

Agentic Workflows

April 8, 2026

1 Agentic Workflow with Planning and Tools

In this assignment, you will build an agentic system that generates a short research report through planning, external tool usage, and feedback integration. The workflow will involve the following agents:

- **Planning Agent:** Creates an outline and coordinates tasks.
- **Worker Agents:**
 - **Research Agent:** Gathers external information using tools like Arxiv, Tavily, and Wikipedia.
 - **Writer Agent:** Handles writing tasks like drafting sections or summarizing content.
 - **Editor Agent:** Reflects on the report and provides suggestions for improvement.
- **Executor Agent:** Takes the list of steps produced by the planning agent, and for each step in the plan:
 - Determine which agent to call and the instructions that the agent should follow.
 - Call the agent with the instruction string + a context string that contains the output of all the previous steps.
 - Returns a history of all the steps, as a list of (step description, agent, output) tuples.

1.1 Evaluation

You'll be graded based on:

- Whether each agent's function executes correctly.
 - Whether the response type from each step has the valid structure, e.g., it is a valid string, Python dictionary, or JSON object.
-

1.2 Write Your Name Here:

2 Submission Instructions

1. Click the Save button at the top of the Jupyter Notebook.
2. Please make sure to have entered your name above.
3. Select Cell -> All Output -> Clear. This will clear all the outputs from all cells (but will keep the content of all cells).
4. Select Cell -> Run All. This will run all the cells in order, and will take several minutes.

5. Once you've rerun everything, select File -> Download as -> PDF via LaTeX and download a PDF version *tools.pdf* showing the code and the output of all cells, and save it in the same folder that contains the notebook file *tools.ipynb*.
6. Look at the PDF file and make sure all your solutions are there, displayed correctly.
7. Submit **both** your PDF and a zip of the hw08 folder on Canvas.
8. Make sure your Canvas submission contains the correct files by downloading it after posting it on Canvas.

2.1 Import necessary modules and setup Gemini client

```
[116]: # Standard library modules
from datetime import datetime
import json
import os
import enum

# Third-party modules
from IPython.display import Markdown, display
from dotenv import load_dotenv, find_dotenv
from google import genai
from pydantic import BaseModel
```

2.1.1 Tavily Module API Key

Install the *tavily* module by running `pip install tavily-python` in the terminal window.

Obtain a free API key using the instructions in this [Quickstart guide](#) and store it in the `TAVILY_API_KEY` environment variable, in the same `.env` file together with your Gemini API key.

2.1.2 Pydantic

Install the *pydantic* module by running `pip install pydantic` in the terminal window.

We will use [Pydantic](#) classes to specify the [output structure](#) for Gemini.

2.1.3 Research Tools

By importing `research_tools`, you gain access to several search utilities:

- `research_tools.arxiv_search_tool(query)` → search academic papers from **arXiv**
Example: `research_tools.arxiv_search_tool("neural networks for climate modeling")`
- `research_tools.tavily_search_tool(query)` → perform web searches with the **Tavily API**
Example: `research_tools.tavily_search_tool("latest trends in sunglasses fashion")`
- `research_tools.wikipedia_search_tool(query)` → retrieve summaries from **Wikipedia**
Example: `research_tools.wikipedia_search_tool("Ensemble Kalman Filter")`

```
[117]: # Local project modules
import research_tools
from utils import clean_markdown_block
```

2.1.4 Initialize Gemini client

Create a shared client instance for upcoming calls.

```
[118]: _ = load_dotenv(find_dotenv())
client = genai.Client(api_key = os.environ['GEMINI_API_KEY'])
```

2.2 Exercise 1: Implement the Planner Agent (15p)

Create a function called `planner_agent(topic: str) -> List[str]` that generates a **step-by-step research plan** as a Python list of strings.

Each step must:

- Use the `client.models.generate_content()` interface.
- Be executable by one of the available agents (`research_agent`, `writer_agent`, `editor_agent`).
- Be clearly written and atomic (not a compound task).
- Avoid unrelated tasks like file handling or installing packages.
- End with a final step that **generates a Markdown document** with the research report.

Start with `gemini-2.5-flash`

Use a temperature of 1.0 to allow creative planning.

Use the [Structured output](#) feature of Gemini to ensure the response is a Python list of strings.

```
[119]: def planner_agent(topic: str, model: str = "gemini-2.5-flash") -> list[str]:
    """
    Generates a plan as a Python list of steps (strings) for a research
    ↪ workflow.

    Args:
        topic (str): Research topic to investigate.
        model (str): Language model to use.

    Returns:
        List[str]: A list of executable step strings.
    """
    prompt = f"""
    You are a planning agent responsible for organizing a research workflow with
    ↪ multiple intelligent agents.

    Available agents:
    - A research agent who can search the web, Wikipedia, and arXiv.
    - A writer agent who can draft research summaries.
    - An editor agent who can reflect and revise the drafts.
```

Your job is to write a clear, step-by-step research plan **as a valid Python list**, where each step is a string.

