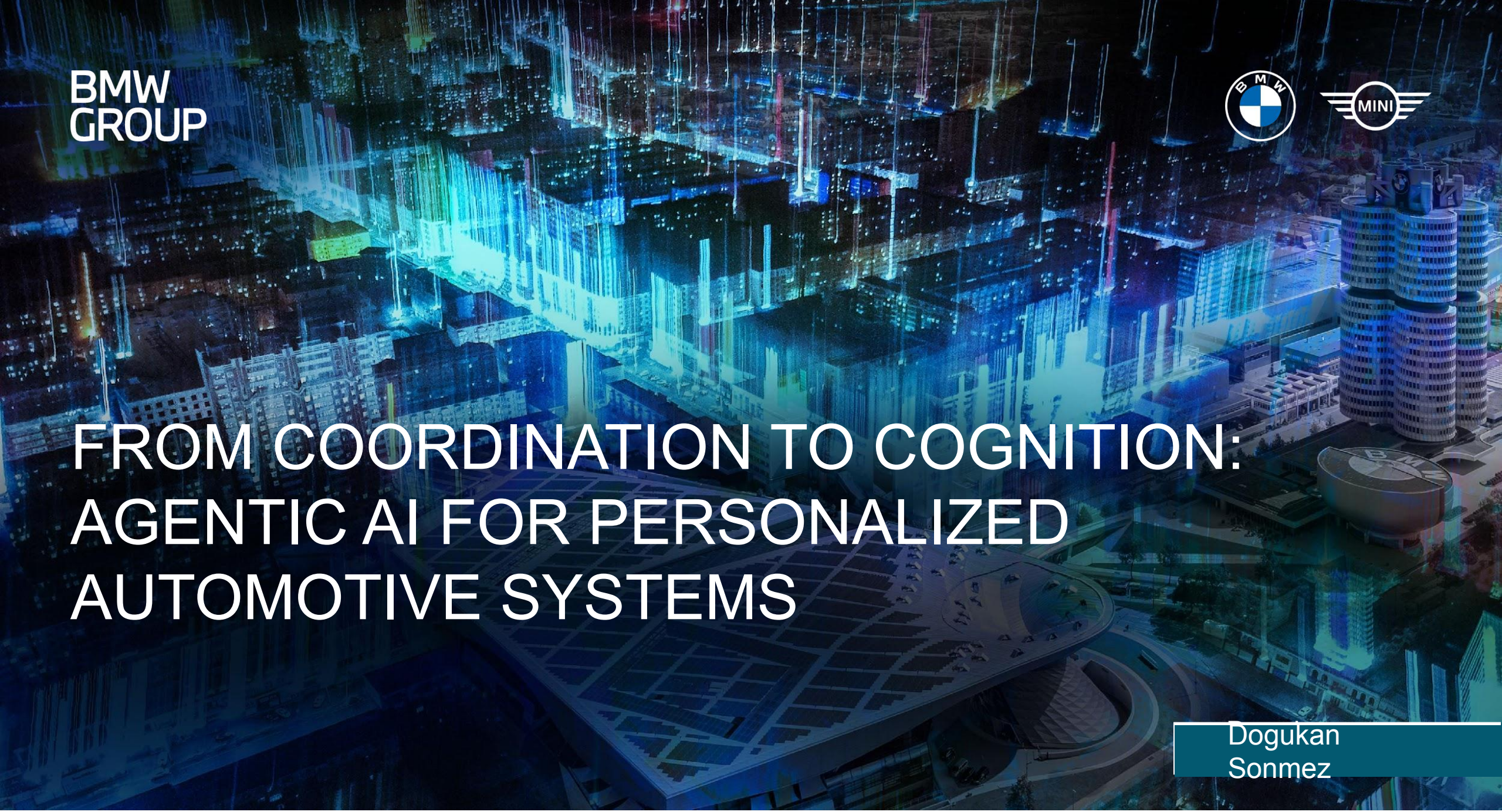


FROM COORDINATION TO COGNITION: AGENTIC AI FOR PERSONALIZED AUTOMOTIVE SYSTEMS

Dogukan Sonmez

Doğukan
Dogukan
Do-u-kan

THE ULTIMATE DRIVING MACHINE + ULTIMATE COMPANION

Driving Only

Cars had a clear purpose: going from A to B — simple and easy to control.

Feature Explosion

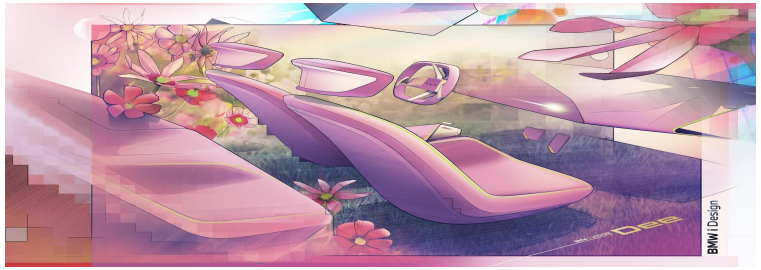
Now we have 1000+ features, apps, and data signals, integrated across navigation, entertainment, safety, and comfort.

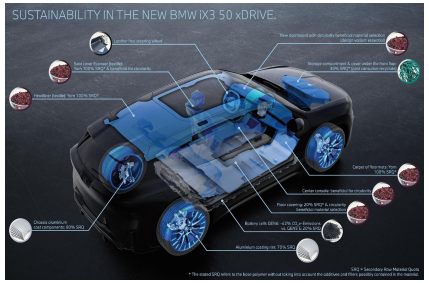
Digital Ecosystem

Cars are becoming adaptive ecosystems, seamlessly personalizing experiences and creating journeys beyond transport.

BEYOND TRANSPORTATION: CARS AS CONNECTED ECOSYSTEMS

- Many instruments (features, apps, departments, data)
- From simple controls to **immersive infotainment ecosystems**
- Driving becomes more than transport — it's an **experience**





