Documentation: `src/bot/graph.py`

This document explains in detail the **structure and functioning** of the `graph.py` module, which orchestrates an AI-driven conversation around **sleep-related health consultations**.
It integrates **LangGraph** state graphs with **LangChain** LLM prompt pipelines to enable smart, stateful, safe, and procedurally guided dialogues.

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1. Purpose

The `graph.py` script defines a **state machine** for the chatbot that:

1. Starts conversations with a patient (optionally using a referral letter).
2. Ensures patient input **stays on-topic** (sleep-related).
3. Performs **safety checks** for self-harm risk.
4. Dynamically decides whether to **ask questions** or **generate a professional summary**.
5. Handles conversation flow persistently using a SQLite checkpointing system.

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2. Key Components

2.1 Dependencies

The script imports several key libraries and modules:

- **LangChain Core**:
  - `HumanMessage`
  - `AIMessage`
  - `ChatPromptTemplate`
- **LangChain OpenAI**: `ChatOpenAI`
- **LangGraph**:
  - `StateGraph` (for defining state transitions)
  - `END` terminal constant
  - `SqliteSaver` checkpoint backend
- **Custom Project Modules**:
  - `GraphState` (state schema definition)
  - Pydantic data models: `GuardrailDecision`, `SuicideCheckDecision`, `SleepSummary`, `RouterDecision`
  - Prompt helper functions for system and human messages
- **Persistence**: `sqlite3` to store conversation states

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3. LLM Configuration

Two LLM instances are initialized:

```
llm = ChatOpenAI(model="gpt-4o")
llm_summary = ChatOpenAI(model="gpt-4o", max_tokens=3000)
```

- `llm` → General dialogue & classification tasks.
- `llm_summary` → Summary generation with more tokens for detailed outputs.

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4. Graph Nodes

The LangGraph is based on **nodes** that mutate `GraphState`.
Nodes return **partial state updates**, merged into the persistent conversation state.

4.1 Guardrail Node

Ensures conversation stays **on-topic (sleep health)**.

- Uses structured LLM output (`GuardrailDecision`) for classification.
- Maintains an `off_topic_counter`.
- After 3 off-topic responses, terminates with a warning.

Prompt Components:

- System: `get_guardrail_prompt()`
- Human: User message + classification instructions.

4.2 Suicide Check Node

Performs a **safety check** to detect self-harm/suicidal intent.

- Looks at last 5 messages.
- Structured output: `SuicideCheckDecision`.
- If **risk detected** at medium/high/immediate → Terminates conversation.
- Custom safety messages based on severity.

Prompt Components:

- System: `get_suicide_check_prompt()`
- Human: Last 5 messages as conversation context.

4.3 Ask Question Node

Asks **sequential consultation questions**.

- If starting conversation → Uses `get_initial_question_prompt()` with referral letter context.
- Else → `get_followup_question_prompt()` with conversation history.

Prompt Components:

- System: `get_ask_question_system_prompt()`

- Human: Initial or follow-up prompt.

Tracks:

- `last_question` for guardrail recovery.
- Increment `questions_answered` when on-topic.

4.4 Summary Node

Generates **summaries** for both the **patient** and **doctor**.

2 Modes:

1. **Initial summary** (after enough questions, confirmation pending).
2. **Final summary** (after patient modifications).

Structured output: `SleepSummary` with:

- `doctor_summary`
- `patient_summary`
- `urgency_level`

Fallback: If structured output fails → plain LLM text.

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5. Router Logic

Controls flow between:

- **"ask_question"**
- **"generate_summary"**

Logic Steps:

1. If summary already confirmed → `generate_summary`.
2. If < 5 questions answered → Continue questions.
3. Else → Let `RouterDecision` AI decide (context-aware).

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6. Termination Check

`should_terminate` function:

- Ends conversation if `terminate_reason` exists in state.

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7. Graph Construction

```
graph_builder = StateGraph(GraphState)

graph_builder.add_node("guardrail", guardrail_node)
graph_builder.add_node("suicide_check", suicide_check_node)
graph_builder.add_node("ask_question", ask_question_node)
graph_builder.add_node("summary", summary_node)
graph_builder.add_node("router", router_node)
```

Edges:

- entry → **guardrail**
- guardrail → suicide_check OR END
- suicide_check → router OR END
- router → ask_question OR summary
- ask_question → END (await new input)
- summary → END OR continue for edits

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8. Persistence

Uses `SqliteSaver` to store full conversation state in **`conversations.sqlite`**, keyed by `thread_id`.

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9. Conversation Loop

The CLI entry point (`main_loop`):

1. Ask for `user_id`.
2. Optionally request referral letter.
3. Start conversation with personalized or default greeting.
4. Resume past sessions if no new referral provided.
5. Stream graph events until conversation termination.

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10. Prompts

Prompts are **template-driven**, combining:

- **System Messages**: Define AI's role & guidelines.
- **Human Messages**: Context (conversation history, referral letter).

They are provided by `helper.py` functions for consistency.

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11. Key Takeaways

- **Safety-first** → Guardrail & Suicide Check always run first.
- **Dynamic flow** → Router logic + patient input determine direction.
- **Persistent** → Conversations resume mid-way even after interruptions.
- **Contextualized** → Referral letters greatly improve question relevance.
- **Dual output** → Summaries tailored both for medical professionals and patients.

