)
- Handles vector similarity search
- LLM integration with API key rotation
- Fallback handling for ResourceExhausted errors

RAG Query Flow



Knowledge Sources

- `data/triotech_content.json` : Fast lookup for basic product info
- `data/triotech_knowledge.txt` : Deep knowledge for RAG processing
- Vector embeddings optimized for technical queries about features, APIs, integration

API Key Management

- Automatic rotation on ResourceExhausted errors
- Environment variable configuration
- Fallback to cached responses on API failures

6. Data Models and Storage

Conversation Logging

Format: `conversations/conversation_YYYYMMDD_HHMMSS.json`

```
{
  "conversation": [
    {
      "role": "user|agent",
      "content": "message text",
      "timestamp": "2025-10-07T16:42:56.532626",
      "source": "google_llm|cartesia_tts"
    }
  ]
}
```

Lead Storage

Format: `leads/lead_YYYYMMDD_HHMMSS.json`

```
{
  "timestamp": "2025-10-07T16:46:08.546889",
  "source": "Friday AI Assistant",
  "status": "new",
  "name": "Full Name",
  "email": "email@example.com",
  "company": "Company Name",
  "interest": "Product/Service",
  "phone": "phone number",
  "budget": "budget range",
  "job_title": "",
  "timeline": ""
}
```

Key Conventions:

- User-facing language: Hinglish (Hindi + English mix)
- Lead JSON fields: English only (for CRM integration)
- Timestamps: ISO 8601 format
- File naming: `YYYYMMDD_HHMMSS` pattern for chronological sorting

Configuration Files

Environment Variables (`.env`):

- `GOOGLE_API_KEY` : For Gemini LLM
- `HUGGINGFACE_API_KEY` : For embeddings
- `LIVEKIT_API_KEY` / `LIVEKIT_API_SECRET` : For LiveKit tokens
- `LLM_MODEL` : Configurable model (default: "gemini-2.5-flash")

SIP Configuration (`sip-setup/inbound_trunk.json`):

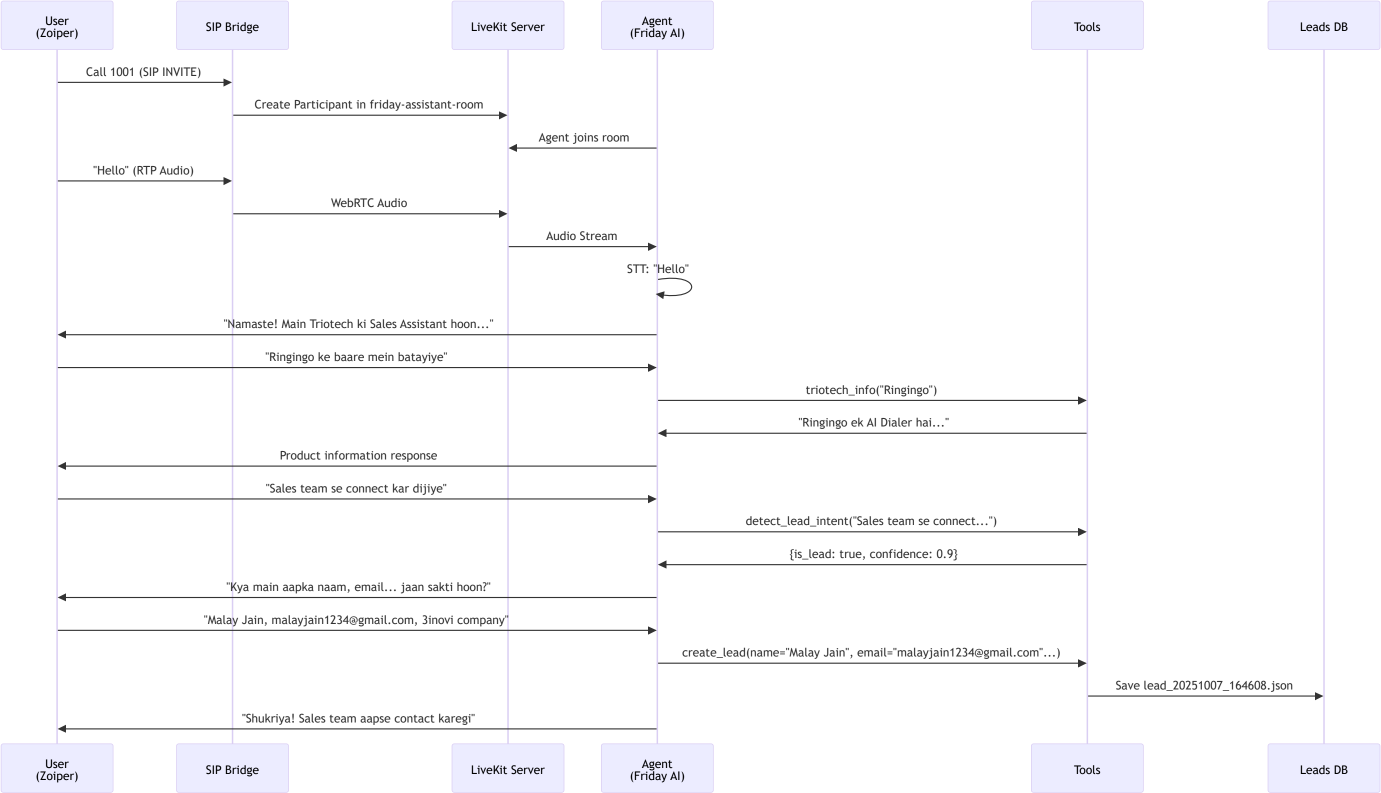
```
{
  "trunk": {
    "name": "Zoiper Local Inbound",
    "auth_username": "1001",
    "auth_password": "1001"
  }
}
```