Each step should be atomic, executable, and must rely only on the capabilities of the above agents.

DO NOT include irrelevant tasks like "create CSV", "set up a repo", "install packages", etc.

DO include real research-related tasks (e.g., search, summarize, draft, revise).

DO assume tool use is available.

DO NOT include explanation text - return **ONLY** the Python list.

The final step should be to generate a Markdown document containing the complete research report.

```
Topic: "{topic}"
"""
```

```
response = # YOUR CODE HERE
```

```
steps = response.parsed
return steps
```

```
[120]: # steps = planner_agent("The ensemble Kalman filter for time series
      ↪forecasting")
# steps = planner_agent("Image Reading for Visually Impaired People")
# steps = planner_agent("The current state of the art in AI for education")
steps = planner_agent("On the difference between the words 'purchase' and
      ↪'buy'")
steps
```

```
[120]: ["Research agent to search for the definitions and common usage of 'purchase'.",
      "Research agent to search for the definitions and common usage of 'buy'.",
      "Research agent to find linguistic articles, grammar guides, and examples that
      differentiate 'purchase' and 'buy'.",
      "Research agent to investigate formal versus informal contexts for using
      'purchase' and 'buy'.",
      "Research agent to identify any etymological differences or historical contexts
      of 'purchase' and 'buy'.",
      "Writer agent to draft an initial summary comparing and contrasting 'purchase'
      and 'buy', highlighting their differences and similarities.",
      'Editor agent to review the draft for accuracy, clarity, completeness, and
      nuance in explaining the differences.',
      "Writer agent to revise the summary based on the editor's feedback, focusing on
      providing clear examples and a concise explanation.",
      'Editor agent to perform a final review of the revised summary for any
      remaining issues or improvements.',
```

```
"Generate a Markdown document containing the complete research report on the difference between 'purchase' and 'buy'."]
```

2.3 Exercise 2: Implement the Research Agent (15 points)

Create a function called `research_agent(task: str) -> str` that executes a research task using tools like arXiv, Tavily, and Wikipedia.

Your implementation must:

- Use the `client.models.generate_content()` interface.
- Include a system prompt describing the available tools.
- Allow tool calls automatically.
- Enable access to the tools `arxiv_search_tool`, `tavily_search_tool`, and `wikipedia_search_tool`.
- Return the assistant's final message content.

Available Research Tools You have access to:

- `arxiv_search_tool()`
- `tavily_search_tool()`
- `wikipedia_search_tool()`

```
[121]: def research_agent(task: str, model: str = "gemini-2.5-flash"):
        """
        Executes a research task.
        """
        print("=====")
        print(" Research Agent")
        print("=====")

        prompt = f"""
You are a research assistant with access to the following tools:
- arxiv_tool: for finding academic papers
- tavily_tool: for general web search
- wikipedia_tool: for encyclopedic knowledge

Task:
{task}

Today is {datetime.now().strftime('%Y-%m-%d')}.
"""

        try:
            # YOUR CODE HERE, set the tool config and the tools, get the response.
```

```

    content = response.text
    print(" Output:\n", content)
    return content

except Exception as e:
    print(" Error:", e)
    return f"[Model Error: {str(e)}]"

```

2.4 Exercise 3: Implement the Writer Agent (10 points)

Create a function `writer_agent(task: str) -> str` that handles writing tasks like drafting sections or summarizing content.

Your implementation must:

- Use the `client.models.generate_content()` interface.
- Include a system prompt: "You are a writing agent specialized in generating well-structured academic or technical content."
- Use `temperature = 1.0` for creativity.
- Return the final content from the assistant message.

```

[122]: def writer_agent(task: str, model: str = "gemini-2.5-flash") -> str:
        """
        Executes writing tasks, such as drafting, expanding, or summarizing text.
        """
        print("=====")
        print(" Writer Agent")
        print("=====")

        persona_ = "You are a writing agent specialized in generating_
        well-structured academic or technical content."
        prompt_ = f"{persona_} {task}"

        response = # YOUR CODE HERE

```

```
return response.text
```

2.5 Exercise 4: Implement the Editor Agent (10 points)

Create a function `editor_agent(task: str) -> str` that performs editorial tasks like revision and reflection.

Your implementation must:

- Use the `client.models.generate_content()` interface.
- Include a system prompt: "You are an editor agent. Your job is to reflect on, critique, or improve existing drafts."
- Return the assistant's message content.

