GridGPT: AI Virtual Assistant for the Smart Grid Application

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Introduction

Problem: The design of the power grid is evolving rapidly. Those in the industry manage new renewable energy sources alongside maintenance of the current grid's infrastructure.

Background: OpenDSS, a open source distribution system simulator, requires scripting to run a power flow simulation and outputs numerical values that require grid operators to filter to what they need for a decision.

Solution: GridGPT simplifies management with AI-powered tools that use natural language to streamline operations and reduce errors.

Technical Details

Technologies Used:

- React - Coding language used to develop User Interface
- Next.js - React framework for features and optimization
- ISU HPC - High-performance computing cluster at ISU for LLM training
- OpenAI - API to use OpenAI GPT models
- Python - Main backend language
- Docker/Compose - To attach our subsystem to the main
- HuggingFace - To fine-tune and leverage open-source LLMs
- Meta AI Llama 3.1 - LLM used for chat bot

Design Approach

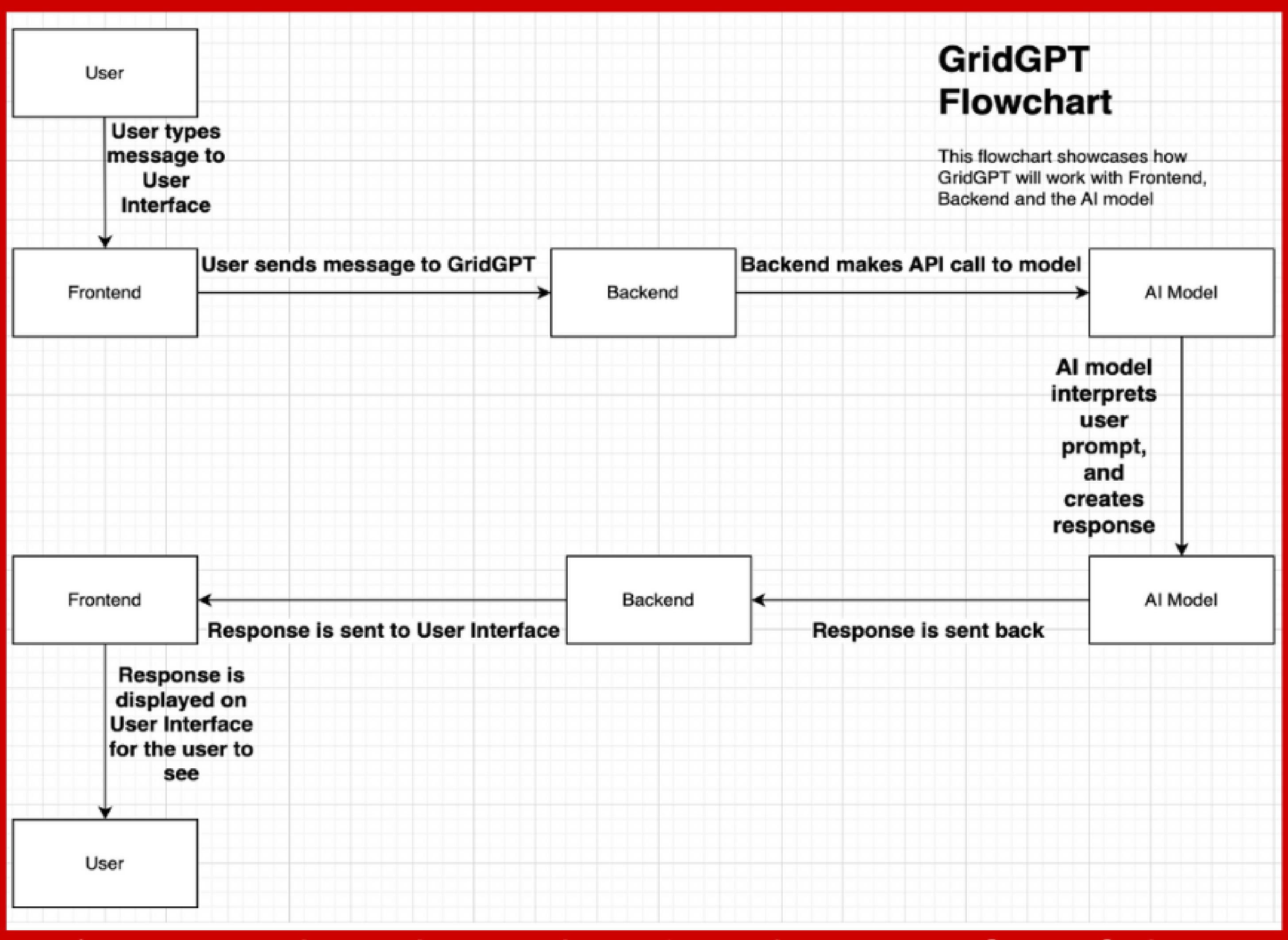

GridGPT Flowchart
This flowchart showcases how GridGPT will work with Frontend, Backend and the AI model
User
User types message to User Interface
Frontend
User sends message to GridGPT
Backend
Backend makes API call to model
AI Model
AI model interprets user prompt, and creates response
AI Model
Response is sent back
Backend
Response is sent to User Interface
Frontend
Response is displayed on User Interface for the user to see
User

Figure 1: *Flowchart showing the transfer of data from the user sending their response to getting a response back from the AI model*

Design Requirements

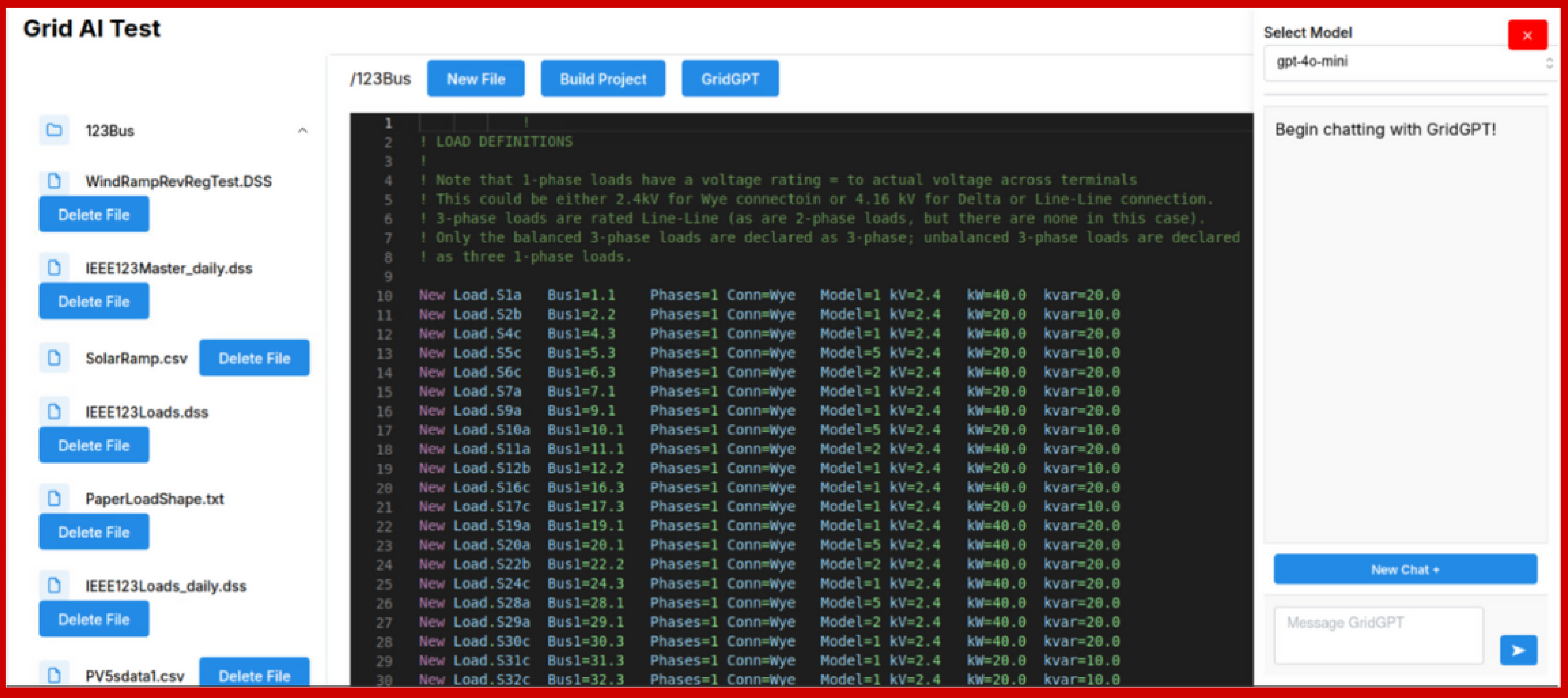
Functional Requirements:

