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# **CAPSTONE PROJECT**

## **AUDIO SIGNAL PROCESSING ASSISTANT AGENT**

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# OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result (Output Image)
- Conclusion
- Future Scope
- References

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# PROBLEM STATEMENT

Audio circuit design involves complex analog components such as preamps, filters, and amplifiers. Engineers often face issues like noise, distortion, or instability in op-amp configurations. Diagnosing these problems manually is time-consuming and requires expert knowledge. There is a need for an intelligent assistant to guide circuit designers in real time with accurate suggestions and explanations.

# PROPOSED SOLUTION

- The proposed system aims to address the challenge of assisting engineers in diagnosing and optimizing audio circuits such as amplifiers, filters, and preamps. This involves leveraging advanced AI models and cloud technologies to deliver real-time, expert-level suggestions for design and debugging. The solution will consist of the following components:
- Query Collection and Interpretation:
  - Gather input natural language queries related to audio signal processing, such as:
    - “Why is my amplifier producing noise?”
    - “How can I reduce distortion in my op-amp circuit?”
- AI-Powered Response Generation
  - Utilize IBM Granite AI, a large language model, to generate intelligent responses.
  - Perform prompt engineering and iterative refinement to ensure accurate and technically sound outputs.inconsistencies.
- Deployment:
  - Develop a user-friendly interface to guide circuit designers in real time with accurate suggestions and explanations.
  - Deploy the solution on a scalable and reliable platform, considering factors like server infrastructure, response time, and user accessibility.
- Evaluation:
  - Assess the effectiveness of AI responses based on: User satisfaction, Relevance and accuracy of suggestions.
  - Result: A functional AI-based assistant capable of real-time, context-aware support for audio circuit design and debugging.

# SYSTEM APPROACH

The agent was developed using IBM Granite AI by providing specific prompts and task definitions, allowing the AI to understand user goals and deliver expert-level suggestions.

- System requirements:

- IBM Cloud Lite account

- IBM Watson Assistant

- IBM Granite LLM

# ALGORITHM & DEPLOYMENT

- **LLM Model Selection:**

- The IBM Granite AI model is a powerful Large Language Model capable of understanding natural language queries and providing intelligent, context-specific responses. It was chosen for this project because it enables Agentic AI behavior, allowing the assistant to reason, plan, and deliver expert suggestions for audio circuit design and debugging. Its ability to process unstructured user inputs and adapt to various problem scenarios makes it ideal for addressing the complex and dynamic nature of audio signal processing support..

- **Data Input:**

- The primary input to the system is natural language queries from users, such as:
  - “Why is my op-amp circuit producing noise?”
  - “How do I design a band-pass filter for audio?”
- These queries are processed using structured prompts, which include:
  - Technical context about audio signal processing
  - Specific task instructions guiding the AI’s response generation.

