Parallel agents

The `ParallelAgent` is a workflow agent that executes its sub-agents *concurrently*. This dramatically speeds up workflows where tasks can be performed independently.

Use `ParallelAgent` when: For scenarios prioritizing speed and involving independent, resource-intensive tasks, a `ParallelAgent` facilitates efficient parallel execution. **When sub-agents operate without dependencies, their tasks can be performed concurrently**, significantly reducing overall processing time.

As with other workflow agents, the `ParallelAgent` is not powered by an LLM, and is thus deterministic in how it executes. That being said, workflow agents are only concerned with their execution (i.e. executing sub-agents in parallel), and not their internal logic; the tools or sub-agents of a workflow agent may or may not utilize LLMs.

Example

This approach is particularly beneficial for operations like multi-source data retrieval or heavy computations, where parallelization yields substantial performance gains. Importantly, this strategy assumes no inherent need for shared state or direct information exchange between the concurrently executing agents.

How it works

When the `ParallelAgent`'s `run_async()` method is called:

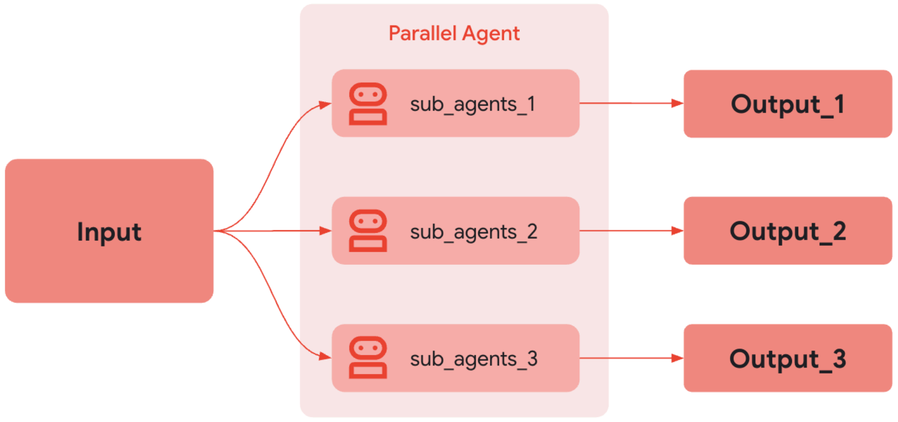
1. **Concurrent Execution:** It initiates the `run_async()` method of *each* sub-agent present in the `sub_agents` list *concurrently*. This means all the agents start running at (approximately) the same time.
2. **Independent Branches:** Each sub-agent operates in its own execution branch. There is ***no* automatic sharing of conversation history or state between these branches** during execution.

3. **Result Collection:** The `ParallelAgent` manages the parallel execution and, typically, provides a way to access the results from each sub-agent after they have completed (e.g., through a list of results or events). The order of results may not be deterministic.

Independent Execution and State Management

It's *crucial* to understand that sub-agents within a `ParallelAgent` run independently. If you *need* communication or data sharing between these agents, you must implement it explicitly. Possible approaches include:

- **Shared `InvocationContext`:** You could pass a shared `InvocationContext` object to each sub-agent. This object could act as a shared data store. However, you'd need to manage concurrent access to this shared context carefully (e.g., using locks) to avoid race conditions.
- **External State Management:** Use an external database, message queue, or other mechanism to manage shared state and facilitate communication between agents.
- **Post-Processing:** Collect results from each branch, and then implement logic to coordinate data afterwards.



Full Example: Parallel Web Research

Imagine researching multiple topics simultaneously:

1. **Researcher Agent 1:** An `LlmAgent` that researches "renewable energy sources."

2. **Researcher Agent 2:** An `LlmAgent` that researches "electric vehicle technology."
3. **Researcher Agent 3:** An `LlmAgent` that researches "carbon capture methods."

   ```
   ParallelAgent(sub_agents=[ResearcherAgent1,
   ResearcherAgent2, ResearcherAgent3])
   ```

These research tasks are independent. Using a `ParallelAgent` allows them to run concurrently, potentially reducing the total research time significantly compared to running them sequentially. The results from each agent would be collected separately after they finish.

