

WHAT ARE AI AGENTS?

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Outline

- 1 INTRODUCTION
- 2 IMPLEMENTATION
- 3 END

About Me

Yogesh Haribhau Kulkarni

Bio:

- ▶ 20+ years in CAD/Engineering software development
- ▶ Got Bachelors, Masters and Doctoral degrees in Mechanical Engineering (specialization: Geometric Modeling Algorithms).
- ▶ Currently doing Coaching in fields such as Data Science, Artificial Intelligence Machine-Deep Learning (ML/DL) and Natural Language Processing (NLP).
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Introduction

What Makes an AI Agent Different?

- ▶ Unlike LLMs that just respond to prompts, agents are autonomous
- ▶ Can look at their environment and analyze the situation
- ▶ Make comprehensive plans to achieve specific goals
- ▶ Actually take action to execute those plans
- ▶ Agents bridge the gap between answering and doing

Welcome to AI Agents

- ▶ AI agents represent one of the most exciting frontiers in AI
- ▶ Not just everyday chatbots - systems that reason, plan, and take action
- ▶ Move beyond AI that just answers questions to AI that does things
- ▶ Can take on complex multi-step tasks autonomously
- ▶ The core promise: AI that accomplishes goals independently
- ▶ Technology is advancing rapidly from conversational to agentic AI

The Impossible Job

- ▶ If your boss tasks you with planning a massive get-together
- ▶ Must research a huge guest list and plan fancy menu
- ▶ Needs to find entertainment for the event
- ▶ A simple chatbot cannot handle these complex requirements
- ▶ You need an AI agent, not just responses, but actions
- ▶ Perfect example of why we need more than conversational AI

Introduction to AI Agents

- ▶ 2025 is expected to be the year of AI agents.
- ▶ AI agents combine multiple components to solve complex problems.
- ▶ Shifting from monolithic models to compound AI systems.
- ▶ Compound AI systems use system design for better problem solving.
- ▶ AI agents improve with reasoning, acting, and memory components.
(ReAct = Reasoning + Acting)

The Evolution of AI Capabilities

- ▶ **Traditional Programming:** Needed code to operate
- ▶ **Traditional ML:** Needed feature engineering
- ▶ **Deep Learning:** task-specific model
- ▶ **ChatGPT (2022):** Many tasks single model
 - ▶ Zero-shot learning (no examples needed)
 - ▶ In-context learning (understands from instructions)
- ▶ **Agents (2024 ...):** Can actually **do things**, not just talk

Why Does “Taking Action” Matter?

- ▶ In 2022, ChatGPT was revolutionary because AI felt conversational
- ▶ By 2024, people wanted more than conversation, they wanted **execution**
- ▶ Examples of what users now expect:
 - ▶ Instead of listing leads ? **email them directly**
 - ▶ Instead of summarizing docs ? **file and create workflow tasks**
 - ▶ Instead of suggesting products ? **customize landing pages**
- ▶ This shift from **information** to **action** defines the agent era

How Agents Work?

- ▶ Agent acts, take you from one state to the other state, provides value by workflow automation. (ReAct paper: Reasoning and Action), it can plan and make decisions.
- ▶ Agents have access to tools (ToolFormer paper) e.g. Search APIs, booking, send email etc.
- ▶ Interacting of external environment and other Agents, etc.
- ▶ Memory to keep the history of conversations/actions done so far.
- ▶ May have human-in-loop to keep it sane in the wild-world.
- ▶ Agents were there from 1950's but they are effective because of LLMs.
- ▶ Agents are systems where LLMs dynamically direct their own processes and tool usage
- ▶ Can operate autonomously over extended periods using various tools
- ▶ Distinct from workflows: agents have dynamic control vs. predefined code paths
- ▶ Essential component in modern AI systems with varying degrees of autonomy

The Agent's Fundamental Game Loop

- ▶ Not a one-and-done action, but a continuous reasoning loop
- ▶ Similar to a programming while loop that keeps iterating
- ▶ **Thought:** Analyzes situation and plans next step
- ▶ **Action:** Calls specific tools to execute the plan
- ▶ **Observation:** Examines results of the action taken
- ▶ Cycle repeats: Thought → Action → Observation
- ▶ Continues until the task is completely accomplished
- ▶ This loop enables continuous adaptation and problem-solving

Agent's Inner Monologue

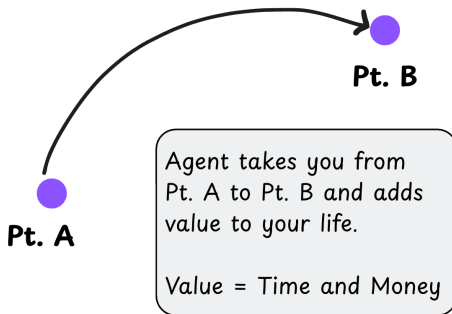
- ▶ Agents have visible thought processes before taking action
- ▶ Example: "User wants weather in New York. I have a tool for that".
- ▶ "My first move is to call the weather API".
- ▶ Internal planning step makes agents more than reactive programs
- ▶ Reasoning through problems before execution
- ▶ This deliberation distinguishes agents from simple scripts
- ▶ Shows intelligent decision-making rather than blind execution

How Do Agents Take Action?

