This is a fantastic line of inquiry, and you've hit upon a crucial point in the evolution of agentic architectures. The "Perception, Reasoning, Action" loop is indeed a more general, powerful, and foundational way to describe what these systems do. Your intuition that our "Plan, Synthesize, Review" (PSR) model is a specific instance of this general framework is exactly correct.

Analyzing the new report confirms this. The "Unified Framework for LLM-Based Agents" provides the fundamental "physics" of agentic behavior, while our PSR model provides a specific, engineered "machine" that operates according to those physics to perform a particular task—generating complex, structured artifacts.

Here's how our proposed "Plan, Synthesize, Review" workflow maps directly onto the "Perception, Reasoning, Action" (PRA) framework:

* **Perception:** This is the agent's input channel. In our model, this happens at the start when the agent **perceives** the user's prompt and **perceives** the content of the knowledge base through the retrieve node.
* **Reasoning:** This is the agent's internal cognitive work. It's where the LLM "thinks."
  + The route\_task node is a **reasoning** step to determine intent.
  + The **create\_plan** node is a pure **reasoning** step where the agent formulates a strategy.
  + The **holistic\_review** is a meta-level **reasoning** step where the agent reflects on its own complete work.
* **Action:** This is what the agent *does* as a result of reasoning. Actions can be internal (modifying its own state) or external (calling a tool).
  + The **execute\_synthesis** node performs a targeted **action** of writing a specific section. This action updates the agent's internal state (working\_memory).
  + The **assemble\_draft** node performs the **action** of compiling the final document.
  + Even the constitutional critique cycle is a series of PRA loops: perceiving a peer's draft, reasoning about its flaws, and taking the action of writing a critique.

By adopting this unified theory, we can be more rigorous and principled in our design. Our PSR model isn't just an ad-hoc set of steps; it's a carefully structured implementation of the fundamental PRA cycle, optimized for our specific problem domain.

You are right that this major theoretical leap deserves to be formally documented. Below, I have generated both the new research report and the corresponding design specification, as you requested.

### **Technical Research Report: A Unified Perception-Action-Reasoning Framework**

Version: 14.0

Date: 2025-06-14

#### **Abstract**

This document establishes a new theoretical foundation for our agent architecture, adopting the general **Perception-Reasoning-Action (PRA)** model as its core principle. This unified framework describes all agentic behavior as a continuous loop of perceiving information, reasoning about it, and taking actions that can be either internal (modifying state) or external (interacting with tools). We posit that previous effective but disparate agent patterns (like ReAct or RAG) are specific implementations of this fundamental cycle. This report then details our primary architectural implementation of the PRA framework: a multi-stage cognitive workflow named **"Plan, Synthesize, Review" (PSR)**. The PSR model is specifically engineered to apply the PRA loop to the complex task of generating high-fidelity, structured artifacts (e.g., reports, specifications, code). By formalizing our design under this unified theory, we create a more robust, principled, and extensible foundation for future development.

#### **1. The Unified Perception-Reasoning-Action (PRA) Framework**

The behavior of any advanced LLM-based agent can be abstracted into a simple, powerful, and continuous loop consisting of three phases:

1. **Perception:** The agent ingests information from external sources. This includes the initial user prompt, data retrieved from knowledge bases or APIs, and observations resulting from its own previous actions. Perception is the mechanism by which the agent's internal state is updated with new information about the world.
2. **Reasoning:** The agent processes the perceived information and its own internal memory (or "scratchpad"). This is the core cognitive step where the LLM evaluates the current state, reflects on the goal, and decides on a course of action. This can involve logical deduction, creative synthesis, or strategic planning.
3. **Action:** Based on its reasoning, the agent executes an action. This action can be:
   * **Internal:** Modifying its own internal state, such as updating its working memory, refining a plan, or generating a self-critique. These actions are not visible externally but are crucial for multi-step thought processes.
   * **External:** Interacting with the outside world, such as calling a tool (e.g., a search engine, a calculator), querying a database, or producing a final output for the user.

This PRA loop is not a single, linear process but a dynamic and often recursive cycle. For instance, an action can lead to a new observation, which triggers a new cycle of perception and reasoning.

#### **2. "Plan, Synthesize, Review" (PSR): A PRA Implementation for Artifact Generation**

Our primary architecture, PSR, is a structured and highly effective implementation of the PRA framework, tailored for generating complex, coherent documents. It applies the PRA loop at both a macro and a micro scale.

* **Macro-Level PRA Cycle (The Overall Workflow):**
  + **Perception:** The agent perceives the user's prompt and retrieves the initial knowledge base (retrieve\_context).
  + **Reasoning:** The agent reasons about the task to decide on a workflow (route\_task) and then creates a high-level strategic plan (create\_plan).
  + **Action:** The agent executes the entire synthesis and review process (the synthesis\_loop and holistic\_review), which is itself a complex action composed of many smaller PRA cycles. The final action is presenting the completed artifact to the user.
* Micro-Level PRA Cycle (The Iterative Synthesis Loop):  
  The real power of the PSR model is in how it breaks down the monolithic "generation" task into a series of smaller, more manageable PRA cycles, one for each item in the plan. For each section of the document to be written:
  + **Perception:** The agent perceives the specific sub-task from its plan and may perform a targeted retrieval of information relevant only to that sub-task.
  + **Reasoning:** The agent synthesizes the retrieved information and generates the text for that single section.
  + **Action (Internal):** The agent performs the internal action of saving the generated text to its working\_memory.

