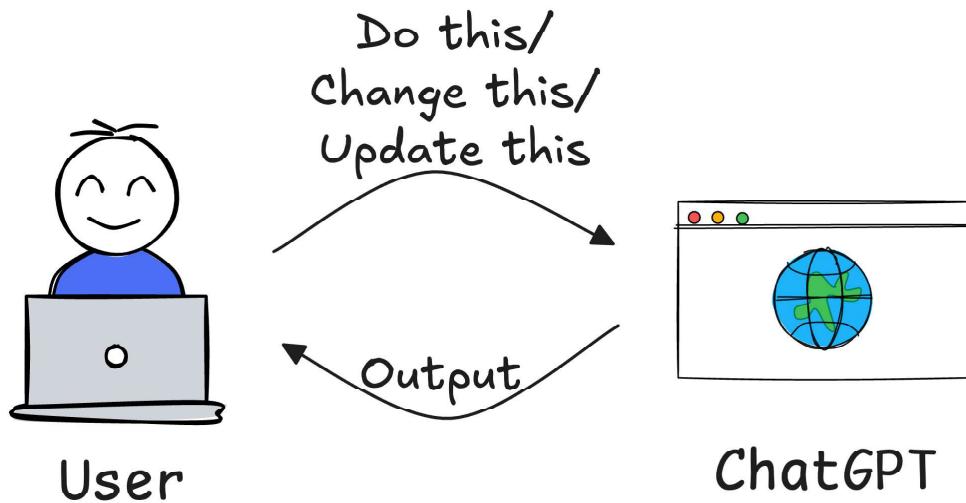


AI Agents

What is an AI Agent?

Imagine you want to generate a report on the latest trends in AI research. If you use a standard LLM, you might:

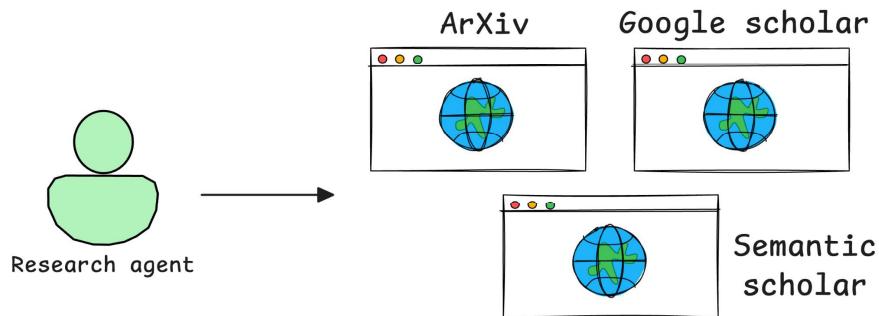


1. Ask for a summary of recent AI research papers.
2. Review the response and realize you need sources.
3. Obtain a list of papers along with citations.
4. Find that some sources are outdated, so you refine your query.
5. Finally, after multiple iterations, you get a useful output.

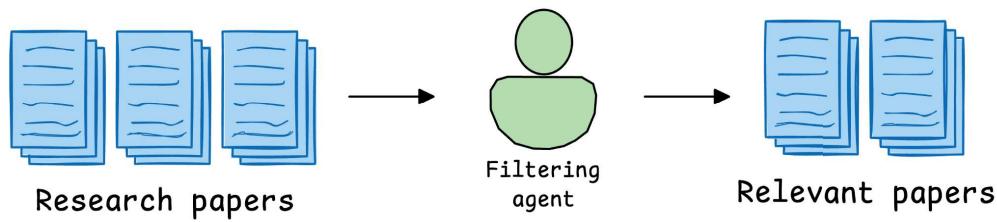
This iterative process takes time and effort, requiring you to act as the decision-maker at every step.

Now, let's see how AI agents handle this differently:

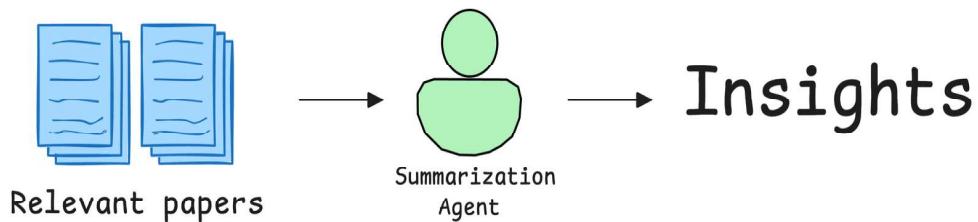
A Research Agent autonomously searches and retrieves relevant AI research papers from arXiv, Semantic Scholar, or Google Scholar.



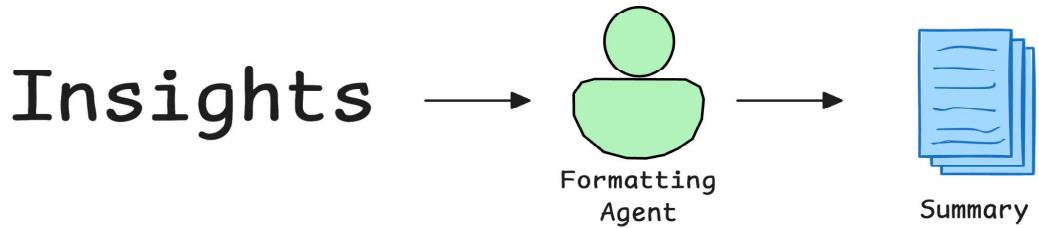
- A Filtering Agent scans the retrieved papers, identifying the most relevant ones based on citation count, publication date, and keywords.



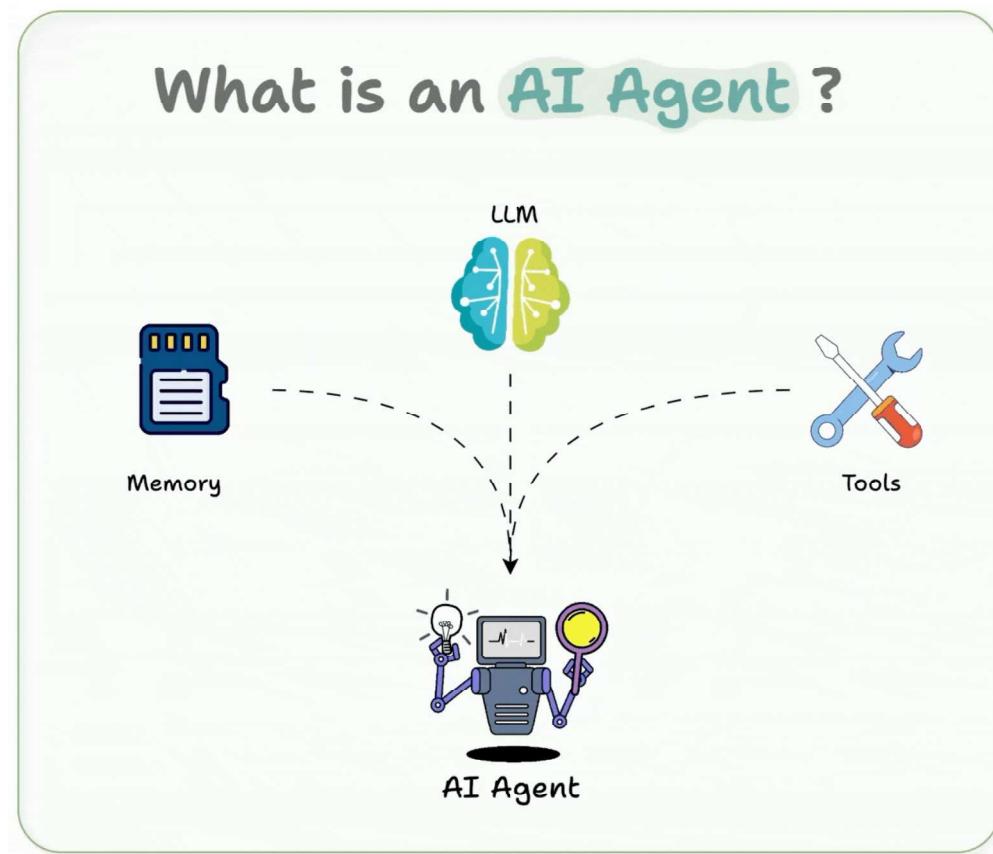
- A Summarization Agent extracts key insights and condenses them into an easy-to-read report.



- A Formatting Agent structures the final report, ensuring it follows a clear, professional layout.



Here, the AI agents not only execute the research process end-to-end but also self-refine their outputs, ensuring the final report is comprehensive, up-to-date, and well-structured - all without requiring human intervention at every step.



To formalize AI Agents are autonomous systems that can reason, think, plan, figure out the relevant sources and extract information from them when needed, take actions, and even correct themselves if something goes wrong.

Agent vs LLM vs RAG



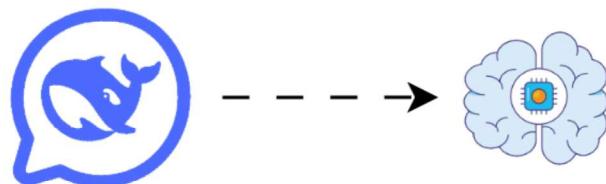
Let's break it down with a simple analogy:

- LLM is the brain.
- RAG is feeding that brain with fresh information.
- An agent is the decision-maker that plans and acts using the brain and the tools.