- ▶ The magic lies in **tools** and **function calling**
- ▶ Agents are paired with APIs, plugins, or external systems
- ▶ Instead of just text responses, LLMs output structured commands:
 - ▶ “Call the send_email() function with these inputs...”
 - ▶ “Fetch records from CRM using this query...”
 - ▶ “Schedule a meeting for Tuesday at 2PM...”
- ▶ **Mental model:** LLM = brain, Tools = hands
- ▶ Without tools, agents just talk. With tools, they act.

Defining AI Agents with an example

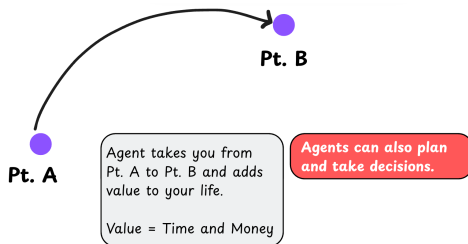
- ▶ Planning a trip involves many complex tasks
- ▶ Point A: Just discussing the trip
- ▶ Point B: All bookings and itinerary ready
- ▶ AI Agents aim to take you from A to B
- ▶ First idea: Agent adds value by saving time/money



(Ref: Vizuara AI Agents Bootcamp)

Evolving Definition of Agents

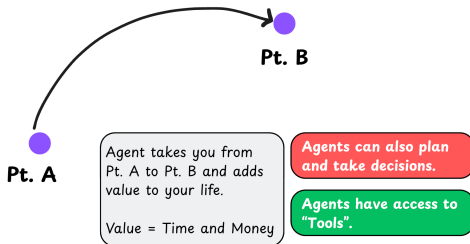
- ▶ Not all tools from A to B are agents (e.g., cars)
- ▶ Agents must plan and make decisions
- ▶ Second definition includes decision-making ability
- ▶ Example: Choosing flights based on budget
- ▶ Planning daily itinerary needs contextual judgment



(Ref: Vizura AI Agents Bootcamp)

Agents Need Tools

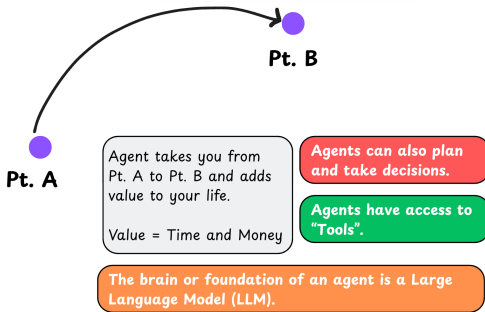
- ▶ Even self-driving cars plan but are not agents
- ▶ Agents need access to external tools
- ▶ Tools = Access to services (e.g., Gmail, Booking)
- ▶ Agents perform tasks using these tools
- ▶ Third definition adds tool access to capabilities



(Ref: Vizuara AI Agents Bootcamp)

Rise of LLMs in Agents

- ▶ Transformers (2017) enabled powerful LLMs
- ▶ LLMs understand and generate human language
- ▶ Agents use LLMs for reasoning and planning
- ▶ LLMs enable understanding of webpages and writing emails
- ▶ Fourth definition: Agents are LLMs with tools and planning ability



(Ref: Vizuara AI Agents Bootcamp)

What Is an Agent? (Technical Definition)

- ▶ Agent acts and takes you from one state to another, providing value through workflow automation
- ▶ Based on ReAct paradigm: **Reasoning + Acting**
- ▶ Key capabilities:
 - ▶ Can plan and make decisions
 - ▶ Has access to tools (search APIs, booking, email, etc.)
 - ▶ Interacts with external environments and other agents
 - ▶ Maintains memory of conversations and actions
 - ▶ May include human-in-the-loop for safety
- ▶ Agents existed since the 1950s but are now effective because of LLMs

Two Ways to Define Agents

Technical View:

- ▶ LLM (brain)
- ▶ + Tools (hands)
- ▶ + Planning (strategy)
- ▶ + Memory (context)
- ▶ + State management

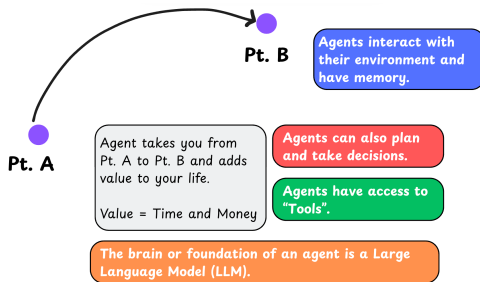
Business View:

- ▶ Systems that complete tasks end-to-end
- ▶ Focus on outcomes, not components
- ▶ Solve real-world problems
- ▶ Provide measurable value

Important: Today's agents are **engineering wrappers** around AI models, the intelligence comes from the LLMs, agents help act on that intelligence.

