Tutorial 11: Built-in Tools and Grounding - Search and Web Access

Difficulty: intermediate
Reading Time: 1 hour
Tags: intermediate, built-in-tools, grounding, search, web-access
Description: Use ADK's built-in tools for web search, grounding, and information retrieval to create agents with real-world knowledge access.

Tutorial 11: Built-in Tools & Grounding

Goal: Learn how to use Gemini 2.0+'s built-in tools for web grounding, location services, and enterprise search - enabling your agents to access current information from the internet.

Prerequisites:

- Tutorial 01 (Hello World Agent)
- Tutorial 02 (Function Tools)
- Gemini 2.0+ model access

What You'll Learn:

- Using `google_search` for web grounding
- Implementing location-based queries with `google_maps_grounding`
- Enterprise compliance search with `enterprise_web_search`
- Understanding `GoogleSearchAgentTool` workaround
- Tracking grounding metadata

- Building a production research assistant

Time to Complete: 45-60 minutes

Why Built-in Tools Matter

Traditional AI models have a knowledge cutoff date - they don't know about recent events, current news, or real-time information. Built-in tools solve this by allowing models to **ground their responses in current web data**.

Key Advantages:

- ✔️ **Current Information**: Access to up-to-date web content
- ✔️ **No Local Execution**: Tools run inside the model (no infrastructure needed)
- ✔️ **Automatic Integration**: Results seamlessly incorporated into responses
- ✔️ **Gemini 2.0+ Feature**: Leverage latest model capabilities
- ✔️ **Production Ready**: Used by real-world applications

Important: Built-in tools are **Gemini 2.0+ only** and raise errors with older models (1.5, 1.0).

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1. Google Search Tool (Web Grounding)

What is google_search?

`google_search` is a **built-in tool** that allows Gemini 2.0+ models to search the web and incorporate results into their responses. Unlike traditional tools, this executes **inside the model** - no local code runs.

Basic Usage

```
from google.adk.agents import Agent
from google.adk.tools import google_search
from google.adk.runners import Runner

# Create agent with google_search
agent = Agent(
    model='gemini-2.0-flash',  # Requires Gemini 2.0+
    name='web_researcher',
    instruction='You are a helpful assistant with access to current web inform
    tools=[google_search]  # Add built-in search capability
)

# Run agent - it can now search the web
runner = Runner()
result = runner.run(
    "What are the latest developments in quantum computing in 2025?",
    agent=agent
)

print(result.content.parts[0].text)
# Model searches web automatically and provides current answer
```

What Happens:

1. Model receives question about current events
2. Model decides to use `google_search` tool
3. Search executes **inside model environment**
4. Results incorporated into response
5. Answer includes up-to-date information with sources

How It Works Internally

Source: `google/adk/tools/google_search_tool.py`

```
# Internal implementation (simplified)
class GoogleSearchTool:
    def process_llm_request(self, llm_request):
        """Adds google_search to model's tool list."""
        # Add built-in search tool
        llm_request.tools.append(
            types.Tool(google_search=types.GoogleSearch())
        )

        # Model now knows it can search the web
        return llm_request
```

Key Details:

- No actual function implementation needed
- Model handles search execution internally
- Results appear in `GroundingMetadata`
- Errors raised for Gemini 1.x models

Grounding Metadata

When the model uses `google_search`, it stores metadata about the search:

```
from google.adk.agents import Agent, Runner
from google.adk.tools import google_search

agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_search]
)

runner = Runner()
result = runner.run(
    "What's the weather in San Francisco today?",
    agent=agent
)

# Access grounding metadata
# Temporarily stored in state during execution
# Key: temp:_adk_grounding_metadata
```

GroundingMetadata Structure:

```
{
    'web_search_queries': [
        'San Francisco weather today',
        'current temperature San Francisco'
    ],
    # Other grounding info...
}
```

Model Compatibility

```
# ✔️ Works with Gemini 2.0+
agent = Agent(model='gemini-2.0-flash', tools=[google_search])
agent = Agent(model='gemini-2.0-flash-exp', tools=[google_search])

# ❌ Raises error with Gemini 1.x
agent = Agent(model='gemini-1.5-flash', tools=[google_search])
# Error: google_search requires Gemini 2.0+
```

2. Google Maps Grounding Tool

What is google_maps_grounding?

`google_maps_grounding` enables location-based queries - finding nearby places, getting directions, understanding geographic context.

Basic Usage

```
from google.adk.agents import Agent
from google.adk.tools import google_maps_grounding
from google.adk.runners import Runner

agent = Agent(
    model='gemini-2.0-flash',  # Gemini 2.0+ only
    name='location_assistant',
    instruction='Help users with location-based queries.',
    tools=[google_maps_grounding]
)

runner = Runner()
result = runner.run(
    "What are the best Italian restaurants within 5 miles of Times Square, NYC
    agent=agent
)

print(result.content.parts[0].text)
# Model uses maps grounding for current location data
```

Use Cases

Navigation:

```
result = runner.run(
    "How do I get from JFK Airport to Central Park using public transit?",
    agent=agent
)
```

Local Discovery:

```
result = runner.run(
    "Find coffee shops open now near Stanford University.",
    agent=agent
)
```

Geographic Context:

```
result = runner.run(
    "What's the distance between Los Angeles and San Diego?",
    agent=agent
)
```

Important Constraints

VertexAI API Only:

```
# ✔️ Works with VertexAI
import os
os.environ['GOOGLE_GENAI_USE_VERTEXAI'] = '1'
os.environ['GOOGLE_CLOUD_PROJECT'] = 'my-project'
os.environ['GOOGLE_CLOUD_LOCATION'] = 'us-central1'

agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_maps_grounding]
)

# ❌ Not available with AI Studio API
os.environ['GOOGLE_GENAI_USE_VERTEXAI'] = '0'
# Maps grounding requires VertexAI
```