LLM (Large Language Model)

An LLM like GPT-4 is trained on massive text data.

It can reason, generate, summarize but only using what it already knows (i.e., its training data).



LLM is smart but static

It's smart, but static. It can't access the web, call APIs, or fetch new facts on its own.

RAG (Retrieval-Augmented Generation)

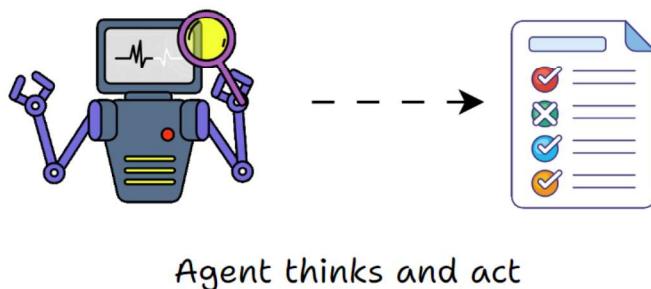
RAG enhances an LLM by retrieving external documents (from a vector DB, search engine, etc.) and feeding them into the LLM as context before generating a response.



RAG makes the LLM aware of updated, relevant info without retraining.

Agent

An Agent adds autonomy to the mix.



It doesn't just answer a question—it decides what steps to take:

Should it call a tool? Search the web? Summarize? Store info?

An Agent uses an LLM, calls tools, makes decisions, and orchestrates workflows just like a real assistant.

Building blocks of AI Agents

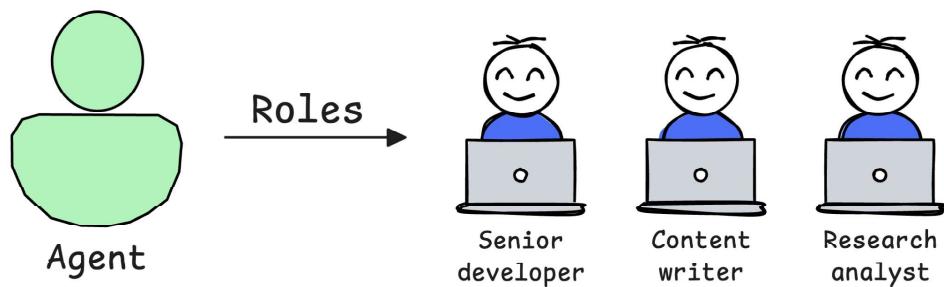
AI agents are designed to reason, plan, and take action autonomously. However, to be effective, they must be built with certain key principles in mind. There are six essential building blocks that make AI agents more reliable, intelligent, and useful in real-world applications:

1. Role-playing
2. Focus
3. Tools
4. Cooperation
5. Guardrails
6. Memory

Let's explore each of these concepts and understand why they are fundamental to building great AI agents.

1) Role-playing

One of the simplest ways to boost an agent's performance is by giving it a clear, specific role.



A generic AI assistant may give vague answers. But define it as a "Senior contract lawyer," and it responds with legal precision and context.

Why?

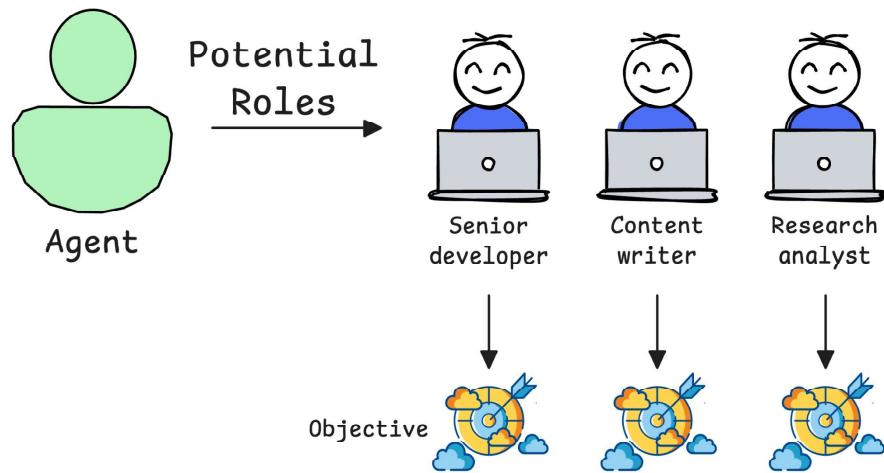
Because role assignment shapes the agent's reasoning and retrieval process. The

more specific the role, the sharper and more relevant the output.

2) Focus/Tasks

Focus is key to reducing hallucinations and improving accuracy.

Giving an agent too many tasks or too much data doesn't help - it hurts.



Overloading leads to confusion, inconsistency, and poor results.

For example, a marketing agent should stick to messaging, tone, and audience not pricing or market analysis.

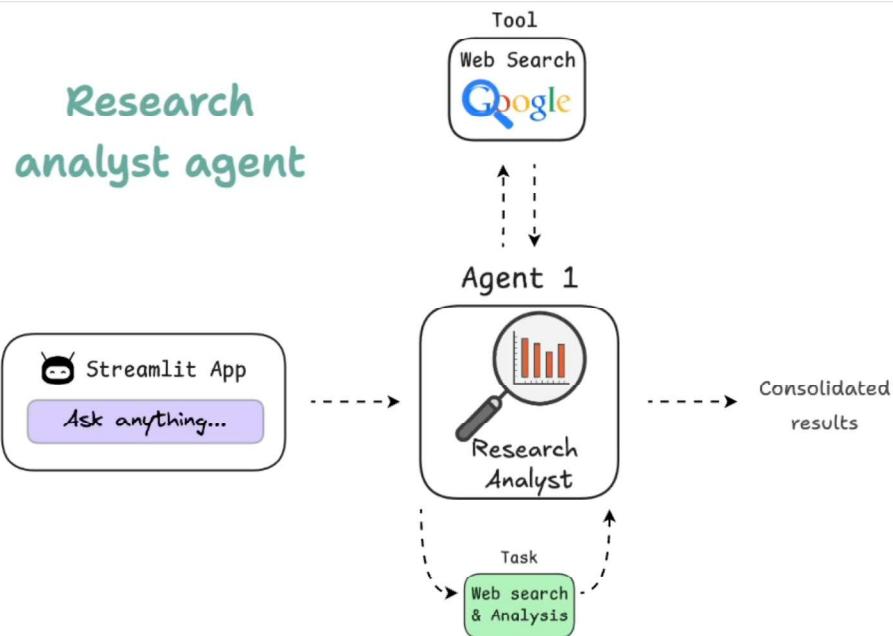
Instead of trying to make one agent do everything, a better approach is to use multiple agents, each with a specific and narrow focus.

Specialized agents perform better - every time.

3) Tools

Agents get smarter when they can use the right tools.

But more tools ≠ better results.



For example, an AI research agent could benefit from:

- A web search tool for retrieving recent publications.
- A summarization model for condensing long research papers.
- A citation manager to properly format references.

But if you add unnecessary tools—like a speech-to-text module or a code execution environment—it could confuse the agent and reduce efficiency.

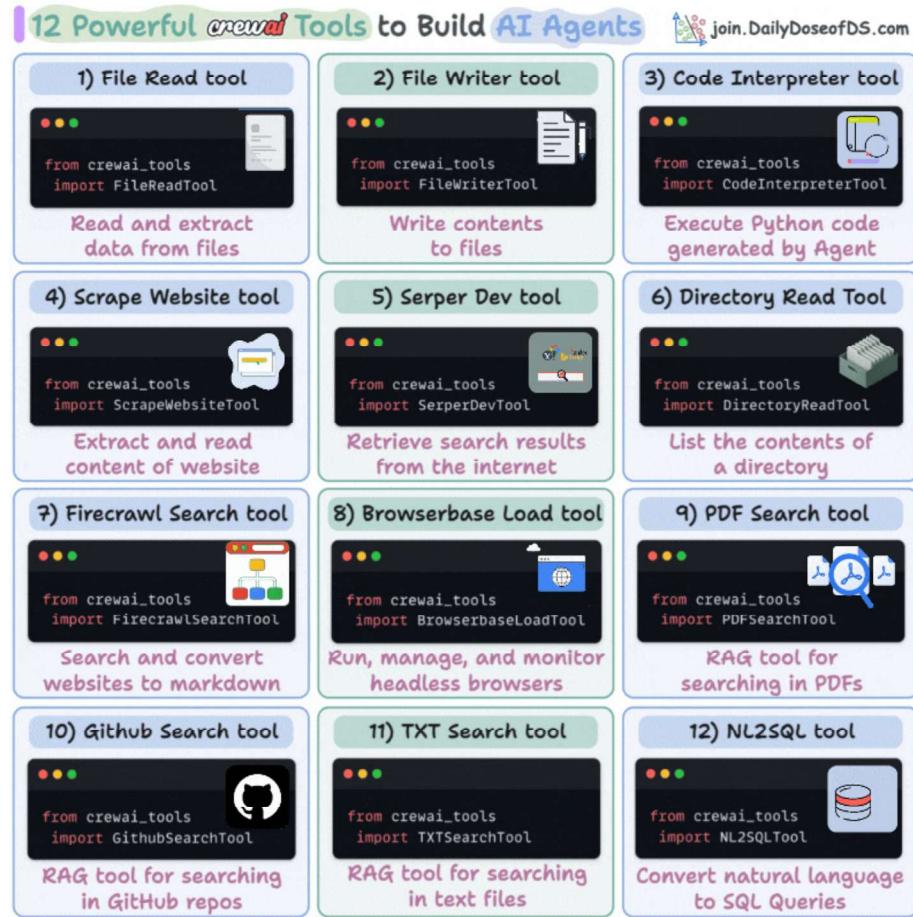
#3.1) Custom tools

While LLM-powered agents are great at reasoning and generating responses, they lack direct access to real-time information, external systems, and specialized computations.

