



SIGINT Agent

A Proof-of-Concept for AI-Powered SIGINT Operator with Open Source tools

3/3/2025

What is SIGINT?

Signals Intelligence

The interception and analysis of communications and non-communications signals for intelligence gathering

- Radar signals
- Telemetry data
- Electronic emissions
- Satellite transmissions
- Electromagnetic patterns

COMINT

Communications Intelligence - A subset of SIGINT focused specifically on intercepting and analyzing the content of communications between people or electronic systems

- Voice communications
- Text messages and emails
- Radio communications
- Digital transmissions

Applications

- National security and defense
- Law enforcement operations
- Emergency response coordination
- Research and monitoring

Key Challenges

Signal detection and isolation

Real-time transcription accuracy

Intelligent analysis of communications

Project Goals



Technical Implementation

- Build an AI assistant using commodity hardware and open-source tools
- Implement automated transcription of radio communications
- Develop real-time analysis capabilities with modern AI frameworks
- Create a user-friendly interface for interacting with intercepted data



Vision & Impact

- Democratize access to advanced SIGINT capabilities
- Empower radio enthusiasts with AI-enhanced monitoring tools
- Bridge the gap between technical complexity and practical usability
- Demonstrate that sophisticated intelligence tools are no longer exclusive to specialized agencies

Hardware Setup



Raspberry Pi

- Raspberry Pi 4 Model B
- 8GB RAM
- 64GB SD Card
- Raspbian OS



RTL-SDR

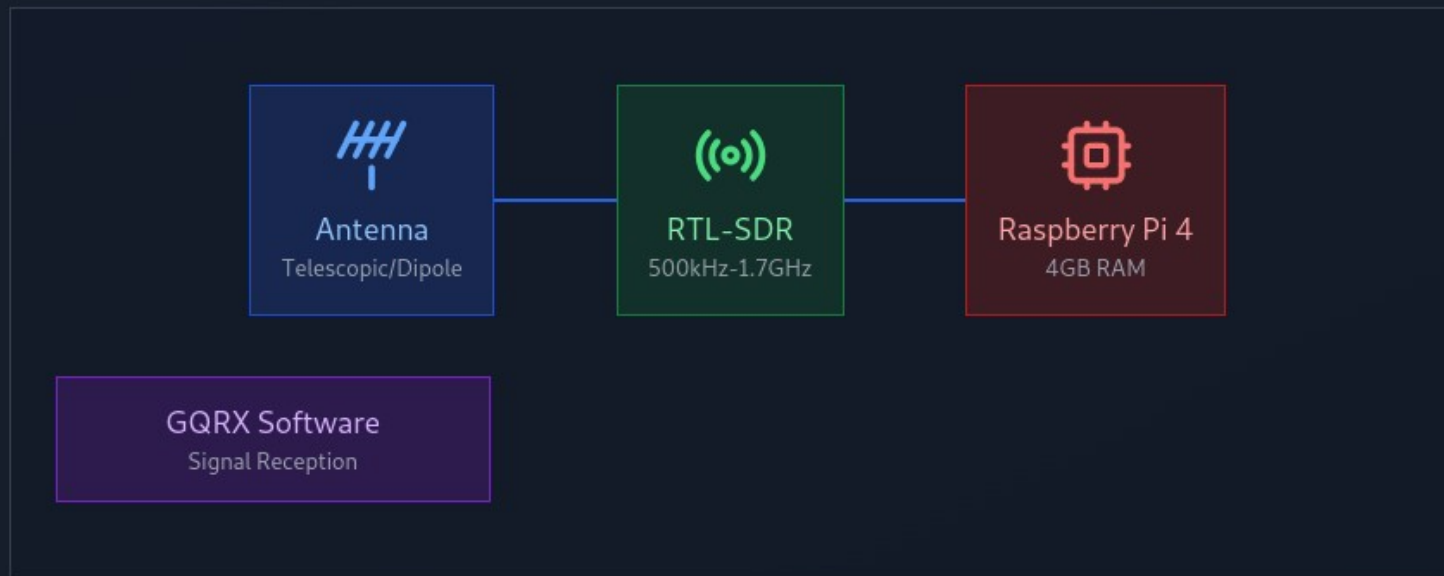
- RTL-SDR V3 Dongle
- Frequency range: 500 kHz - 1.7 GHz
- USB 2.0 connection
- SMA antenna connector



GQRX Software

- Open-source SDR receiver
- Configurable for RTL-SDR
- UDP streaming capability
- Frequency control via remote commands

Hardware Architecture



Antenna & Signal Optimization



Antenna Types

Telescopic

General purpose, adjustable length

Dipole

Better for specific frequencies

Discone

Wideband reception

Yagi

Directional, high gain



Practical Tricks

- Squelch: -55dB; filter out noise
- AGC: Fast; improved listening experience; maintains consistent volume levels
- Mode: Narrow FM and adjust depending on signal
- LNA optimization for improved sensitivity



Signal-to-Noise Optimization

- Proper antenna placement away from interference sources
- RF gain adjustment to prevent overloading
- Digital noise reduction filters in GQRX
- Frequency fine-tuning for optimal reception