Final Definition of Agents


- ▶ Agents can learn from feedback and environment
- ▶ Agents interact with tools, humans, and websites
- ▶ They improve with experience (memory)
- ▶ Fifth definition: LLMs + Tools + Planning + Learning
- ▶ Agents evolve over time via memory and feedback



(Ref: Vizuara AI Agents Bootcamp)

Understanding Agency

- ▶ Agency = Level of autonomy an agent has
- ▶ Low agency → less value
- ▶ High agency → high value
- ▶ More autonomous agents can handle complex tasks
- ▶ Agency is key to measuring agent usefulness

Agency Level	Description	Name	Example	
●○○○○	Agent does not influence what happens next	Simple Processor	Grammar checker that rewrites sentences	
●●○○○	Agent determines basic control flow	Router	Customer Query → Tech Support or Sales	
●●●○○	Agent determines function execution	Tool Caller	A smart calendar assistant that spots "let's meet on Tuesday" and books the meeting	
●●●●○	Lays out a short plan and carries it step by step	Multi-step Agent	Personal travel planner that gathers flight options, hotels, local activities	
●●●●●	One agentic workflow starts another agentic workflow	Multi-agent	Travel planner agent → Booking agent ← Email agent	

(Ref: Vizuara AI Agents Bootcamp)

Tools: The Agent's Hands

- ▶ LLM is the agent's brain; tools are its hands
- ▶ Tools are functions agents call to interact with the world
- ▶ Can search web, run calculations, or query databases
- ▶ Bridge between thinking and doing in the real world
- ▶ Enable agents to move from planning to execution
- ▶ Without tools, agent thoughts would be useless
- ▶ Tools provide the interface to external systems and data

Two Ways Agents Use Tools

- ▶ **JSON Agent:** Writes structured work orders for other systems
- ▶ JSON approach requires external system to read and execute
- ▶ **Code Agent:** Directly writes and runs code blocks
- ▶ Code approach is more direct and powerful
- ▶ Code is naturally more expressive than JSON
- ▶ Can handle complex logic like loops and conditionals
- ▶ Modular, easier to debug, and taps into existing libraries
- ▶ Code agents can access thousands of APIs directly

Code Agent in Action

- ▶ Alfred needs a gala menu - agent has “suggest_menu” tool
- ▶ Agent doesn't just make up suggestions randomly
- ▶ Generates and runs actual code to call the specific tool
- ▶ Gets real results from the tool execution
- ▶ Super direct, efficient, and powerful way to take action
- ▶ Code generation enables precise tool interaction
- ▶ Results are based on actual tool capabilities, not hallucination

Advanced Pattern: Agentic RAG

- ▶ Traditional RAG: Retrieval Augmented Generation fetches info before answering
- ▶ Agentic RAG supercharges this with intelligent multi-step processes
- ▶ Turns retrieval itself into an agent-driven task
- ▶ Like having a master researcher on staff
- ▶ Doesn't just do one search - runs complete research processes
- ▶ Rewrites queries for better results and runs multiple searches
- ▶ Uses findings to inform next searches and validates accuracy
- ▶ Pulls from both private data and public web sources

Multi-Agent Systems: Digital Teams

- ▶ Complex problems like finding the missing Batmobile need teams
- ▶ Single agents can't handle web searches, calculations, and visualization
- ▶ Solution: Build teams of specialized agents
- ▶ Manager agent acts as project lead breaking down big tasks
- ▶ Delegates work to specialist agents with specific skills
- ▶ Web agent handles online searching while manager coordinates
- ▶ Manager focuses on big picture and final integration
- ▶ Digital division of labor for complex problem solving

The GAIA Benchmark Reality Check

- ▶ GAIA benchmark tests real-world multi-step problems
- ▶ Measures how well systems handle tricky, complex tasks
- ▶ Results are eye-opening and show current limitations
- ▶ Humans solve these tasks with 92% accuracy
- ▶ Today's most advanced AI models: only 15% accuracy
- ▶ Massive 77% gap between human and AI performance
- ▶ This gap is exactly what agentic systems aim to close
- ▶ Shows the enormous potential for improvement

The Fundamental Shift

- ▶ Moving from conversational AI to agentic AI era
- ▶ Old paradigm: Ask questions, get answers
- ▶ New paradigm: State goals, systems plan and accomplish them
- ▶ Represents fundamental change in human-computer interaction
- ▶ Technology for building personal AI assistants advancing rapidly
- ▶ Not a question of “if” but “when” this becomes reality
- ▶ The future Alfred is closer than we think
- ▶ Prepare for AI that can handle “impossible” complex tasks

Papers that Shaped AI Agents

- ▶ Core research papers laid the foundation
- ▶ Introduced key frameworks and architectures
- ▶ Sparked recent boom in agent development
- ▶ Include Transformer and Agentic frameworks
- ▶ Major driving force in LLM-based agent systems

Chain-of-Thought Prompting Elicits Reasoning in Large Language Models

Jason Wei Xuezhi Wang Dale Schuurmans Maarten Bosma
 Brian Ichter Fei Xia Ed H. Chi Quoc V. Le Denny Zhou
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REACT: SYNERGIZING REASONING AND ACTING IN LANGUAGE MODELS

Shunyu Yao^{1,1}, Jeffrey Zhao², Dian Yu², Nan Du², Izhak Shafran², Karthik Narasimhan¹, Yuan Cao²
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Toolformer: Language Models Can Teach Themselves to Use Tools

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 Maria Lomeli Luke Zettlemoyer Nicola Cancedda Thomas Scialom
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Generative Agents: Interactive Simulacra of Human Behavior

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(Ref: Vizua AI Agents Bootcamp)

When to Use Agents?