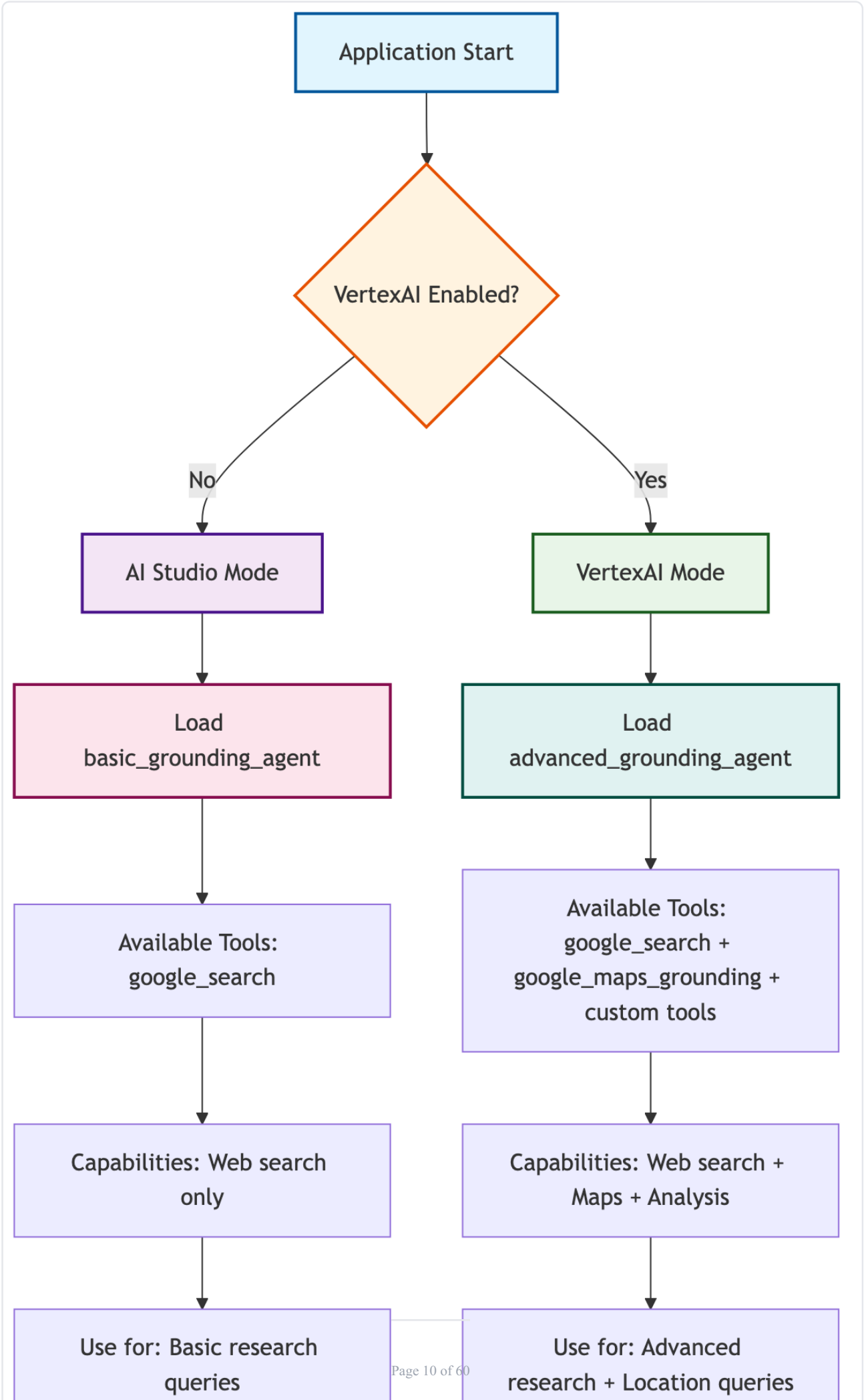
Conditional Environment Detection

For production applications, implement conditional tool loading based on environment:

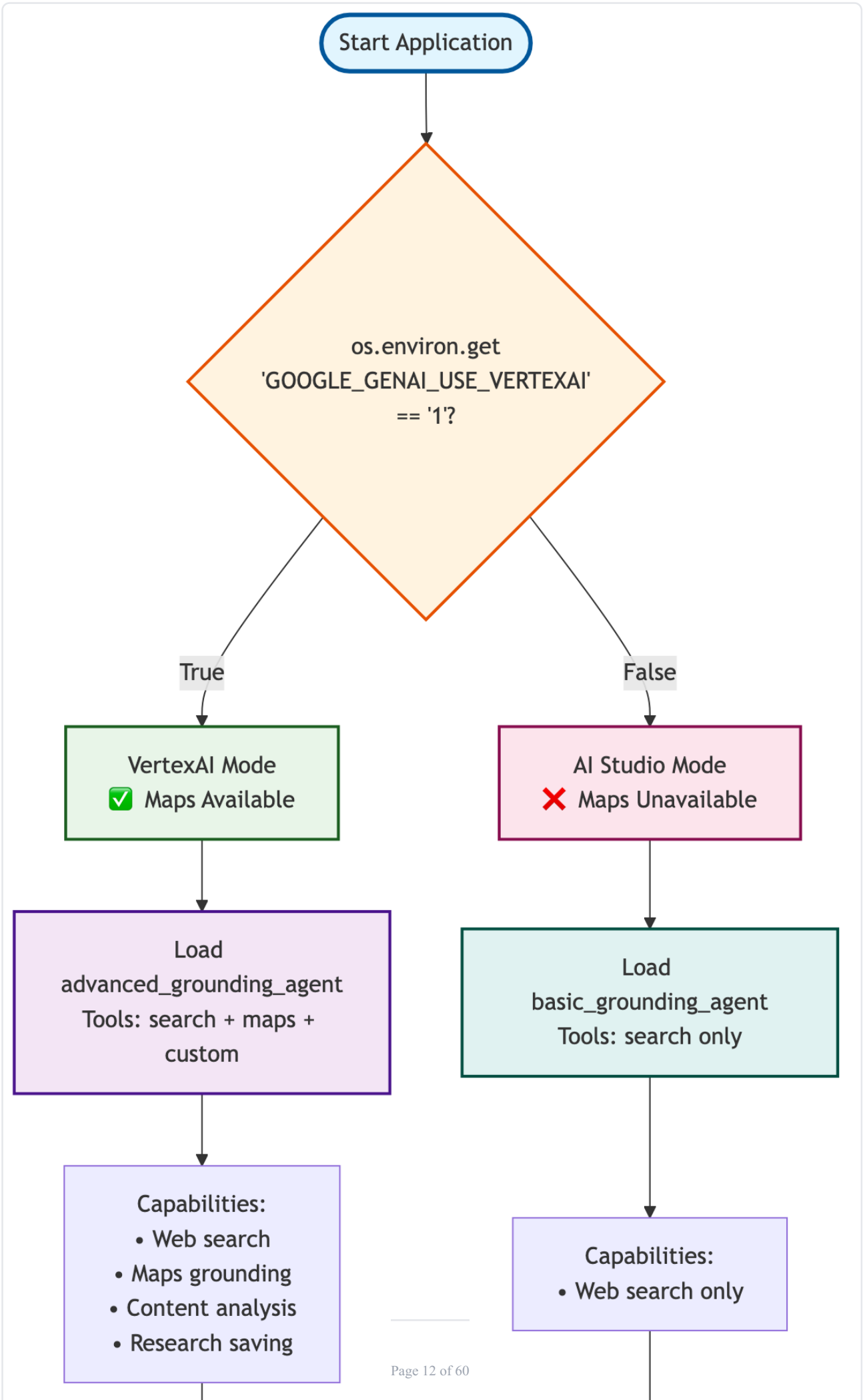
```
from google.adk.agents import Agent
from google.adk.tools import google_search, google_maps_grounding

def is_vertexai_enabled() -> bool:
    """Check if VertexAI is enabled via environment variable."""
    return os.environ.get('GOOGLE_GENAI_USE_VERTEXAI') == '1'

def get_available_grounding_tools():
    """Get available grounding tools based on environment."""
    tools = [google_search]  # Always available

    # Add maps grounding only if VertexAI is enabled
    if is_vertexai_enabled():
        tools.append(google_maps_grounding)

    return tools

def get_agent_capabilities_description() -> str:
    """Get description of agent capabilities based on available tools."""
    capabilities = ["web search for current information"]

    if is_vertexai_enabled():
        capabilities.append("location-based queries and maps grounding")

    return " and ".join(capabilities)

# Create agent with conditional tools
agent = Agent(
    model='gemini-2.0-flash',
    name='conditional_grounding_agent',
    instruction=f"""You are a research assistant with access to {get_agent_cap

When asked questions:
1. Use google_search to find current, accurate information
{"2. Use google_maps_grounding for location-based queries when available" if i
{("3. " if is_vertexai_enabled() else "2. ")}Provide clear, factual answers ba
{("4. " if is_vertexai_enabled() else "3. ")}Always cite that information come
{("5. " if is_vertexai_enabled() else "4. ")}If information seems outdated or

Be helpful, accurate, and indicate when you're using search capabilities.""",
    tools=get_available_grounding_tools()
)
```

This approach ensures your agent works in both AI Studio (web search only) and VertexAI (web search + maps) environments automatically.