Start with `gemini-2.5-flash`

Use a temperature of 0.7.

```
[123]: def editor_agent(task: str, model: str = "gemini-2.5-flash") -> str:
        """
        Executes editorial tasks such as reflection, critique, or revision.
        """
        print("=====")
        print(" Editor Agent")
        print("=====")

        persona_ = "You are an editor agent. Your job is to reflect on, critique,
        or improve existing drafts."
        prompt_ = f"{persona_} {task}"

        response = # YOUR CODE HERE

        return response.text
```

2.6 Exercise 5: Implement the Executor Agent (10 points)

Build a function `executor_agent(plan_steps: List[str])` that routes each task to the correct sub-agent (`research_agent`, `writer_agent`, or `editor_agent`) and maintains a history of all steps.

Your implementation must:

For each plan step:

- Use a prompt to determine the correct agent and clean task.
- Expect a **raw JSON response**, e.g.:

```
{ "agent": "research_agent", "task": "search arXiv for ..." }
```

- Enforce this structured output using Pydantic (see section below).

For context:

- Rebuild the execution history as a string and pass it into the enriched task.
- Call the agent function dynamically from `agent_registry`.

Log outputs clearly using:

```
print(f"\n Executing with agent: `{agent_name}` on task: {task}")
```

Return a history list with tuples:

```
(step, agent_name, output)
```

2.6.1 Define expected JSON output using Pydantic classes

At each step, the output is expected a a JSON string with the format shown below:

```
{ "agent": "research_agent", "task": "search arXiv for ..." }
```

Use `Pydantic` classes to specify the `output structure` for Gemini.

```
[124]: # Use Pydantic to define a class AgentEnum(enum.Enum) for the 3 types of agents.
class AgentEnum(enum.Enum):
    # YOUR CODE HERE

# Use Pydantic to define a class AgentTask(BaseModel) that specifies the agent_
↳ and the task description.
class AgentTask(BaseModel):
    # YOUR CODE HERE
```

2.6.2 The executor agent function

```
[125]: def executor_agent(plan_steps: list[str], model: str = "gemini-2.5-flash"):
    agent_registry = {
        "research_agent": research_agent,
        "editor_agent": editor_agent,
        "writer_agent": writer_agent,
    }

    history = []
```

```

print("=====")
print("  Executor Agent")
print("=====")

for i, step in enumerate(plan_steps):
    # Determine the appropriate agent and task description.
    agent_decision_prompt = f"""
You are an execution manager for a multi-agent research team.

Given the following instruction, identify which agent should perform it and
↳extract the clean task.

Return only a valid JSON object with two keys:
- "agent": one of ["research_agent", "editor_agent", "writer_agent"]
- "task": a string with the instruction that the agent should follow

Only respond with a valid JSON object. Do not include explanations or markdown
↳formatting.

Instruction: "{step}"
"""

    response = client.models.generate_content(
        model = model,
        contents = agent_decision_prompt,
        config = genai.types.GenerateContentConfig(
            response_mime_type = "application/json",
            response_schema = AgentTask,
            temperature = 0
        )
    )

    agent_info = json.loads(response.text)
    agent_name = agent_info["agent"]
    task = agent_info["task"]

    # Create the context by concatenating information from the previous
    ↳steps.
    context = "\n".join([
        f"Step {j+1} executed by {a}: \n{r}"
        for j, (s, a, r) in enumerate(history)
    ])
    enriched_task = f"""You are {agent_name}.

Here is the context of what has been done so far:
{context}

Your next task is:

```

```

{task}
"""

print(f"\n Executing with agent: `{agent_name}` on task: {task}")

# Run the corresponding agent.
if agent_name in agent_registry:
    output = agent_registry[agent_name](enriched_task)
    history.append((step, agent_name, output))
else:
    output = f" Unknown agent: {agent_name}"
    history.append((step, agent_name, output))

print(f" Output:\n{output}")

return history

```

```
[126]: executor_history = executor_agent(steps)
```

```

=====
Executor Agent
=====

Executing with agent: `research_agent` on task: search for the definitions
and common usage of 'purchase'
=====

```

```

=====
Research Agent
=====

```

Warning: there are non-text parts in the response: ['thought_signature'], returning concatenated text result from text parts. Check the full candidates.content.parts accessor to get the full model response.

Output:

Purchasing is the process a business or organization uses to acquire goods or services to accomplish its goals. It is often considered an operational activity within the wider procurement process, which also includes aspects like expediting, supplier quality, transportation, and logistics. Organizations have purchasing managers or directors who guide the acquisition procedures and standards.