- ▶ Best suited for tasks requiring flexibility and model-driven decision-making
- ▶ Consider tradeoffs: agents increase latency and cost for better task performance
- ▶ Recommended for open-ended problems with unpredictable steps
- ▶ Simple solutions preferred - single LLM calls with retrieval often sufficient

Future AI Applications

- ▶ What are future AI applications like?
 - ▶ **Generative:** Generate content like text and images
 - ▶ **Agentic:** Execute complex tasks on behalf of humans
- ▶ How do we empower every developer to build them?
 - ▶ **Co-Pilots:** Human-AI collaboration
 - ▶ **Autonomous:** Independent task execution
- ▶ 2024 is expected to be the year of AI agents

The Big Question

- ▶ Agentic AI technology is moving incredibly fast
- ▶ Personal AI assistants will soon be capable of complex tasks
- ▶ Think beyond simple queries to multi-step accomplishments
- ▶ Consider what “impossible” tasks you want to delegate
- ▶ What complex, party-of-the-century level challenge will you tackle?
- ▶ The era of AI that truly does rather than just discusses
- ▶ Prepare for AI assistants that can handle your biggest challenges

Google ADK (Agent Development Kit)

Introduction to ADK Framework

- ▶ ADK (Agent Development Kit) is Google's framework for building sophisticated AI agents and agentic applications
- ▶ Official documentation available at:
<https://google.github.io/adk-docs/>
- ▶ Designed for production-ready agentic systems with focus on scalability and reliability
- ▶ Supports multi-agent systems, tool integration, and flexible deployment options
- ▶ Built on Google's Gemini models with support for multiple LLM providers
- ▶ Framework emphasizes type safety, async operations, and enterprise-grade features

Key Components

- ▶ **Agents:** Core building blocks with instructions, tools, and model configuration
- ▶ **Tools:** Functions that agents can call to interact with external systems and APIs
- ▶ **Sessions:** Manage conversation context and state across multiple interactions
- ▶ **Runners:** Execute agent logic with support for streaming and async operations
- ▶ **Memory:** Store and retrieve conversation history and context
- ▶ **Multi-Agent Support:** Coordinate multiple specialized agents working together
- ▶ **Deployment:** Built-in support for FastAPI and serverless deployment

ADK Architecture Levels

- ▶ **Basic Agents:** Single agent with tools and instructions
- ▶ **Stateful Agents:** Agents with session management and memory
- ▶ **Multi-Agent Systems:** Multiple specialized agents collaborating
- ▶ **Agentic Workflows:** Complex orchestration with control flow
- ▶ **Production Systems:** Deployed services with monitoring and scaling
- ▶ Each level provides additional capabilities for building sophisticated AI applications

Key Features - Model Support & Flexibility

- ▶ **Gemini Integration:** Native support for Google's Gemini models (1.5 Pro, 2.0 Flash)
- ▶ **Multi-Provider:** Works with OpenAI, Anthropic, and other LLM providers
- ▶ **Type Safety:** Full TypeScript/Python type annotations for reliability
- ▶ **Async-First:** Built on async/await for high-performance concurrent operations
- ▶ **Streaming Support:** Real-time response streaming for better UX
- ▶ **Tool Calling:** Native function calling with structured input/output
- ▶ **Production Ready:** Built-in FastAPI integration and deployment patterns

Advanced Capabilities - Grounding & Multi-Modal

- ▶ **Google Search Grounding:** Connect agents to real-time web search results
- ▶ **Multi-Modal Input:** Support for text, images, audio, and video
- ▶ **Code Execution:** Built-in code interpreter for dynamic computation
- ▶ **Vertex AI Integration:** Enterprise features like RAG and vector search
- ▶ **Function Calling:** Structured tool execution with automatic parameter extraction
- ▶ **Safety Filters:** Built-in content safety and harm prevention

Enterprise Features - State & Deployment

- ▶ **Session Management:** Persistent conversation state across interactions
- ▶ **Cloud Integration:** Native support for Google Cloud services
- ▶ **Structured Output:** Pydantic models for type-safe responses
- ▶ **Error Handling:** Robust retry logic and error recovery
- ▶ **Monitoring:** Integration with Cloud Logging and Tracing
- ▶ **Authentication:** Built-in OAuth and API key management
- ▶ **Scalability:** Designed for high-throughput production workloads

Installation & Setup

- ▶ **Simple Installation:** Install via pip with minimal dependencies
- ▶ **CLI Tools:** Built-in commands for project creation and management
- ▶ **Project Generation:** Automatic scaffolding with best practices
- ▶ **API Key Creation:** Get the API key from <https://aistudio.google.com/api-keys>
- ▶ **API Key Setup:** Configure Gemini API key via environment variable
- ▶ **Quick Start:** Start building agents immediately after installation

```
1 pip install google-adk
2 pip install google-adk --use-deprecated=legacy-resolver
3
4 # Create a new agent project
5 adk create my_agent
6
7 # Set API key in .env file
8 echo 'GOOGLE_API_KEY="YOUR_API_KEY"' > my_agent/.env # write your API key into
9 an .env
```