SIP Dispatch (`sip-setup/sip_dispatch.json`):

```
{
  "dispatch_rule": {
    "name": "Zoiper to Assistant Room Rule",
    "trunk_ids": ["ST_TRUNK_ID"],
    "rule": {
      "dispatchRuleDirect": {
        "roomName": "friday-assistant-room"
      }
    }
  }
}
```

7. Complete End-to-End Flow Example

Real Call Session Example


User
(Zoiper)
SIP Bridge
LiveKit Server
Agent
(Friday AI)
Tools
Leads DB
Call 1001 (SIP INVITE)
Create Participant in friday-assistant-room
Agent joins room
"Hello" (RTP Audio)
WebRTC Audio
Audio Stream
STT: "Hello"
"Namaste! Main Triotech ki Sales Assistant hoon..."
"Ringingo ke baare mein batayiye"
triotech_info("Ringingo")
"Ringingo ek AI Dialer hai..."
Product information response
"Sales team se connect kar dijiye"
detect_lead_intent("Sales team se connect...")
{is_lead: true, confidence: 0.9}
"Kya main aapka naam, email... jaan sakti hoon?"
"Malay Jain, malayjain1234@gmail.com, 3inovi company"
create_lead(name="Malay Jain", email="malayjain1234@gmail.com"...)
Save lead_20251007_164608.json
"Shukriya! Sales team aapse contact karegi"
User
(Zoiper)
SIP Bridge
LiveKit Server
Agent
(Friday AI)
Tools
Leads DB

Directory Structure After Operation

```
Friday - Copy/
├── conversations/
│   ├── transcripts.jsonl                     # Streaming events (STT chunks + committed items)
│   └── transcript_session_2025-10-07T16-42-56.json  # Complete call snapshot
├── leads/
│   └── lead_20251007_164608.json           # Extracted lead data
├── sip-setup/
│   ├── config.yaml                         # SIP bridge config
│   ├── inbound_trunk.json                  # SIP trunk definition
│   └── sip_dispatch.json                   # Call routing rules
├── model/
│   ├── chroma_db/                          # Vector database
│   ├── build_db.py                         # DB builder
│   └── runapi.py                           # RAG API server
├── data/
│   ├── triotech_content.json               # Fast lookup data
│   └── triotech_knowledge.txt              # RAG knowledge base
├── cagent.py                               # Voice agent entry point
├── tools.py                                # Business logic functions
├── prompts.py                              # Hinglish prompts
├── config.py                               # Config helpers
└── livekit.yaml                            # LiveKit server config
```

8. Deployment and Operations

Service Startup Sequence

```
# 1. Verify prerequisites
redis-cli ping                               # Should return PONG

# 2. Start LiveKit server
livekit-server --config livekit.yaml        # Port 7880

# 3. Start SIP bridge (separate terminal)
cd sip-setup && ./livekit-sip --config config.yaml # Port 5060

# 4. Setup SIP routing (one-time)
lk project add friday --url ws://192.168.109.66:7880 --api-key APIntavBoHTqApw --api-secret pRkd16t4
lk sip inbound create --project friday inbound_trunk.json
lk sip dispatch create --project friday sip_dispatch.json

# 5. Start voice agent
python cagent.py                             # Joins friday-assistant-room

# 6. Start RAG API (optional, for complex queries)
python model/runapi.py                       # Port 5000
```