- **Training Process:**

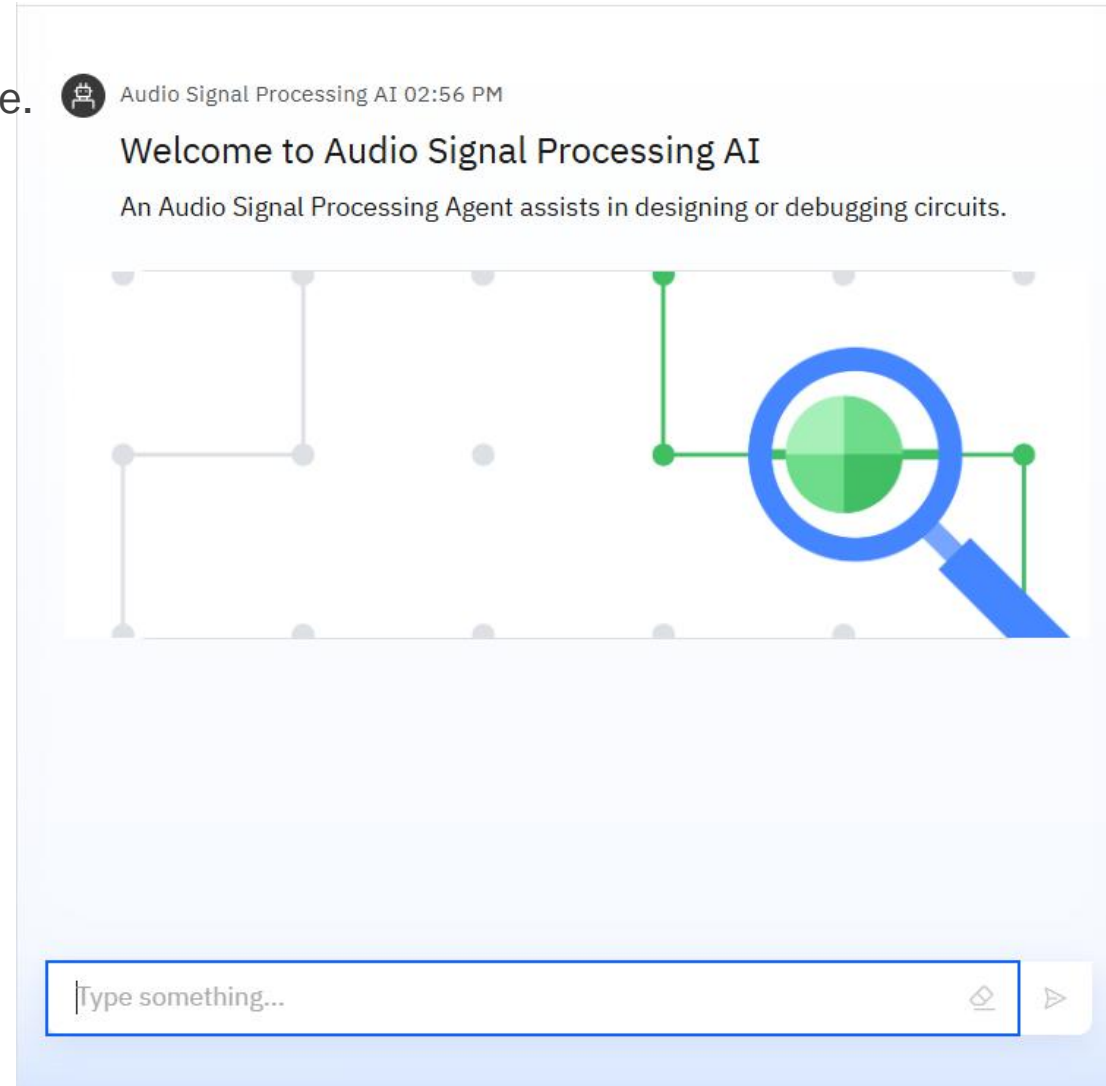
- The IBM Granite AI model is a pre-trained Large Language Model, so no additional model training was required. Instead, prompt was used to tailor the AI’s behavior for audio signal processing tasks.

- **Response Process:**

- When the user query is processed and sent to the IBM Granite AI model, the model analyzes the query’s context and identifies the user’s intent. Based on the provided prompt, the AI generates a detailed, accurate response that includes troubleshooting tips, design suggestions, or relevant explanations for the audio circuit issue.