Use CLI not VS code

Use Anaconda prompt with Admin permissions.

```
(google-adk) D:\Yogesh\GitHub\TeachingDataScience\Code\google-adk>adk create my_agent
Choose a model for the root agent:
1. gemini-2.5-flash
2. Other models (fill later)
Choose model (1, 2): 1
1. Google AI
2. Vertex AI
Choose a backend (1, 2): 1

Don't have API Key? Create one in AI Studio: https://aistudio.google.com/apikey

Enter Google API key [AIzaSyCwIfLYXGOVC0L3W5Cj49M-hVajZDu7X0c]:

Agent created in D:\Yogesh\GitHub\TeachingDataScience\Code\google-adk\my_agent:
- .env
- __init__.py
- agent.py
```

Explore the agent project

- ▶ The created agent project has the following structure, with the agent.py file containing the main control code for the agent.
- ▶ The agent.py file contains a root_agent definition which is the only required element of an ADK agent. You can also define tools for the agent to use. Update the generated agent.py
- ▶ Run your agent using the adk run command-line tool.
- ▶ The ADK framework provides web interface you can use to test and interact with your agent.

```
my_agent/  
2  agent.py      # main agent code  
   .env         # API keys or project IDs  
4  __init__.py  
  
6  adk run my_agent  
  
8  adk web --port 8000 my_agent
```

Wrong time!!

```
(google-adk) D:\Yogesh\GitHub\TeachingDataScience\Code\google-adk>adk run my_agent
log setup complete: C:\Users\yoges\AppData\Local\Temp\agents_log\agent.20251027_181028.log
to access latest log: tail -F C:\Users\yoges\AppData\Local\Temp\agents_log\agent.latest.log
D:\Yogesh\anaconda3\envs\google-adk\Lib\site-packages\google\adk\cli\cli.py:154: UserWarning: [EXPERIMENTAL] InMemoryC
redentialService: This feature is experimental and may change or be removed in future versions without notice. It may in
troduce breaking changes at any time.
  credential_service = InMemoryCredentialService()
D:\Yogesh\anaconda3\envs\google-adk\Lib\site-packages\google\adk\auth\credential_service\in_memory_credential_service.
py:33: UserWarning: [EXPERIMENTAL] BaseCredentialService: This feature is experimental and may change or be removed in f
uture versions without notice. It may introduce breaking changes at any time.
  super().__init__()
Running agent root_agent, type exit to exit.
D:\Yogesh\anaconda3\envs\google-adk\Lib\site-packages\google\adk\cli\cli.py:98: UserWarning: [EXPERIMENTAL] App: This
feature is experimental and may change or be removed in future versions without notice. It may introduce breaking change
at any time.
  else App(name=session.app_name, root_agent=root_agent_or_app)
[user]: what can i do?
[root_agent]: I can tell you the current time in a specified city.
[user]: What is the current time in Pune?
[root_agent]: The current time in Pune is 10:30 AM.
[user]: bye
[root_agent]: Goodbye!
[user]:
aborted!
```

Basic Agent Example - Simple Setup

- ▶ Create a basic agent with Gemini 2.0 Flash model
- ▶ Define tools using Python functions with type hints
- ▶ Agent automatically handles function calling and response generation
- ▶ Clean separation between tool definition and agent logic
- ▶ Synchronous execution for simple use cases

```
1 from adk import Agent
2 from adk.models import GeminiModel
3 import yfinance as yf
4
5 def get_stock_price(symbol: str) -> dict:
6     """Get current stock price for a given symbol."""
7     # Implementation using yfinance or similar
8     stock = yf.Ticker(symbol)
9     return {"symbol": symbol, "price": stock.info.get('currentPrice')}
10
11 agent = Agent(
12     model=GeminiModel(model_name="gemini-2.0-flash-exp"),
13     tools=[get_stock_price],
14     instructions="You are a helpful financial assistant. Use tools when needed."
15 )
16
17 response = agent.run("What is NVIDIA's current stock price?")
18 print(response.text)
```

Agent with Multiple Tools

- ▶ Define multiple specialized tools for the agent with docstring
- ▶ Agent selects appropriate tools based on dcostring and user query

```
1 from adk import Agent
2 from adk.models import GeminiModel
3 import yfinance as yf
4
5 def get_stock_price(symbol: str) -> float:
6     """Get current stock price."""
7     return yf.Ticker(symbol).info.get('currentPrice', 0)
8
9 def get_company_info(symbol: str) -> dict:
10    """Get company information."""
11    ticker = yf.Ticker(symbol)
12    return {"name": ticker.info.get('longName'),
13           "sector": ticker.info.get('sector'),
14           "summary": ticker.info.get('longBusinessSummary')}
15
16 def get_analyst_recommendations(symbol: str) -> str:
17    """Get analyst recommendations."""
18    return yf.Ticker(symbol).recommendations.to_string()
19
20 agent = Agent(model=GeminiModel(model_name="gemini-2.0-flash-exp"),
21              tools=[get_stock_price, get_company_info, get_analyst_recommendations],
22              instructions="Provide detailed financial analysis using available tools.")
23
24 for chunk in agent.run_stream("Write a report on NVIDIA stock"):
25     print(chunk.text, end="", flush=True)
26
```