Agent Selection Flow


Application Start
VertexAI Enabled?
No
Yes
AI Studio Mode
VertexAI Mode
Load basic_grounding_agent
Load advanced_grounding_agent
Available Tools: google_search
Available Tools: google_search + google_maps_grounding + custom tools
Capabilities: Web search only
Capabilities: Web search + Maps + Analysis
Use for: Basic research queries
Use for: Advanced research + Location queries

Environment Detection Logic


Start Application
os.environ.get 'GOOGLE_GENAI_USE_VERTEXAI' == '1'?
True
False
VertexAI Mode
✅ Maps Available
AI Studio Mode
❌ Maps Unavailable
Load advanced_grounding_agent
Tools: search + maps + custom
Load basic_grounding_agent
Tools: search only
Capabilities:
• Web search
• Maps grounding
• Content analysis
• Research saving
Capabilities:
• Web search only

3. Enterprise Web Search Tool

What is enterprise_web_search?

`enterprise_web_search` provides **enterprise-compliant web grounding** with additional controls for corporate environments.

Documentation: Web Grounding for Enterprise (https://cloud.google.com/vertex-ai/generative-ai/docs/grounding/web-grounding-enterprise)

Basic Usage

```
from google.adk.agents import Agent
from google.adk.tools import enterprise_web_search
from google.adk.runners import Runner

agent = Agent(
    model='gemini-2.0-flash',  # Gemini 2+ only
    name='enterprise_assistant',
    instruction='Provide information using enterprise-compliant sources.',
    tools=[enterprise_web_search]
)

runner = Runner()
result = runner.run(
    "What are the latest GDPR compliance requirements?",
    agent=agent
)

print(result.content.parts[0].text)
# Uses enterprise search with compliance controls
```

When to Use Enterprise Search

Use `enterprise_web_search` **when**:

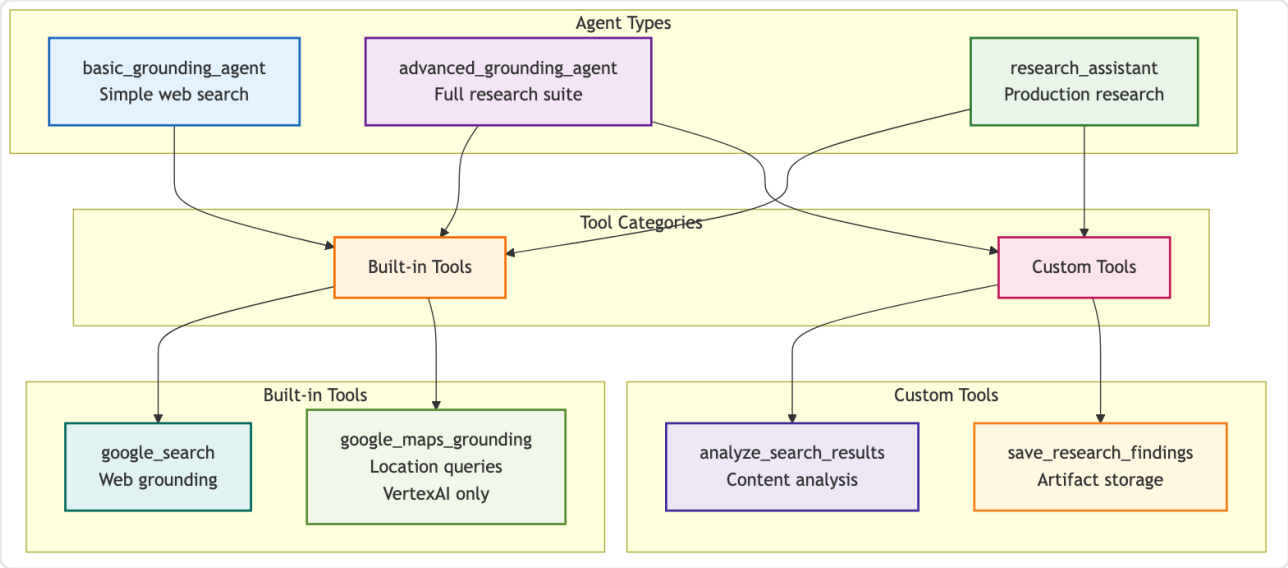
- Operating in corporate/regulated environments
- Need audit trails for information sources

- Require content filtering and compliance
- Want controlled web access
- Building enterprise applications

Use `google_search` when:

- Building consumer applications
- Need general web information
- Don't have enterprise compliance requirements
- Want simpler setup

Agent Hierarchy & Tool Composition



4. GoogleSearchAgentTool (Workaround)

The Problem

Current Limitation: Built-in tools (like `google_search`) **cannot be combined** with custom function tools in the same agent.

```
# ❌ This doesn't work as expected
from google.adk.tools import google_search, FunctionTool

def my_custom_tool(query: str) -> str:
    return f"Custom result for: {query}"

agent = Agent(
    model='gemini-2.0-flash',
    tools=[
        google_search,  # Built-in tool
        FunctionTool(my_custom_tool)  # Custom tool
    ]
)
# Only one type of tool will work
```

The Workaround: GoogleSearchAgentTool

`GoogleSearchAgentTool` creates a **sub-agent with google_search** and wraps it as a regular tool.

Source: `google/adk/tools/google_search_agent_tool.py`

```python
from google.adk.agents import Agent
from google.adk.tools import GoogleSearchAgentTool, FunctionTool
from google.adk.runners import Runner

# Custom tool
def calculate_tax(amount: float, rate: float) -> float:
    """Calculate tax on amount."""
    return amount * rate

# Create GoogleSearchAgentTool wrapper
search_tool = GoogleSearchAgentTool()

# Now you can combine them!
agent = Agent(
    model='gemini-2.0-flash',
    name='hybrid_assistant',
    instruction='Answer questions using both web search and calculations.',
    tools=[
        search_tool,  # Wrapped google_search
        FunctionTool(calculate_tax)  # Custom tool
    ]
)

runner = Runner()

# Use both tools
result = runner.run(
    "What's the current California sales tax rate, and how much tax on $100?",
    agent=agent
)

print(result.content.parts[0].text)
# Agent uses search for tax rate, calculation for amount
```

How GoogleSearchAgentTool Works

```
# Internal implementation (simplified)
class GoogleSearchAgentTool:
    def __init__(self):
        # Create sub-agent with google_search
        self.search_agent = Agent(
            model='gemini-2.0-flash',
            tools=[google_search]
        )

    async def _run_async_impl(self, query: str, tool_context):
        """Run search via sub-agent."""
        runner = Runner()
        result = await runner.run_async(query, agent=self.search_agent)

        # Forward grounding metadata to parent
        if 'temp:_adk_grounding_metadata' in result.state:
            tool_context.invocation_context.state[
                'temp:_adk_grounding_metadata'
            ] = result.state['temp:_adk_grounding_metadata']

        return result.content.parts[0].text
```

Helper Function

```
from google.adk.tools.google_search_agent_tool import create_google_search_age

# Create preconfigured search agent
search_agent = create_google_search_agent()

# Use as sub-agent
main_agent = Agent(
    name='orchestrator',
    sub_agents=[search_agent],
    flow='sequential'
)
```

When the Workaround Won't Be Needed

```
# TODO(b/448114567): Remove once workaround no longer needed
# Google is working on allowing built-in + custom tools together
# Check ADK releases for updates
```

5. Real-World Example: Research Assistant

Let's build a production-ready research assistant that can search the web, process results, and provide citations.

