

Spectrum Intelligence via Multi-Agent Hybrid Retrieval-Augmented Generation

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SPECTRUM

BACKGROUND

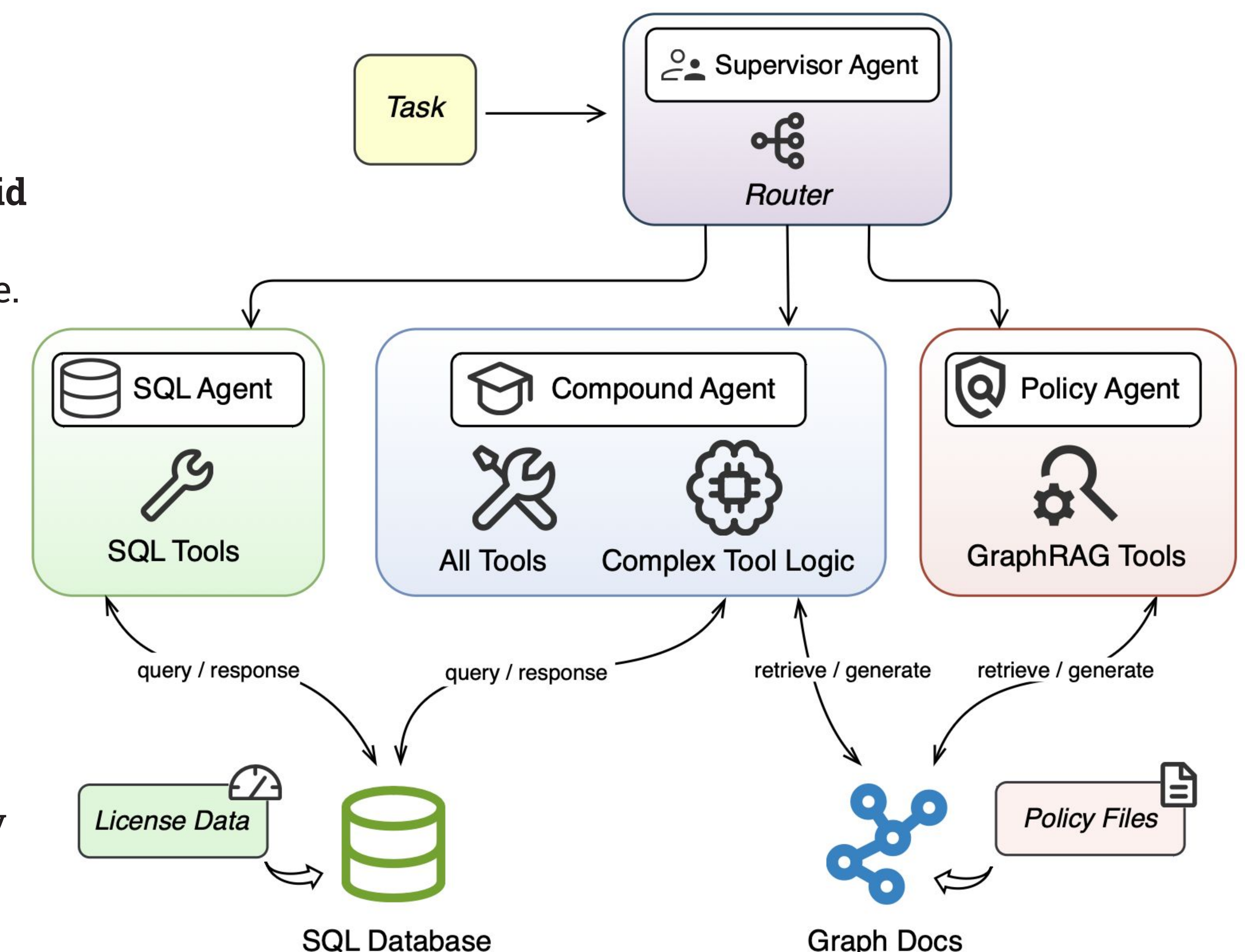
- Spectrum policy making requires reviewing large volumes of information, including stakeholder filings and incumbent licenses, which makes the process slow and resource-intensive.
- We propose a **multi-agent hybrid Retrieval-Augmented Generation (RAG)** system for analyzing spectrum proceeding documents and license data.

RESEARCH QUESTIONS

- Developing an AI agent that can comprehend complex spectrum proceeding documents and license data to support automated question answering.
- **Dataset**
 - *Spectrum Licenses*: 1,346 records across 12.7–13.25 GHz, 92–94 GHz, and 94.2–95 GHz bands, providing information on incumbent users.
 - *Public Proceedings*: 698 documents from FCC/NTIA consultations, reflecting stakeholder and societal perspectives.

METHODOLOGY

- **SQL Agent**
 - Spectrum license data are stored in a **structured SQL database**.
 - The agent **converts human queries into valid SQL queris** via tool calls, retrieves answers, and presents the results in natural language.
- **Policy Agent**
 - Proceeding documents are stored as a **knowledge graph** capturing entities, relationships and communities.
 - The agent selects **different retrieval strategies (basic, local, or global)** based on the question type.
- **Compound Agent**
 - Equipped with all tools from both the Policy and SQL Agents. Capable of answering compound questions involving both proceeding and license data.



RESULTS

- We establish a **benchmark dataset** which contains 140 questions with gold answers.
- We compared our system with two baseline RAG approaches, a **naive RAG** and a **web-search enhanced RAG**, using an LLM as the judge.
- Sing. = Single, Mult. = Multiple, Par. = Parallel, Seq. = Sequential, Avg. = Average.

RAG Method	Win Rate (%)									
	Proceeding			License			Compound			Overall
	Sing.	Mult.	Avg.	Sing.	Mult.	Avg.	Par.	Seq.	Avg.	
<i>Web-search RAG</i>										
LLM Judge	6.3	7.1	6.7	0.0	0.0	0.0	12.5	9.1	10.5	4.6
Human Judge	3.1	0.0	1.7	0.0	0.0	0.0	0.0	9.1	5.3	1.5
<i>Naive RAG</i>										
LLM Judge	18.8	17.9	18.3	0.0	0.0	0.0	0.0	0.0	0.0	8.5
Human Judge	31.3	7.1	20.0	4.8	0.0	2.0	0.0	0.0	0.0	10.0
<i>Agentic RAG (Ours)</i>										
LLM Judge	75	67.9	71.6	95.2	100	98.0	75.0	90.9	84.2	83.8
Human Judge	62.5	89.3	75.0	95.2	100	98.0	100	81.9	89.5	86.2

TRY ME NOW!

Ask me anything about **Satellite Spectrum Abundance!**



ACKNOWLEDGEMENTS

- This work has been supported in part through SpectrumX, the National Science Foundation (NSF) Spectrum Innovation Center, funded via Award AST 21-32700 and operated under Cooperative Agreement with NSF by the University of Notre Dame.
- Special thanks to Connor Howington and Le Li Kruczek for their contributions to UI design and software-side optimization, and to Zhiyu Shen and Yuxi Chen for their work on data collection.