Agent with Session Management

- ▶ Sessions maintain conversation history and context
- ▶ Enable multi-turn conversations with memory
- ▶ Store and retrieve previous interactions
- ▶ Support for persistent storage backends

```
1 from adk import Agent, Session
2 from adk.models import GeminiModel
3 from adk.storage import InMemoryStorage
4 import yfinance as yf
5
6 def get_stock_price(symbol: str) -> float:
7     """Get current stock price."""
8     return yf.Ticker(symbol).info.get('currentPrice', 0)
9
10 def get_company_info(symbol: str) -> dict:
11     """Get company information."""
12     ticker = yf.Ticker(symbol)
13     return {"name": ticker.info.get('longName'),
14            "sector": ticker.info.get('sector'),
15            "summary": ticker.info.get('longBusinessSummary')}
16
17 # Create storage for session history
18 storage = InMemoryStorage()
19
20 agent = Agent(
21     model=GeminiModel(model_name="gemini-2.0-flash-exp"),
22     tools=[get_stock_price, get_company_info],
23     instructions="You are a financial advisor. Remember previous conversations."
24 )
25
```


Agent with Session Management

```
1 # Create a session for this conversation
session = Session(
3     agent=agent,
      storage=storage,
5     session_id="user-123"
6 )
7
8 # Multi-turn conversation
9 response1 = session.run("What's NVIDIA's stock price?")
10 print(response1.text)
11
12 # Agent remembers previous context
13 response2 = session.run("How about their competitor AMD?")
14 print(response2.text)
15
16 # Session history is maintained
17 response3 = session.run("Compare both companies")
18 print(response3.text)
19
```

Agent with Google Search Grounding

- ▶ Google Search grounding provides real-time web information
- ▶ Automatically cites sources in responses
- ▶ Reduces hallucination with factual grounding
- ▶ Requires Vertex AI setup for production use

```
1 from adk import Agent
2 from adk.models import GeminiModel
3 from adk.extensions import GoogleSearchGrounding
4
5 agent = Agent(
6     model=GeminiModel(
7         model_name="gemini-2.0-flash-exp",
8         extensions=[GoogleSearchGrounding()]
9     ),
10    instructions="Provide well-researched answers with citations."
11)
12
13 response = agent.run(
14     "What are the latest developments in AI semiconductor technology?"
15 )
16 print(response.text)
17 # Response will include citations from search results
18
```

Structured Output with Pydantic

- ▶ Define expected output schema to ensure type-safe and structured responses
- ▶ Automatic validation ideal for integration with downstream systems

```
1 from adk import Agent
2 from adk.models import GeminiModel
3 from pydantic import BaseModel, Field
4 def get_stock_price(symbol: str) -> float:
5     :
6 def get_company_info(symbol: str) -> dict:
7     :
8 class StockAnalysis(BaseModel):
9     symbol: str = Field(description="Stock ticker symbol")
10    current_price: float = Field(description="Current stock price")
11    recommendation: str = Field(description="Buy/Hold/Sell recommendation")
12    reasoning: str = Field(description="Analysis reasoning")
13 agent = Agent(
14     model=GeminiModel(model_name="gemini-2.0-flash-exp"),
15     tools=[get_stock_price, get_company_info],
16     output_schema=StockAnalysis,
17     instructions="Analyze the stock and provide structured recommendation.")
18 result: StockAnalysis = agent.run("Analyze NVIDIA stock")
19 print(f"Symbol: {result.symbol}")
20 print(f"Price: ${result.current_price}")
21 print(f"Recommendation: {result.recommendation}")
22 print(f"Reasoning: {result.reasoning}")
23
```

Multi-Agent System - Architecture

- ▶ **Specialized Agents:** Each agent focuses on specific domain expertise
- ▶ **Orchestration:** Coordinator agent manages task delegation
- ▶ **Parallel Execution:** Multiple agents can work simultaneously
- ▶ **Result Aggregation:** Combine outputs from multiple agents
- ▶ **Scalable Design:** Handle complex workflows through collaboration

Multi-Agent Implementation - Part 1

```
2 from adk import Agent
3 from adk.models import GeminiModel
4
5 def web_search(query: str) -> str:
6     """Search the web for information."""
7     # Implementation using search API
8     pass
9
10 def get_stock_data(symbol: str) -> dict:
11     """Get comprehensive stock data."""
12     import yfinance as yf
13     ticker = yf.Ticker(symbol)
14     return {
15         "price": ticker.info.get('currentPrice'),
16         "recommendations": ticker.recommendations.tail(5).to_dict()
17     }
18
19 web_agent = Agent(
20     name="Web Agent",
21     model=GeminiModel(model_name="gemini-2.0-flash-exp"),
22     tools=[web_search],
23     instructions="Search the web and provide sourced information."
24 )
25
26 finance_agent = Agent(
27     name="Finance Agent",
28     model=GeminiModel(model_name="gemini-2.0-flash-exp"),
29     tools=[get_stock_data],
30     instructions="Analyze financial data and present in clear tables."
31 )
```