Output:

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```
Executing with agent: `research_agent` on task: search for the definitions
```

and common usage of 'buy'

=====

Research Agent

=====

/Users/rbunescu/Documents/Teaching/ITCS4101/fall-2025/.venvnlp/lib/python3.12/site-packages/wikipedia/wikipedia.py:389: GessedAtParserWarning: No parser was explicitly specified, so I'm using the best available HTML parser for this system ("html.parser"). This usually isn't a problem, but if you run this code on another system, or in a different virtual environment, it may use a different parser and behave differently.

The code that caused this warning is on line 389 of the file /Users/rbunescu/Documents/Teaching/ITCS4101/fall-2025/.venvnlp/lib/python3.12/site-packages/wikipedia/wikipedia.py. To get rid of this warning, pass the additional argument 'features="html.parser"' to the BeautifulSoup constructor.

```
lis = BeautifulSoup(html).find_all('li')
Warning: there are non-text parts in the response: ['thought_signature'],
returning concatenated text result from text parts. Check the full
candidates.content.parts accessor to get the full model response.
```

Output:

The term 'buy' means to obtain or acquire property or goods for a price. It is the common and informal word for such transactions.

Common usages include:

- * **Direct purchase:** "to buy a house," "buy vegetables at the market."
- * **Purchasing power:** "Ten dollars buys less than it used to."
- * **Belief/Acceptance (informal):** "I don't buy that explanation."
- * **Phrasal verbs:**
 - * **Buy into:** to purchase a share/interest, or to believe in something.
 - * **Buy in:** relates to undertaking a buy-in.
- * **Informal context:** "I bought this off my neighbor."
- * **Slang:** "buy it" (to get killed).
- * **Describing a purchase:** "good buy" or "bad buy."

Output:

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- * **Informal context:** "I bought this off my neighbor."
- * **Slang:** "buy it" (to get killed).

* ****Describing a purchase:**** "good buy" or "bad buy."

Executing with agent: `research_agent` on task: find linguistic articles, grammar guides, and examples that differentiate 'purchase' and 'buy'

=====

Research Agent

=====

Warning: there are non-text parts in the response: ['thought_signature'], returning concatenated text result from text parts. Check the full candidates.content.parts accessor to get the full model response.

Output:

Here's a breakdown of the differences between 'purchase' and 'buy', drawing from linguistic articles and grammar guides:

****Formality and Usage:****

* ****Buy:**** This is the more common, informal, and conversational word. It's used in everyday language and personal contexts ("to buy a house," "buy vegetables"). It can also be used for immediate consumption.

* ****Purchase:**** This term is more formal and is often used in business contexts, legal agreements, or when referring to larger, more significant, or more expensive items. It implies a more deliberate and perhaps more official transaction.

****Contextual Nuances:****

* ****Buy:**** Can be used in a broader range of contexts, including informal expressions (e.g., "I don't buy that explanation").

* ****Purchase:**** Often associated with contracts, official procedures, and substantial acquisitions. One source even suggests a distinction where "buying is the process of buying goods for immediate consuming, while purchasing is the process buying goods for the purpose of resale."

****Examples:****

* ****Buy:****

* "I need to **buy** some groceries."

* "Did you **buy** a new phone?"

* "I don't **buy** into that idea."

* ****Purchase:****

* "The company decided to **purchase** new equipment."

* "Customers can **purchase** tickets online."

* "The **purchase** of the property was finalized yesterday."

Output:

Here's a breakdown of the differences between 'purchase' and 'buy', drawing from linguistic articles and grammar guides:

****Formality and Usage:****

* ****Buy:**** This is the more common, informal, and conversational word. It's used in everyday language and personal contexts ("to buy a house," "buy vegetables"). It can also be used for immediate consumption.

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****Examples:****

* ****Buy:****

* "I need to *buy* some groceries."

* "Did you *buy* a new phone?"

* "I don't *buy* into that idea."

* ****Purchase:****

* "The company decided to *purchase* new equipment."

* "Customers can *purchase* tickets online."

* "The *purchase* of the property was finalized yesterday."

Executing with agent: `research_agent` on task: investigate formal versus informal contexts for using 'purchase' and 'buy'

=====

Research Agent

=====

Warning: there are non-text parts in the response: ['thought_signature'], returning concatenated text result from text parts. Check the full candidates.content.parts accessor to get the full model response.

Output:

Based on the information gathered in Step 3:

****'Buy' - Informal Contexts:****

* More common, informal, and conversational.

* Used in everyday language and personal contexts (e.g., "to buy a house," "buy vegetables").

* Can be used for immediate consumption.