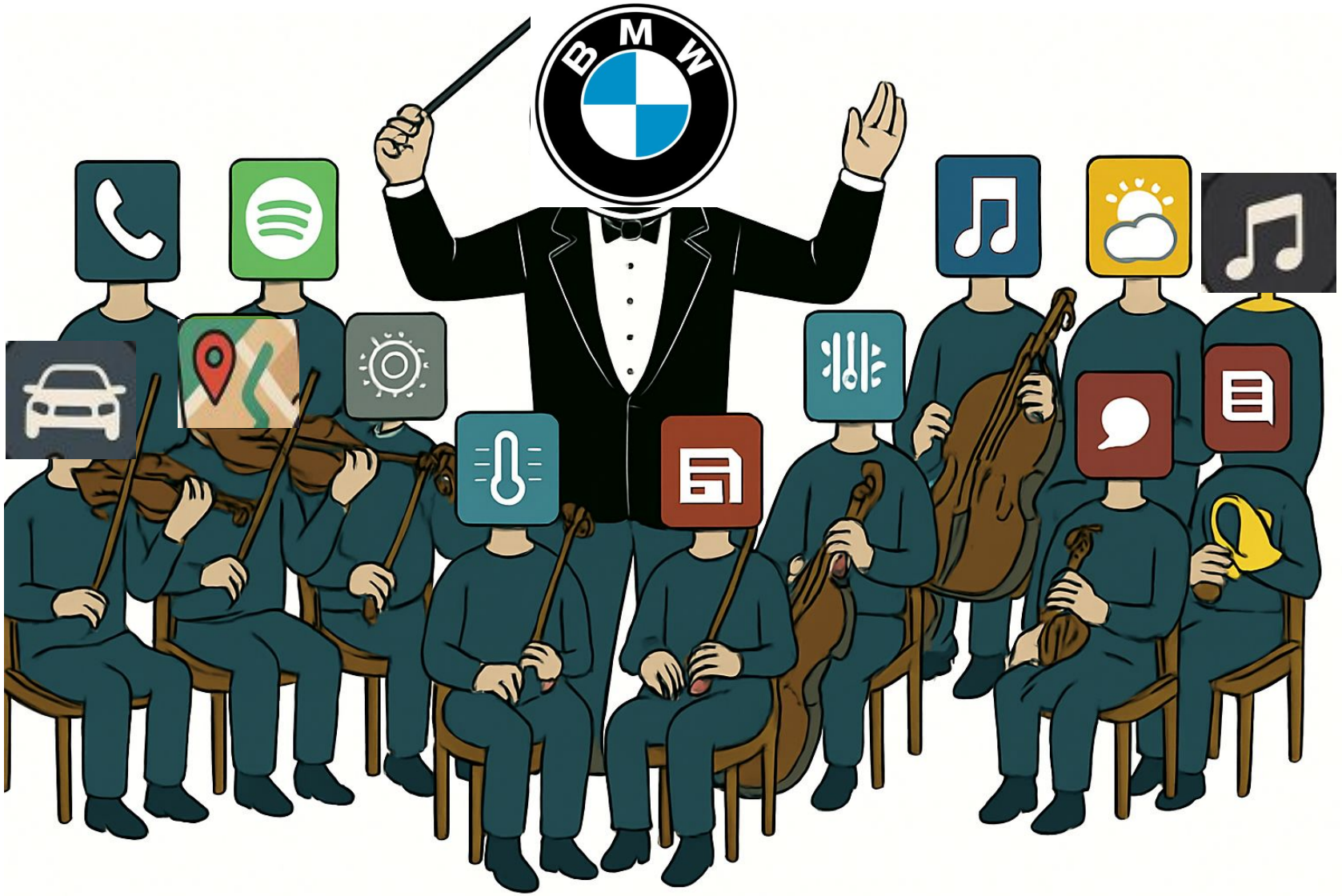
A CAR IS LIKE A SYMPHONY ORCHESTRA

🎼 *Each feature is an instrument; navigation, music, communication, comfort..*

🎶 *Harmony creates seamless, enjoyable journeys.*

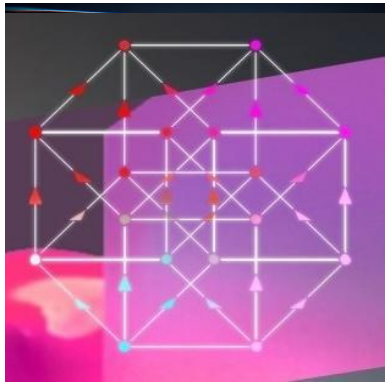
🔇 *Without orchestration, it's just noise.*

👨‍✈️ *The car becomes the conductor, delivering a personalized experience every drive.*



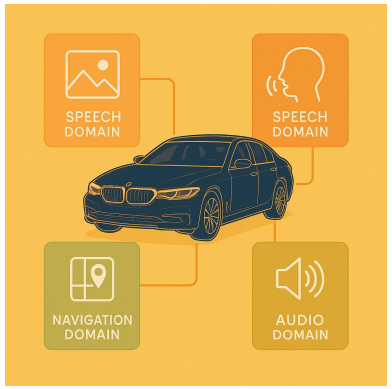
CHALLENGES BENEATH THE SURFACE

True personalization requires orchestration: The car must act as conductor.



Context is multi-dimensional: user, location, time, weather, traffic, mood.

Preferences are constantly changing and highly situational



Technical heterogeneity: sensors, APIs, different data formats, Each app has its own domain

Privacy by design is essential with so much personal data flowing through the car

THE OLD WORLD OF IF-ELSE

Rule-Based Personalization

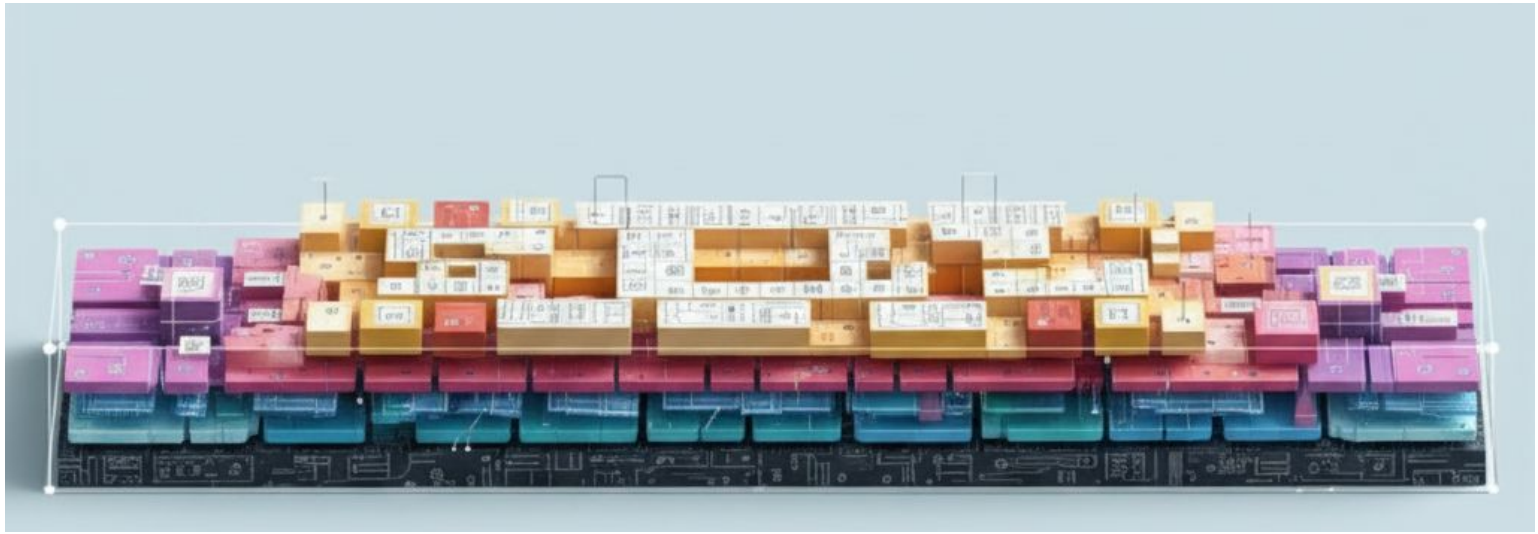
- Works for **toy problems**
- Rules grow exponentially, impossible to maintain at scale

  If morning → turn on seat heating
  If traffic jam → suggest alternative route
  If raining → adjust wipers & lights

```
def route_request(ctx):
    if ctx.level1:
        if ctx.level2:
            if ctx.level3:
                if ctx.level4:
                    if ctx.level5:
                        if ctx.level6:
                            if ctx.level7:
                                if ctx.level8:
                                    if ctx.level9:
                                        if ctx.level10:
                                            return handle_deep(ctx)
                                        else:
                                            return handle_alt10(ctx)
                                    else:
                                        return handle_alt9(ctx)
                                else:
                                    return handle_alt8(ctx)
                            else:
                                return handle_alt7(ctx)
                        else:
                            return handle_alt6(ctx)
```

Single Foundation Model

- **Too big** → difficult to embed in **resource-constrained environments**
- **Too rigid** → prevents **modular development** and team scalability



SEARCH FOR A BETTER SOLUTION

Agentic AI is rapidly emerging, with agents appearing across tools, services, and platforms

ChatGPT 5

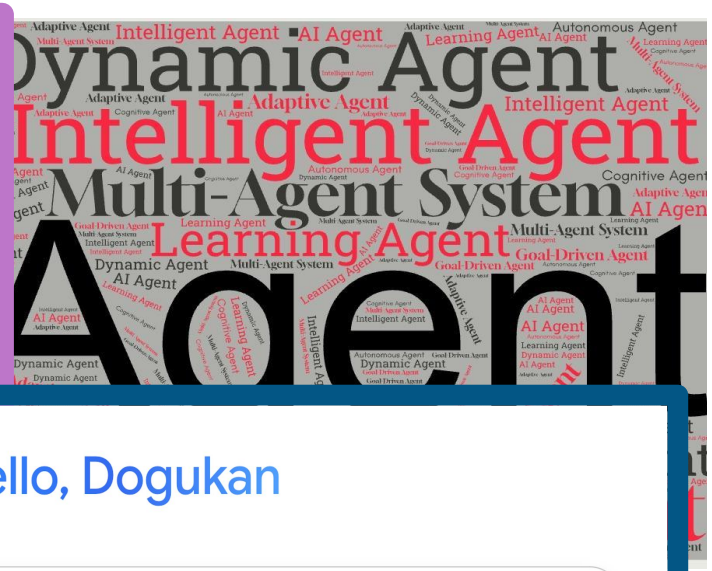
What are the latest AI trends?