Multi-Agent Implementation - Part 2

- ▶ Coordinator agent orchestrates multiple specialized agents
- ▶ Delegates tasks to appropriate agents based on requirements
- ▶ Aggregates and synthesizes results from multiple sources

```
1 from adk import Agent, MultiAgentOrchestrator
2 from adk.models import GeminiModel
3
4 orchestrator = MultiAgentOrchestrator(
5     agents=[web_agent, finance_agent],
6     coordinator=Agent(
7         model=GeminiModel(model_name="gemini-2.0-flash-exp"),
8         instructions="""You coordinate a team of specialized agents.
9             - Use Web Agent for market news and trends
10            - Use Finance Agent for stock data and analysis
11            - Synthesize their outputs into comprehensive reports.""" ))
12
13 # Run multi-agent workflow
14 result = orchestrator.run(
15     "Provide a comprehensive analysis of AI semiconductor companies "
16     "including market outlook and financial performance")
17
18 print(result.text)
19
20 # Access individual agent outputs
21 for agent_name, agent_result in result.agent_outputs.items():
22     print(f"\n{agent_name} output:")
23     print(agent_result.text)
24
```

FastAPI Deployment

Deploy agents as REST APIs using FastAPI

```
1 from fastapi import FastAPI, HTTPException
2 from fastapi.responses import StreamingResponse
3 from adk import Agent, Session
4 from adk.models import GeminiModel
5 from pydantic import BaseModel
6 import uvicorn
7
8 app = FastAPI(title="ADK Agent API")
9
10 agent = Agent(
11     model=GeminiModel(model_name="gemini-2.0-flash-exp"),
12     tools=[get_stock_price, get_company_info],
13     instructions="You are a financial assistant API."
14 )
15
16 class QueryRequest(BaseModel):
17     message: str
18     session_id: str
19
```

FastAPI Deployment

```
1 @app.post("/chat")
3 async def chat(request: QueryRequest):
4     session = Session(agent=agent, session_id=request.session_id)
5     response = await session.run_async(request.message)
6     return {"response": response.text}
7
8 @app.post("/chat/stream")
9 async def chat_stream(request: QueryRequest):
10     session = Session(agent=agent, session_id=request.session_id)
11
12     async def generate():
13         async for chunk in session.run_stream_async(request.message):
14             yield chunk.text
15
16     return StreamingResponse(generate(), media_type="text/plain")
17
18 if __name__ == "__main__":
19     uvicorn.run(app, host="0.0.0.0", port=8000)
```


Vertex AI Integration

```
1 from adk import Agent
2 from adk.models import VertexAIModel
3 from adk.extensions import VertexAIVectorSearch
4 from google.cloud import aiplatform
5
6 # Initialize Vertex AI
7 aiplatform.init(project="your-project-id", location="us-central1")
8
9 # Create agent with Vertex AI backend
10 agent = Agent(
11     model=VertexAIModel(
12         model_name="gemini-2.0-flash-exp",
13         project="your-project-id",
14         location="us-central1"
15     ),
16     extensions=[
17         VertexAIVectorSearch(
18             index_endpoint="your-index-endpoint",
19             deployed_index_id="your-index-id"
20         )
21     ],
22     instructions="Answer questions using both your knowledge and the vector store."
23 )
24
25 response = agent.run("What are our company policies on remote work?")
26 print(response.text)
27
```

Error Handling & Reliability

```
1 from adk import Agent
2 from adk.models import GeminiModel
3 from adk.exceptions import ToolExecutionError, ModelError
4 import logging
5 import yfinance as yf
6 logging.basicConfig(level=logging.INFO)
7 logger = logging.getLogger(__name__)
8
9 def safe_tool_wrapper(func):
10     """Decorator for safe tool execution with fallback."""
11     def wrapper(*args, **kwargs):
12         try:
13             return func(*args, **kwargs)
14         except Exception as e:
15             logger.error(f"Tool {func.__name__} failed: {e}")
16             return {"error": str(e), "fallback": True}
17     return wrapper
18
19 @safe_tool_wrapper
20 def get_stock_price(symbol: str) -> dict:
21     """Get stock price with error handling."""
22     return {"price": yf.Ticker(symbol).info['currentPrice']}
23
24
```

Error Handling & Reliability

```
1 agent = Agent(  
2     model=GeminiModel(  
3         model_name="gemini-2.0-flash-exp",  
4         max_retries=3,  
5         timeout=30  
6     ),  
7     tools=[get_stock_price],  
8     instructions="Handle errors gracefully and inform users."  
9 )  
  
11 try:  
12     response = agent.run("What's the price of NVDA?")  
13     print(response.text)  
14 except ModelError as e:  
15     logger.error(f"Model error: {e}")  
16     print("Sorry, I'm having trouble processing your request.")  
17
```