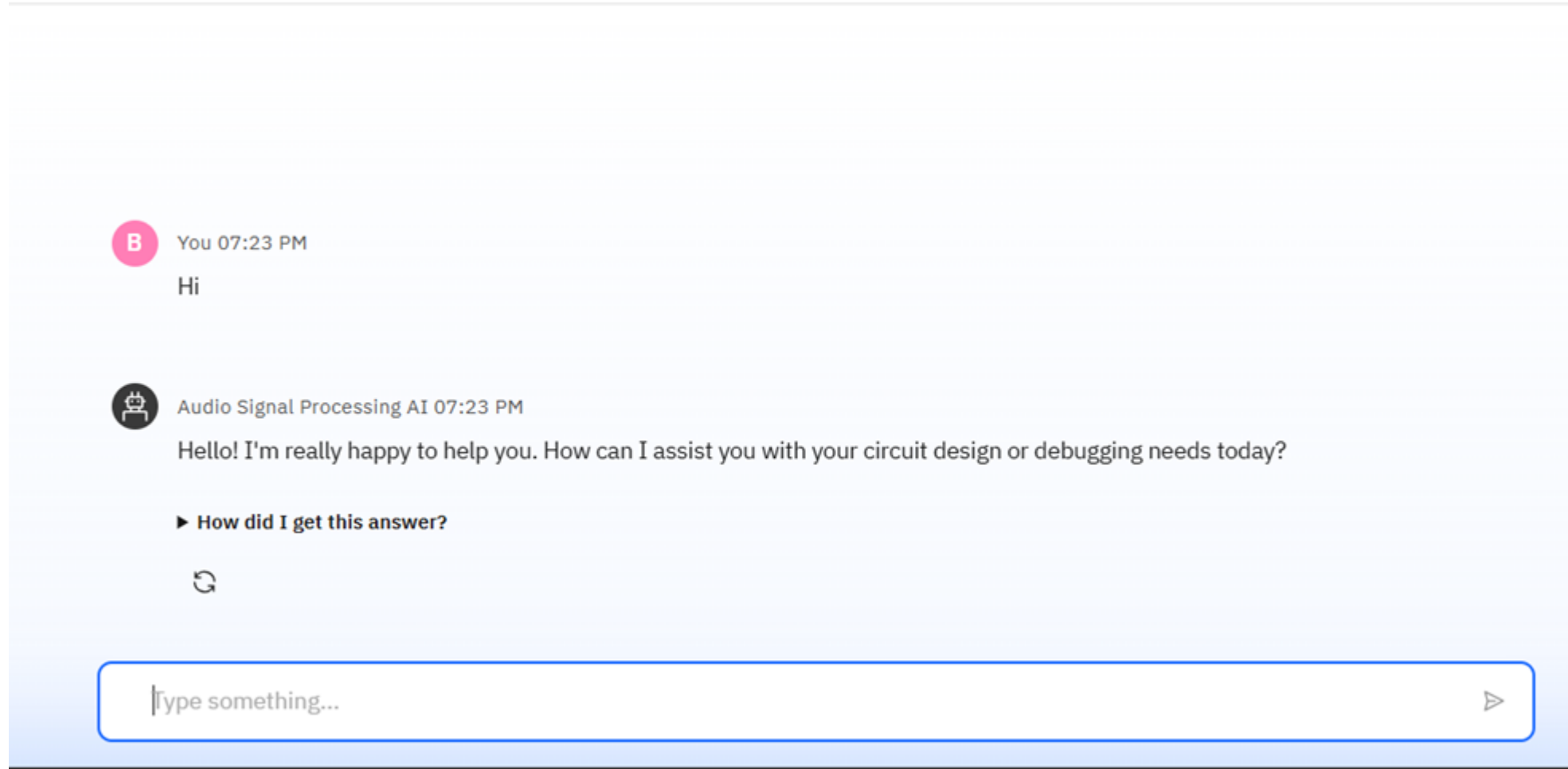
# RESULT

1.This is the Audio Signal Processing AI Home page.



# RESULT

## 2.Initial Interaction – User Says ‘Hi’





# RESULT

## 3. Query 1 – ‘Why is my audio amplifier producing noise?’



You 08:03 PM

Why is my audio amplifier producing noise?’



Audio Signal Processing AI 08:03 PM

Audio amplifier noise can be caused by several factors. Here are some common reasons and potential solutions:

1. **Power Supply Noise:** The power supply can introduce noise into the amplifier circuit. To mitigate this, use proper decoupling capacitors close to the power pins of the amplifier IC. Also, consider using a linear power supply or a well-regulated switching power supply.
2. **Poor Grounding:** Inadequate grounding can lead to ground loops and introduce noise. Ensure that your circuit has a solid ground plane and that all ground connections are short and direct.
3. **Inadequate Shielding:** If your amplifier is near sources of electromagnetic interference (EMI), such as motors or digital circuits, it can pick up noise. Shielding the amplifier circuit or using twisted-pair cables can help reduce EMI.
4. **Component Quality:** Low-quality or incorrect components, such as capacitors or resistors, can introduce noise. Use high-quality components, especially those specified in the amplifier's datasheet.
5. **Layout Issues:** Poor PCB layout can contribute to noise. Keep signal paths short, avoid running high-current paths near sensitive analog signals, and maintain proper spacing between components.
6. **Feedback Loop Issues:** Improperly configured feedback loops can amplify noise. Ensure that feedback components are correctly chosen and placed according to the amplifier's design.
7. **Thermal Noise:** High temperatures can increase thermal noise. Ensure that the amplifier IC is adequately cooled.

To diagnose the exact cause of noise in your specific amplifier, you might need to perform measurements with an oscilloscope or a spectrum analyzer. Look for noise peaks at specific frequencies, which can help pinpoint the source of the problem.

If you need more detailed information or specific troubleshooting steps for a particular amplifier design, please provide the model or schematic, and I can offer more targeted advice.

Type something...



# RESULT

## 4. Query 2 – ‘How do I reduce distortion in my op-amp circuit?’

How do I reduce distortion in my op-amp circuit



Audio Signal Processing AI 08:08 PM

Reducing distortion in an operational amplifier (op-amp) circuit involves several strategies:

1. **Proper Biasing:** Ensure that the op-amp is operating within its linear region. If the input or output is clipped, it will introduce distortion. Use appropriate biasing to keep the signal within the amplifier's linear range.
2. **Feedback Network Design:** The feedback network is crucial for linearity. Use precision resistors with low temperature coefficients to maintain consistent gain over temperature variations. Also, consider using a feedback capacitor to roll off high frequencies, which can help reduce distortion caused by slew rate limitations.
3. **Power Supply Decoupling:** Proper decoupling of the power supply can reduce noise and distortion. Place decoupling capacitors close to the op-amp's power pins to minimize supply noise.
4. **Input Signal Level:** Keep the input signal level within the recommended range for the op-amp. Exceeding the maximum input can lead to non-linear behavior and distortion.
5. **Choose the Right Op-Amp:** Different op-amps have different distortion characteristics. Some are designed for low distortion, such as those used in audio applications. Review the datasheet for the op-amp you're using to understand its distortion specifications.
6. **Temperature Compensation:** Temperature changes can affect the performance of the op-amp, including distortion. If your application is temperature-sensitive, consider using temperature compensation techniques or selecting an op-amp with built-in compensation.
7. **Layout and Grounding:** A well-designed PCB layout can minimize distortion. Keep signal paths short, maintain proper grounding, and avoid running high-current paths near sensitive analog signals to reduce noise and interference.
8. **Use of Distortion-Reduction Circuits:** Some circuits, like those using negative feedback and careful component selection, can specifically target distortion reduction. For example, a distortion-reduction loop can be implemented to monitor and correct for distortion in real-time.

Type something...



# RESULT

- **Audio Signal Processing Assistant Agent** successfully answered user queries related to audio circuit issues with accurate, real-time responses.
- The system demonstrated effective agentic behavior, handling follow-up questions and offering design suggestions.
- Deployed on IBM Cloud.

# CONCLUSION

- **Audio Signal Processing Assistant Agent** provides an intelligent and accessible way to support circuit designers and learners in resolving common analog design problems.
- It reduces trial-and-error by delivering quick, expert-level advice using IBM Granite LLM.
- The project demonstrates the power of domain-specific Agentic AI for education and engineering use cases.