Here are some of the *latest AI trends* for 2025–2026, drawn from academic, industry, and news sources. If you want, I can zoom in on specific sectors (e.g. healthcare, robotics, ethics), too.

🔍 **Key AI Trends**

1. **Agentic AI**

Autonomous agents that can act, plan, an
moving beyond tools to collaborators that



Hello, Dogukan

What are the latest AI trends?

Tools

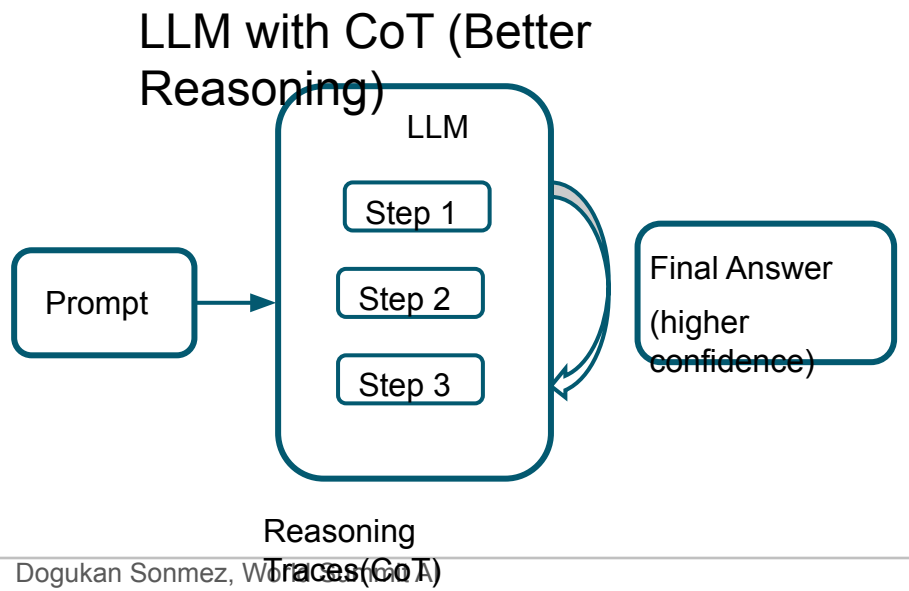
The artificial intelligence landscape is evolving at a rapid pace. Here are some of the most significant and recent trends shaping the field:

1. The Rise of Agentic AI and Autonomous Systems

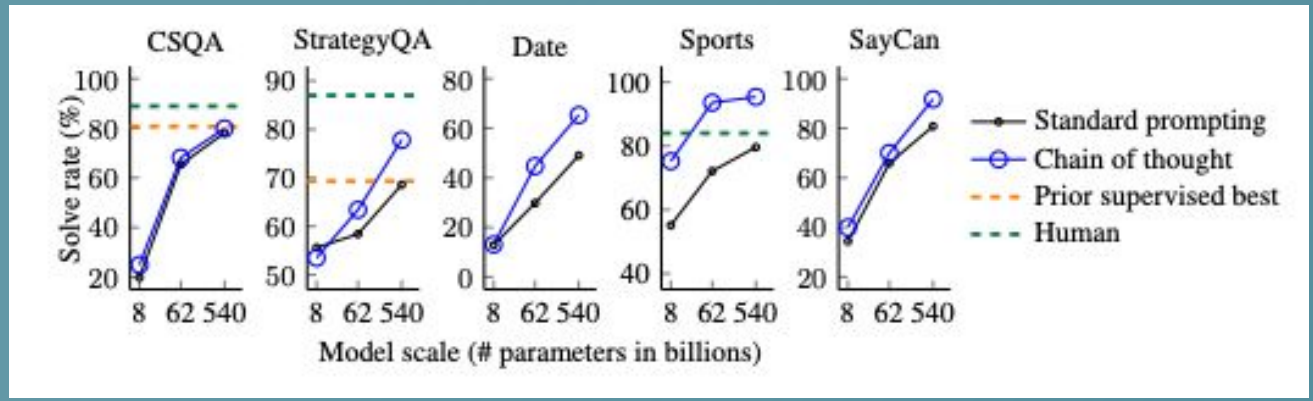
This is one of the most significant shifts. While traditional AI models respond to specific commands, "agentic" AI is designed to act autonomously to achieve a goal. These systems can:

LLM REASONING: THE PATH TO AGENTIC AI

- **Intermediate steps** improve accuracy through step-by-step reasoning.
- **Self-consistency** boosts reliability by aggregating multiple reasoning paths.
- **Limitations:** sensitive to distractions, poor self-correction, lack of knowledge.



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



Jason Wei, Xuezhi Wang, Dale Schuurmans, Maarten Bosma, Brian Ichter, Fei Xia, Ed Chi, Quoc Le, and Denny Zhou. Chain-of-thought prompting elicits reasoning in large language models. NeurIPS 2022

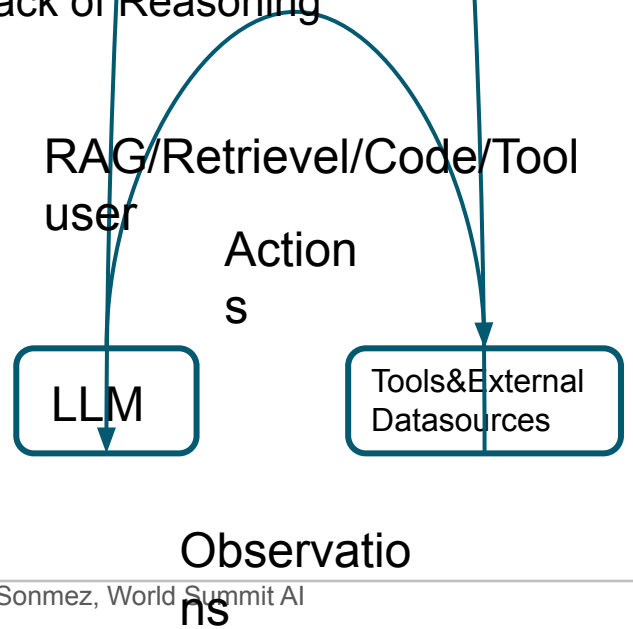
LLM KNOWLEDGE AND TOOL USAGE: THE PATH TO AGENTIC AI

Knowledge gaps: LLMs need external data for up-to-date or specialized information.

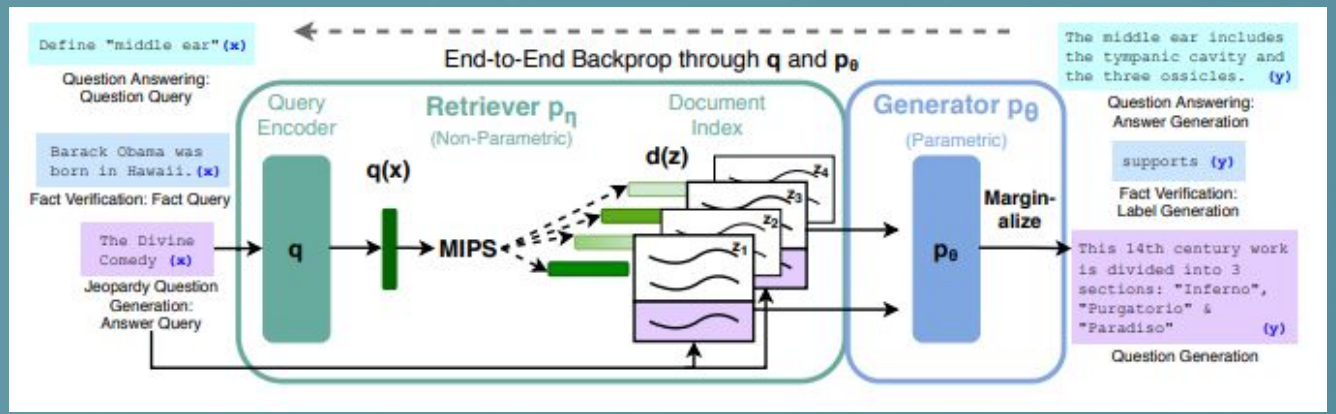
Tool integration: Some tasks require specific tools or computations beyond text generation.