Debugging and Monitoring

SIP Traffic Analysis:

```
# Monitor SIP packets
sngrep

# Check port status
ss -tulnp | grep -E "5060|7880|6379"

# Verify room participants
lk room participants --room friday-assistant-room
```

Log Analysis:

- SIP Bridge: Look for "SIP invite authentication successful"
- LiveKit Server: Check for participant join/leave events
- Agent: Monitor conversation logs in `conversations/`

- RAG API: Check vector database queries and LLM responses

Common Issues:

- **"sip not connected"**: Redis not accessible to both LiveKit server and SIP bridge
- **API key mismatch**: `livekit.yaml` and `sip-setup/config.yaml` must have identical keys
- **RTP audio issues**: Firewall blocking UDP ports 10000-20000
- **Agent not responding**: Verify agent joined correct room name

Security Considerations

- **API Secrets**: Never commit LiveKit API secrets to version control
- **PII Protection**: Leads and conversations contain sensitive data
- **Network Security**: Use firewalls to restrict SIP/RTP ports to trusted networks
- **Token Management**: Prefer backend token minting over frontend secret exposure

Performance Optimization

- **RAG Database**: Rebuild after knowledge base updates: `python model/build_db.py`
- **Conversation Cleanup**: Archive old conversations to prevent disk bloat
- **Lead Deduplication**: Implement lead validation to prevent duplicates
- **Plugin Caching**: Use modified plugins in `backup_plugin_modifications/` for consistent performance

9. Testing and Validation

Unit Tests

```
# Core functionality tests
python test_triotech_assistant.py          # Tool function tests
python test_dummy_plugins.py               # Plugin integration tests
python test_lead_detection.py              # Lead capture validation

# Build and test RAG system
python model/build_db.py                   # Rebuild vector database
python -c "import requests; print(requests.get('http://localhost:5000/health').json())"
```

Integration Tests

SIP Call Testing:

1. Configure Zoiper with SIP server `192.168.109.66:5060`

2. Register as user `1001` , password `1001`
3. Dial any number to test call routing
4. Verify agent response and conversation logging

Expected Test Results:

- SIP registration successful in Zoiper
- Call connects and agent responds in Hinglish
- Conversation saved to `conversations/`
- Lead detection and capture working for sales inquiries
- RAG responses for complex technical queries

Quality Gates

Pre-deployment Checklist:

- □ All unit tests passing
- □ SIP bridge can authenticate test calls
- □ Agent joins room and responds to audio
- □ Lead creation saves valid JSON with English keys
- □ RAG API returns relevant responses
- □ Conversation logs are properly formatted
- □ No API secrets committed to version control

Development Workflow

```
# Standard development cycle
git pull origin main
pip install -r requirements.txt
python model/build_db.py                    # If knowledge changed
python test_triotech_assistant.py           # Verify core functions
python cagent.py                             # Test agent locally
```

10. Developer Onboarding

Quick Start for New Developers

1. **Read these files first**:
    - `cagent.py` - Agent entry point and session management
    - `tools.py` - Core business logic and function tools
    - `prompts.py` - Hinglish prompts and conversation rules

   - `Comprehensive Setup Guide_ Integrating a SIP Client with a Self-Hosted LiveKit Environment.md`

2. **Set up development environment**:

   ```
   # Clone and install
   git clone <repository-url>
   cd friday-ai
   cp .env.example .env        # Fill in API keys
   pip install -r requirements.txt

   # Build knowledge base
   python model/build_db.py

   # Test basic functionality
   python test_triotech_assistant.py
   ```

3. **Understand the data flow**:
   - SIP calls → LiveKit rooms → Agent processing → Tools → Storage
   - User queries → JSON lookup or RAG → Hinglish responses
   - Lead intent → Validation → JSON storage with English keys
4. **Key conventions to follow**:
   - User-facing strings in Hinglish
   - Lead JSON keys in English only
   - Function tools use `@function_tool()` decorator
   - Conversation logs: `conversation_YYYYMMDD_HHMMSS.json`
   - Lead files: `lead_YYYYMMDD_HHMMSS.json`

Adding New Features

1. **New tool functions**: Add to `tools.py` with decorator
2. **New prompts**: Update `prompts.py` with Hinglish templates
3. **Knowledge updates**: Edit `data/triotech_knowledge.txt` then rebuild: `python model/build_db.py`
4. **Plugin modifications**: Use `backup_plugin_modifications/` and `docker_scripts/`

Documentation Updates

When making changes, update:

- This architecture document for structural changes
- `.github/copilot-instructions.md` for quick agent guidance
- Function docstrings for API changes
- Test files for new functionality validation