Tools allow the Agent to:

- Search the web for real-time data.
- Retrieve structured information from APIs and databases.
- Execute code to perform calculations or data transformations.
- Analyze images, PDFs, and documents beyond just text inputs.

CrewAI supports several tools that you can integrate with Agents, as depicted below:

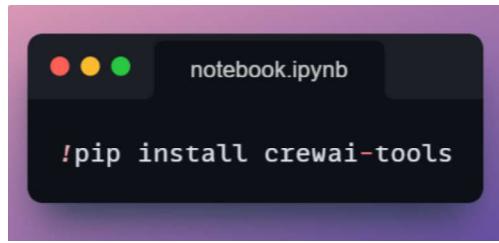


However, you may need to build custom tools at times.

In this example, we're building a real-time currency conversion tool inside CrewAI. Instead of making an LLM guess exchange rates, we integrate a custom tool that fetches live exchange rates from an external API and provides some insights.

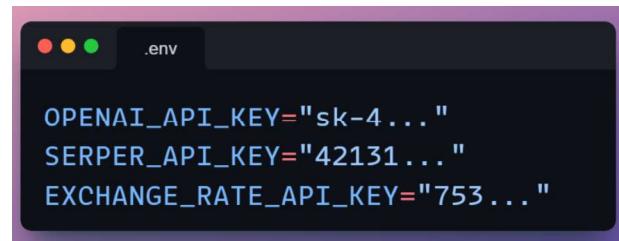
Below, let's look at how you can build one for your custom needs in the CrewAI framework.

Firstly, make sure the tools package is installed:



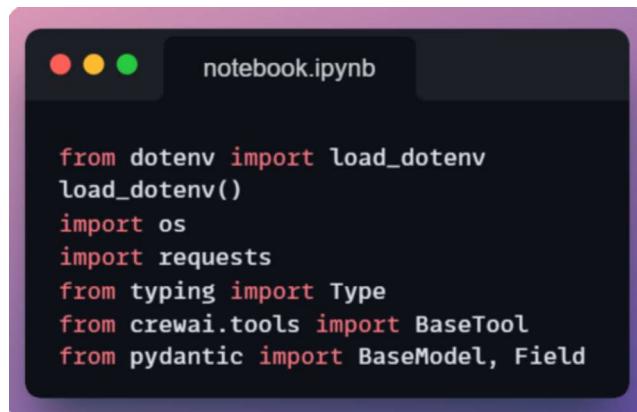
```
!pip install crewai-tools
```

You would also need an API key from here: <https://www.exchangerate-api.com/> (it's free). Specify it in the .env file as shown below:



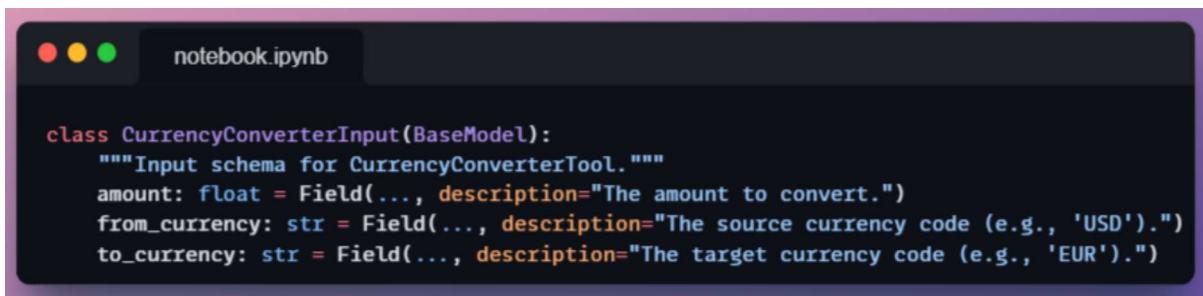
```
OPENAI_API_KEY="sk-4..."  
SERPER_API_KEY="42131..."  
EXCHANGE_RATE_API_KEY="753..."
```

Once that's done, we start with some standard import statements:



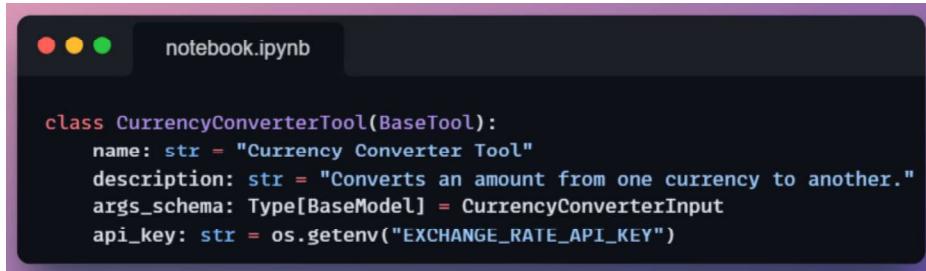
```
from dotenv import load_dotenv  
load_dotenv()  
import os  
import requests  
from typing import Type  
from crewai.tools import BaseTool  
from pydantic import BaseModel, Field
```

Next, we define the input fields the tool expects using Pydantic.



```
class CurrencyConverterInput(BaseModel):  
    """Input schema for CurrencyConverterTool."""  
    amount: float = Field(..., description="The amount to convert.")  
    from_currency: str = Field(..., description="The source currency code (e.g., 'USD').")  
    to_currency: str = Field(..., description="The target currency code (e.g., 'EUR').")
```

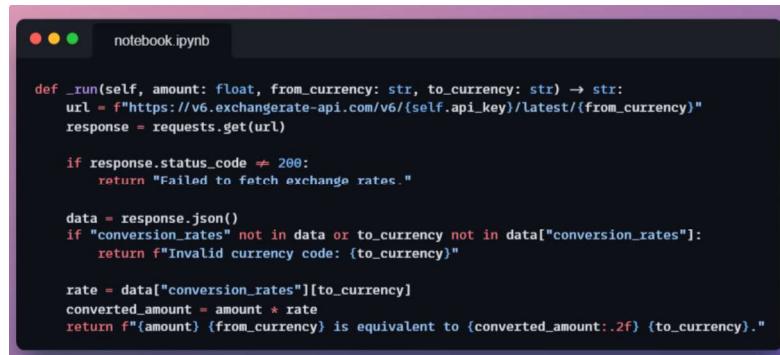
Now, we define the CurrencyConverterTool by inheriting from *BaseTool*:



```
class CurrencyConverterTool(BaseTool):
    name: str = "Currency Converter Tool"
    description: str = "Converts an amount from one currency to another."
    args_schema: Type[BaseModel] = CurrencyConverterInput
    api_key: str = os.getenv("EXCHANGE_RATE_API_KEY")
```

Every tool class should have the `_run` method which we will execute whenever the Agents wants to make use of it.

For our use case, we implement it as follows:



```
def _run(self, amount: float, from_currency: str, to_currency: str) -> str:
    url = f"https://v6.exchangerate-api.com/v6/{self.api_key}/latest/{from_currency}"
    response = requests.get(url)

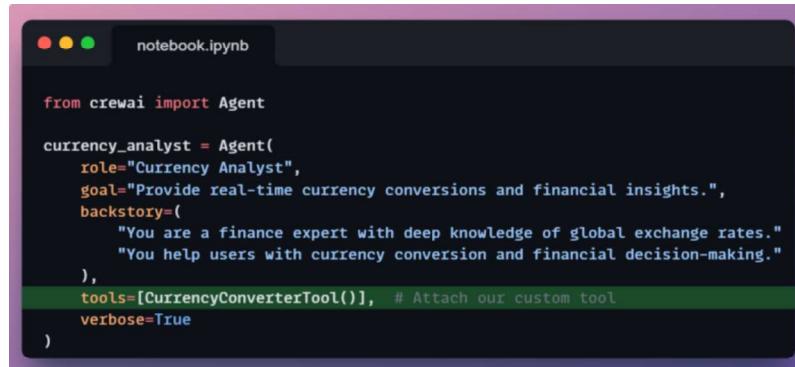
    if response.status_code != 200:
        return "Failed to fetch exchange rates."

    data = response.json()
    if "conversion_rates" not in data or to_currency not in data["conversion_rates"]:
        return f"Invalid currency code: {to_currency}"

    rate = data["conversion_rates"][to_currency]
    converted_amount = amount * rate
    return f"{amount} {from_currency} is equivalent to {converted_amount:.2f} {to_currency}."
```

In the above code, we fetch live exchange rates using an API request. We also handle errors if the request fails or the currency code is invalid.