Research Workflow

```
sequenceDiagram
    participant U as User
    participant A as Agent
    participant S as google_search
    participant M as google_maps_grounding
    participant T1 as analyze_search_results
    participant T2 as save_research_findings

    U->>A: Research query
    A->>S: Search web for information
    S-->>A: Search results
    A->>M: Location-based queries (if VertexAI)
    M-->>A: Maps data (if available)
    A->>T1: Analyze search results
    T1-->>A: Analysis insights
    A->>T2: Save research findings
    T2-->>A: Saved artifact confirmation
    A-->>U: Comprehensive research response

    Note over S,M: Built-in tools (automatic)
    Note over T1,T2: Custom tools (manual implementation)

    style U fill:#e3f2fd,stroke:#1565c0
    style A fill:#f3e5f5,stroke:#6a1b9a
    style S fill:#e8f5e8,stroke:#2e7d32
    style M fill:#fff3e0,stroke:#ef6c00
    style T1 fill:#fce4ec,stroke:#c2185b
    style T2 fill:#e0f2f1,stroke:#00695c
```

Complete Implementation

```
"""
Research Assistant with Web Grounding
Searches web, extracts key information, provides citations.
"""

import asyncio
import os
from datetime import datetime
from google.adk.agents import Agent, Runner
from google.adk.tools import google_search, FunctionTool, GoogleSearchAgentToo
from google.adk.tools.tool_context import ToolContext
from google.genai import types

# Environment setup
os.environ['GOOGLE_GENAI_USE_VERTEXAI'] = '1'
os.environ['GOOGLE_CLOUD_PROJECT'] = 'your-project-id'
os.environ['GOOGLE_CLOUD_LOCATION'] = 'us-central1'

# Custom tool: Save research notes
async def save_research_notes(
    topic: str,
    findings: str,
    tool_context: ToolContext
) -> str:
    """Save research findings as artifact."""

    # Create research document
    timestamp = datetime.now().strftime('%Y-%m-%d %H:%M:%S')
    document = f"""
# Research Report: {topic}
Generated: {timestamp}

## Findings
{findings}

## Metadata
- Topic: {topic}
- Generated by: Research Assistant
- Model: gemini-2.0-flash
    """.strip()

    # Save as artifact
    filename = f"research_{topic.replace(' ', '_')}.md"
    version = await tool_context.save_artifact(
        filename=filename,
        part=types.Part.from_text(document)
```

```
    )

    return f"Research saved as {filename} (version {version})"

# Custom tool: Extract key facts
def extract_key_facts(text: str, num_facts: int = 5) -> list[str]:
    """Extract key facts from text (simplified)."""
    # In production, use more sophisticated extraction
    sentences = text.split('.')
    return sentences[:num_facts]

# Create search tool (using workaround for mixing with custom tools)
search_tool = GoogleSearchAgentTool()

# Create research assistant
research_assistant = Agent(
    model='gemini-2.0-flash',
    name='research_assistant',
    description='Conducts web research and compiles findings',
    instruction="""
You are an expert research assistant with access to:
1. Web search via search_tool
2. Fact extraction via extract_key_facts
3. Note saving via save_research_notes

When given a research topic:
1. Use search_tool to find current information
2. Extract key facts using extract_key_facts
3. Synthesize findings into clear summary
4. Save research using save_research_notes
5. Provide summary with key points

Be comprehensive but concise. Always cite your sources.
    """.strip(),
    tools=[
        search_tool,
        FunctionTool(extract_key_facts),
        FunctionTool(save_research_notes)
    ],
    generate_content_config=types.GenerateContentConfig(
        temperature=0.3,  # Lower for factual accuracy
        max_output_tokens=2048
    )
)

async def conduct_research(topic: str):
    """Conduct comprehensive research on topic."""
```

```
    print(f"\n{'='*60}")
    print(f"RESEARCH TOPIC: {topic}")
    print(f"{'='*60}\n")

    runner = Runner()

    # Run research
    result = await runner.run_async(
        f"Research this topic and provide a comprehensive summary: {topic}",
        agent=research_assistant
    )

    # Display results
    print("\n📊 RESEARCH RESULTS:\n")
    print(result.content.parts[0].text)

    # Check if grounding metadata available
    if 'temp:_adk_grounding_metadata' in result.state:
        metadata = result.state['temp:_adk_grounding_metadata']
        if 'web_search_queries' in metadata:
            print("\n\n🔍 SEARCH QUERIES USED:")
            for query in metadata['web_search_queries']:
                print(f"  - {query}")

    print(f"\n{'='*60}\n")

# Example usage
async def main():
    """Run research examples."""

    # Research recent technology
    await conduct_research(
        "Quantum computing breakthroughs in 2025"
    )

    await asyncio.sleep(2)

    # Research current events
    await conduct_research(
        "Latest developments in renewable energy technology"
    )

    await asyncio.sleep(2)

    # Research scientific topic
    await conduct_research(
```

```
        "CRISPR gene editing applications in medicine"
    )

if __name__ == '__main__':
    asyncio.run(main())
```

Running the Research Assistant

Setup:

```
# Install dependencies
pip install google-adk

# Set environment

# Run
python research_assistant.py
```

Expected Output:

```
============================================================
RESEARCH TOPIC: Quantum computing breakthroughs in 2025
============================================================

📊 RESEARCH RESULTS:

# Quantum Computing Breakthroughs in 2025

## Overview
Recent developments in quantum computing have shown significant progress...

## Key Developments
1. **Error Correction**: New quantum error correction codes...
2. **Qubit Scaling**: IBM announced a 1000+ qubit processor...
3. **Practical Applications**: Google demonstrated quantum advantage...

## Impact
These breakthroughs represent major steps toward practical quantum computers..

[Research saved as research_quantum_computing_breakthroughs_in_2025.md (versio

🔍 SEARCH QUERIES USED:
  - quantum computing 2025 breakthroughs
  - latest quantum computer developments
  - quantum computing applications 2025

============================================================
```

6. Memory Tools - Persistent State Management

Source: `google/adk/tools/__init__.py`, `google/adk/tools/memory_tools.py`

ADK provides built-in tools for managing persistent memory across agent sessions. These tools enable agents to store, retrieve, and manage context that persists beyond single conversations.

load_memory - Load Persistent Memory

Load previously saved memory state into the current session.

```
from google.adk.agents import Agent
from google.adk.tools import load_memory
from google.adk.runners import Runner

agent = Agent(
    model='gemini-2.5-flash',
    name='memory_agent',
    instruction='You can remember information from previous conversations usin
    tools=[load_memory]
)

runner = Runner()
result = runner.run(
    "Load my previous conversation history and summarize what we discussed.",
    agent=agent
)
```

When to use:

- Multi-session conversations
- Resuming previous work
- Accessing historical context
- Building long-term memory systems

preload_memory - Initialize Memory

Preload memory state before agent execution starts.

```
from google.adk.tools import preload_memory

agent = Agent(
    model='gemini-2.5-flash',
    name='preloaded_agent',
    instruction='You have access to preloaded user preferences and context.',
    tools=[preload_memory]
)

# Memory loads automatically before first turn
```