# FUTURE SCOPE

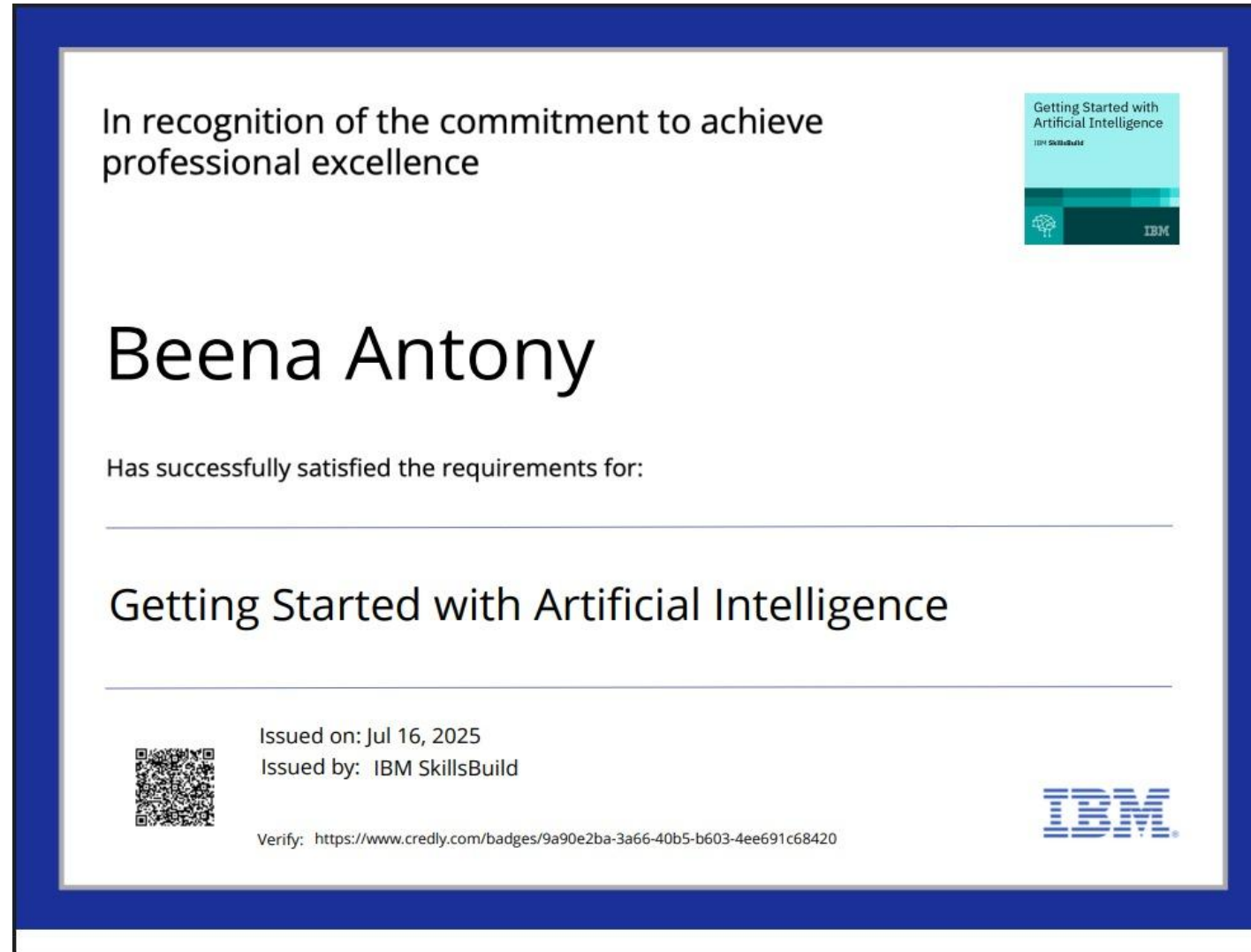
- Connect to circuit simulation tools (LTspice/Falstad)
- Introduce voice-based interaction
- Expand assistant to support RF and biomedical circuits
- Add multilingual support
- Enable offline use with Edge AI models

# REFERENCES

- [1] IBM Granite AI Documentation
- [2] IBM Cloud Lite Services
- [3] Audio Signal Processing Basics – Analog Devices Op-Amp Applications Handbook
- [4] IBM Code Engine Documentation