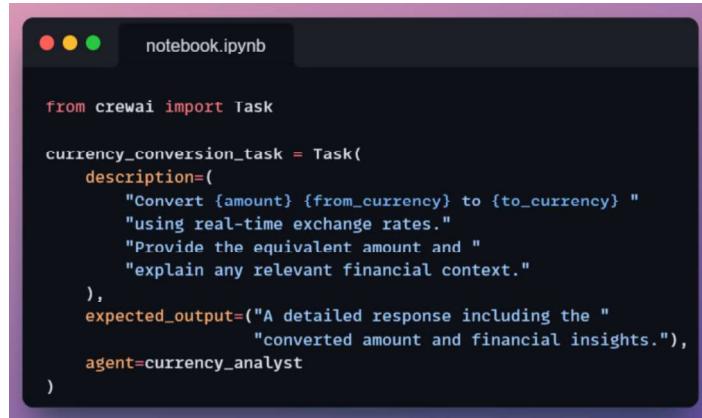
Now, we define an agent that uses the tool for real-time currency analysis and attach our CurrencyConverterTool, allowing the agent to call it directly if needed:



```
from crewai import Agent

currency_analyst = Agent(
    role="Currency Analyst",
    goal="Provide real-time currency conversions and financial insights.",
    backstory=(
        "You are a finance expert with deep knowledge of global exchange rates."
        "You help users with currency conversion and financial decision-making."
    ),
    tools=[CurrencyConverterTool()], # Attach our custom tool
    verbose=True
)
```

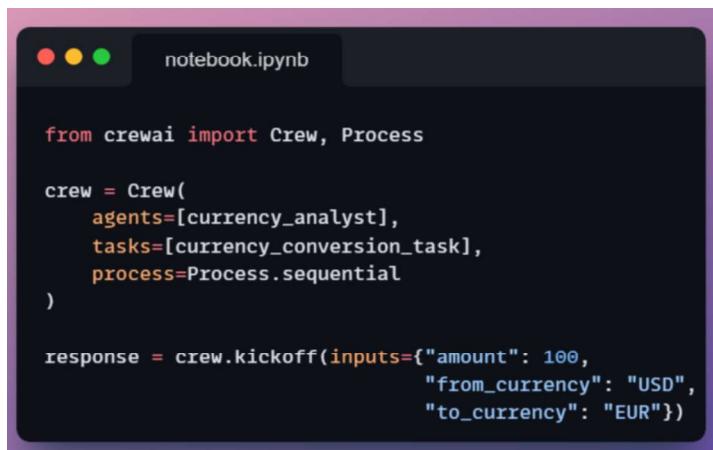
We assign a task to the currency_analyst agent.



```
from crewai import Task

currency_conversion_task = Task(
    description=(
        "Convert {amount} {from_currency} to {to_currency} "
        "using real-time exchange rates."
        "Provide the equivalent amount and "
        "explain any relevant financial context."
    ),
    expected_output=("A detailed response including the "
                    "converted amount and financial insights."),
    agent=currency_analyst
)
```

Finally, we create a Crew, assign the agent to the task, and execute it.

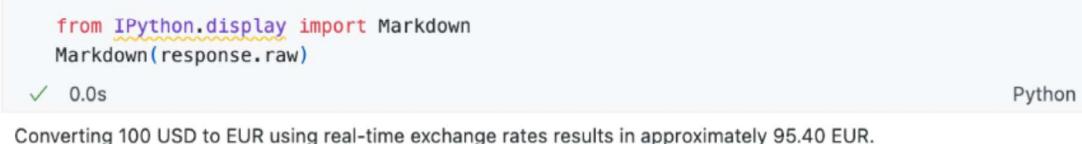


```
from crewai import Crew, Process

crew = Crew(
    agents=[currency_analyst],
    tasks=[currency_conversion_task],
    process=Process.sequential
)

response = crew.kickoff(inputs={"amount": 100,
                                "from_currency": "USD",
                                "to_currency": "EUR"})
```

Printing the response, we get the following output:



```
from IPython.display import Markdown
Markdown(response.raw)
```

✓ 0.0s Python

Converting 100 USD to EUR using real-time exchange rates results in approximately 95.40 EUR.

In the financial context, it's worth noting that exchange rates can fluctuate due to various factors like economic indicators, interest rates, and geopolitical events. As of now, the conversion reflects current market conditions, which are influenced by the latest economic data releases and monetary policies in both the United States and the Eurozone. Given the recent trends, if you're planning a trip to Europe or making an investment, these rates may change, so it's beneficial to monitor them regularly.

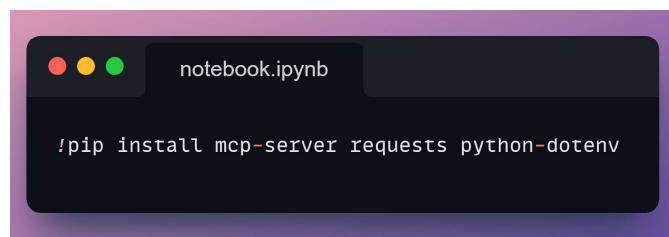
Works as expected!

#3.2) Custom tools via MCP

Now, let's take it a step further.

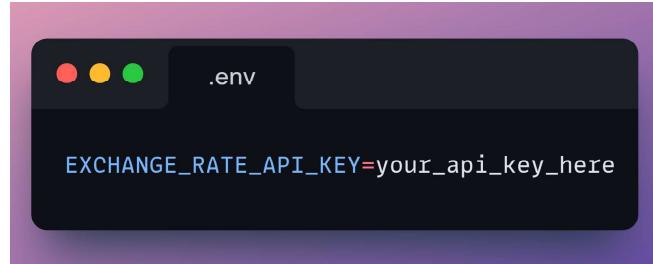
Instead of embedding the tool directly in every Crew, we'll expose it as a reusable MCP tool—making it accessible across multiple agents and flows via a simple server.

First, install the required packages:



```
/pip install mcp-server requests python-dotenv
```

We'll continue using ExchangeRate-API in our .env file:



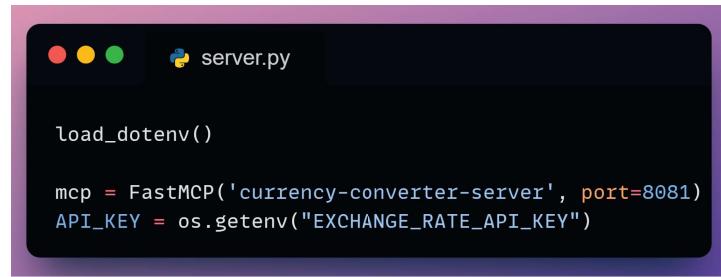
```
EXCHANGE_RATE_API_KEY=your_api_key_here
```

We'll now write a lightweight server.py script that exposes the currency converter tool. We start with the standard imports:



```
import requests, os
from dotenv import load_dotenv
from mcp.server.fastmcp import FastMCP
```

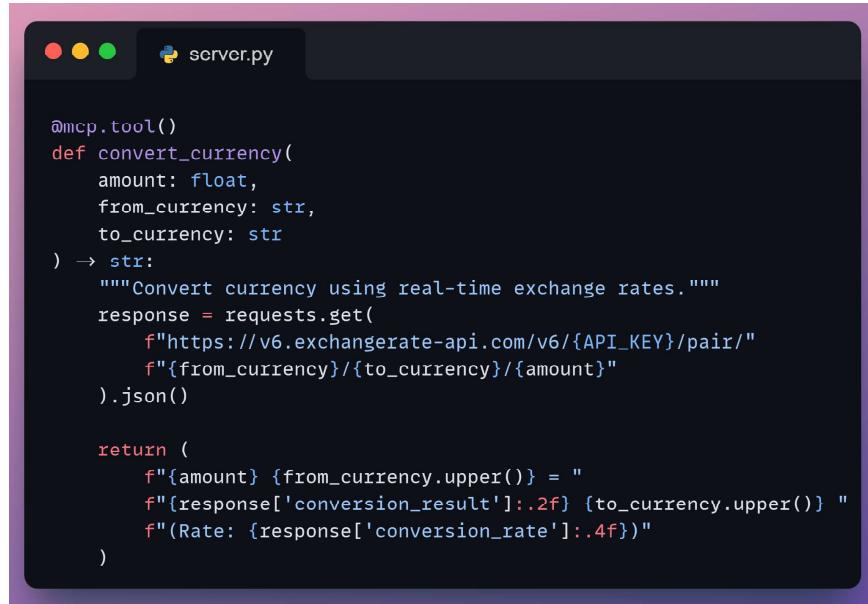
Now, we load environment variables and initialize the server:



```
load_dotenv()

mcp = FastMCP('currency-converter-server', port=8081)
API_KEY = os.getenv("EXCHANGE_RATE_API_KEY")
```

Next, we define the tool logic with `@mcp.tool()`:



```
@mcp.tool()
def convert_currency(
    amount: float,
    from_currency: str,
    to_currency: str
) -> str:
    """Convert currency using real-time exchange rates."""
    response = requests.get(
        f"https://v6.exchangerate-api.com/v6/{API_KEY}/pair/"
        f"{from_currency}/{to_currency}/{amount}"
    ).json()

    return (
        f"{amount} {from_currency.upper()} = "
        f"{response['conversion_result']:.2f} {to_currency.upper()} "
        f"(Rate: {response['conversion_rate']:.4f})"
    )
```

This function takes three inputs—amount, source currency, and target currency—and returns the converted result using the real-time exchange rate API.