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12. Visual Flow Diagram (Detailed)

```
flowchart TD
    A[Start / Entry Point] --> B[Guardrail Node]
    B -->|OFF-TOPIC limit reached| T[END: Terminate - Off-topic]
    B -->|Continue| C[Suicide Check Node]

    C -->|Risk detected| U[END: Terminate - Suicide Risk]
    C -->|Continue| D[Router Node]

    D -->|Ask More Questions| E[Ask Question Node]
    E --> G[END: Await User Input]

    D -->|Generate Summary| F[Summary Node]
    F -->|Finalized or Terminated| H[END]
    F -->|Await patient additions| H2[END: Await User Additions]

    H2 --> B
```

This **Mermaid diagram** illustrates the path branching and termination logic.

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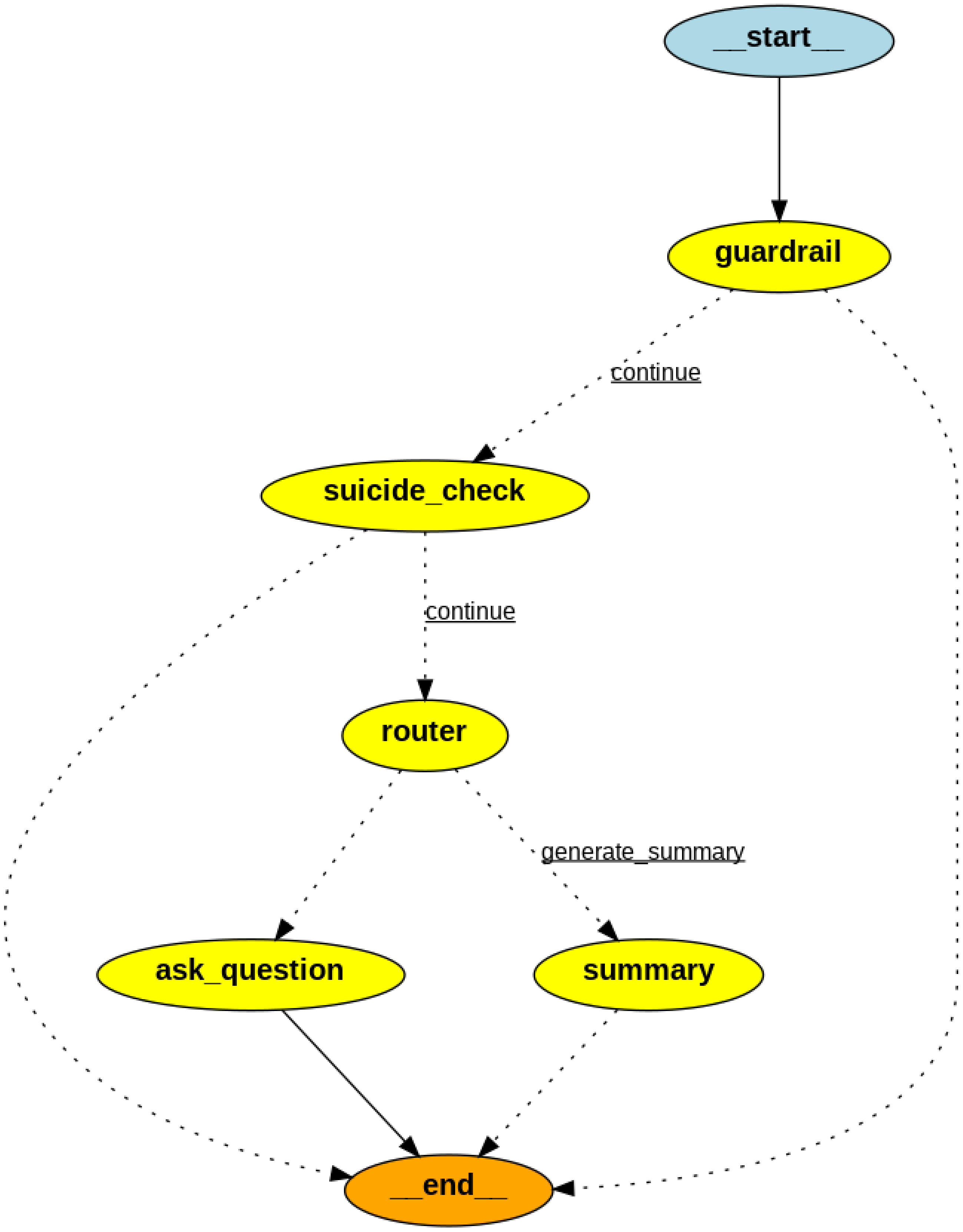
13. Graph Visualization (Generated)

Below is the actual **graph image** generated when running `graph.py` as the main module:



This PNG is built dynamically by `app.get_graph().draw_png()` during startup, ensuring it matches the code's current logic.

Maintained across nodes; can include:

- `messages` (chat history)
- `off_topic_counter`
- `questions_answered`

- `last_question`
- `terminate_reason`
- `summary_confirmed`
- `referral_letter`
- `doctor_summary`
- `patient_summary`
- `urgency_level`

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14. Extensibility

Possible improvements:

- Add multilingual support in prompts.
- Save LLM reasoning metadata for audits.
- Include sentiment analysis tracking.