Full Code

Python

```
# Part of agent.py --> Follow https://google.github.io/adk-
docs/get-started/quickstart/ to learn the setup
# --- 1. Define Researcher Sub-Agents (to run in parallel) ---

# Researcher 1: Renewable Energy
researcher_agent_1 = LlmAgent(
    name="RenewableEnergyResearcher",
    model=GEMINI_MODEL,
    instruction="""You are an AI Research Assistant
specializing in energy.
Research the latest advancements in 'renewable energy sources'.
Use the Google Search tool provided.
Summarize your key findings concisely (1-2 sentences).
Output *only* the summary.
""",
    description="Researches renewable energy sources.",
    tools=[google_search],
    # Store result in state for the merger agent
    output_key="renewable_energy_result"
)

# Researcher 2: Electric Vehicles
researcher_agent_2 = LlmAgent(
    name="EVResearcher",
    model=GEMINI_MODEL,
    instruction="""You are an AI Research Assistant
specializing in transportation.
Research the latest developments in 'electric vehicle
technology'.
Use the Google Search tool provided.
Summarize your key findings concisely (1-2 sentences).
Output *only* the summary.
""",
    description="Researches electric vehicle technology.",
    tools=[google_search],
    # Store result in state for the merger agent
    output_key="ev_technology_result"
)

# Researcher 3: Carbon Capture
researcher_agent_3 = LlmAgent(
    name="CarbonCaptureResearcher",
    model=GEMINI_MODEL,
    instruction="""You are an AI Research Assistant
specializing in climate solutions.
Research the current state of 'carbon capture methods'.
Use the Google Search tool provided.
Summarize your key findings concisely (1-2 sentences).
Output *only* the summary.
""",
     description="Researches carbon capture methods.",
     tools=[google_search],
     # Store result in state for the merger agent
     output_key="carbon_capture_result"
 )

 # --- 2. Create the ParallelAgent (Runs researchers 
concurrently) ---
 # This agent orchestrates the concurrent execution of the 
researchers.
 # It finishes once all researchers have completed and stored 
their results in state.
 parallel_research_agent = ParallelAgent(
     name="ParallelWebResearchAgent",
     sub_agents=[researcher_agent_1, researcher_agent_2, 
researcher_agent_3],
     description="Runs multiple research agents in parallel to 
gather information."
 )

 # --- 3. Define the Merger Agent (Runs *after* the parallel 
agents) ---
 # This agent takes the results stored in the session state by 
the parallel agents
 # and synthesizes them into a single, structured response with 
attributions.
 merger_agent = LlmAgent(
     name="SynthesisAgent",
     model=GEMINI_MODEL,  # Or potentially a more powerful model 
if needed for synthesis
     instruction="""You are an AI Assistant responsible for 
combining research findings into a structured report.

 Your primary task is to synthesize the following research 
summaries, clearly attributing findings to their source areas. 
Structure your response using headings for each topic. Ensure 
the report is coherent and integrates the key points smoothly.

 **Crucially: Your entire response MUST be grounded 
*exclusively* on the information provided in the 'Input 
Summaries' below. Do NOT add any external knowledge, facts, or 
details not present in these specific summaries.**

 **Input Summaries:**

 *   **Renewable Energy:**
     {renewable_energy_result}

 *   **Electric Vehicles:**
     {ev_technology_result}

 *   **Carbon Capture:**
     {carbon_capture_result}

 **Output Format:**

 ## Summary of Recent Sustainable Technology Advancements
 ### Renewable Energy Findings
 (Based on RenewableEnergyResearcher's findings)
 [Synthesize and elaborate *only* on the renewable energy input
summary provided above.]

 ### Electric Vehicle Findings
 (Based on EVResearcher's findings)
 [Synthesize and elaborate *only* on the EV input summary
provided above.]

 ### Carbon Capture Findings
 (Based on CarbonCaptureResearcher's findings)
 [Synthesize and elaborate *only* on the carbon capture input
summary provided above.]

 ### Overall Conclusion
 [Provide a brief (1-2 sentence) concluding statement that
connects *only* the findings presented above.]

 Output *only* the structured report following this format. Do
not include introductory or concluding phrases outside this
structure, and strictly adhere to using only the provided input
summary content.
 """,
     description="Combines research findings from parallel
agents into a structured, cited report, strictly grounded on
provided inputs.",
     # No tools needed for merging
     # No output_key needed here, as its direct response is the
final output of the sequence
 )


 # --- 4. Create the SequentialAgent (Orchestrates the overall
flow) ---
 # This is the main agent that will be run. It first executes
the ParallelAgent
 # to populate the state, and then executes the MergerAgent to
produce the final output.
 sequential_pipeline_agent = SequentialAgent(
     name="ResearchAndSynthesisPipeline",
     # Run parallel research first, then merge
     sub_agents=[parallel_research_agent, merger_agent],
     description="Coordinates parallel research and synthesizes
the results."
 )

 root_agent = sequential_pipeline_agent
```