Challenges:

- Multiple tool calls increase complexity
- Lack of Reasoning



Retrieval-Augmented Generation for Knowledge-Intensive NLP Tasks



Lewis, P., Yih, W.-t., Riedel, S., & Yih, W.-t. (2020). *Retrieval-Augmented Generation for Knowledge-Intensive NLP Tasks*. arXiv preprint arXiv:2005.11417.

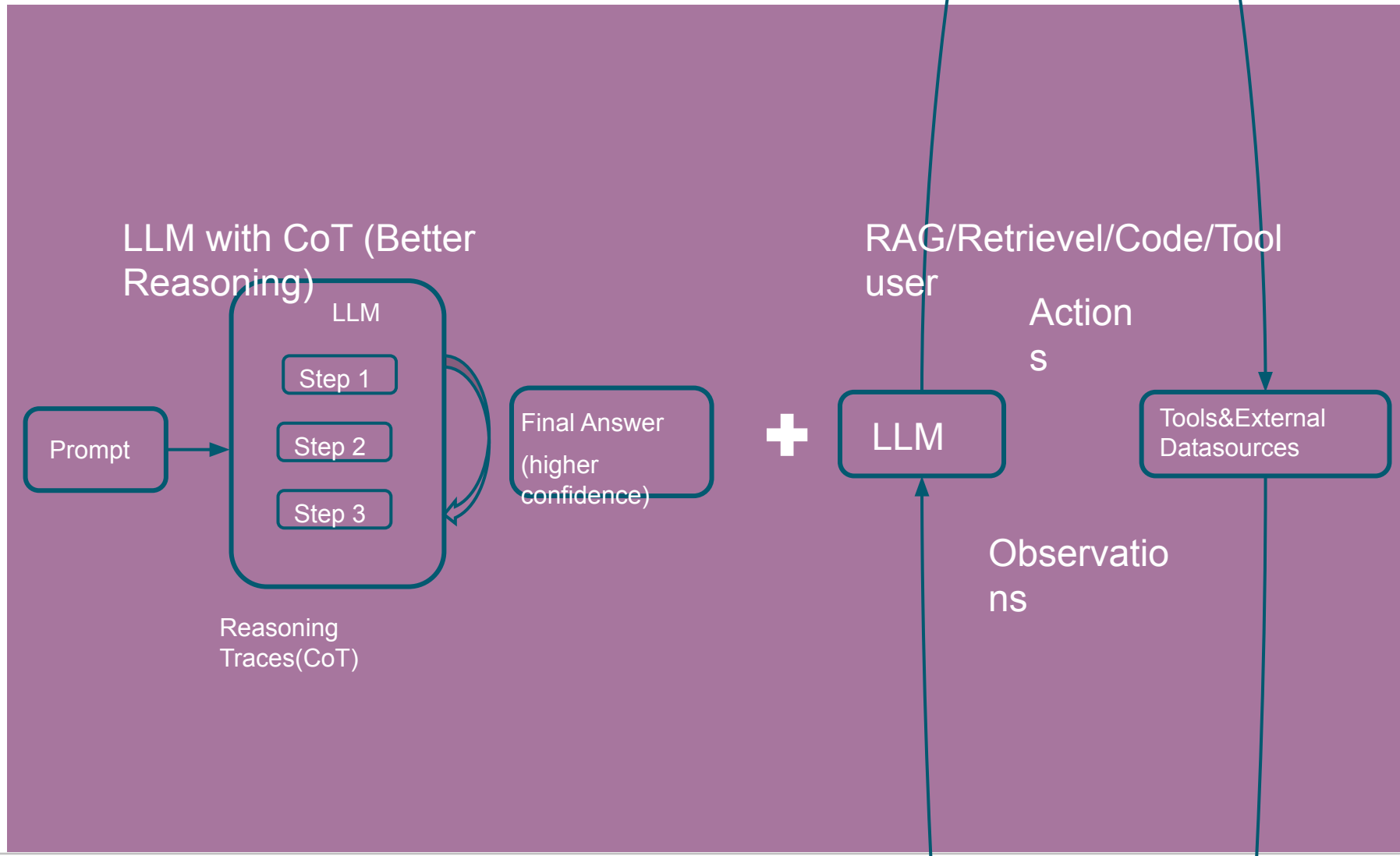
UNIFIED SOLUTION: THE PATH TO AGENTIC AI

🧩 ***Reasoning*** *(CoT)* → Breaks problems into logical steps.

📚 ***Knowledge*** *(RAG)* → Fills gaps with up-to-date, specialized data.

🛠️ ***Tools*** → Execute actions beyond text (APIs, computations, services).

🚀 *Combined* → Adaptive workflows that solve real-world challenges.



LLM POWERED AI AGENT

👀 *Perception & Memory* → Capture context and user preferences.

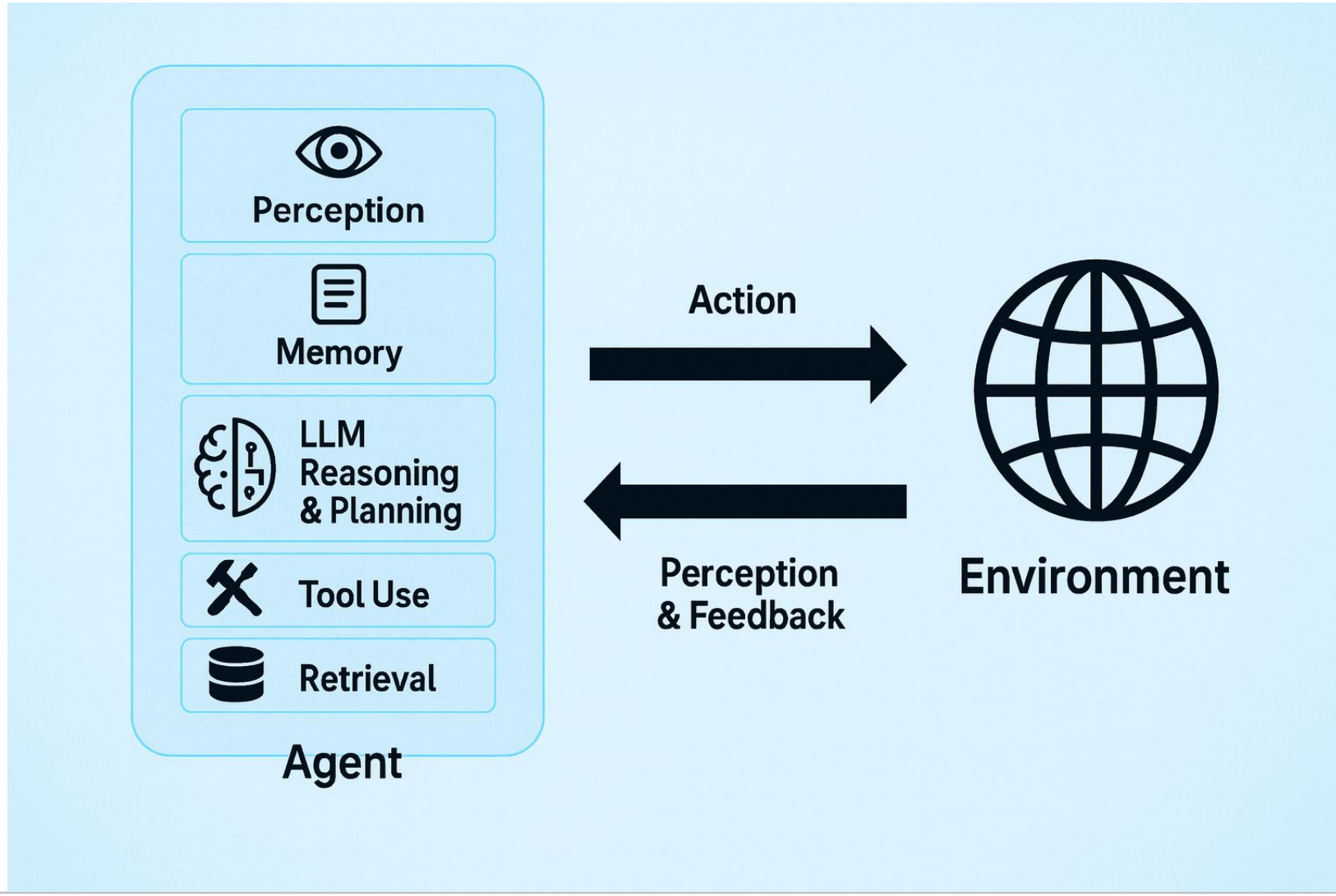
🧠 *Reasoning & Planning* → Decide next best actions.