To make the tool accessible, we need to run the MCP server. Add this at the end of your script:

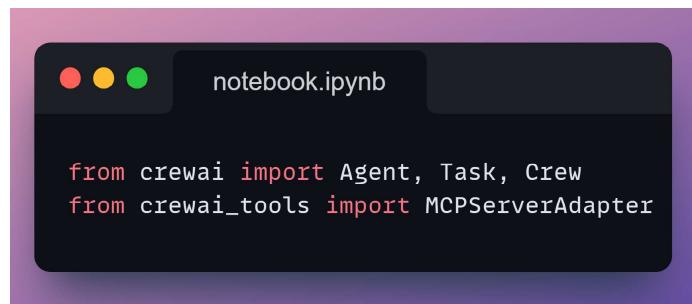


```
if __name__ == "__main__":
    mcp.run(transport="sse")
```

This starts the server and exposes your convert_currency tool at:
`http://localhost:8081/sse`.

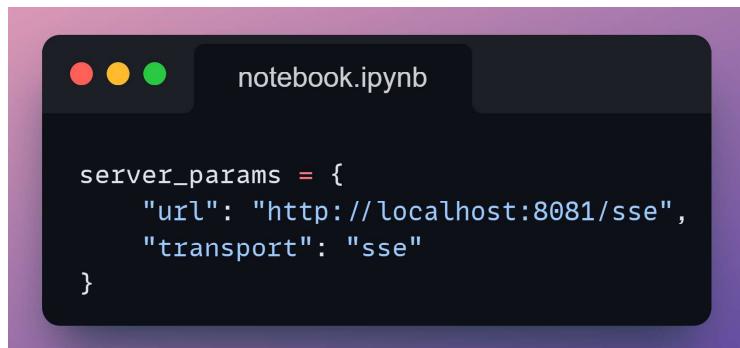
Now any CrewAI agent can connect to it using MCPServerAdapter. Let's now consume this tool from within a CrewAI agent.

First, we import the required CrewAI classes. We'll use Agent, Task, and Crew from CrewAI, and MCPServerAdapter to connect to our tool server.



```
from crewai import Agent, Task, Crew
from crewai_tools import MCPServerAdapter
```

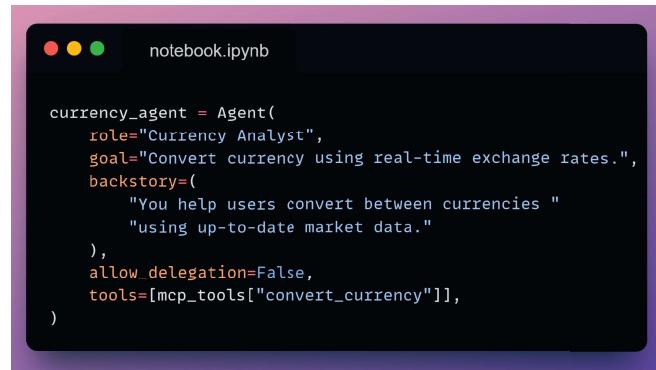
Next, we connect to the MCP tool server. Define the server parameters to connect to your running tool (from server.py).



```
server_params = {
    "url": "http://localhost:8081/sse",
    "transport": "sse"
}
```

Now, we use the discovered MCP tool in an agent:

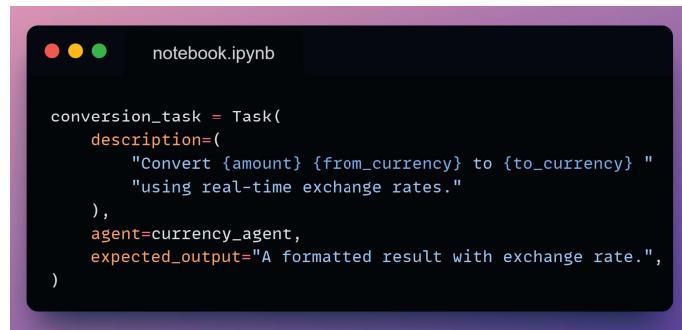
This agent is assigned the convert_currency tool from the remote server. It can now call the tool just like a locally defined one.



```
notebook.ipynb

currency_agent = Agent(
    role="Currency Analyst",
    goal="Convert currency using real-time exchange rates.",
    backstory=(
        "You help users convert between currencies "
        "using up-to-date market data."
    ),
    allow_delegation=False,
    tools=[mcp_tools["convert_currency"]],
)
```

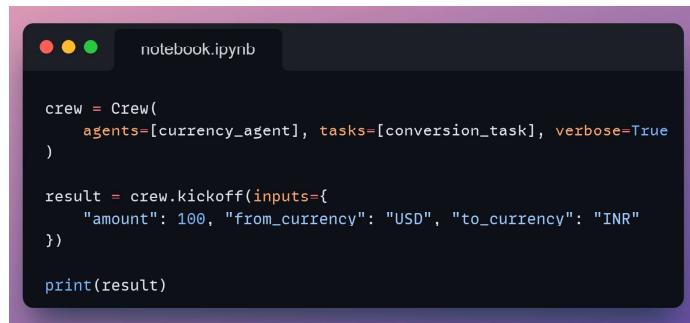
We give the agent a task description:



```
notebook.ipynb

conversion_task = Task(
    description=(
        "Convert {amount} {from_currency} to {to_currency} "
        "using real-time exchange rates."
    ),
    agent=currency_agent,
    expected_output="A formatted result with exchange rate.",
)
```

Finally, we create the Crew, pass in the inputs and run it:



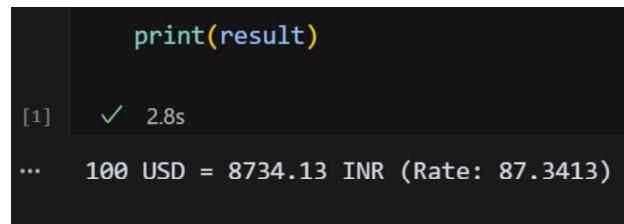
```
notebook.ipynb

crew = Crew(
    agents=[currency_agent], tasks=[conversion_task], verbose=True
)

result = crew.kickoff(inputs={
    "amount": 100, "from_currency": "USD", "to_currency": "INR"
})

print(result)
```

Printing the result, we get the following output:



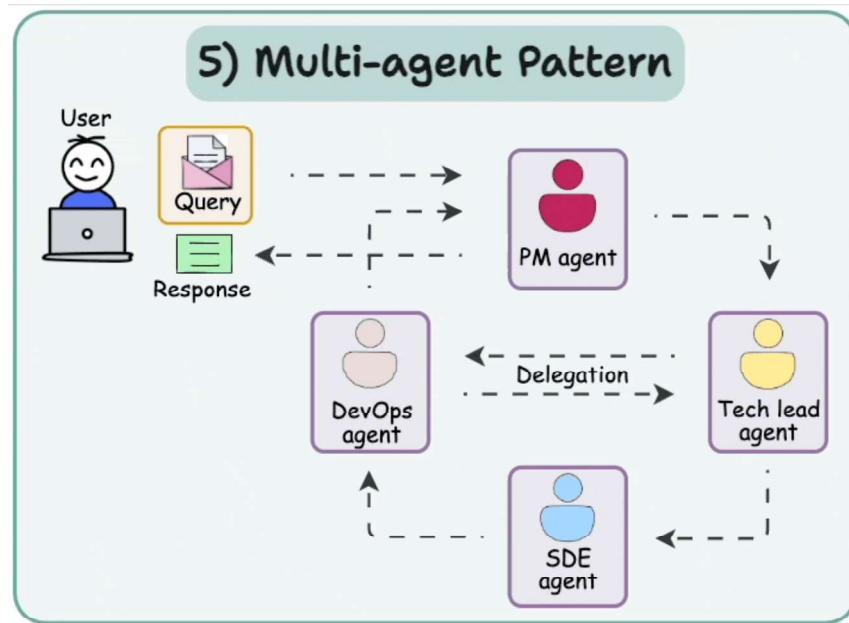
```
print(result)

[1] ✓ 2.8s
...
... 100 USD = 8734.13 INR (Rate: 87.3413)
```

4) Cooperation

Multi-agent systems work best when agents collaborate and exchange feedback.

Instead of one agent doing everything, a team of specialized agents can split tasks and improve each other's outputs.



Consider an AI-powered financial analysis system:

- One agent gathers data
- another assesses risk,
- a third builds strategy,
- and a fourth writes the report

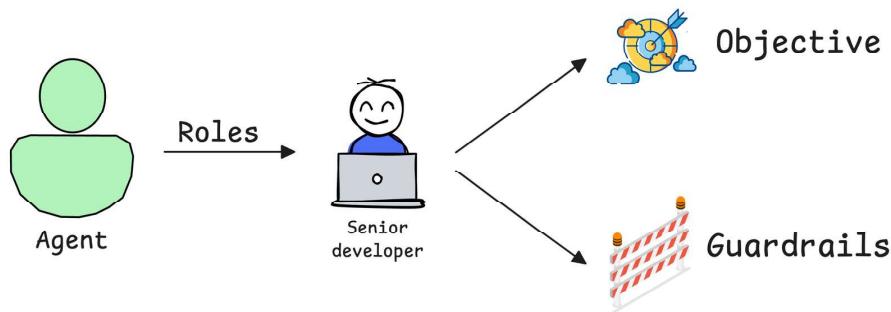
Collaboration leads to smarter, more accurate results.