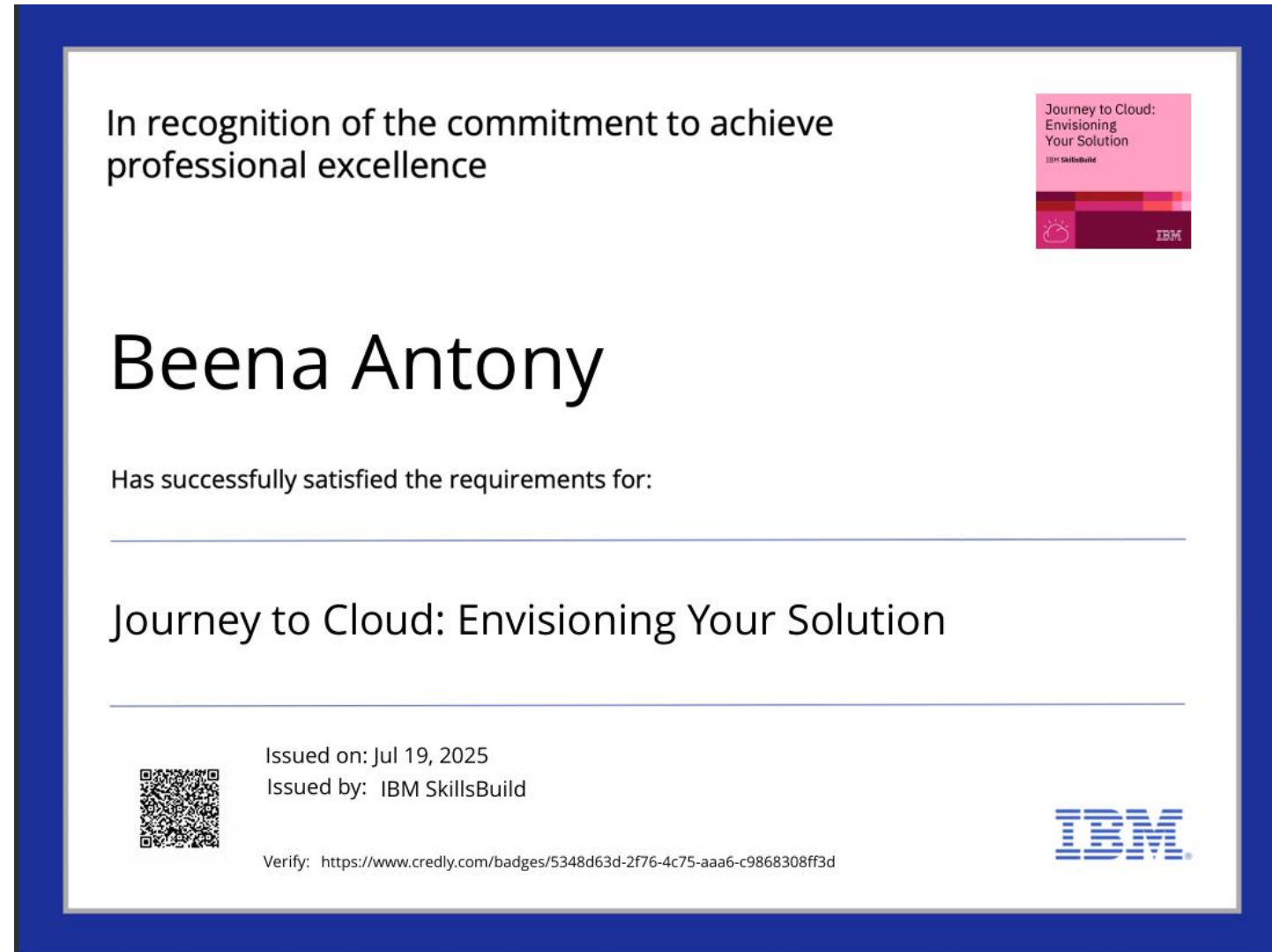
# IBM CERTIFICATIONS

- Credly certificate( getting started with AI)



# IBM CERTIFICATIONS

- Credly certificate( Journey to Cloud)





# IBM CERTIFICATIONS

- Credly certificate( RAG Lab)





**THANK YOU**