🛠️ *Retrieval & Tool Use* → Access knowledge and execute tasks.

🔄 *Action & Feedback* → Adapt and evolve in real time.

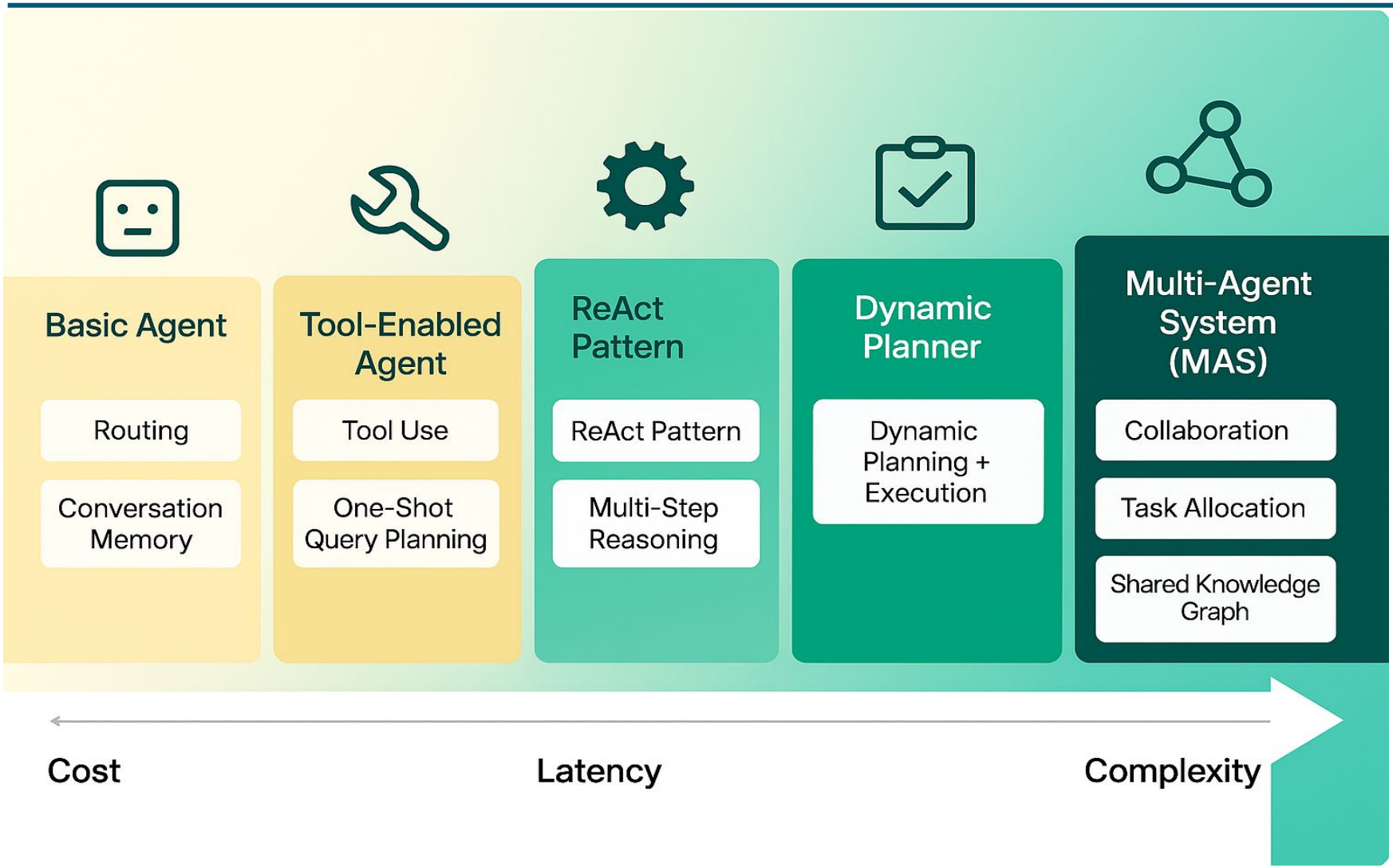
⚡ *Performance Boost*

- GPT-3.5 (zero-shot): **48.1%**
- GPT-4 (zero-shot): **67.0%**
- GPT-3.5 + Agent Loop: **95.1%**



SCALING AGENT CAPABILITIES

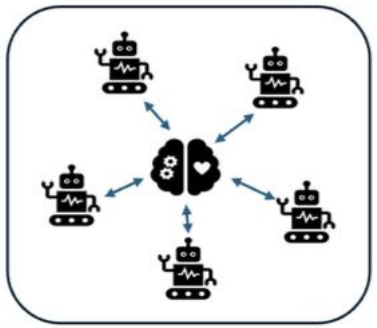
- ***Single-Agent*** → Simple, lightweight tasks.
- ***Collaborative Agents*** → Coordinate for more complex workflows.
- ***Multi-Agent Systems*** →
- Dynamic, large-scale orchestration.



COORDINATION UNLOCKS COGNITION - MULTI-AGENT SYSTEMS (MAS)

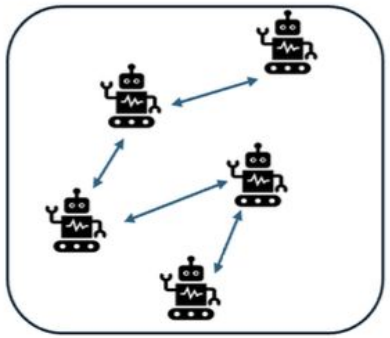
Core Traits of MAS:

- ***Autonomy*** — agents act independently
- ***Task Distribution*** — subtasks split and assigned
- ***Communication*** — coordinate and delegate actions
- ***Adaptation & Feedback*** — adjust dynamically
- ***Aggregation*** — combine results into coherent outcomes