- Custom LLM Model Implementation
  - Incorporate and customize a pre-trained Hugging Face LLM model.
- Incorporate OpenAI GPT-4
  - Use as a benchmark for our Hugging Face model.
- User Experience Requirements
  - The User Interface will need to be responsive and easily accessible.

Non-functional requirements:

- Portability - GridGPT will be able to be integrated with other power grid software.
- Security - GridGPT will not allow unauthorized users to access sensitive data.

User Interface



```
!
! LOAD DEFINITIONS
!
! Note that 1-phase loads have a voltage rating = to actual voltage across terminals
! This could be either 2.4kV for Wye connectoin or 4.16 kV for Delta or Line-Line connection.
! 3-phase loads are rated Line-Line (as are 2-phase loads, but there are none in this case).
! Only the balanced 3-phase loads are declared as 3-phase; unbalanced 3-phase loads are declared
! as three 1-phase loads.

New Load.S1a   Bus1=1.1    Phases=1 Conn=Wye   Model=1 kV=2.4   kW=40.0  kvar=20.0
New Load.S2b   Bus1=2.2    Phases=1 Conn=Wye   Model=1 kV=2.4   kW=20.0  kvar=10.0
New Load.S4c   Bus1=4.3    Phases=1 Conn=Wye   Model=1 kV=2.4   kW=40.0  kvar=20.0
New Load.S5c   Bus1=5.3    Phases=1 Conn=Wye   Model=5 kV=2.4   kW=20.0  kvar=10.0
New Load.S6c   Bus1=6.3    Phases=1 Conn=Wye   Model=2 kV=2.4   kW=40.0  kvar=20.0
New Load.S7a   Bus1=7.1    Phases=1 Conn=Wye   Model=1 kV=2.4   kW=20.0  kvar=10.0
New Load.S9a   Bus1=9.1    Phases=1 Conn=Wye   Model=1 kV=2.4   kW=40.0  kvar=20.0
New Load.S10a  Bus1=10.1   Phases=1 Conn=Wye   Model=5 kV=2.4   kW=20.0  kvar=10.0
New Load.S11a  Bus1=11.1   Phases=1 Conn=Wye   Model=2 kV=2.4   kW=40.0  kvar=20.0
New Load.S12b  Bus1=12.2   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=20.0  kvar=10.0
New Load.S16c  Bus1=16.3   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=40.0  kvar=20.0
New Load.S17c  Bus1=17.3   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=20.0  kvar=10.0
New Load.S19a  Bus1=19.1   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=40.0  kvar=20.0
New Load.S20a  Bus1=20.1   Phases=1 Conn=Wye   Model=5 kV=2.4   kW=40.0  kvar=20.0
New Load.S22b  Bus1=22.2   Phases=1 Conn=Wye   Model=2 kV=2.4   kW=40.0  kvar=20.0
New Load.S24c  Bus1=24.3   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=40.0  kvar=20.0
New Load.S28a  Bus1=28.1   Phases=1 Conn=Wye   Model=5 kV=2.4   kW=40.0  kvar=20.0
New Load.S29a  Bus1=29.1   Phases=1 Conn=Wye   Model=2 kV=2.4   kW=40.0  kvar=20.0
New Load.S30c  Bus1=30.3   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=40.0  kvar=20.0
New Load.S31c  Bus1=31.3   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=20.0  kvar=10.0
New Load.S32c  Bus1=32.3   Phases=1 Conn=Wye   Model=1 kV=2.4   kW=20.0  kvar=10.0
```

Figure 2: *User Interface showing GridGPT chat window*

Testing

- Manual end-to-end tests
- Regressive testing
- Acceptance testing

Next Steps

Implement Python version of OpenDSS with code to generate input-output pairs to fine tune pretrained AI models