Java

```
 import com.google.adk.agents.LlmAgent;
 import com.google.adk.agents.ParallelAgent;
 import com.google.adk.agents.SequentialAgent;
 import com.google.adk.events.Event;
 import com.google.adk.runner.InMemoryRunner;
 import com.google.adk.sessions.Session;
 import com.google.adk.tools.GoogleSearchTool;
 import com.google.genai.types.Content;
 import com.google.genai.types.Part;
 import io.reactivex.rxjava3.core.Flowable;

 public class ParallelResearchPipeline {

   private static final String APP_NAME =
"parallel_research_app";
   private static final String USER_ID = "research_user_01";
   private static final String GEMINI_MODEL = "gemini-2.0-
flash";

   // Assume google_search is an instance of the
GoogleSearchTool
   private static final GoogleSearchTool googleSearchTool = new
GoogleSearchTool();

   public static void main(String[] args) {
     String query = "Summarize recent sustainable tech
advancements.";
     SequentialAgent sequentialPipelineAgent = initAgent();
     runAgent(sequentialPipelineAgent, query);
   }

   public static SequentialAgent initAgent() {
     // --- 1. Define Researcher Sub-Agents (to run in parallel)
---
     // Researcher 1: Renewable Energy
     LlmAgent researcherAgent1 = LlmAgent.builder()
         .name("RenewableEnergyResearcher")
         .model(GEMINI_MODEL)
         .instruction("""
                     You are an AI Research Assistant
specializing in energy.
                     Research the latest advancements in
'renewable energy sources'.
                     Use the Google Search tool provided.
                     Summarize your key findings concisely (1-2
sentences).
                     Output *only* the summary.
                     """)
         .description("Researches renewable energy sources.")
         .tools(googleSearchTool)
         .outputKey("renewable_energy_result") // Store result
in state
         .build();

     // Researcher 2: Electric Vehicles
     LlmAgent researcherAgent2 = LlmAgent.builder()
         .name("EVResearcher")
         .model(GEMINI_MODEL)
         .instruction("""
                     You are an AI Research Assistant
specializing in transportation.
```

```
                        Research the latest developments in
'electric vehicle technology'.
                        Use the Google Search tool provided.
                        Summarize your key findings concisely (1-2
sentences).
                        Output *only* the summary.
                        """)
          .description("Researches electric vehicle technology.")
          .tools(googleSearchTool)
          .outputKey("ev_technology_result") // Store result in
state
          .build();

     // Researcher 3: Carbon Capture
     LlmAgent researcherAgent3 = LlmAgent.builder()
          .name("CarbonCaptureResearcher")
          .model(GEMINI_MODEL)
          .instruction("""
                        You are an AI Research Assistant
specializing in climate solutions.
                        Research the current state of 'carbon
capture methods'.
                        Use the Google Search tool provided.
                        Summarize your key findings concisely (1-2
sentences).
                        Output *only* the summary.
                        """)
          .description("Researches carbon capture methods.")
          .tools(googleSearchTool)
          .outputKey("carbon_capture_result") // Store result in
state
          .build();

     // --- 2. Create the ParallelAgent (Runs researchers
concurrently) ---
     // This agent orchestrates the concurrent execution of the
researchers.
     // It finishes once all researchers have completed and
stored their results in state.
     ParallelAgent parallelResearchAgent =
         ParallelAgent.builder()
             .name("ParallelWebResearchAgent")
             .subAgents(researcherAgent1, researcherAgent2,
researcherAgent3)
             .description("Runs multiple research agents in
parallel to gather information.")
             .build();

     // --- 3. Define the Merger Agent (Runs *after* the
parallel agents) ---
     // This agent takes the results stored in the session state
by the parallel agents
     // and synthesizes them into a single, structured response