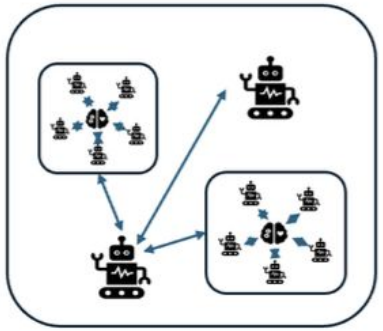
Centralized

One controller assigns tasks

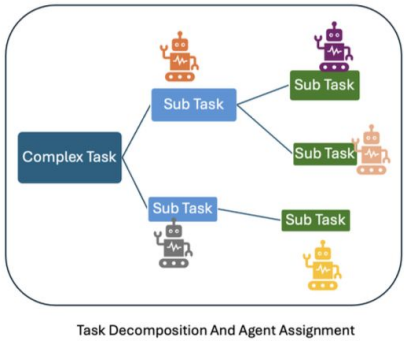


Decentralized

Peer-to-peer decision-making



Hierarchical/Hybrid Central guidance + local autonomy



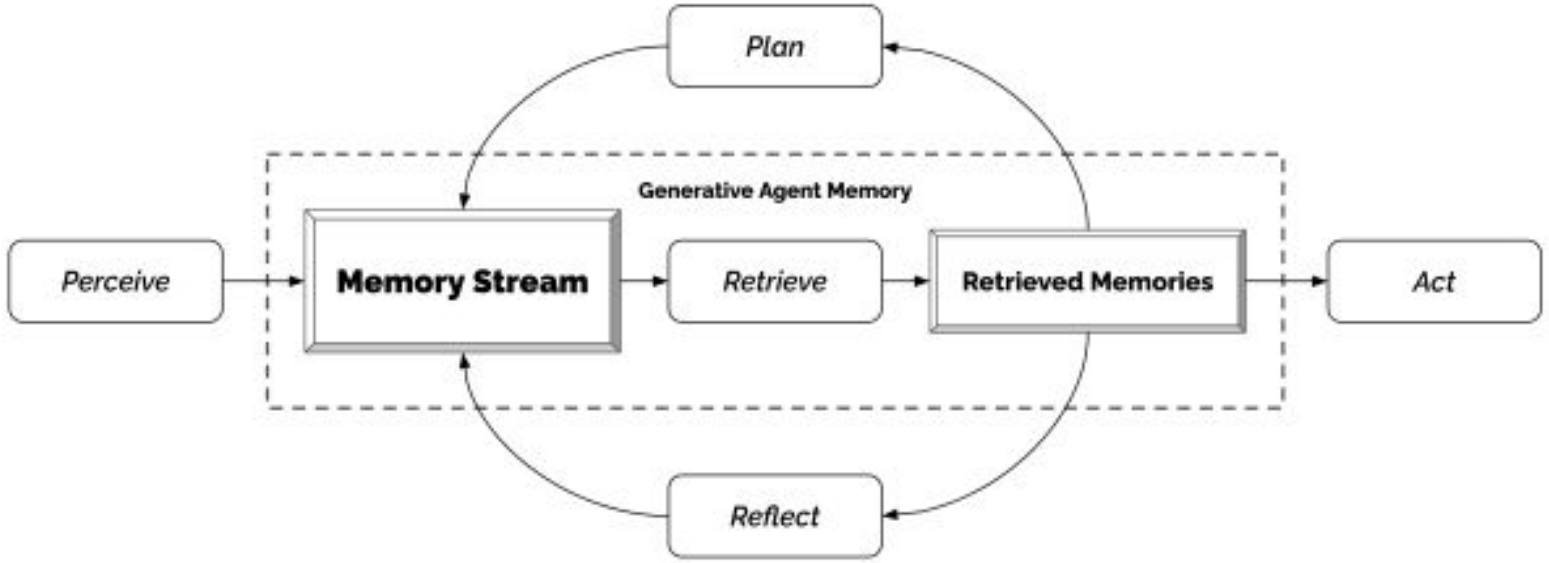
Task Decomposition And Agent Assignment

Workflows

A workflow defines how tasks are decomposed, delegated, and executed across agents to achieve a common goal.

COGNITIVE ARCHITECTURES

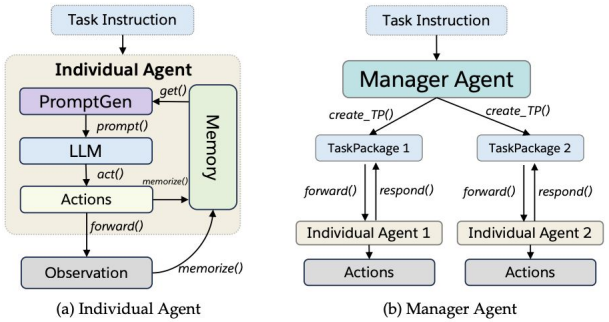
- Can cognitive architectures help us understand how the human mind works?
- Can we design general-purpose computational agents capable of performing human tasks?



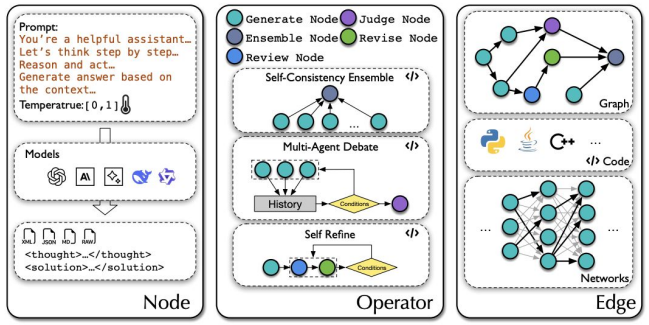
Cognitive architectures capture the shared mechanisms behind diverse cognitive behaviors, aiming for a unified understanding of human cognition.

J. S. Park, J. C. O'Brien, C. J. Cai, M. R. Morris, P. Liang, M. S. Bernstein, Generative agents: Interactive simulacra of human behavior, in Proceedings of the 36th Annual ACM Symposium on User Interface Software and Technology (ACM, 2023)

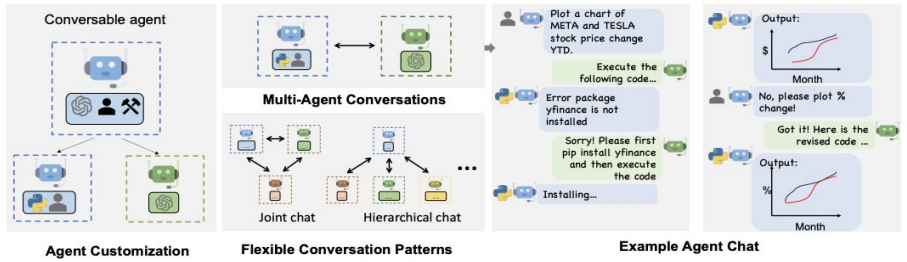
EXISTING MAS APPROACHES – MAS FRAMEWORKS



Z. Liu et al. *AgentLite*: *A lightweight library for building and advancing task-oriented LLM agent systems*. arXiv, 2024.



Z. Li et al. *Autoflow*: *Automated workflow generation for large language model agents*. arXiv, 2024.



Q. Wu et al. *Autogen*: *Enabling next-gen LLM applications via multi-agent conversation*. arXiv, 2023.

AgentLite

Multi-agent hierarchical orchestration with layered planning and task decomposition

Autoflow

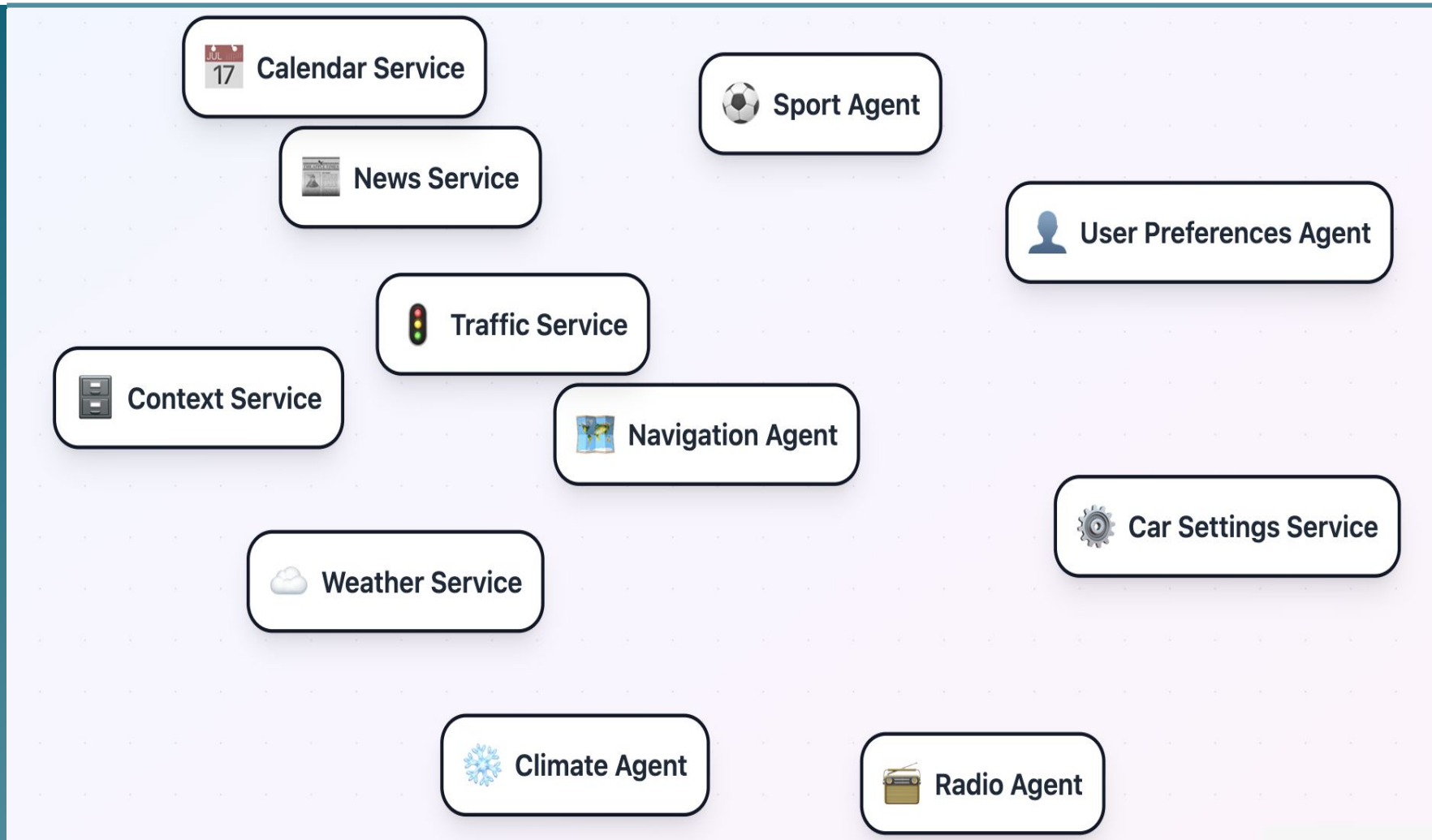
Automates workflow generation using LLM-driven programs