Framework Comparison: LangGraph vs Agno vs ADK

Feature	LangGraph	Agno	ADK
Primary Focus	Graph-based workflows	Multi-agent systems	Enterprise AI agents
Developer	LangChain AI	Agno (ex-phidata)	Google
Architecture	State machines & graphs	Agent teams	Agent orchestration
Model Support	100+ providers	23+ providers	Gemini + multi-provider
Learning Curve	Steep (graph concepts)	Moderate	Moderate
Setup Time	Complex	Minutes	Minutes
Performance	Good	3µs instantiation	Optimized for Gemini
State Management	Built-in (checkpoints)	Session storage	Session & Cloud
Memory	Memory modules	Built-in drivers	In-memory & Cloud
Multi-Agent	Via subgraphs	Native teams	Orchestrator pattern
Workflow Control	Explicit graphs	Coordinate mode	Coordinator agent
Streaming	Yes	Yes	Yes (native async)
RAG Support	Vector stores	20+ vector DBs	Vertex AI Search
Deployment	Custom	FastAPI built-in	FastAPI + Cloud Run
Monitoring	LangSmith	agno.com	Cloud Console
Production Ready	Yes	Yes	Yes (enterprise)
Best For	Complex workflows	Fast prototyping	Google Cloud users
Unique Feature	Graph visualization	6.5KB/agent memory	Search grounding

Best Practices

- ▶ **Start Simple:** Begin with basic agents before adding complexity
- ▶ **Clear Instructions:** Provide specific, actionable instructions to agents
- ▶ **Tool Design:** Keep tools focused and well-documented with type hints
- ▶ **Error Handling:** Always implement proper error handling and retries
- ▶ **Testing:** Test agents thoroughly before production deployment
- ▶ **Monitoring:** Implement logging and monitoring for production systems
- ▶ **Security:** Validate inputs and sanitize outputs
- ▶ **Cost Management:** Monitor API usage and implement rate limiting

Getting Started - Next Steps

- ▶ **Documentation:** Explore comprehensive guides at <https://google.github.io/adk-docs/>
- ▶ **Examples Repository:** Check out example projects and templates
- ▶ **Community:** Join Google Cloud community for support
- ▶ **Start Building:** Begin with simple agents and iterate
- ▶ **Cloud Integration:** Leverage Google Cloud services for production
- ▶ **Vertex AI:** Explore enterprise features for advanced use cases
- ▶ **Monitoring:** Use Cloud Console for production monitoring

Resources & References

- ▶ **Official Documentation:** <https://google.github.io/adk-docs/>
- ▶ **GitHub Repository:** <https://github.com/google/adk>
- ▶ **Gemini API:** <https://ai.google.dev/>
- ▶ **Vertex AI:** <https://cloud.google.com/vertex-ai>
- ▶ **Google Cloud:** <https://cloud.google.com/>
- ▶ **Community Support:** Google Cloud Community forums

References

- ▶ CS 194/294-196 (LLM Agents) - Lecture 3, Chi Wang and Jerry Liu
- ▶ LLM Powered Autonomous Agents Lil'Log
- ▶ Power of Autonomous AI Agents - Yogesh Kulkarni
- ▶ Microsoft AutoGen- Yogesh Kulkarni
- ▶ Microsoft AutoGen using Open Source Models- Yogesh Kulkarni
- ▶ A CAMEL ride - Yogesh Kulkarni
- ▶ Autonomous AI Agents (LLM, VLM, VLA) - Code Your Own AI
- ▶ Awesome LLM-Powered Agent
<https://github.com/hyp1231/awesome-llm-powered-agent>
- ▶ Autonomous Agents (LLMs). Updated daily
<https://github.com/tmgthb/Autonomous-Agents>

Thanks ...

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(<https://medium.com/@yogeshharibhaukulkarni>)



(<https://www.github.com/yogeshhk/>)

Pune AI Community (PAIC)

▶ Two-way communication:

- ▶ Website [puneaicommunity dot org](https://puneaicommunity.org)
- ▶ Email [puneaicommunity at gmail dot com](mailto:puneaicommunity@gmail.com)
- ▶ Call + 9 1 9 8 9 0 2 5 1 4 0 6
- ▶ LinkedIn:
<https://linkedin.com/company/pune-ai-community>

▶ One-way Announcements:

- ▶ Twitter (X) @puneaicommunity
- ▶ Instagram @puneaicommunity
- ▶ WhatsApp Community: Invitation Link
<https://chat.whatsapp.com/LluOrhyEzuQLDr25ixZ>
- ▶ Luma Event Calendar: [puneaicommunity](https://puneaicommunity.org)

▶ Contribution Channels:

- ▶ GitHub: [Pune-AI-Community and puneaicommunity](https://github.com/pune-ai-community)
- ▶ Medium: [pune-ai-community](https://medium.com/pune-ai-community)
- ▶ YouTube: @puneaicommunity



Website

Pune AI Community (PAIC) QR codes



Website



Medium Blogs



Twitter-X



LinkedIn Page



Github Repository



WhatsApp Invite



Luma Events

YouTube Videos

Instagram