Frequency Scanning

Scanning Techniques

- Automated band scanning to identify active frequencies
- Signal strength threshold detection
- Dwell time of 5 seconds on active frequencies
- Bookmarking of frequencies with consistent activity
- Periodic revisiting of active channels

Frequency Bands of Interest

VHF Low
30-50 MHz
Public services, business

VHF High
136-174 MHz
Marine, weather, business

UHF
400-512 MHz
Public safety, business

FRS/GMRS
462-467 MHz
Personal communications

Transmission Classification

Voice Communications

Identified by modulation patterns and frequency characteristics typical of human speech

Digital Signals

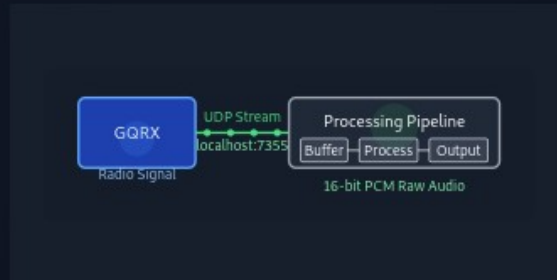
Distinguished by consistent patterns, regular intervals, and distinctive digital modulation

Noise/Interference

Filtered out by analyzing signal patterns and comparing to known interference signatures

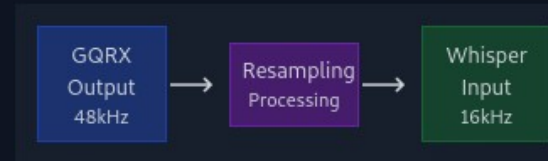
Audio Stream Processing

UDP Streaming Architecture



- GQRX configured to stream audio via UDP to localhost:7355
- Raw audio captured as 16-bit PCM data
- Stream buffered in memory for processing
- Continuous monitoring with minimal latency

Audio Sampling Process



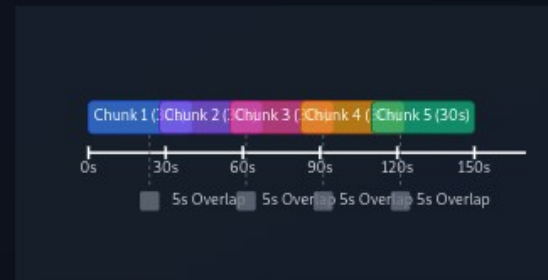
- Downsampling from 48kHz to 16kHz for Whisper compatibility
- Mono channel conversion for efficient processing
- Bit depth maintained at 16-bit for quality

Silence Detection



- RMS (Root Mean Square) amplitude calculation on 16-bit PCM audio
- Configurable threshold (default: 150.0) for silence detection
- Numpy-based implementation for efficient processing
- Prevents transcription of empty or noise-only audio segments

Audio Chunking Approach



- 30-second chunks for optimal transcription performance
- 5-second overlap between chunks to prevent missed content
- Chunks stored temporarily for processing
- Processed audio archived with metadata (frequency, timestamp)

Transcription System



Groq's Whisper Integration

- Whisper large-v3 model for high-accuracy transcription
- API integration with Groq for fast inference
- Optimized for radio communications vocabulary
- Supports multiple languages and accents
- Low-latency processing for near real-time results



Transcription Challenges

- Radio static and interference
- Specialized terminology and codes
- Varying audio quality and signal strength
- Multiple speakers with overlapping transmissions
- Abbreviated communications and jargon



Transcription Accuracy Analysis

Clear Signal



Moderate Noise

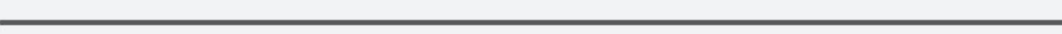




Heavy Interference



Sample Audio & Transcription

Original audio sample:

▶ 0:00 / 0:16   

Transcription Results:

"Ya la está cortizando Santa, ¿qué pasa aquí en el centro? Santa, que está bien trinquado todo el centro Comenta Santa"

"¿Qué pasa? No, no he ido para allá."



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Agent Implementation



LLM Selection

Groq's llama-3.3-70b-versatile

- Fine-tuned for effective function calling
- Optimized for real-time intelligence analysis
- Excellent context understanding for radio communications
- Low-latency inference via Groq API
- 70 billion parameters for high-quality responses



Function Calling Implementation

```
{
  "name": "set_frequency",
  "description": "Set radio to a specific frequency",
  "parameters": {
    "type": "object",
    "properties": {
      "frequency": {
        "type": "number",
        "description": "Frequency in MHz"
      }
    },
    "required": ["frequency"]
  }
}
```

Function calling enables the agent to perform actions like tuning the radio, retrieving transcripts, and generating summaries through a natural language interface.



Tool Definitions

Set Frequency

Tunes the radio to a specific frequency (e.g., "Tune to 420.120 MHz")

Get Current Frequency

Returns the currently monitored frequency

Get Recent Intercepts

Retrieves the last 10 minutes of intercepted communications

Get Frequency Summary

Generates an LLM-powered summary of all intercepted communications on a specific frequency

Agent Implementation (cont.)