Autogen

Modular, conversational framework with flexible communication.

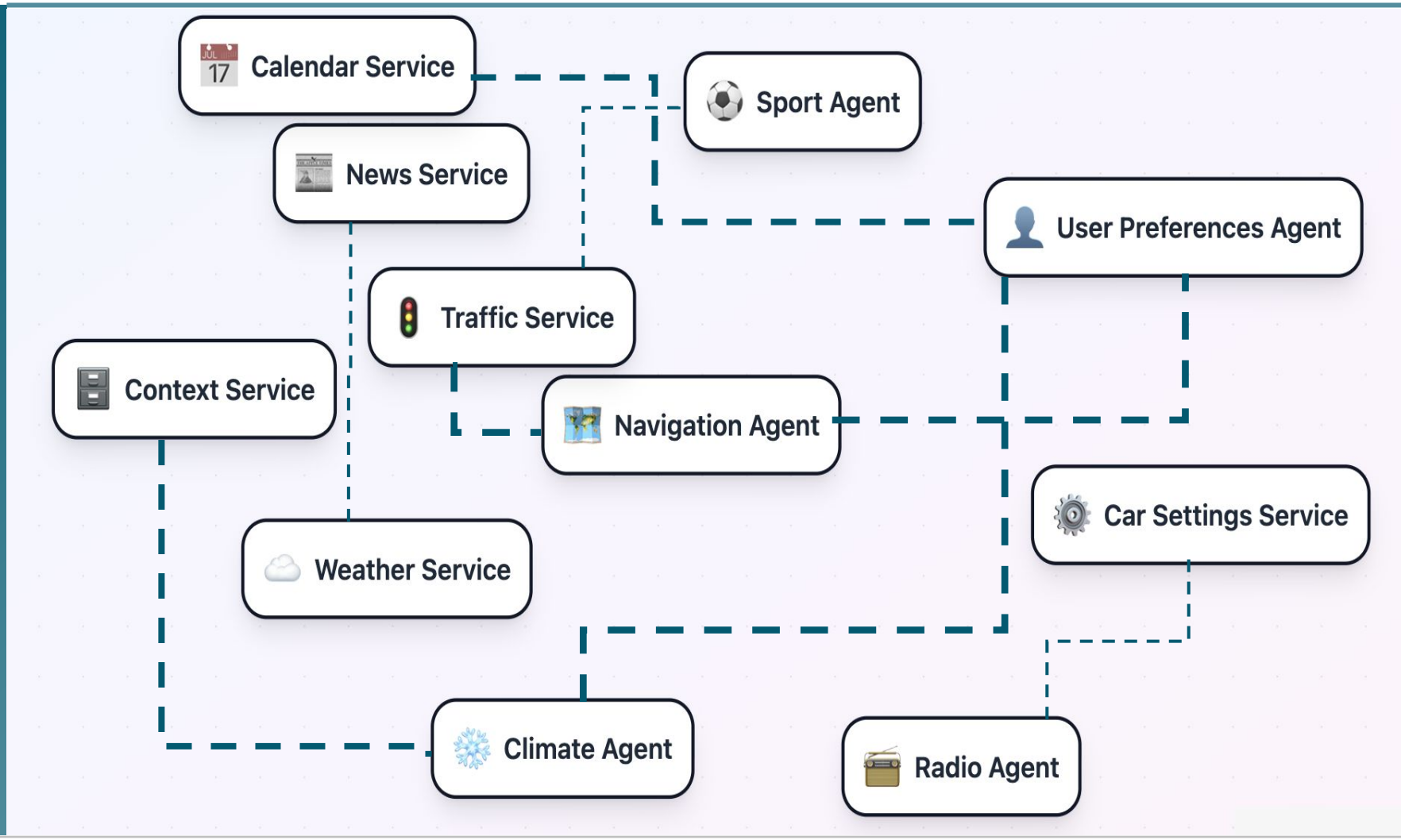
FROM SILOS TO HARMONY IN THE CAR

- Each function evolves into an **autonomous agent**
- **Services and tools** connect seamlessly via **standard protocols(MCP or A2A)**.
- Reduce **complexity** and integrates diverse systems across departments.



FROM AGENTS TO PERSONALIZED INTELLIGENCE

- ***Graph-Orchestration*** → Connects all agents and services into one system.
- ***Decision Engine*** → Evaluates inputs and selects the best action.
- ***Personal Knowledge Graph*** → Built from each driver's unique preferences, context, and behavior.

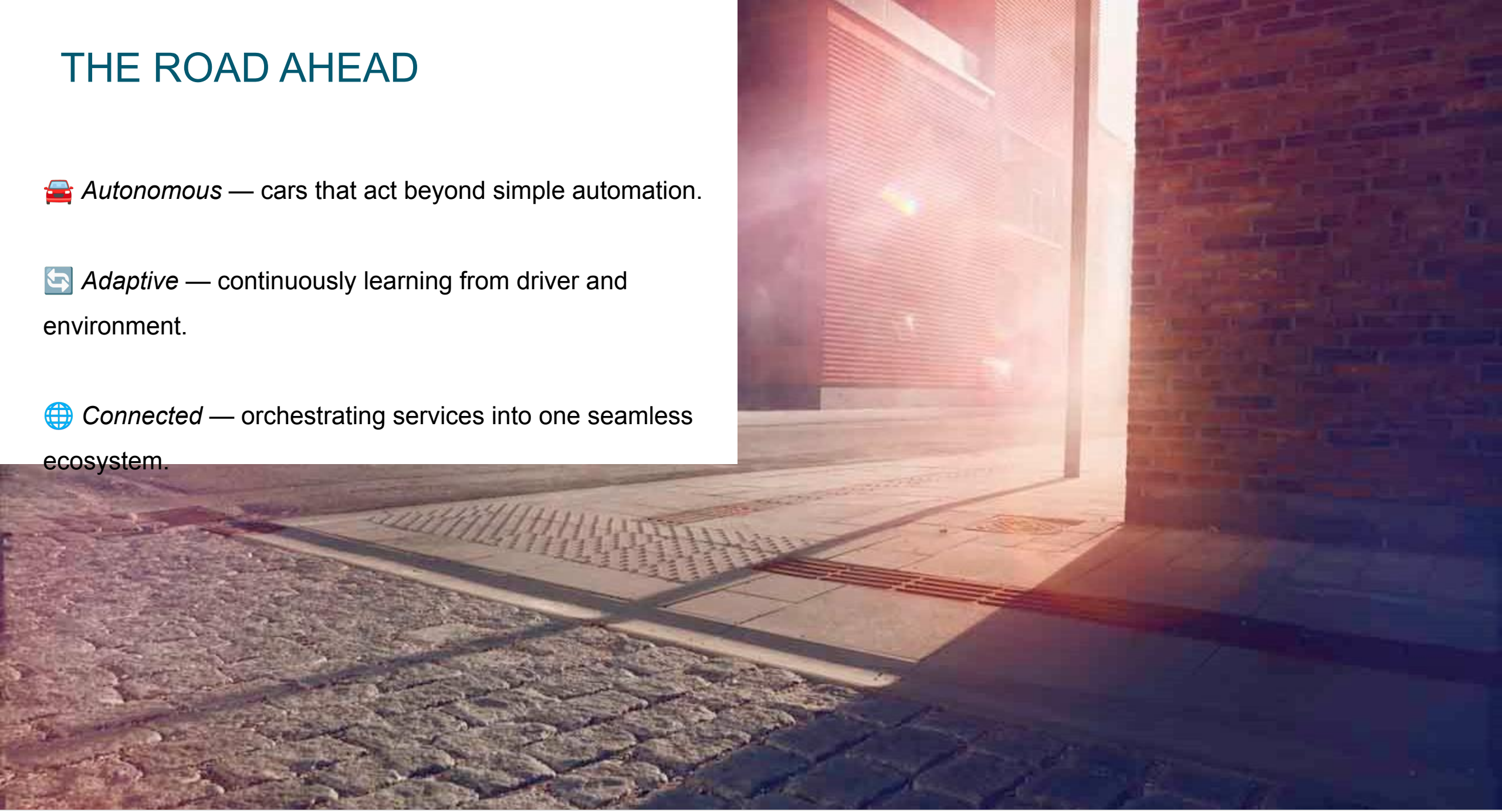


THE ROAD AHEAD

🚗 *Autonomous* — cars that act beyond simple automation.

🔄 *Adaptive* — continuously learning from driver and environment.

🌐 *Connected* — orchestrating services into one seamless ecosystem.



MULTI MODEL AGENTIC REASONING

Agentic AI for Multi-Agent Reasoning

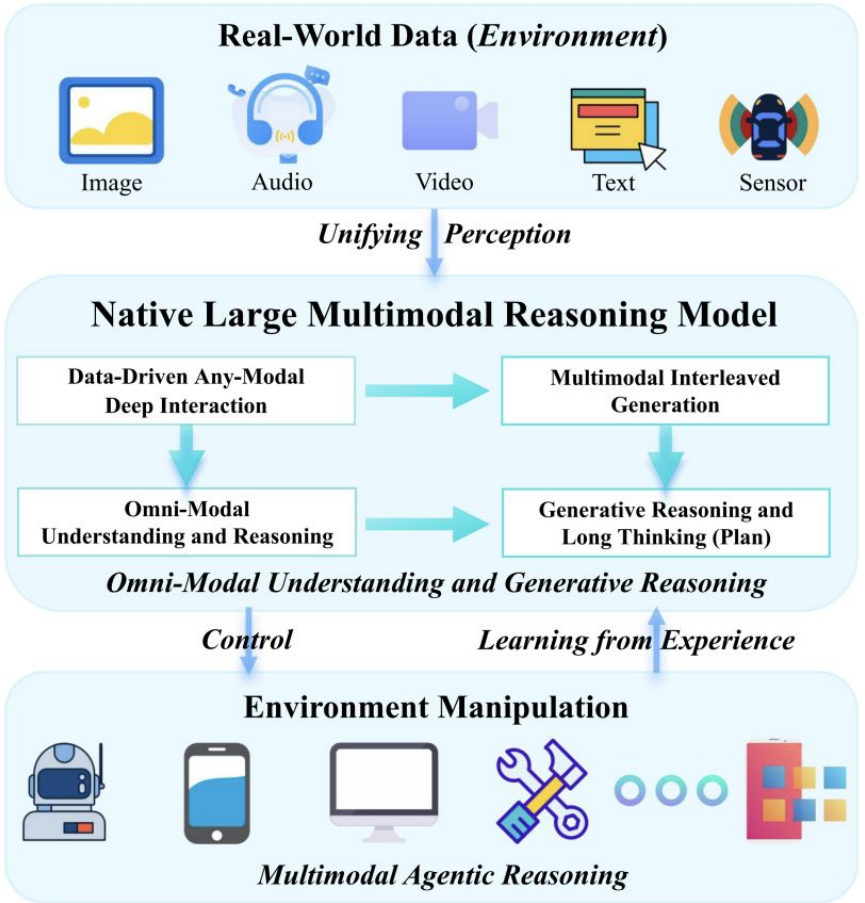
Teach a reasoning routine:

1. list all diagram elements
2. detect arrows & directions
3. infer the process order

Enable tool use:

4. retrieve similar images (web/RAG) →
5. measure with an image tool
6. query a knowledge graph.

Agentic Collaboration → Specialized agents coordinate via feedback loops



Y. Li et al. *Perception, Reason, Think, and Plan: A Survey on Large Multimodal Reasoning Models*. arXiv:2505.04921, 2025.

SCALING AGENTIC AI WITH SMALL LANGUAGE MODELS

Small Models, Big Wins

SLMs handle repetitive agent tasks with lower **latency**, cost, and on-device deployment.

Hybrid setup: SLMs run core loops, large LMs step in for complex reasoning.

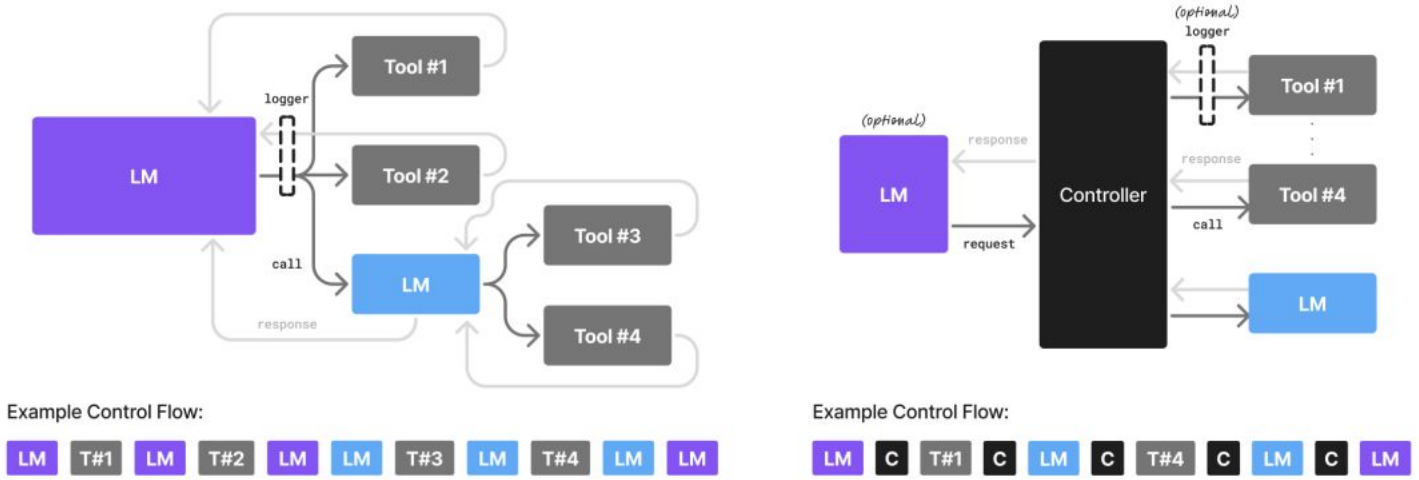


Figure 1: An illustration of agentic systems with different modes of agency. *Left: Language model agency.* The language model acts both as the HCI and the orchestrator of tool calls to carry out a task. *Right: Code agency.* The language model fills the role of the HCI (optionally) while a dedicated controller code orchestrates all interactions.

P. Belcak et al. *Small Language Models are the Future of Agentic AI*. arXiv:2506.02153, 2025.

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