When to use:

- User preference initialization
- Session setup
- Context bootstrapping
- Pre-loading known information

load_artifacts - Access Stored Data

Load previously saved artifacts (documents, files, data) into the conversation.

```
from google.adk.tools import load_artifacts

agent = Agent(
    model='gemini-2.5-flash',
    name='artifact_agent',
    instruction='You can load and reference saved documents using load_artifac
    tools=[load_artifacts]
)

runner = Runner()
result = runner.run(
    "Load the research document from last week and continue where we left off.
    agent=agent
)
```

When to use:

- Document retrieval
- Data access

- File management
- Content continuation

---

7. Workflow Tools - Agent Control Flow

Source: `google/adk/tools/__init__.py`, `google/adk/tools/workflow_tools.py`

Workflow tools allow agents to control their own execution flow and interact with user orchestration.

exit_loop - Terminate Execution

Allow the agent to decide when to stop execution in a loop.

```
from google.adk.agents import Agent
from google.adk.tools import exit_loop

agent = Agent(
    model='gemini-2.5-flash',
    name='loop_agent',
    instruction="""
Process tasks until complete, then call exit_loop.
You decide when work is finished.
    """,
    tools=[exit_loop]
)

# Agent will call exit_loop when satisfied
```

When to use:

- Iterative processing
- Agent-controlled termination
- Dynamic execution length
- Self-directed workflows

get_user_choice - Request User Input

Request explicit user input during execution.

```
from google.adk.tools import get_user_choice

agent = Agent(
    model='gemini-2.5-flash',
    name='interactive_agent',
    instruction="""
When you need clarification, use get_user_choice to ask the user.
Wait for their response before proceeding.
    """,
    tools=[get_user_choice]
)

runner = Runner()
result = runner.run(
    "Help me plan a vacation.",
    agent=agent
)

# Agent may call: get_user_choice("What's your budget: high, medium, or low?")
# User provides answer
# Agent continues with that information
```

When to use:

- Ambiguity resolution
- User preference collection
- Interactive workflows
- Decision points requiring human input

transfer_to_agent - Agent Handoff

Transfer control to another agent in a multi-agent system.

```
from google.adk.agents import Agent
from google.adk.tools import transfer_to_agent

# Specialist agents
coding_agent = Agent(
    model='gemini-2.5-pro',
    name='coding_expert',
    instruction='You are an expert programmer.'
)

research_agent = Agent(
    model='gemini-2.5-flash',
    name='research_expert',
    instruction='You are a research specialist.'
)

# Router agent
router_agent = Agent(
    model='gemini-2.5-flash',
    name='router',
    instruction="""
Analyze the user's request and transfer to the appropriate specialist:
- For coding questions, transfer to coding_expert
- For research questions, transfer to research_expert
Use transfer_to_agent tool.
    """,
    sub_agents=[coding_agent, research_agent],
    tools=[transfer_to_agent]
)

runner = Runner()
result = runner.run(
    "Explain how quicksort works and implement it in Python.",
    agent=router_agent
)

# Router transfers to coding_expert automatically
```

When to use:

- Multi-agent orchestration
- Specialist agent routing
- Dynamic workflow routing
- Complex task delegation

8. Context Tools - External Data Access

Source: `google/adk/tools/url_context_tool.py`

Context tools enable agents to access external data sources during execution.

url_context - Load Content from URLs

Fetch and incorporate content from URLs into the conversation.

```
from google.adk.agents import Agent
from google.adk.tools import url_context
from google.adk.runners import Runner

agent = Agent(
    model='gemini-2.5-flash',
    name='url_agent',
    instruction='You can load content from URLs using url_context to answer qu
    tools=[url_context]
)

runner = Runner()
result = runner.run(
    "Summarize the content from https://example.com/article",
    agent=agent
)

# Agent calls url_context("https://example.com/article")
# Content loaded and analyzed
```

When to use:

- Document analysis
- Web content summarization
- External data integration
- Dynamic content loading

Note: Requires appropriate permissions and respects robots.txt.

9. Enterprise Tools - Production Systems

Source: `google/adk/tools/__init__.py`, `google/adk/tools/vertex_ai_search_tool.py`

Enterprise tools connect agents to Google Cloud production services.

VertexAiSearchTool - Enterprise Search

Connect to Vertex AI Search (formerly Discovery Engine) for enterprise-grade search.

```
from google.adk.agents import Agent
from google.adk.tools import VertexAiSearchTool
from google.adk.runners import Runner

# Create Vertex AI Search tool
search_tool = VertexAiSearchTool(
    project_id='your-project-id',
    location='global',
    data_store_id='your-datastore-id'
)

agent = Agent(
    model='gemini-2.5-flash',
    name='enterprise_search_agent',
    instruction='Search the enterprise knowledge base using vertex_ai_search.'
    tools=[search_tool]
)

runner = Runner()
result = runner.run(
    "Find company policies related to remote work.",
    agent=agent
)
```

When to use:

- Enterprise document search
- Internal knowledge bases
- Compliance requirements
- Corporate data access

Requirements:

- Google Cloud Project
- Vertex AI Search configured
- Data store created and populated
- Appropriate IAM permissions

DiscoveryEngineSearchTool - Legacy Search

Older name for VertexAiSearchTool (same functionality).

```
from google.adk.tools import DiscoveryEngineSearchTool

# Equivalent to VertexAiSearchTool
search_tool = DiscoveryEngineSearchTool(
    project_id='your-project-id',
    location='global',
    engine_id='your-engine-id'
)
```

Migration: Use `VertexAiSearchTool` for new projects.

---

10. Integration Wrappers - Third-Party Tools

Source: `google/adk/tools/__init__.py`

ADK provides wrappers to integrate third-party framework tools.

LangchainTool - LangChain Integration

Wrap any LangChain tool for use in ADK agents.

```python
from google.adk.tools import LangchainTool
from google.adk.agents import Agent
from langchain_community.tools import TavilySearchResults

# Create LangChain tool
tavily = TavilySearchResults(max_results=5)

# Wrap for ADK
adk_tavily = LangchainTool(tool=tavily)

agent = Agent(
    model='gemini-2.5-flash',
    name='langchain_agent',
    instruction='Use tavily_search for web searches.',
    tools=[adk_tavily]
)
```

When to use:

- Leveraging LangChain ecosystem (100+ tools)
- Existing LangChain integrations
- Community-built tools
- Rapid prototyping with existing tools

Installation: `pip install langchain_community tavily-python`

CrewaiTool - CrewAI Integration

Wrap CrewAI tools for ADK.

```python
from google.adk.tools import CrewaiTool
from crewai_tools import SerperDevTool

# Create CrewAI tool
serper = SerperDevTool(n_results=10)

# Wrap for ADK (must provide name and description!)
adk_serper = CrewaiTool(
    name="InternetNewsSearch",
    description="Searches the internet for news articles",
    tool=serper
)

agent = Agent(
    model='gemini-2.5-flash',
    name='crewai_agent',
    instruction='Use InternetNewsSearch for finding news.',
    tools=[adk_serper]
)
```

Critical: CrewAI tools require explicit name and description (unlike LangChain).

When to use:

- CrewAI tool ecosystem (20+ tools)
- Existing CrewAI workflows
- Specialized CrewAI integrations

Installation: `pip install crewai-tools`

---

11. Tool Classes & Toolsets

Source: `google/adk/tools/__init__.py`

ADK provides base classes and toolsets for advanced tool management.

FunctionTool - Function Wrapper

Wrap regular Python functions as tools (covered in Tutorial 02).

```
from google.adk.tools import FunctionTool

def calculate_tax(amount: float, rate: float) -> float:
    """Calculate tax on amount."""
    return amount * rate

# Wrap as tool
tax_tool = FunctionTool(calculate_tax)

agent = Agent(
    model='gemini-2.5-flash',
    tools=[tax_tool]
)
```

AgentTool - Agent as Tool

Wrap an entire agent as a tool for another agent.

```
from google.adk.tools import AgentTool
from google.adk.agents import Agent

# Specialist agent
math_agent = Agent(
    model='gemini-2.5-pro',
    name='math_expert',
    instruction='Solve complex math problems.'
)

# Wrap as tool
math_tool = AgentTool(agent=math_agent)

# Use in another agent
orchestrator = Agent(
    model='gemini-2.5-flash',
    name='orchestrator',
    instruction='Use math_expert for complex calculations.',
    tools=[math_tool]
)
```

When to use:

- Agent composition
- Specialist delegation

- Modular agent architectures

MCPToolset - Model Context Protocol

Access external MCP servers (covered in Tutorial 16).

```
from google.adk.tools import MCPToolset

# Connect to MCP server
mcp_tools = MCPToolset(
    server_uri='http://localhost:3000/mcp',
    description='External tool server'
)

agent = Agent(
    model='gemini-2.5-flash',
    name='mcp_agent',
    instruction='Use MCP tools for external capabilities.',
    tools=[mcp_tools]
)
```

When to use:

- External tool servers
- Third-party integrations
- Standardized tool protocols
- Microservice architectures

OpenAPIToolset - REST API Integration

Automatically generate tools from OpenAPI specifications (covered in Tutorial 03).

```python
from google.adk.tools import OpenAPIToolset

# Load API from OpenAPI spec
api_tools = OpenAPIToolset.from_url(
    'https://api.example.com/openapi.json',
    allow_operations=['GetUser', 'CreateOrder']
)

agent = Agent(
    model='gemini-2.5-flash',
    name='api_agent',
    instruction='Use API tools to interact with external services.',
    tools=[api_tools]
)
```

When to use:

- REST API integration
- External service access
- Auto-generated tool interfaces
- API-first architectures

---

12. Complete Builtin Tools Reference

Source: `google/adk/tools/__init__.py`

Here's the comprehensive list of all ADK builtin tools:

Grounding Tools (3)

- ✔️ `google_search` - Web search grounding (Gemini 2.0+)
- ✔️ `google_maps_grounding` - Location-based queries (VertexAI only)
- ✔️ `enterprise_web_search` - Enterprise-compliant web search

Memory Tools (3)

- ✔️ `load_memory` - Load persistent memory state

- ✔️ `preload_memory` - Preload memory before execution
- ✔️ `load_artifacts` - Load saved artifacts/documents

Workflow Tools (3)

- ✔️ `exit_loop` - Agent-controlled termination
- ✔️ `get_user_choice` - Request user input
- ✔️ `transfer_to_agent` - Agent handoff

Context Tools (1)

- ✔️ `url_context` - Load content from URLs

Enterprise Tools (2)

- ✔️ `VertexAiSearchTool` - Enterprise search (Vertex AI Search)
- ✔️ `DiscoveryEngineSearchTool` - Legacy name for VertexAiSearchTool

Integration Wrappers (2)

- ✔️ `LangchainTool` - Wrap LangChain tools
- ✔️ `CrewaiTool` - Wrap CrewAI tools

Tool Classes (5)

- ✔️ `FunctionTool` - Wrap Python functions
- ✔️ `AgentTool` - Wrap agents as tools
- ✔️ `GoogleSearchAgentTool` - Wrapped google_search for mixing
- ✔️ `Tool` - Base tool class
- ✔️ `AsyncTool` - Base async tool class

Toolsets (3)

- ✔️ `MCPToolset` - Model Context Protocol integration
- ✔️ `OpenAPIToolset` - REST API integration

- ✔️ `Toolset` - Base toolset class

Framework Integration (1)

- ✔️ AG-UI Protocol - Agent-Human Interaction (via `research/ag-ui/`)

Specialized Tools (2)

- ✔️ `McpTool` - Individual MCP tool wrapper
- ✔️ `OpenApiTool` - Individual OpenAPI endpoint wrapper

Total: 30+ builtin tools and classes

---

13. Real-World Example: Comprehensive Agent System

Let's build an agent that uses multiple builtin tool categories:

```
"""
Comprehensive Multi-Tool Agent
Demonstrates: Grounding, Memory, Workflow, Context, Enterprise tools
"""

import os
import asyncio
from google.adk.agents import Agent, Runner
from google.adk.tools import (
    google_search,
    load_memory,
    load_artifacts,
    exit_loop,
    transfer_to_agent,
    url_context,
    FunctionTool
)
from google.genai import types

# Environment setup
os.environ['GOOGLE_GENAI_USE_VERTEXAI'] = '1'
os.environ['GOOGLE_CLOUD_PROJECT'] = 'your-project'
os.environ['GOOGLE_CLOUD_LOCATION'] = 'us-central1'

# Custom analysis function
def analyze_data(data: str) -> dict:
    """Analyze data and return insights."""
    # Simplified analysis
    word_count = len(data.split())
    return {
        "status": "success",
        "report": f"Analysis: {word_count} words, data quality: good"
    }

# Specialist: Research agent
research_agent = Agent(
    model='gemini-2.5-flash',
    name='research_specialist',
    instruction="""
You are a research specialist. Use google_search and url_context
to gather comprehensive information. Save important findings
using load_artifacts.
    """,
    tools=[google_search, url_context, load_artifacts]
)
```

```
# Specialist: Data analyst
analyst_agent = Agent(
    model='gemini-2.5-pro',
    name='data_analyst',
    instruction="""
You are a data analyst. Use analyze_data to process information.
Provide detailed insights and recommendations.
    """,
    tools=[FunctionTool(analyze_data)]
)

# Main orchestrator
orchestrator = Agent(
    model='gemini-2.5-flash',
    name='orchestrator',
    description='Multi-tool agent system',
    instruction="""
You coordinate research and analysis tasks:

1. Load previous context using load_memory if continuing work
2. For research tasks, transfer to research_specialist
3. For data analysis, transfer to data_analyst
4. When work is complete, call exit_loop

You decide the workflow based on user needs.
    """,
    sub_agents=[research_agent, analyst_agent],
    tools=[
        load_memory,
        transfer_to_agent,
        exit_loop
    ],
    generate_content_config=types.GenerateContentConfig(
        temperature=0.3
    )
)

async def main():
    """Run comprehensive agent system."""

    runner = Runner()

    print("="*60)
    print("COMPREHENSIVE AGENT SYSTEM")
    print("="*60 + "\n")

    query = """
```

```
    Research the latest developments in quantum computing,
    analyze the key technological breakthroughs,
    and provide strategic recommendations.
    """

    result = await runner.run_async(query, agent=orchestrator)

    print("\n📊 RESULT:\n")
    print(result.content.parts[0].text)

    print("\n" + "="*60 + "\n")

if __name__ == '__main__':
    asyncio.run(main())
```

Expected Workflow:

1. Orchestrator receives query
2. Loads any previous memory (if continuing session)
3. Transfers to research_specialist
4. Research agent uses google_search for quantum computing news
5. Research agent uses url_context to load article content
6. Research agent saves findings with load_artifacts
7. Control returns to orchestrator
8. Orchestrator transfers to data_analyst
9. Analyst processes findings with analyze_data
10. Analyst provides strategic recommendations
11. Control returns to orchestrator
12. Orchestrator calls exit_loop when satisfied
13. Final response compiled

---

14. Advanced Patterns

Pattern 1: Multi-Source Research

Combine multiple built-in tools for comprehensive research:

```
from google.adk.agents import Agent
from google.adk.tools import google_search, google_maps_grounding

# Agent with multiple grounding sources
multi_source_agent = Agent(
    model='gemini-2.0-flash',
    name='multi_source_researcher',
    instruction="""
Use all available tools to provide comprehensive answers:
- google_search for web information
- google_maps_grounding for location data

Synthesize information from multiple sources.
    """,
    tools=[google_search, google_maps_grounding]
)

runner = Runner()
result = runner.run(
    "What are the top tech companies in Silicon Valley and where are they loca
    agent=multi_source_agent
)
# Uses both web search and maps grounding
```

Pattern 2: Fact-Checking Agent

Build an agent that verifies claims using web search:

```
fact_checker = Agent(
    model='gemini-2.0-flash',
    name='fact_checker',
    instruction="""
You are a fact-checking assistant. For each claim:
1. Search the web for authoritative sources
2. Compare claim against found information
3. Provide verdict: TRUE, FALSE, or NEEDS_CONTEXT
4. Cite sources

Be objective and thorough.
    """,
    tools=[google_search],
    generate_content_config=types.GenerateContentConfig(
        temperature=0.1  # Very low for accuracy
    )
)

runner = Runner()
result = runner.run(
    "Check this claim: 'The Great Wall of China is visible from space.'",
    agent=fact_checker
)
```

Pattern 3: Trend Analysis

Analyze current trends using time-based searches:

```
trend_analyzer = Agent(
    model='gemini-2.0-flash',
    name='trend_analyzer',
    instruction="""
Analyze trends by searching for information from different time periods.
Compare current information with past data.
Identify patterns and changes over time.
    """,
    tools=[google_search]
)

runner = Runner()
result = runner.run(
    """
Analyze the trend of electric vehicle adoption:
- Current status (2025)
- Growth over past 3 years
- Projections for next 2 years
    """,
    agent=trend_analyzer
)
```

Pattern 4: Competitive Intelligence

Research competitors using web search:

```
competitive_intel = Agent(
    model='gemini-2.0-flash',
    name='competitive_intel',
    instruction="""
Research companies and provide competitive analysis:
- Products and services
- Recent news and announcements
- Market position
- Strengths and weaknesses

Focus on publicly available information only.
    """,
    tools=[google_search]
)

runner = Runner()
result = runner.run(
    "Provide competitive analysis of OpenAI, Anthropic, and Google DeepMind",
    agent=competitive_intel
)
```

7. Best Practices

✔️ DO: Use Appropriate Model

```
# ✔️ Good - Gemini 2.0+
agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_search]
)

# ❌ Bad - Wrong model version
agent = Agent(
    model='gemini-1.5-flash',  # Will raise error
    tools=[google_search]
)
```

✔️ DO: Handle Mixed Tools Correctly

```
# ✔️ Good - Use GoogleSearchAgentTool for mixing
from google.adk.tools import GoogleSearchAgentTool, FunctionTool

agent = Agent(
    model='gemini-2.0-flash',
    tools=[
        GoogleSearchAgentTool(),  # Wrapped
        FunctionTool(my_custom_function)
    ]
)

# ❌ Bad - Direct mixing doesn't work
agent = Agent(
    model='gemini-2.0-flash',
    tools=[
        google_search,  # Built-in
        FunctionTool(my_custom_function)  # Custom
    ]
)
```

✔️ DO: Set Low Temperature for Facts

```
# ✔️ Good - Low temperature for factual queries
agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_search],
    generate_content_config=types.GenerateContentConfig(
        temperature=0.2  # More deterministic
    )
)

# ❌ Bad - High temperature for facts
agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_search],
    generate_content_config=types.GenerateContentConfig(
        temperature=0.9  # Too creative for facts
    )
)
```

✔️ DO: Provide Clear Instructions

```
# ✔️ Good - Clear search guidance
agent = Agent(
    model='gemini-2.0-flash',
    instruction="""
When answering questions:
1. Use web search for current information
2. Always cite sources
3. Verify facts from multiple sources
4. Indicate if information is uncertain
    """,
    tools=[google_search]
)

# ❌ Bad - Vague instructions
agent = Agent(
    model='gemini-2.0-flash',
    instruction="Answer questions",
    tools=[google_search]
)
```

✔️ DO: Check VertexAI Requirements

```
# ✔️ Good - Check API type for maps
if os.environ.get('GOOGLE_GENAI_USE_VERTEXAI') == '1':
    agent = Agent(
        model='gemini-2.0-flash',
        tools=[google_maps_grounding]
    )
else:
    print("Maps grounding requires VertexAI")
```

8. Troubleshooting

Error: "google_search requires Gemini 2.0+"

Problem: Using google_search with Gemini 1.x model

Solution:

```
# ❌ This causes error
agent = Agent(
    model='gemini-1.5-flash',
    tools=[google_search]
)

# ✔️ Use Gemini 2.0+
agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_search]
)
```

Error: "Built-in tools not working with custom tools"

Problem: Trying to mix built-in and custom tools directly

Solution:

```
# ❌ Doesn't work
agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_search, FunctionTool(my_func)]
)

# ✔️ Use GoogleSearchAgentTool wrapper
agent = Agent(
    model='gemini-2.0-flash',
    tools=[GoogleSearchAgentTool(), FunctionTool(my_func)]
)
```

Error: "Maps grounding not available"

Problem: Using AI Studio API instead of VertexAI

Solution:

```
# ❌ AI Studio doesn't support maps
os.environ['GOOGLE_GENAI_USE_VERTEXAI'] = '0'
agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_maps_grounding]  # Error
)

# ✔️ Use VertexAI
os.environ['GOOGLE_GENAI_USE_VERTEXAI'] = '1'
os.environ['GOOGLE_CLOUD_PROJECT'] = 'your-project'
os.environ['GOOGLE_CLOUD_LOCATION'] = 'us-central1'

agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_maps_grounding]  # Works
)
```

Issue: "Search results not appearing in response"

Problem: Model not using search tool

Solutions:

1. **Make query require current information**:

```
# ❌ Model might not search
result = runner.run("What is AI?", agent=agent)

# ✔️ Requires current information
result = runner.run("What are the latest AI developments in 2025?", agent=agen
```

1. **Explicitly instruct to search**:

```
agent = Agent(
    model='gemini-2.0-flash',
    instruction="""
ALWAYS use web search for questions about:
- Current events
- Recent news
- Latest developments
- Real-time information
    """,
    tools=[google_search]
)
```

Issue: "Grounding metadata not accessible"

Problem: Trying to access metadata after execution

Solution:

```
# Grounding metadata is temporary
# Stored in: temp:_adk_grounding_metadata
# Only available during/immediately after execution

result = runner.run(query, agent=agent)

# ✔️ Access immediately after
if 'temp:_adk_grounding_metadata' in result.state:
    metadata = result.state['temp:_adk_grounding_metadata']
    print(metadata)
```

9. Testing Your Agent

Unit Test: Search Tool Integration

```python
import pytest
from google.adk.agents import Agent, Runner
from google.adk.tools import google_search

@pytest.mark.asyncio
async def test_search_agent_current_info():
    """Test agent can access current information."""

    agent = Agent(
        model='gemini-2.0-flash',
        tools=[google_search]
    )

    runner = Runner()
    result = await runner.run_async(
        "What year is it now?",
        agent=agent
    )

    # Should return current year (2025)
    assert '2025' in result.content.parts[0].text

@pytest.mark.asyncio
async def test_search_agent_with_citations():
    """Test agent provides sources."""

    agent = Agent(
        model='gemini-2.0-flash',
        instruction='Always cite sources for information.',
        tools=[google_search]
    )

    runner = Runner()
    result = await runner.run_async(
        "What are the latest developments in AI?",
        agent=agent
    )

    text = result.content.parts[0].text.lower()
    # Should mention sources or citations
    assert any(word in text for word in ['source', 'according to', 'based on']

@pytest.mark.asyncio
async def test_mixed_tools_with_wrapper():
    """Test GoogleSearchAgentTool with custom tools."""
```

```
from google.adk.tools import GoogleSearchAgentTool, FunctionTool

def custom_tool(x: int) -> int:
    return x * 2

agent = Agent(
    model='gemini-2.0-flash',
    tools=[
        GoogleSearchAgentTool(),
        FunctionTool(custom_tool)
    ]
)

runner = Runner()
result = await runner.run_async(
    "What's 21 doubled? Also, what's the current date?",
    agent=agent
)

text = result.content.parts[0].text
# Should use both tools
assert '42' in text  # Custom tool result
assert '2025' in text  # Search tool result
```

Integration Test: Maps Grounding

```python
@pytest.mark.asyncio
@pytest.mark.skipif(
    os.environ.get('GOOGLE_GENAI_USE_VERTEXAI') != '1',
    reason="Maps grounding requires VertexAI"
)
async def test_maps_grounding():
    """Test location-based queries."""

    from google.adk.tools import google_maps_grounding

    agent = Agent(
        model='gemini-2.0-flash',
        tools=[google_maps_grounding]
    )

    runner = Runner()
    result = await runner.run_async(
        "What's near the Eiffel Tower?",
        agent=agent
    )

    text = result.content.parts[0].text.lower()
    # Should mention Paris or French landmarks
    assert any(word in text for word in ['paris', 'france', 'seine'])
```

10. Performance Considerations

Latency

Built-in tools add latency:

- Web search: +2-5 seconds per query
- Maps grounding: +1-3 seconds per query
- Model decides when to use tools (adds thinking time)

Optimization strategies:

```python
# 1. Use specific queries
agent = Agent(
    model='gemini-2.0-flash',
    instruction='Ask focused questions to get targeted results.',
    tools=[google_search]
)

# 2. Set output limits
agent = Agent(
    model='gemini-2.0-flash',
    tools=[google_search],
    generate_content_config=types.GenerateContentConfig(
        max_output_tokens=1024  # Shorter = faster
    )
)

# 3. Use streaming for better UX
from google.adk.agents import RunConfig, StreamingMode

run_config = RunConfig(streaming_mode=StreamingMode.SSE)

runner = Runner()
async for event in runner.run_async(
    query,
    agent=agent,
    run_config=run_config
):
    # Show progress while waiting for search
    print(event.content.parts[0].text, end='', flush=True)
```

Cost Implications

Token usage increases with built-in tools:

- Input: Query + tool definitions + search results
- Output: Response incorporating search results
- Typically 2-5x more tokens than non-grounded responses

Cost optimization:

```
# 1. Use search only when needed
agent = Agent(
    model='gemini-2.0-flash',
    instruction="""
Use search ONLY for:
- Current events (news, stock prices, weather)
- Recent developments (tech, science, politics)
- Time-sensitive information

Use your training data for:
- Historical facts
- Well-established knowledge
- General concepts
    """,
    tools=[google_search]
)

# 2. Use smaller model when possible
agent = Agent(
    model='gemini-2.0-flash',  # Not gemini-2.0-pro
    tools=[google_search]
)

# 3. Monitor usage
import logging
logging.basicConfig(level=logging.INFO)
# ADK logs token usage automatically
```

Summary

You've mastered ADK's complete builtin tools ecosystem:

Key Takeaways:

Grounding Tools (Gemini 2.0+):

- ✔️ `google_search` - Web grounding for current information
- ✔️ `google_maps_grounding` - Location queries (VertexAI only)
- ✔️ `enterprise_web_search` - Compliance-focused web access
- ✔️ `GoogleSearchAgentTool` - Wrapper for mixing with custom tools

Memory Tools:

- ✔️ `load_memory` - Load persistent memory state
- ✔️ `preload_memory` - Initialize memory before execution
- ✔️ `load_artifacts` - Access saved documents/data

Workflow Tools:

- ✔️ `exit_loop` - Agent-controlled termination
- ✔️ `get_user_choice` - Request user input
- ✔️ `transfer_to_agent` - Agent handoff/delegation

Context & Enterprise:

- ✔️ `url_context` - Load content from URLs
- ✔️ `VertexAiSearchTool` - Enterprise search integration

Integration Wrappers:

- ✔️ `LangchainTool` - Wrap 100+ LangChain tools
- ✔️ `CrewaiTool` - Wrap 20+ CrewAI tools

Toolsets:

- ✔️ `MCPToolset` - Model Context Protocol (Tutorial 16)
- ✔️ `OpenAPIToolset` - REST API integration (Tutorial 03)

Total: 30+ builtin tools and classes available

Production Checklist:

- [ ] Using Gemini 2.5-flash (default) or 2.0+ for grounding
- [ ] Clear instructions for when to use which tools
- [ ] Error handling for tool failures
- [ ] Monitoring token usage and costs
- [ ] Testing with current vs. historical queries
- [ ] Using GoogleSearchAgentTool for mixing tools
- [ ] Setting appropriate temperature (0.1-0.3 for facts)
- [ ] Checking VertexAI vs AI Studio requirements
- [ ] [ ] **NEW**: Implementing conditional VertexAI detection for maps grounding
- [ ] [ ] **NEW**: Using environment-aware agent configuration

- [ ] Memory management for multi-session agents
- [ ] Workflow control for complex agent systems
- [ ] Enterprise tool permissions configured

Next Steps:

- **Tutorial 12**: Learn about Built-in Planners and Thinking configuration for advanced reasoning
- **Tutorial 13**: Explore Code Execution for data analysis and calculations
- **Tutorial 14**: Implement Streaming for better user experience

Resources:

- ADK Built-in Tools Docs (https://google.github.io/adk-docs/tools/built-in-tools/)
- Web Grounding for Enterprise (https://cloud.google.com/vertex-ai/generative-ai/docs/grounding/web-grounding-enterprise)
- Gemini 2.0 Features (https://cloud.google.com/vertex-ai/generative-ai/docs/model-reference/gemini)

🎉 **Tutorial 11 Complete!** You now know how to build agents with web grounding capabilities. Continue to Tutorial 12 to learn about advanced reasoning with planners and thinking configuration.

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