The best practice is to enable agent collaboration by designing workflows where agents can exchange insights and refine their responses together.

5) Guardrails

Agents are powerful but without constraints, they can go off track. They might hallucinate, loop endlessly, or make bad calls.

Guardrails ensure that agents stay on track and maintain quality standards.



Examples of useful guardrails include:

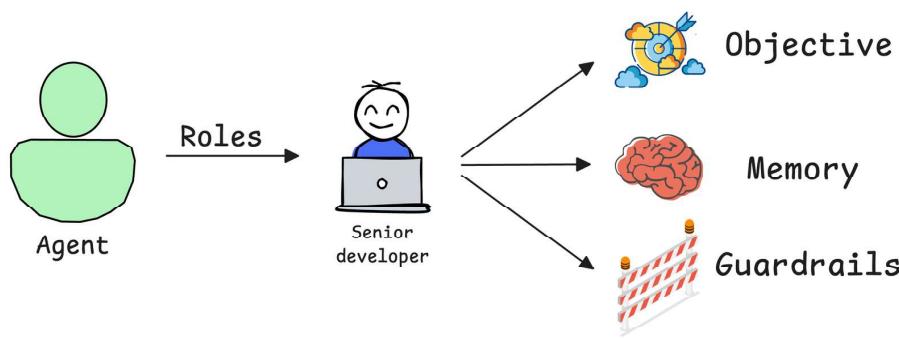
- Limiting tool usage: Prevent an agent from overusing APIs or generating irrelevant queries.
- Setting validation checkpoints: Ensure outputs meet predefined criteria before moving to the next step.
- Establishing fallback mechanisms: If an agent fails to complete a task, another agent or human reviewer can intervene.

For example, an AI-powered legal assistant should avoid outdated laws or false claims - guardrails ensure that.

6) Memory

Finally, we have memory, which is one of the most critical components of AI agents.

Without memory, an agent would start fresh every time, losing all context from previous interactions. With memory, agents can improve over time, remember past actions, and create more cohesive responses.



Different types of memory in AI agents include:

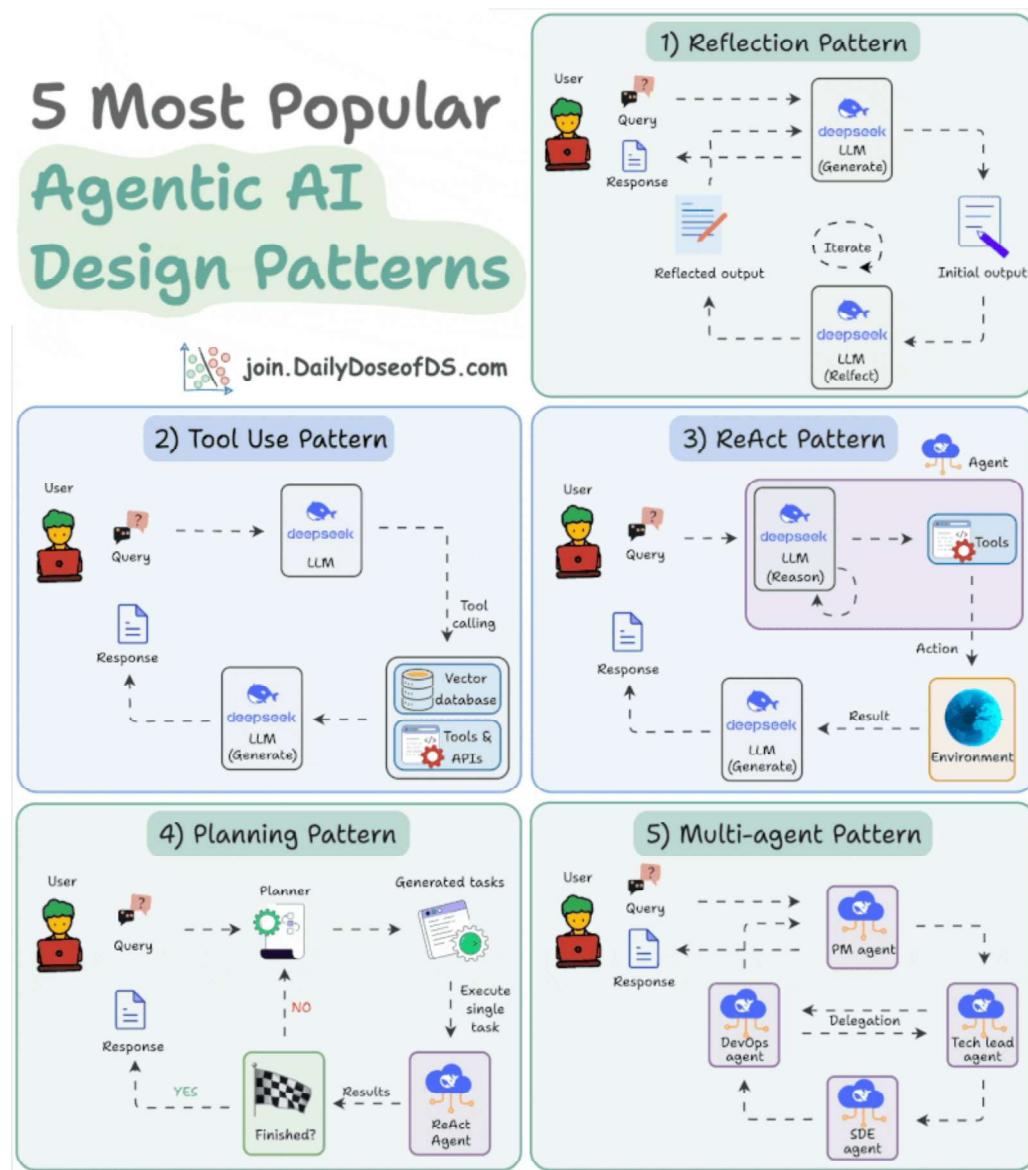
- Short-term memory – Exists only during execution (e.g., recalling recent conversation history).
- Long-term memory – Persists after execution (e.g., remembering user preferences over multiple interactions).
- Entity memory – Stores information about key subjects discussed (e.g., tracking customer details in a CRM agent).

For example, in an AI-powered tutoring system, memory allows the agent to recall past lessons, tailor feedback, and avoid repetition.

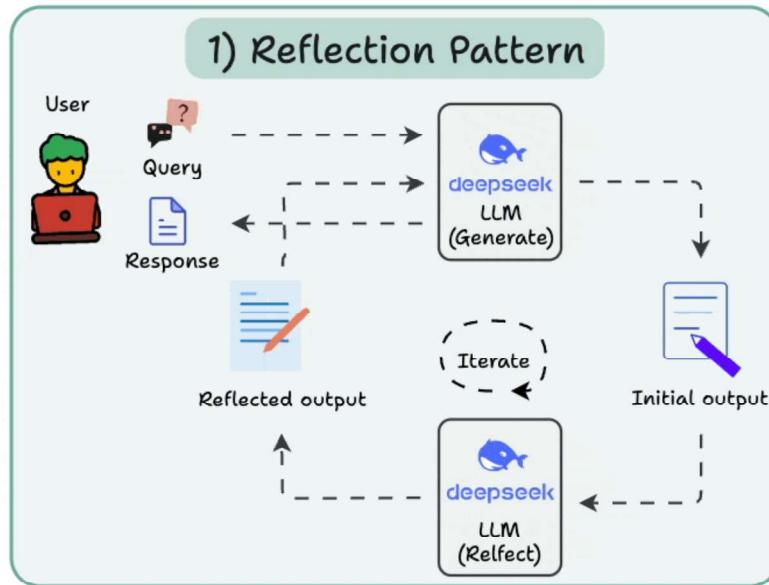
5 Agentic AI Design Patterns

Agentic behaviors allow LLMs to refine their output by incorporating self-evaluation, planning, and collaboration!

The following visual depicts the 5 most popular design patterns employed in building AI agents.

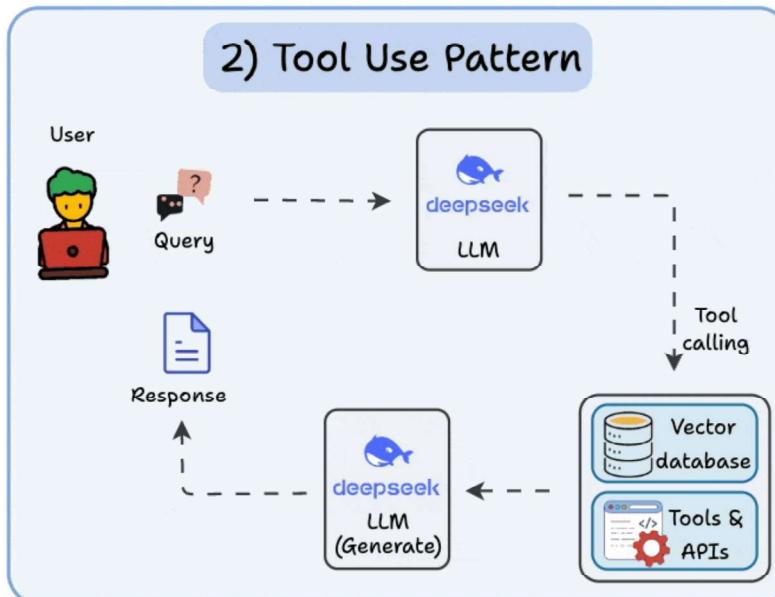


#1) Reflection pattern



The AI reviews its own work to spot mistakes and iterate until it produces the final response.

#2) Tool use pattern

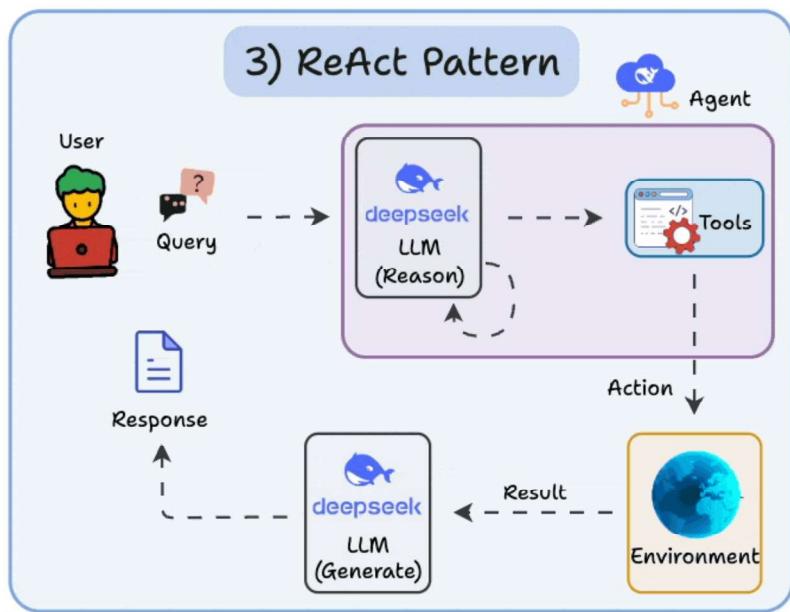


Tools allow LLMs to gather more information by:

- Querying a vector database
- Executing Python scripts
- Invoking APIs, etc.

This is helpful since the LLM is not solely reliant on its internal knowledge.

#3) ReAct (Reason and Act) pattern

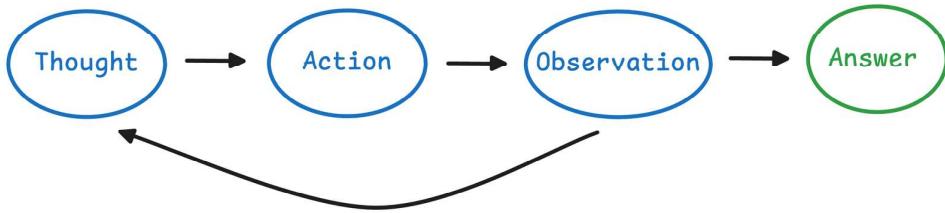


ReAct combines the above two patterns:

- The Agent reflects on the generated outputs.
- It interacts with the world using tools.

A ReAct agent operates in a loop of Thought → Action → Observation, repeating until it reaches a solution or a final answer. This is analogous to how humans solve problems:

ReAct Pattern



Note: Frameworks like CrewAI primarily use this by default.

To understand this, consider the output of a multi-agent system below:

```

# Agent: News Collector
## Task: Search for the latest news on Agent2Agent Protocol

# Agent: News Collector
## Final Answer:
1. **"Agent2Agent Protocol Expands Blockchain Communication"** - November 18, 2023**
   The Agent2Agent Protocol has announced its latest advancements in facilitating seamless communication between decentralized agents on various blockchain networks. This development marks a significant step forward in the protocol's interoperability and scalability.

2. **"Agent2Agent Protocol Announces Strategic Partnership"** - November 7, 2023**
   A significant partnership has been formed between Agent2Agent Protocol and a leading technology firm to broaden their capabilities in artificial intelligence and machine learning.

# Agent: News Reporter
## Task: Create a news headline on Agent2Agent Protocol from the News Collector. Also validate the news is relevant to Agent2Agent Protocol using the search results.

# Agent: News Reporter
## Thought: I need to validate the relevance of the news related to the Agent2Agent Protocol by searching the internet for recent developments.
## Using tool: Search the Internet
## Tool Input:
"{"search_query": "Agent2Agent Protocol news November 2023"}"
## Tool Output:

Search results: Title: Announcing the Agent2Agent Protocol (A2A)
Link: https://developers.googleblog.com/en/a2a-a-new-era-of-agent-interoperability/
Snippet: Today, we're launching a new, open protocol called Agent2Agent (A2A), with support and contributions from more than 50 technology partners

# Agent: News Reporter
## Thought: Thought: The search results indicate that the Agent2Agent Protocol is currently being discussed in various contexts, especially in relation to its latest announcements and partnerships.
## Using tool: Search the Internet
## Tool Input:
"{"search_query": "Agent2Agent Protocol latest news"}"
## Tool Output:

Search results: Title: Announcing the Agent2Agent Protocol (A2A)
Link: https://developers.googleblog.com/en/a2a-a-new-era-of-agent-interoperability/
Snippet: Today, we're launching a new, open protocol called Agent2Agent (A2A), with support and contributions from more than 50 technology partners

# Agent: News Reporter
## Thought: Thought: The Agent2Agent Protocol has made significant strides recently with new announcements and partnerships involving AI and blockchain technology.
## Using tool: Search the Internet
## Tool Input:
"{"search_query": "Agent2Agent Protocol news updates"}"
## Tool Output:

Search results: Title: Announcing the Agent2Agent Protocol (A2A)
Link: https://developers.googleblog.com/en/a2a-a-new-era-of-agent-interoperability/
Snippet: Today, we're launching a new, open protocol called Agent2Agent (A2A), with support and contributions from more than 50 technology partners
  
```

As shown above, the Agent is going through a series of thought activities before producing a response.

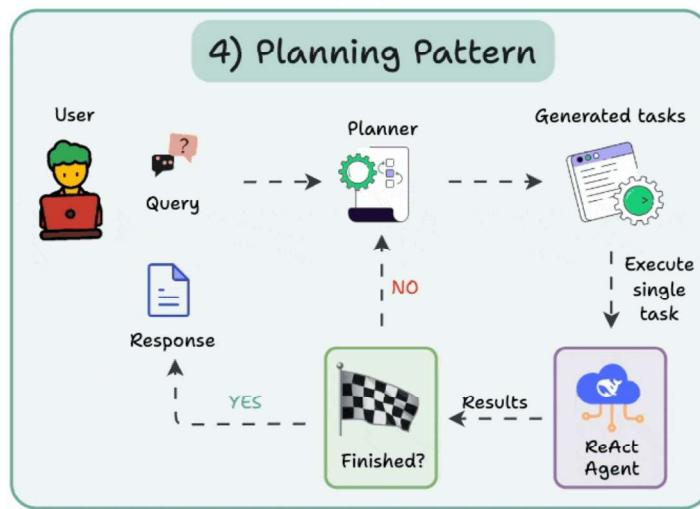
This is the ReAct pattern in action!

More specifically, under the hood, many such frameworks use the ReAct (Reasoning and Acting) pattern to let LLM think through problems and use tools to act on the world.

For example, an agent in CrewAI typically alternates between reasoning about a task and acting (using a tool) to gather information or execute steps, following the ReAct paradigm.

This enhances an LLM agent's ability to handle complex tasks and decisions by combining chain-of-thought reasoning with external tool use like in this [ReAct implementation from scratch](#).

#4) Planning pattern



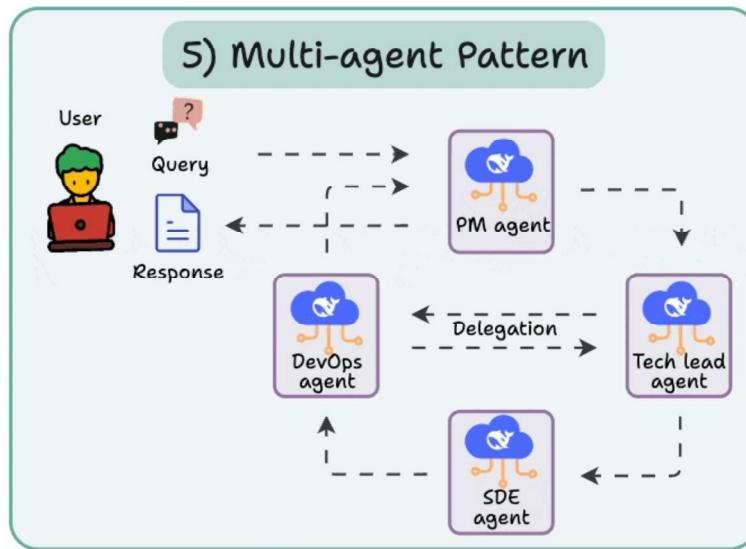
Instead of solving a task in one go, the AI creates a roadmap by:

- Subdividing tasks
- Outlining objectives

This strategic thinking solves tasks more effectively.

Note: In CrewAI, specify `planning=True` to use Planning.

#5) Multi-Agent pattern



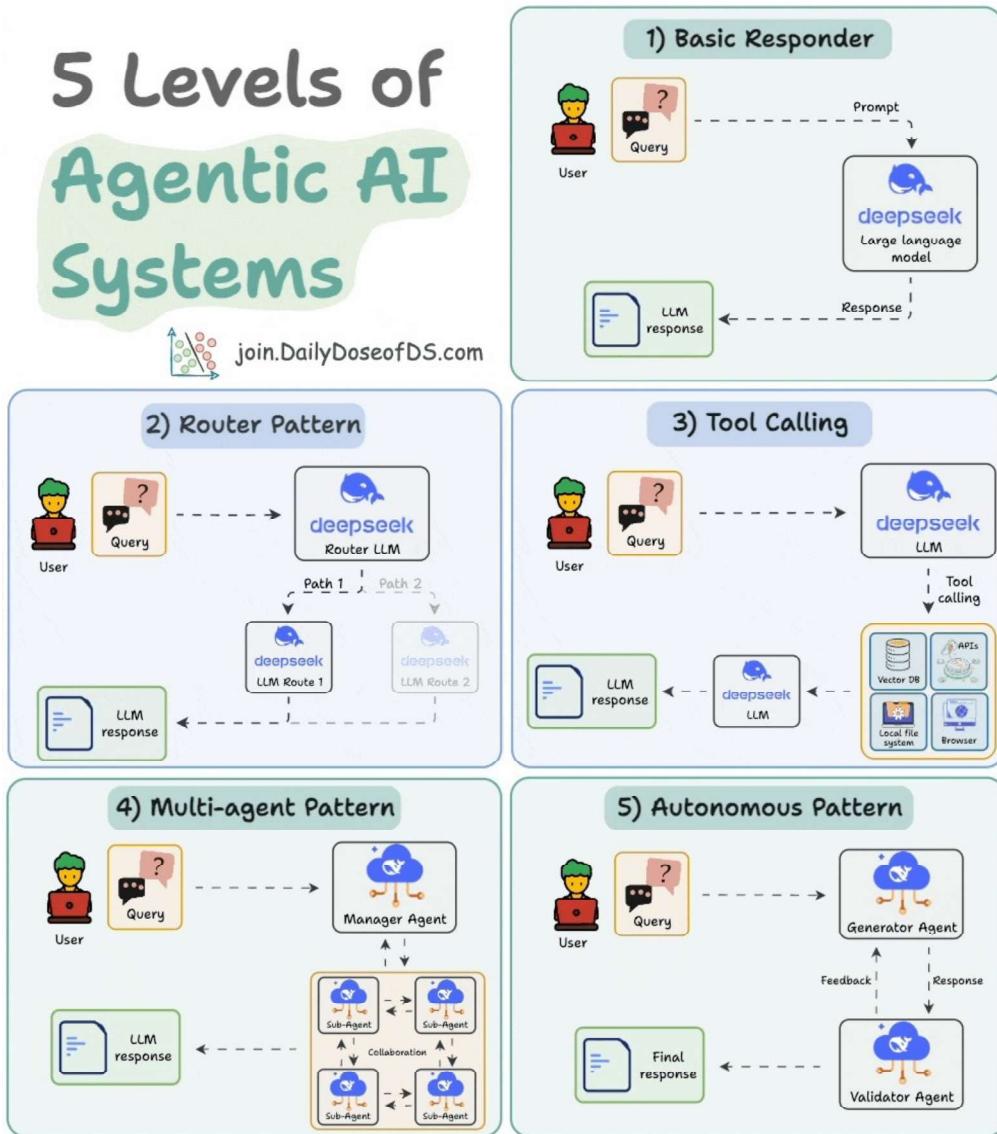
- There are several agents, each with a specific role and task.
- Each agent can also access tools.

All agents work together to deliver the final outcome, while delegating tasks to other agents if needed.

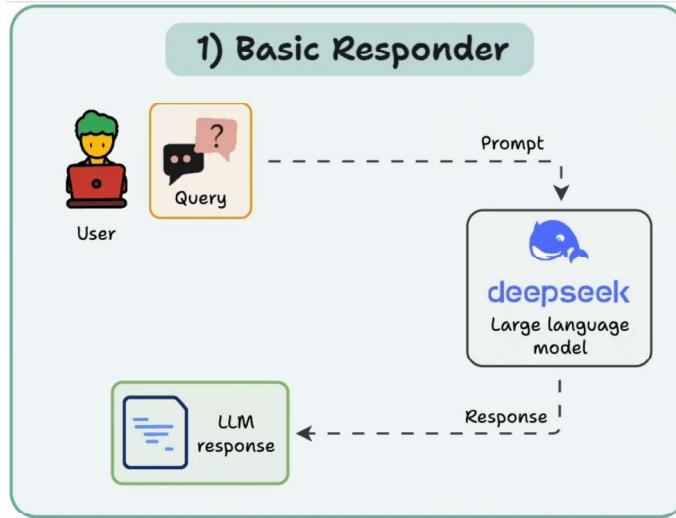
5 Levels of Agentic AI Systems

Agentic AI systems don't just generate text; they can make decisions, call functions, and even run autonomous workflows.

The visual explains 5 levels of AI agency—from simple responders to fully autonomous agents.



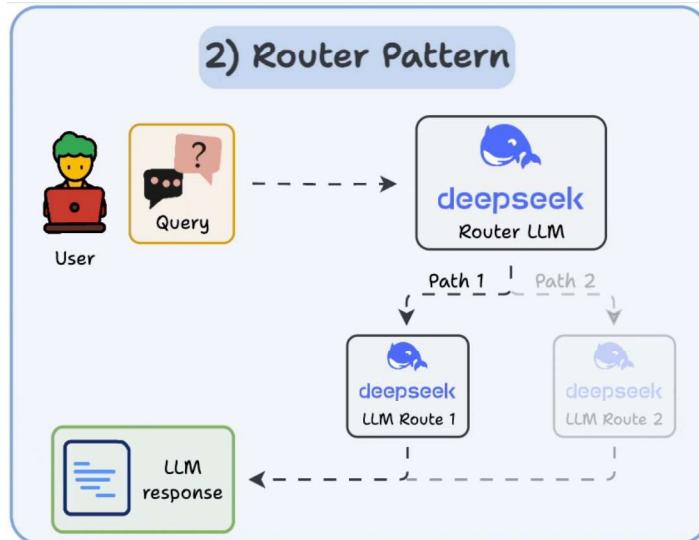
#1) Basic responder



A human guides the entire flow.

The LLM is just a generic responder that receives an input and produces an output. It has little control over the program flow.

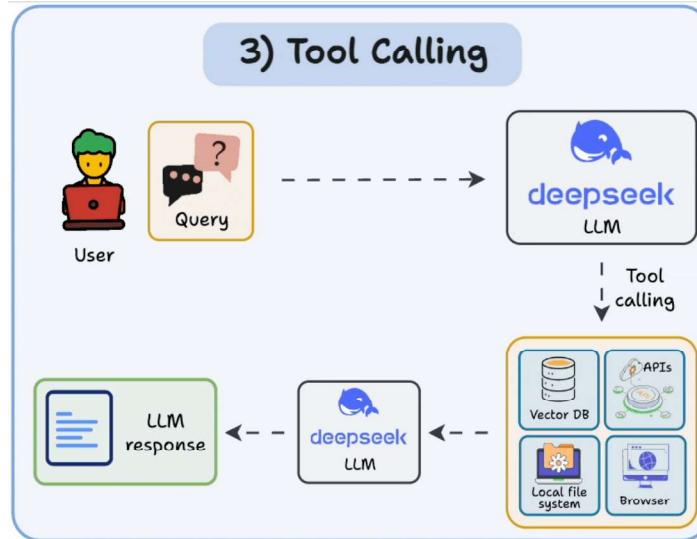
#2) Router pattern



A human defines the paths/functions that exist in the flow.

The LLM makes basic decisions on which function or path it can take.

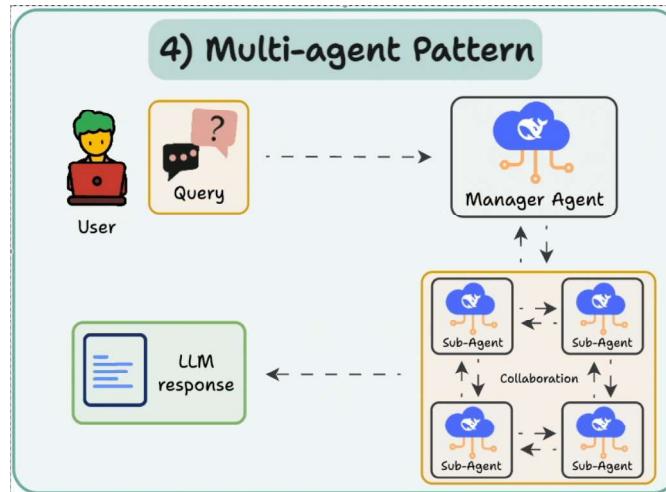
#3) Tool calling



A human defines a set of tools the LLM can access to complete a task.

LLM decides when to use them and also the arguments for execution.

#4) Multi-agent pattern



A manager agent coordinates multiple sub-agents and decides the next steps iteratively.

A human lays out the hierarchy between agents, their roles, tools, etc.