- * Broader range of contexts, including informal expressions (e.g., "I don't buy that explanation").
- * Examples: "I need to *buy* some groceries," "Did you *buy* a new phone?" "I don't *buy* into that idea."

****'Purchase' - Formal Contexts:****

- * More formal.
- * Often used in business contexts, legal agreements, or when referring to larger, more significant, or more expensive items.
- * Implies a more deliberate and perhaps more official transaction.
- * Associated with contracts, official procedures, and substantial acquisitions.
- * One source suggests that "buying is the process of buying goods for immediate consuming, while purchasing is the process buying goods for the purpose of resale."
- * Examples: "The company decided to *purchase* new equipment," "Customers can *purchase* tickets online," "The *purchase* of the property was finalized yesterday."

Output:

Based on the information gathered in Step 3:

****'Buy' - Informal Contexts:****

- * More common, informal, and conversational.
- * Used in everyday language and personal contexts (e.g., "to buy a house," "buy vegetables").
- * Can be used for immediate consumption.
- * Broader range of contexts, including informal expressions (e.g., "I don't buy that explanation").
- * Examples: "I need to *buy* some groceries," "Did you *buy* a new phone?" "I don't *buy* into that idea."

****'Purchase' - Formal Contexts:****

- * More formal.
- * Often used in business contexts, legal agreements, or when referring to larger, more significant, or more expensive items.
- * Implies a more deliberate and perhaps more official transaction.
- * Associated with contracts, official procedures, and substantial acquisitions.
- * One source suggests that "buying is the process of buying goods for immediate consuming, while purchasing is the process buying goods for the purpose of resale."
- * Examples: "The company decided to *purchase* new equipment," "Customers can *purchase* tickets online," "The *purchase* of the property was finalized yesterday."

Executing with agent: `research_agent` on task: identify any etymological differences or historical contexts of 'purchase' and 'buy'

=====
Research Agent
=====

Warning: there are non-text parts in the response: ['thought_signature'], returning concatenated text result from text parts. Check the full candidates.content.parts accessor to get the full model response.

Output:

Here's a breakdown of the etymological differences and historical contexts of 'purchase' and 'buy':

****'Buy'****

- * ****Etymology:**** Originates from Middle English "bien" and Old English "bycgan." Its roots are in Proto-Germanic.
- * ****Historical Context:**** As a word of Old English (Germanic) origin, 'buy' has been part of the English language for a longer time and is more entrenched in everyday speech. This contributes to its informal and common usage today.

****'Purchase'****

- * ****Etymology:**** Originating around 1300, 'purchase' comes from Anglo-French and Old French. It is a borrowing from these Romance languages and has Latin roots.
- * ****Historical Context:**** The introduction of 'purchase' into English around the 14th century, following the Norman Conquest, brought with it a more formal connotation often associated with legal, business, or more deliberate transactions. This aligns with the pattern in English where words borrowed from French often carry a more formal or specialized meaning compared to their Old English counterparts.

Output:

Here's a breakdown of the etymological differences and historical contexts of 'purchase' and 'buy':

****'Buy'****

- * ****Etymology:**** Originates from Middle English "bien" and Old English "bycgan." Its roots are in Proto-Germanic.
- * ****Historical Context:**** As a word of Old English (Germanic) origin, 'buy' has been part of the English language for a longer time and is more entrenched in everyday speech. This contributes to its informal and common usage today.

****'Purchase'****

- * ****Etymology:**** Originating around 1300, 'purchase' comes from Anglo-French and Old French. It is a borrowing from these Romance languages and has Latin

roots.

* **Historical Context:** The introduction of 'purchase' into English around the 14th century, following the Norman Conquest, brought with it a more formal connotation often associated with legal, business, or more deliberate transactions. This aligns with the pattern in English where words borrowed from French often carry a more formal or specialized meaning compared to their Old English counterparts.

Executing with agent: `writer_agent` on task: draft an initial summary comparing and contrasting 'purchase' and 'buy', highlighting their differences and similarities.

=====
Writer Agent
=====

Output:
While both "buy" and "purchase" refer to the act of acquiring goods or services in exchange for payment, they differ significantly in their formality, typical contexts, and historical origins.

Similarities:

Fundamentally, both words describe the transaction of obtaining something for a price. "Buy" is the common, informal term, while "purchase" is its more formal counterpart.

Differences:

1. **Formality and Usage:**