Prompt Engineering

You are a secret SIGINT operator helping in ir
Your tone and style is that of a secret agent,
You have control over a GQRX host to set the f

If the user inputs float values for the frequ
assume they are in MHz and convert to Hz for 1

Use the get_current_frequency function to get
Use the set_frequency function to set a new f
Use the get_last_10_minutes function to get tl
If results are empty suggest the user to wait
If results are available do not provide the u
Use the get_frequency_summary function to get
If results are empty suggest the user to wait
attempt to use the last 10 minutes function.

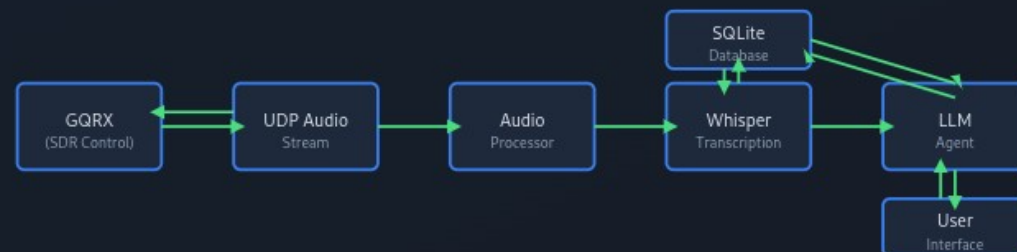
Do not use any function unless the user explic
Do not refer as the captured communications as
Do not list actions to the user.
Always use JSON to format function calling.

- Clear role definition for the agent
- Specific instructions for intelligence analysis
- Guidance on response format and style
- Tool usage description

Intelligence Analysis

- Entity extraction (people, locations, organizations)
- Pattern recognition across multiple transmissions
- Anomaly detection in communication patterns
- Frequency usage analysis
- Temporal analysis of communications
- Content summarization and key points extraction

System Architecture



The architecture follows an event-driven design where audio capture triggers transcription, which is stored in the database and made available to the LLM agent for analysis and user interaction.

Demo

```
○ (.env) devtbit@tp1:~/Dev/rtl/sigint-agent-poc$
```

▶ 0:00 / 0:45



Demo

```
Y88b d88P 888 Y88b d88P 888 888 Y8888 888
"Y8888P" 8888888 "Y8888P" 8888888 888 Y888 888
```

```
      d8888 .d8888b. 88888888888 888b 888 888888888888
      d88888 d88P Y88b 888 8888b 888 888
      d88P888 888 888 888 88888b 888 888
      d88P 888 888 8888888 888Y88b 888 888
      d88P 888 888 88888 888 888 Y88b888 888
      d88P 888 888 888 888 888 Y88888 888
      d8888888888 Y88b d88P 888 888 Y8888 888
      d88P 888 "Y8888P" 88888888888 888 Y888 888
```

=====

v0.1.0

Type '.exit' or '.quit' to end the session

=====

You: hi sir

Operator: Good day to you, my fellow operative. I'm ready to assist you with our surveillance operations. What's the first move?

You: we are targeting the enemy on frequency 457.614

Operator: Frequency set to 457.614 MHz. We're now tuned in and ready to capture any intercepts. What's the next step in our operation?

You: have we caught anything?

Operator: It seems we haven't captured any intercepts yet. Perhaps we should give it a couple of minutes to allow for some communications to take place. Let's wait and then try again. The silence is deafening, but patience is a virtue in our line of work.

▶ 0:00 / 0:18



Demo

```
d88P 888 888      8888888  888Y88b 888      888
d88P 888 888 88888 888      888 Y88b888 888
d88P 888 888 888 888      888 Y88888 888
d88888888888 Y88b d88P 888      888 Y8888 888
d88P 888 "Y8888P" 88888888888 888 Y888 888
=====
v0.1.0

Type '.exit' or '.quit' to end the session
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You: any updates?

Operator: We've got something. It appears to be a coded message, but our intercepts suggest it's related to a shipment or a meeting. The mention of "Luis Ángel" and "firma 46" could be key to unraveling the enemy's plans. I'll keep monitoring the frequency for more information. This could be the break we've been waiting for.
```

▶ 0.00 / 0.49



Final Thoughts



Accessible Technology

- Low-cost SDR hardware makes signal capture widely available
- Open source LLMs enable sophisticated analysis capabilities
- Function calling APIs allow for agents to leverage hardware



Empowering Innovation

The SIGINT Agent demonstrates how combining accessible hardware with open source LLMs democratizes technology that was once limited to specialized agencies, enabling researchers, hobbyists, and organizations to build sophisticated signal intelligence systems.

As open source LLMs continue to advance, we're entering an era where anyone with basic technical skills can develop powerful SIGINT applications for emergency response, scientific research, and community safety initiatives.



Thank You

Thank you for your attention! Questions and discussion are welcome.

Repository



github.com/devtbit/sigint-agent-poc