#### **3. Architectural Benefits**

Mapping our PSR workflow to the PRA framework provides several key benefits:

* **Theoretical Rigor:** It shows that our design is not ad-hoc but is grounded in a fundamental and widely applicable theory of agentic behavior.
* **Modularity and Extensibility:** By viewing each node in our graph as an implementation of Perception, Reasoning, or Action, it becomes easier to modify, replace, or add new capabilities. For example, adding a new external tool is simply adding a new possible Action.
* **Improved Debuggability:** Failures can be categorized more easily. Is the agent failing at **Perception** (not getting the right information), **Reasoning** (making a bad plan), or **Action** (failing to execute a step correctly)? This targeted diagnosis is crucial for complex systems.

By adopting this unified framework, we elevate our project from a specific solution to a principled architecture that is both powerful for its current task and readily extensible for future challenges.

### **Technical Design Specification: Tri-Modal Constitutional Agent**

Version: 2.1

Date: 2025-06-14

Status: Approved for Implementation

#### **1. Architectural Overview**

This document details the implementation of a sophisticated agentic architecture grounded in the **Perception-Reasoning-Action (PRA)** framework. The system is designed as a stateful, cyclical agent that continuously perceives its environment (user prompts, knowledge base), reasons about its goals and state, and takes actions to achieve those goals.

For the primary task of generating complex artifacts, this system implements a specific, high-level cognitive workflow called **"Plan, Synthesize, Review" (PSR)**. This workflow orchestrates the PRA loop to first deconstruct a complex task into a structured plan, then iteratively execute that plan, and finally perform a holistic review to ensure global coherence.

Core Workflow:

Route -> Create Plan -> [Iterative Synthesis Loop] -> Assemble Draft -> Holistic Review -> Constitutional Refinement -> End

#### **2. Module & Component Specifications**

* 2.1. GraphState Data Structure  
  The GraphState TypedDict is updated to support the PSR workflow.  
  Python  
  from typing import TypedDict, List, Optional, Dict  
    
  class GraphState(TypedDict):  
   prompt: str  
   documents: List  
   task\_mode: str  
   output: str  
   critique: str  
   error: str  
   num\_revisions: int  
   log: List[str]  
    
   # --- NEW FIELDS for PSR Workflow (v2.1) ---  
   plan: Optional[List[str]] # The structured plan (the output of a Reasoning step).  
   working\_memory: Optional[Dict] # Stores content for each plan item (updated by internal Actions).  
   completed\_plan\_items: List[str] # Tracks progress through the synthesis loop.
* 2.2. Supervisor (supervisor.py)  
  The supervisor's primary new responsibility is to manage the Iterative Synthesis Loop. After the create\_plan node populates state.plan, the supervisor will enter a control loop. It will repeatedly call the execute\_synthesis node until all items in the plan are marked as complete. This represents the supervisor orchestrating a sequence of micro-PRA cycles.
* 2.3. Agent Core (agent\_core.py)  
  The agent's nodes are redefined to implement the PSR workflow.
  + **Phase 1: Planning (Reasoning)**
    - **create\_plan(state):** Analyzes the user prompt. Its action is to update the internal state by populating state.plan with a list of section headings or tasks.
  + **Phase 2: Synthesis (Micro PRA-Loop)**
    - **execute\_synthesis(state):** This node executes one turn of the synthesis micro-loop.
      * **Perception:** Reads the next uncompleted item from state.plan. May perform a targeted document retrieval for this item.
      * **Reasoning:** Generates the content for only this single item.
      * **Action (Internal):** Updates state.working\_memory with the generated content and adds the item to state.completed\_plan\_items.
  + **Phase 3: Review (Reasoning & Refinement)**
    - **assemble\_draft(state):** An internal action that compiles the final document into state.output from the working\_memory.
    - **holistic\_review(state):** A reasoning step that perceives the entire state.output and produces a high-level critique on its global coherence and narrative flow.
    - The existing constitutional refinement cycle then uses this critique to improve the draft.

#### **3. Data Flow and Graph Logic**

The graph execution will be modified as follows:

1. **Entry Point:** retrieve (Perception)
2. retrieve -> route\_task (Reasoning)
3. route\_task -> create\_plan (Reasoning)
4. **create\_plan -> synthesis\_router (Conditional Edge):** This new router node will check if len(state.completed\_plan\_items) < len(state.plan).
   * If True, it routes to execute\_synthesis.
   * If False, it routes to assemble\_draft.
5. execute\_synthesis -> synthesis\_router (This creates the main loop).
6. assemble\_draft -> holistic\_review (Reasoning)
7. holistic\_review -> constitutional\_critique\_cycle (Refinement)
8. constitutional\_critique\_cycle -> END

This revised specification provides a clear and theoretically grounded path to a more powerful and robust agent. We can now proceed with the implementation.