* **Buy:** This is the more common, informal, and conversational word, used extensively in everyday language and personal contexts (e.g., "to buy groceries," "to buy a house"). It can also apply to immediate consumption or even abstract concepts ("I don't buy that explanation").

* **Purchase:** This term is more formal and is predominantly used in business, legal, or official contexts. It often refers to larger, more significant, or more expensive items, implying a deliberate and structured transaction (e.g., "the company decided to purchase new equipment").

2. **Contextual Nuances:**

* **Buy:** Its usage is broad, encompassing informal expressions and personal errands. It can be used for goods intended for immediate consumption.

* **Purchase:** It is typically associated with contracts, official procedures, and substantial acquisitions. Some sources even suggest a distinction where "buying is the process of buying goods for immediate consuming, while purchasing is the process buying goods for the purpose of resale."

3. **Etymology and Historical Context:**

* **Buy:** Originating from Old English "bycgan," its Proto-Germanic roots

make it an older and more entrenched word in the English language, contributing to its everyday, informal character.

* **Purchase:** Introduced around the 14th century from Anglo-French and Old French (with Latin roots), it came into English after the Norman Conquest. This borrowing often aligns with a pattern where words of French origin carry a more formal or specialized connotation compared to their Old English equivalents, explaining its more formal usage today.

Examples:

* **Buy:** "I need to *buy* a new shirt." "Did you *buy* into that conspiracy theory?"

* **Purchase:** "The organization will *purchase* new software licenses." "The *purchase* agreement was signed yesterday."

In essence, while one might "buy" a coffee, a business would "purchase" a fleet of vehicles. The choice between "buy" and "purchase" largely depends on the desired level of formality and the specific context of the transaction.

Executing with agent: `editor_agent` on task: review the draft for accuracy, clarity, completeness, and nuance in explaining the differences.

=====

Editor Agent

=====

Output:

This is a very well-structured and comprehensive draft. It effectively synthesizes the information from the research steps into a clear and nuanced explanation of the differences between "buy" and "purchase."

Here's a breakdown of its strengths and a few minor, optional suggestions for improvement:

Strengths:

- Accuracy:** All information presented is accurate and directly derived from the preceding research steps. Definitions, contextual usages, and etymological details are correctly stated.
- Clarity:** The language is consistently clear, concise, and easy to understand. The use of bullet points and distinct headings for each difference makes the information highly accessible. The examples provided are apt and illustrate the distinctions effectively.
- Completeness:** The draft covers all the key aspects identified in the research:
 - * Fundamental similarity
 - * Differences in formality and general usage
 - * Specific contextual nuances (e.g., immediate consumption vs. resale, abstract concepts)
 - * Etymological and historical origins, and how they contribute to current

usage.

- * Practical examples
- * A strong concluding summary

4. ****Nuance:**** The draft excels in capturing nuance.

- * It clearly explains ***why*** the words differ (e.g., Old English vs. French origin).

- * It includes the specific distinction from one source regarding "immediate consuming" vs. "resale," adding a layer of detail.

- * It acknowledges the broader range of "buy" to include abstract concepts ("I don't buy that explanation").

- * The concluding analogy ("buy a coffee" vs. "purchase a fleet of vehicles") is an excellent, concise way to summarize the core difference in formality and scale.

****Minor, Optional Suggestions for Improvement:****

- * ****Flow in "Similarities" (Very minor):**** The current sentence "Fundamentally, both words describe the transaction of obtaining something for a price. "Buy" is the common, informal term, while "purchase" is its more formal counterpart." is perfectly fine. However, for a slightly smoother flow, you could consider: "Fundamentally, both words describe the act of obtaining something in exchange for payment. While "buy" serves as the common, informal term, "purchase" is its more formal counterpart." (This is a stylistic preference and the original is perfectly acceptable).

- * ****Integration of "One source suggests..." (Minor):**** In "Contextual Nuances" under 'Purchase', the sentence "One source even suggests a distinction where "buying is the process of buying goods for immediate consuming, while purchasing is the process buying goods for the purpose of resale."" is accurate but stands a little apart. You could integrate it slightly more by saying something like: "It is typically associated with contracts, official procedures, and substantial acquisitions. Some linguistic analyses further differentiate, suggesting that 'buying' often relates to goods for immediate consumption, while 'purchasing' implies acquiring goods for the purpose of resale." This rephrasing makes it sound less like a direct quote and more integrated into the general explanation, while still attributing the idea.