with attributions.
     LlmAgent mergerAgent =
         LlmAgent.builder()
             .name("SynthesisAgent")
             .model(GEMINI_MODEL)
             .instruction(
                 """
                       You are an AI Assistant responsible for
combining research findings into a structured report.
                       Your primary task is to synthesize the
following research summaries, clearly attributing findings to
their source areas. Structure your response using headings for
each topic. Ensure the report is coherent and integrates the key
points smoothly.
                       **Crucially: Your entire response MUST be
grounded *exclusively* on the information provided in the 'Input
Summaries' below. Do NOT add any external knowledge, facts, or
details not present in these specific summaries.**
                       **Input Summaries:**

                       *   **Renewable Energy:**
                           {renewable_energy_result}

                       *   **Electric Vehicles:**
                           {ev_technology_result}

                       *   **Carbon Capture:**
                           {carbon_capture_result}

                       **Output Format:**

                       ## Summary of Recent Sustainable
Technology Advancements

                       ### Renewable Energy Findings
                       (Based on RenewableEnergyResearcher's
findings)
                       [Synthesize and elaborate *only* on the
renewable energy input summary provided above.]

                       ### Electric Vehicle Findings
                       (Based on EVResearcher's findings)
                       [Synthesize and elaborate *only* on the
EV input summary provided above.]

                       ### Carbon Capture Findings
                       (Based on CarbonCaptureResearcher's
findings)
                       [Synthesize and elaborate *only* on the
carbon capture input summary provided above.]

                       ### Overall Conclusion
                       [Provide a brief (1-2 sentence)
concluding statement that connects *only* the findings presented
above.]

                       Output *only* the structured report
following this format. Do not include introductory or concluding
phrases outside this structure, and strictly adhere to using
only the provided input summary content.
                       """)
             .description(
                 "Combines research findings from parallel
agents into a structured, cited report, strictly grounded on
provided inputs.")
             // No tools needed for merging
             // No output_key needed here, as its direct
response is the final output of the sequence
             .build();

     // --- 4. Create the SequentialAgent (Orchestrates the
overall flow) ---
     // This is the main agent that will be run. It first
executes the ParallelAgent
     // to populate the state, and then executes the MergerAgent
to produce the final output.
     SequentialAgent sequentialPipelineAgent =
         SequentialAgent.builder()
             .name("ResearchAndSynthesisPipeline")
             // Run parallel research first, then merge
             .subAgents(parallelResearchAgent, mergerAgent)
             .description("Coordinates parallel research and
synthesizes the results.")
             .build();

     return sequentialPipelineAgent;
   }

   public static void runAgent(SequentialAgent
sequentialPipelineAgent, String query) {
     // Create an InMemoryRunner
     InMemoryRunner runner = new
InMemoryRunner(sequentialPipelineAgent, APP_NAME);
     // InMemoryRunner automatically creates a session service.
Create a session using the service
     Session session =
runner.sessionService().createSession(APP_NAME,
USER_ID).blockingGet();
     Content userMessage =
Content.fromParts(Part.fromText(query));

     // Run the agent
     Flowable<Event> eventStream = runner.runAsync(USER_ID,
session.id(), userMessage);

     // Stream event response
     eventStream.blockingForEach(
         event -> {
           if (event.finalResponse()) {
             System.out.printf("Event Author: %s \n Event
Response: %s \n\n\n", event.author(), event.stringifyContent());
           }
         });
   }
 }
```