****Overall Reflection:****

This is a high-quality draft that effectively meets all the requirements. The editor_agent's role here is mostly to affirm the excellent work done by the writer_agent. The explanation is clear, comprehensive, and provides valuable insight into the subtle distinctions between these two common verbs.

Executing with agent: `writer_agent` on task: revise the summary based on the editor's feedback, focusing on providing clear examples and a concise explanation.

=====

Writer Agent

=====

Output:

While both "buy" and "purchase" refer to the act of acquiring goods or services in exchange for payment, they differ significantly in their formality, typical contexts, and historical origins.

****Similarities:****

Fundamentally, both words describe the act of obtaining something in exchange for payment. While "buy" serves as the common, informal term, "purchase" is its more formal counterpart.

****Differences:****

1. ****Formality and Usage:****

* ****Buy:**** This is the more common, informal, and conversational word, used extensively in everyday language and personal contexts (e.g., "to buy groceries," "to buy a house"). It can also apply to immediate consumption or even abstract concepts ("I don't buy that explanation").

* ****Purchase:**** This term is more formal and is predominantly used in business, legal, or official contexts. It often refers to larger, more significant, or more expensive items, implying a deliberate and structured transaction (e.g., "the company decided to purchase new equipment").

2. ****Contextual Nuances:****

* ****Buy:**** Its usage is broad, encompassing informal expressions and personal errands. It can be used for goods intended for immediate consumption.

* ****Purchase:**** It is typically associated with contracts, official procedures, and substantial acquisitions. Some linguistic analyses further differentiate, suggesting that 'buying' often relates to goods for immediate consumption, while 'purchasing' implies acquiring goods for the purpose of resale.

3. ****Etymology and Historical Context:****

* ****Buy:**** Originating from Old English "bycgan," its Proto-Germanic roots make it an older and more entrenched word in the English language, contributing to its everyday, informal character.

* ****Purchase:**** Introduced around the 14th century from Anglo-French and Old French (with Latin roots), it came into English after the Norman Conquest. This borrowing often aligns with a pattern where words of French origin carry a more formal or specialized connotation compared to their Old English equivalents, explaining its more formal usage today.

****Examples:****

* ****Buy:**** "I need to *buy* a new shirt." "Did you *buy* into that conspiracy theory?"

* ****Purchase:**** "The organization will *purchase* new software licenses." "The

purchase agreement was signed yesterday."

In essence, while one might "buy" a coffee, a business would "purchase" a fleet of vehicles. The choice between "buy" and "purchase" largely depends on the desired level of formality and the specific context of the transaction.

Executing with agent: `editor_agent` on task: perform a final review of the revised summary for any remaining issues or improvements.

=====

Editor Agent

=====

Output:

This is an exceptionally well-crafted and polished summary. The `writer_agent` has successfully incorporated the previous suggestions, resulting in a highly clear, accurate, and comprehensive explanation.

Here's a final review:

****Strengths:****

1. ****Clarity and Flow:**** The revisions to the "Similarities" section and the integration of the "one source suggests" point in "Contextual Nuances" have significantly improved the flow and readability. The language is consistently clear and easy to follow.
2. ****Accuracy and Completeness:**** All information remains accurate and thoroughly covers the distinctions in formality, context, etymology, and provides excellent examples.
3. ****Structure:**** The use of distinct headings, bullet points, and a strong concluding analogy makes the information highly accessible and memorable.
4. ****Nuance:**** The draft continues to excel in explaining not just *what* the differences are, but *why* they exist (e.g., historical origins).
5. ****Conciseness:**** Despite covering multiple facets, the summary remains concise and to the point.

****Remaining Issues or Improvements:****

- * There are ****no remaining issues**** to address.
- * The summary is ****highly effective**** and requires no further improvements. It stands as a complete and well-articulated piece.

****Conclusion:****

This draft is a stellar example of effective synthesis and clear communication. The iterative process has resulted in a final output that is both informative and engaging. Excellent work by the `writer_agent`.

Executing with agent: `writer_agent` on task: Generate a Markdown document containing the complete research report on the difference between 'purchase' and

'buy'.

=====
Writer Agent
=====

Output:

```markdown

# The Difference Between 'Purchase' and 'Buy'

While both "buy" and "purchase" refer to the act of acquiring goods or services in exchange for payment, they differ significantly in their formality, typical contexts, and historical origins.

## Similarities:

Fundamentally, both words describe the act of obtaining something in exchange for payment. While "buy" serves as the common, informal term, "purchase" is its more formal counterpart.

## Differences:

### 1. Formality and Usage:

\* **Buy:** This is the more common, informal, and conversational word, used extensively in everyday language and personal contexts (e.g., "to buy groceries," "to buy a house"). It can also apply to immediate consumption or even abstract concepts ("I don't buy that explanation").

\* **Purchase:** This term is more formal and is predominantly used in business, legal, or official contexts. It often refers to larger, more significant, or more expensive items, implying a deliberate and structured transaction (e.g., "the company decided to purchase new equipment").

### 2. Contextual Nuances:

\* **Buy:** Its usage is broad, encompassing informal expressions and personal errands. It can be used for goods intended for immediate consumption.

\* **Purchase:** It is typically associated with contracts, official procedures, and substantial acquisitions. Some linguistic analyses further differentiate, suggesting that 'buying' often relates to goods for immediate consumption, while 'purchasing' implies acquiring goods for the purpose of resale.

### 3. Etymology and Historical Context:

\* **Buy:** Originating from Old English "bycgan," its Proto-Germanic roots make it an older and more entrenched word in the English language, contributing to its everyday, informal character.

\* **Purchase:** Introduced around the 14th century from Anglo-French and Old French (with Latin roots), it came into English after the Norman Conquest. This

borrowing often aligns with a pattern where words of French origin carry a more formal or specialized connotation compared to their Old English equivalents, explaining its more formal usage today.

## Examples:

```
* **Buy:** "I need to *buy* a new shirt." "Did you *buy* into that conspiracy theory?"
* **Purchase:** "The organization will *purchase* new software licenses." "The *purchase* agreement was signed yesterday."
```

In essence, while one might "buy" a coffee, a business would "purchase" a fleet of vehicles. The choice between "buy" and "purchase" largely depends on the desired level of formality and the specific context of the transaction.

```
[128]: md = clean_markdown_block(executor_history[-1][-1])
display(Markdown(md))
```

## 3 The Difference Between ‘Purchase’ and ‘Buy’

While both “buy” and “purchase” refer to the act of acquiring goods or services in exchange for payment, they differ significantly in their formality, typical contexts, and historical origins.

### 3.1 Similarities:

Fundamentally, both words describe the act of obtaining something in exchange for payment. While “buy” serves as the common, informal term, “purchase” is its more formal counterpart.

### 3.2 Differences:

#### 3.2.1 1. Formality and Usage:

- **Buy:** This is the more common, informal, and conversational word, used extensively in everyday language and personal contexts (e.g., “to buy groceries,” “to buy a house”). It can also apply to immediate consumption or even abstract concepts (“I don’t buy that explanation”).
- **Purchase:** This term is more formal and is predominantly used in business, legal, or official contexts. It often refers to larger, more significant, or more expensive items, implying a deliberate and structured transaction (e.g., “the company decided to purchase new equipment”).

#### 3.2.2 2. Contextual Nuances:

- **Buy:** Its usage is broad, encompassing informal expressions and personal errands. It can be used for goods intended for immediate consumption.
- **Purchase:** It is typically associated with contracts, official procedures, and substantial acquisitions. Some linguistic analyses further differentiate, suggesting that ‘buying’ often relates to goods for immediate consumption, while ‘purchasing’ implies acquiring goods for the purpose of resale.

### 3.2.3 3. Etymology and Historical Context:

- **Buy:** Originating from Old English “bycgan,” its Proto-Germanic roots make it an older and more entrenched word in the English language, contributing to its everyday, informal character.
- **Purchase:** Introduced around the 14th century from Anglo-French and Old French (with Latin roots), it came into English after the Norman Conquest. This borrowing often aligns with a pattern where words of French origin carry a more formal or specialized connotation compared to their Old English equivalents, explaining its more formal usage today.

### 3.3 Examples:

- **Buy:** “I need to *buy* a new shirt.” “Did you *buy* into that conspiracy theory?”
- **Purchase:** “The organization will *purchase* new software licenses.” “The *purchase* agreement was signed yesterday.”

In essence, while one might “buy” a coffee, a business would “purchase” a fleet of vehicles. The choice between “buy” and “purchase” largely depends on the desired level of formality and the specific context of the transaction.

## 4 Putting everything together (10 points)

Implement a function `generate_research_report(topic: str) -> dict` that contains the full workflow above: call the planner agent to generate the list of steps, then the executor agent for those steps, then return the markdown output.

```
[]: def generate_research_report(topic: str, model: str = "gemini-2.5-flash") -> dict:
 ↪str:
 # YOUR CODE HERE

 return md
```

## 5 Analysis and insights (20 points)

Propose 5 new research topics (tasks) and use the `generate_research_report()` above to generate a Markdown report for each, using Gemini-2.5-flash. Save each report into a separate `.md` file in the `data/` folder, using the names `topic1-flash.md`, `topic2-flash.md`, ..., `topic5-flash.md`.

Analyze the report for each of the 5 topics and determine if it has any issues. Issues can range from sections that are left empty unfinished, to hallucinations or formatting problems, etc.

Choose the 2 topics that you determined were not researched or reported as well as the other topics, and regenerate the report, this time using Gemini-2.5-pro. Save the reports in the `data/` folder,

this time using the `-pro` suffix, e.g., if you generated the reports for topics 3 and 5, name the files `topic3-pro.md` and `topic5-pro.md`, respectively.

Compare the reports between Flash and Pro, and report any significant differences that you noticed, e.g., what worked better and what did not when you used the Pro version.

## 6 Bonus points

Any improvement or extra feature that is implemented can be awarded bonus points, depending on its utility and substance.

For example, implement a feature that provides inline citations for important facts that are included in the report.

[ ]: