

IEEE RAS Day 2026 – IEEE RAS Egypt Chapter

From Digital AI to Physical AI in Smart Mobility

The Paradigm Shift from Screen-Confined Intelligence to Embodied Autonomous Systems

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Chair of IEEE ITSS Saudi Chapter

Founder of IEEE RAS Egypt Chapter

[AI for Smart Mobility Lab](#)

Outline

- » About KFUPM and AI for Smart Mobility Lab
- » From Digital AI to Physical AI
- » Intent-driven Agentic Workflow
- » Common Patterns for AI Use Cases
- » Use Cases in Smart Mobility and Logistics



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About KFUPM

1 Our Home

Dhahran, Saudi Arabia
Driving to Bahrain, Qatar, UAE, Kuwait

2 Our Community

A diverse and thriving student body



80+

Countries of
students



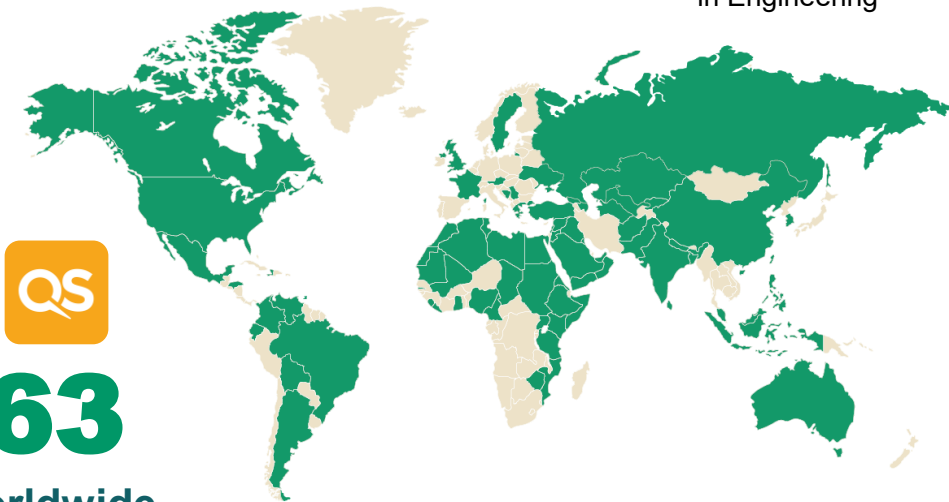
40%

Graduate students
of total



50%

Female enrollment
in Engineering



#63

Worldwide

3 Exclusive admission

3% admit-to-apply 1435 SAT bottom 25th percentile
*Demands **higher** scores than medical schools*

Dream Big
and Accomplish



4 Pivot into 10 Critical Sectors

No longer just *Petroleum*



Comprehensive
Energy & Minerals



Manufacturing



Mobility &
Logistics



Fintech



Biotechnology



Chemicals &
Materials



Environment
& Sustainability



Digital
Economy



Aerospace &
Defense



Design & Built
Environment

AI+X[®]

Where Every
Discipline in
Built on AI

About AI for Smart Mobility Lab

1

Situational Awareness

Multimodal sensing and perception, vulnerable road user behavior and intent prediction, cooperative perception in mixed traffic, and context-aware causal observability for software-defined vehicles.

2

Reasoning and Action

Agentic AI systems that integrate perception, reasoning, planning, and action to deliver adaptive, context-aware, and personalized mobility services and intelligent service orchestration.

3

Optimization

Advanced search and optimization for complex design, planning, and control problems across people mobility, logistics, and transportation infrastructure — efficient, sustainable, antifragile.



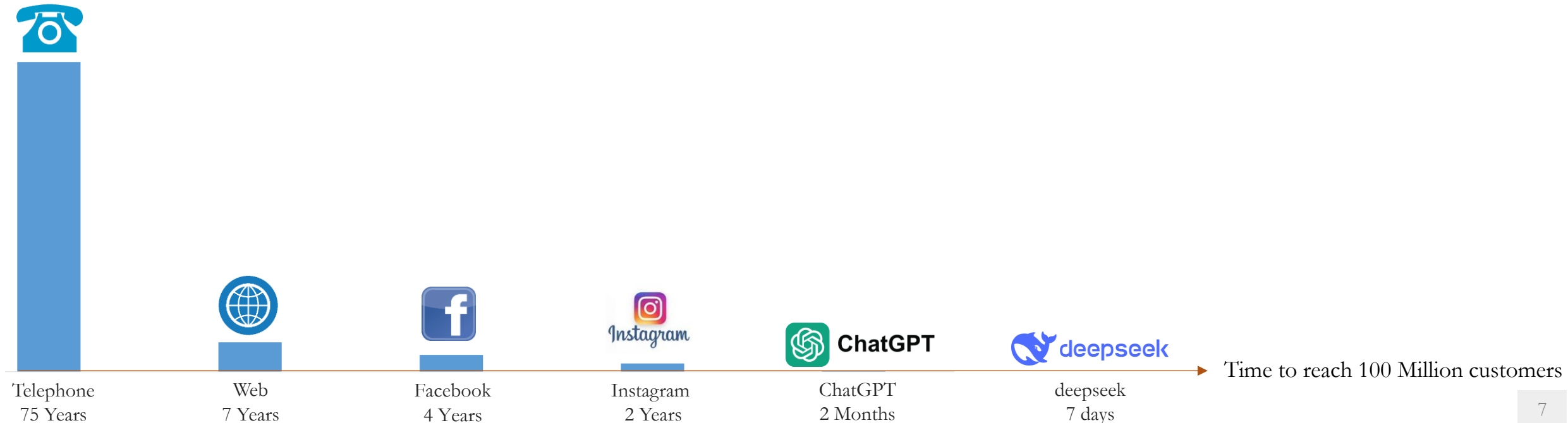
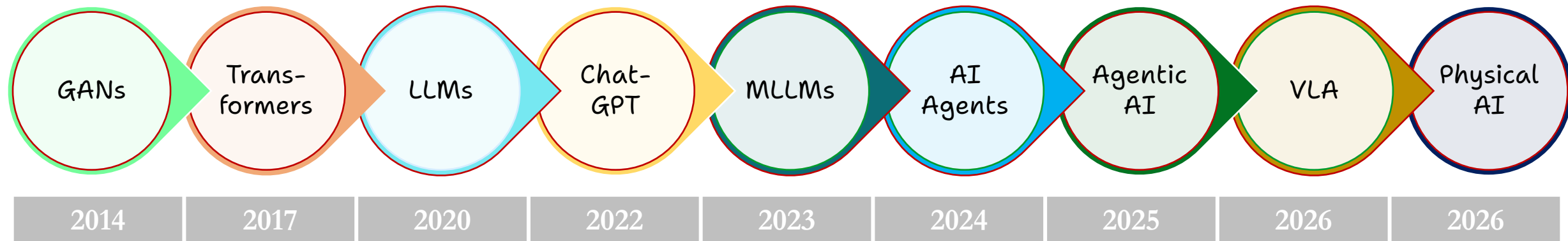
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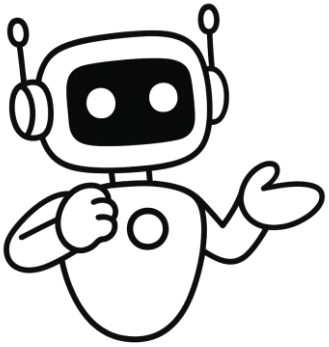
From Digital AI to Physical AI

» The Alphabet Soup of AI



From Digital AI to Physical AI

» What is AI Agent



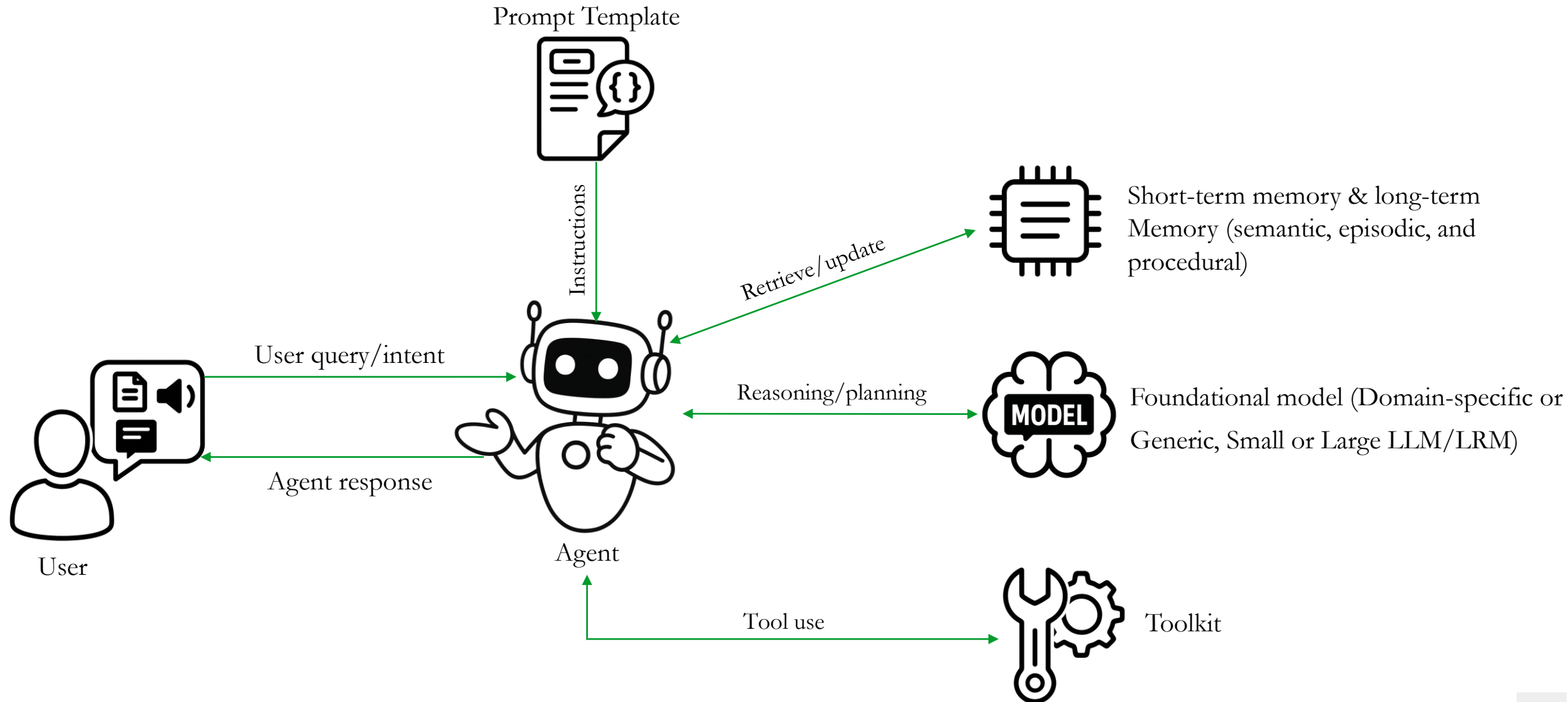
An AI agent is a **goal-oriented autonomous computational entity** that **connects reasoning and action** using foundation models, memory systems, and external tools to **achieve contextually intelligent outcomes**.

Main Characteristics:

1. Goal-oriented
2. Autonomous
3. Able to perceive, reason, plan, act, and learn.
4. Achieve contextually intelligent outcomes.

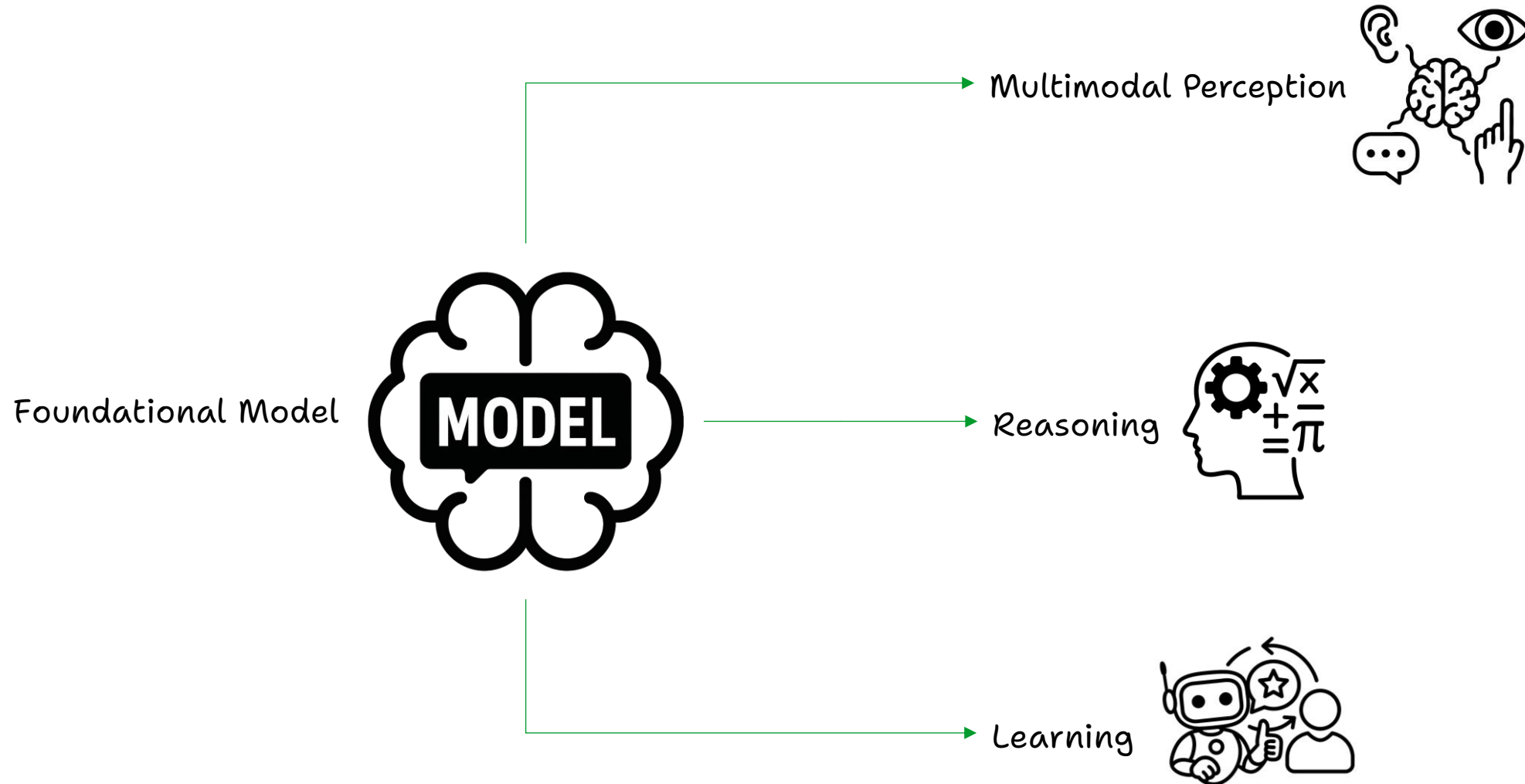
From Digital AI to Physical AI

» AI Agent Components



From Digital AI to Physical AI

» Foundational Model



From Digital AI to Physical AI

» Foundational Model

Scale	Type	Modality	Use Case Focus	Example Models
Large Language Models (LLMs) 30B – 400B+ parameters)	Reasoning / General LLM	Multimodal (or evolving)	Advanced reasoning, planning, multimodal agents	GPT-5, GPT-4 (OpenAI), Claude 3 (Anthropic), Gemini Pro (Google), Llama 3 70B (Meta)
Small Language Models (SLMs) 1B – 13B parameters)	Language / lightweight reasoning	Unimodal or limited multimodal	Fast inference, fine-tuning, domain tasks	Llama 3 8B / 3B (Meta), Mistral 7B (Mistral), Phi-3 small (Microsoft), Gemma 2 (Google), Qwen-7B (Alibaba)



Mistral AI



Qwen



deepseek



OpenRouter



Jan



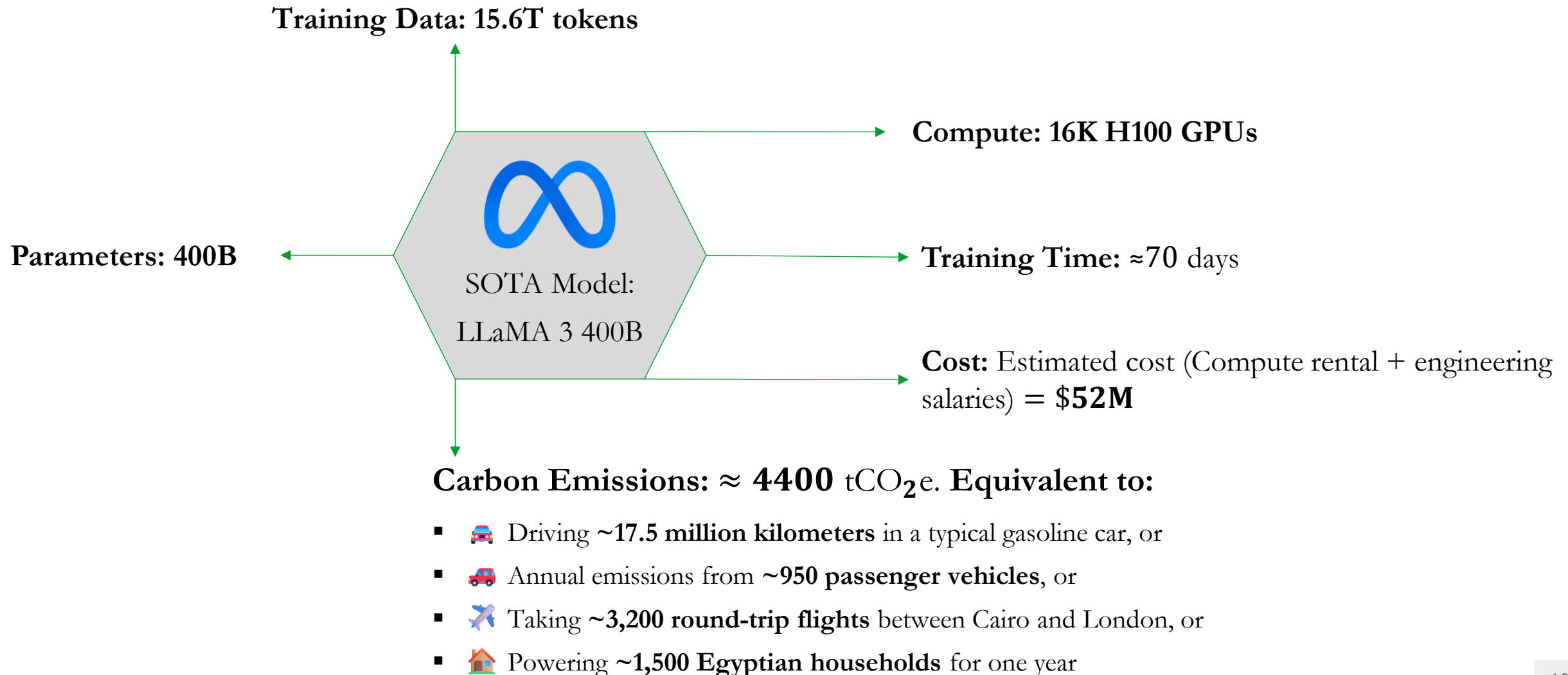
Ollama



Novita

From Digital AI to Physical AI

» General LLM Training Pipeline



From Digital AI to Physical AI

» Reasoning



System 1: Fast, Intuitive



System 2: Slow, Deliberate

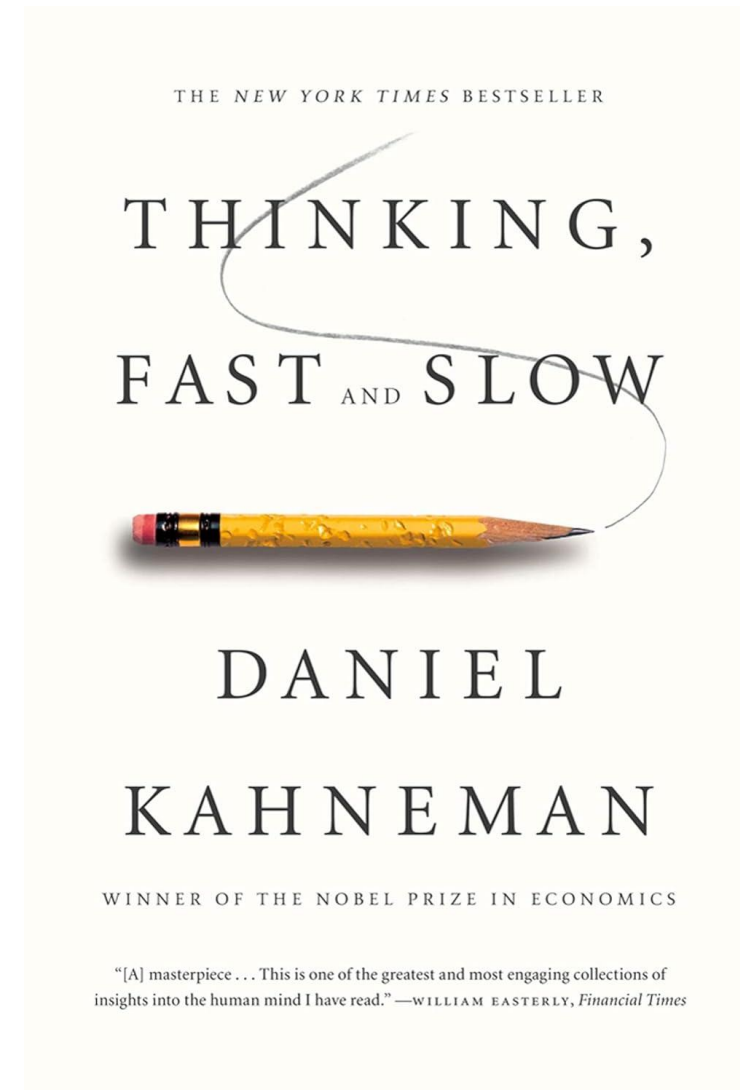
Question: What is $48 \div 4$?

System 1: $48 \div 4 = 12$

System 2: Let me check carefully:

- 4 goes into 40 ten times, remainder 8.
- 4 goes into 8 two times.
- $10 + 2 = 12$
- So, $48 \div 4 = 12$.

Same output, different approach to problem-solving



From Digital AI to Physical AI

» Reasoning



System 1: Fast, Intuitive



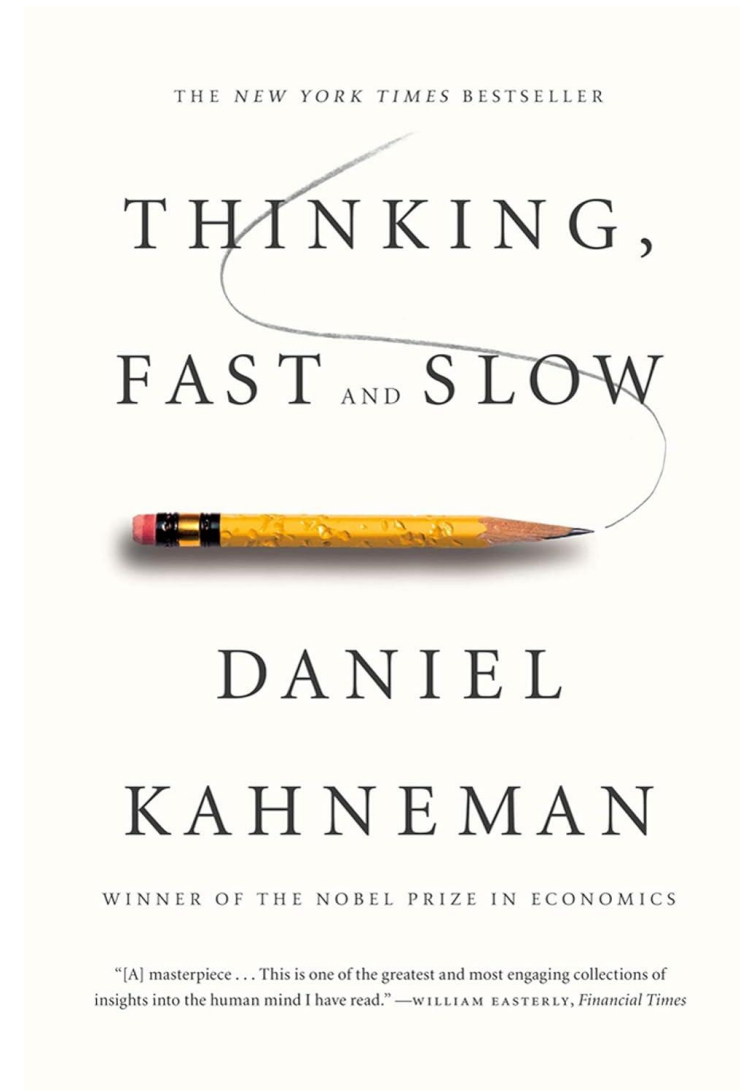
Text generation via
next-word prediction



System 2: Slow, Deliberate

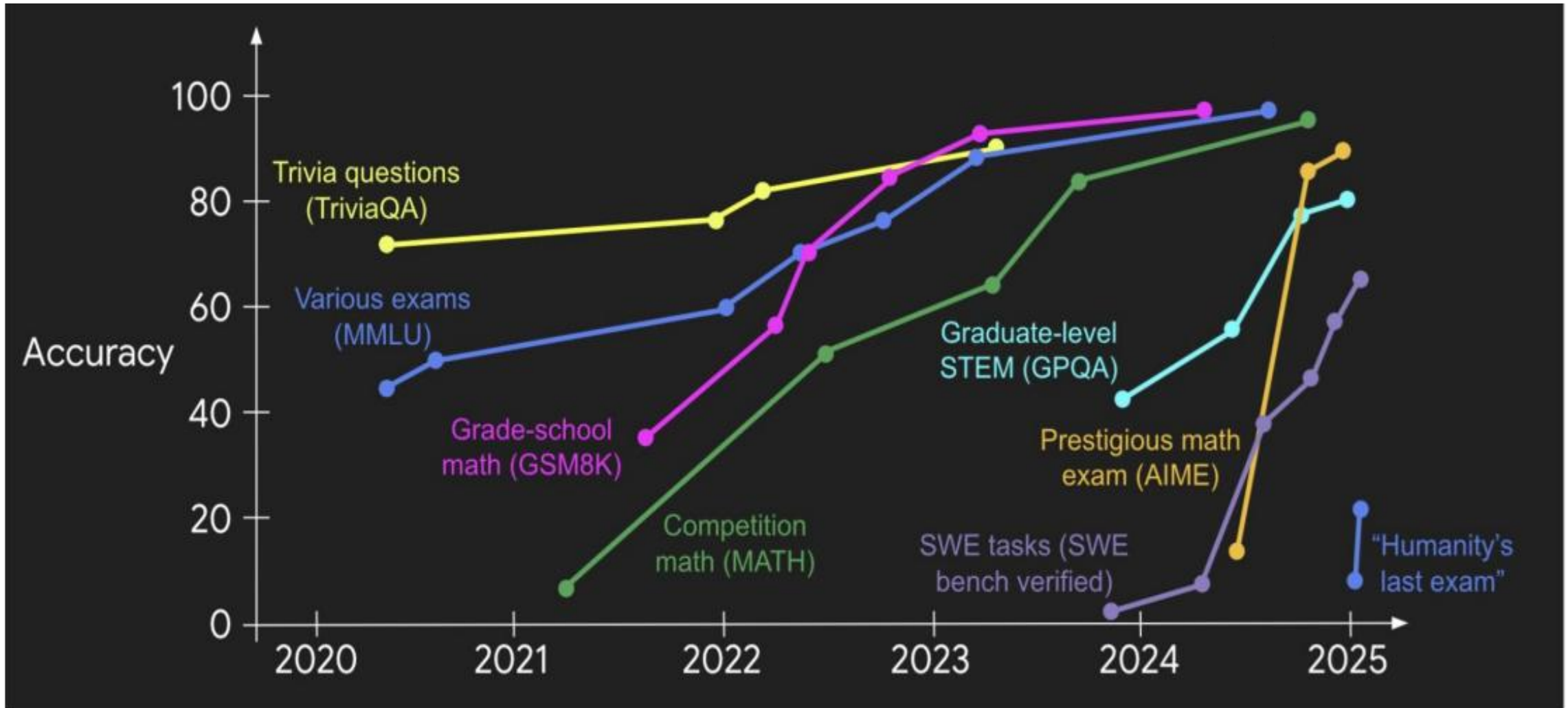


Multi-step Problem Solving
ReAct, Chain-of-Thought (CoT), Chain of
Continuous Thought (Coconut), Tree-of-
Thoughts (ToT), Distilling Reasoning



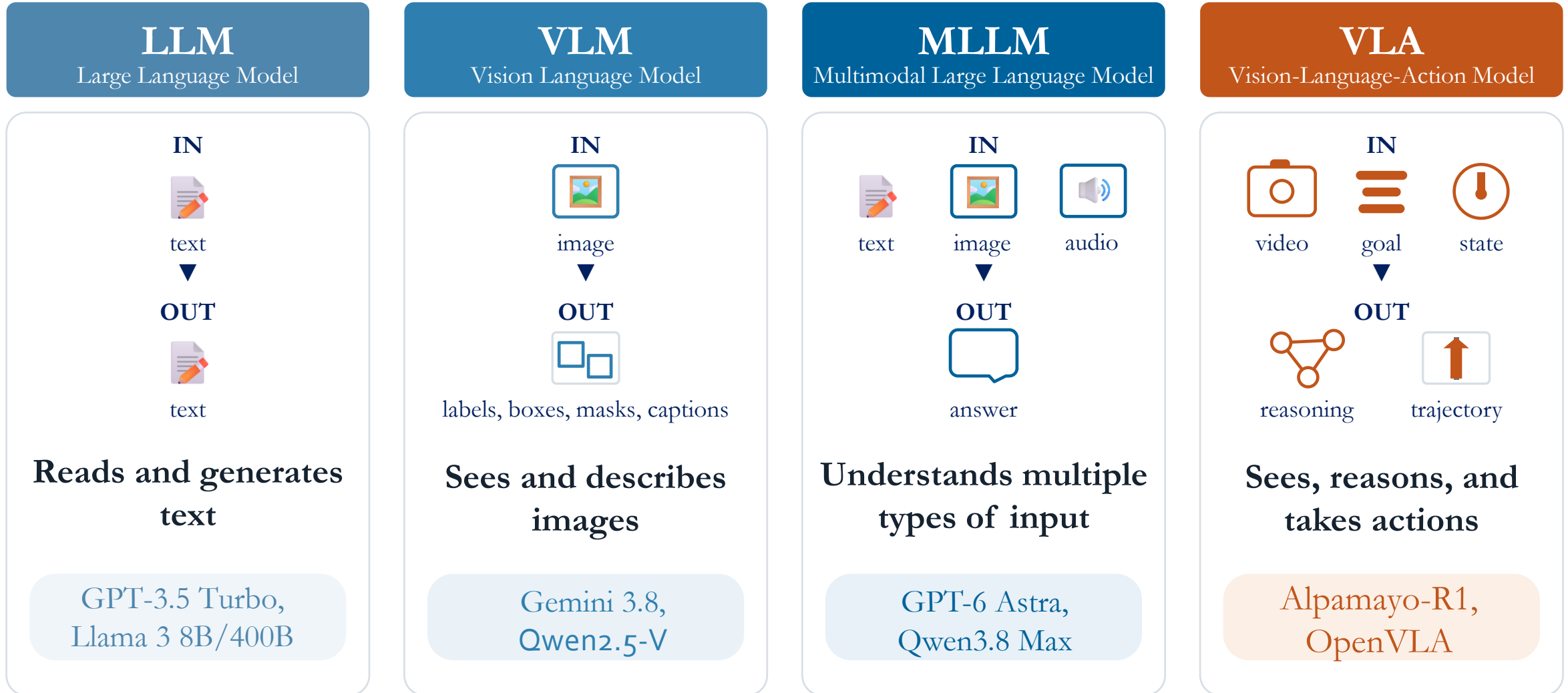
From Digital AI to Physical AI

» Reasoning: Progress on AI benchmarks in the past five years



From Digital AI to Physical AI

» AI Agent Components: Foundation Model



From Digital AI to Physical AI

» Digital Agentic AI vs. Physical Agentic AI

Shared agent loop

Perceive



Reason



Plan



Act



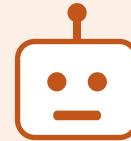
Learn



Digital Agentic AI

It changes **bits**.

Books a trip · files a claim · reconciles an invoice



Physical Agentic AI

It changes **atoms**.

Drives a robotaxi · moves a container · inspects a line



Apps & web



Databases



Documents



Workflows



Vehicles



Robots



Machines



Ports & plants

Logs, APIs, text, screens, databases

Perceives

Cameras, lidar, radar, IMU, force sensors

API calls, code, transactions, messages

Acts through

Motors, brakes, steering, grippers, valves

Milliseconds — retry, roll back, re-run

Feedback loop

Real time — no undo once mass is moving

Wrong record or wasted spend — recoverable

Cost of error

Collision, damage, injury — irreversible

Copy the agent; scaling is near-free

How it scales

Build hardware; fleets, maintenance, safety cases

Outline

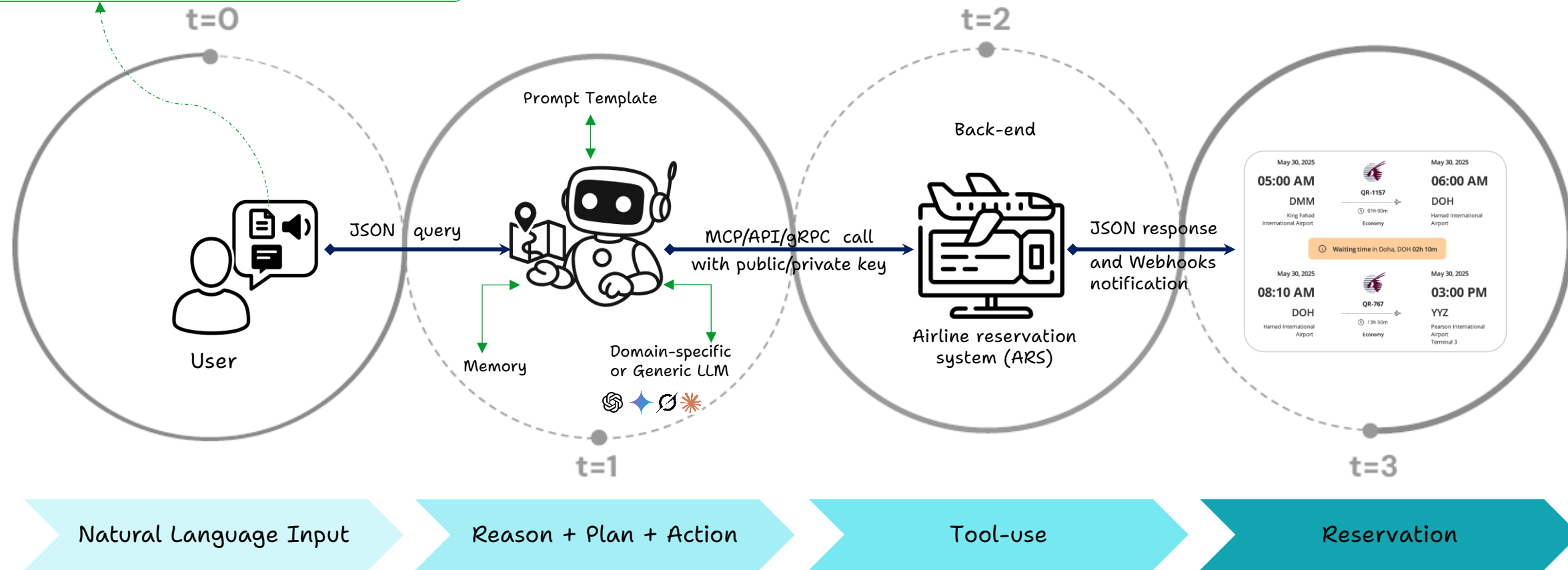
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Intent-driven Agentic Workflow

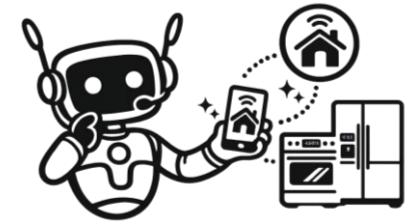
» Digital Agentic AI: Trip Planning

Could you please help me book a flight from Dammam to Toronto on May 30? I'd prefer a flight with no more than one stop, and I'd like to keep the total travel time as reasonable as possible. If there are multiple options, please prioritize the one with the shortest layover and a departure time after 5:00 AM local time in Dammam and arrival before 5:00PM local time in Toronto.



Intent-driven Agentic Workflow

» Physical Agentic AI: Home Physical AI Assistant



Home Physical AI Assistant



nVIDIA®



Intent-driven Agentic Workflow

» Physical Agentic AI: Inspection Assistant



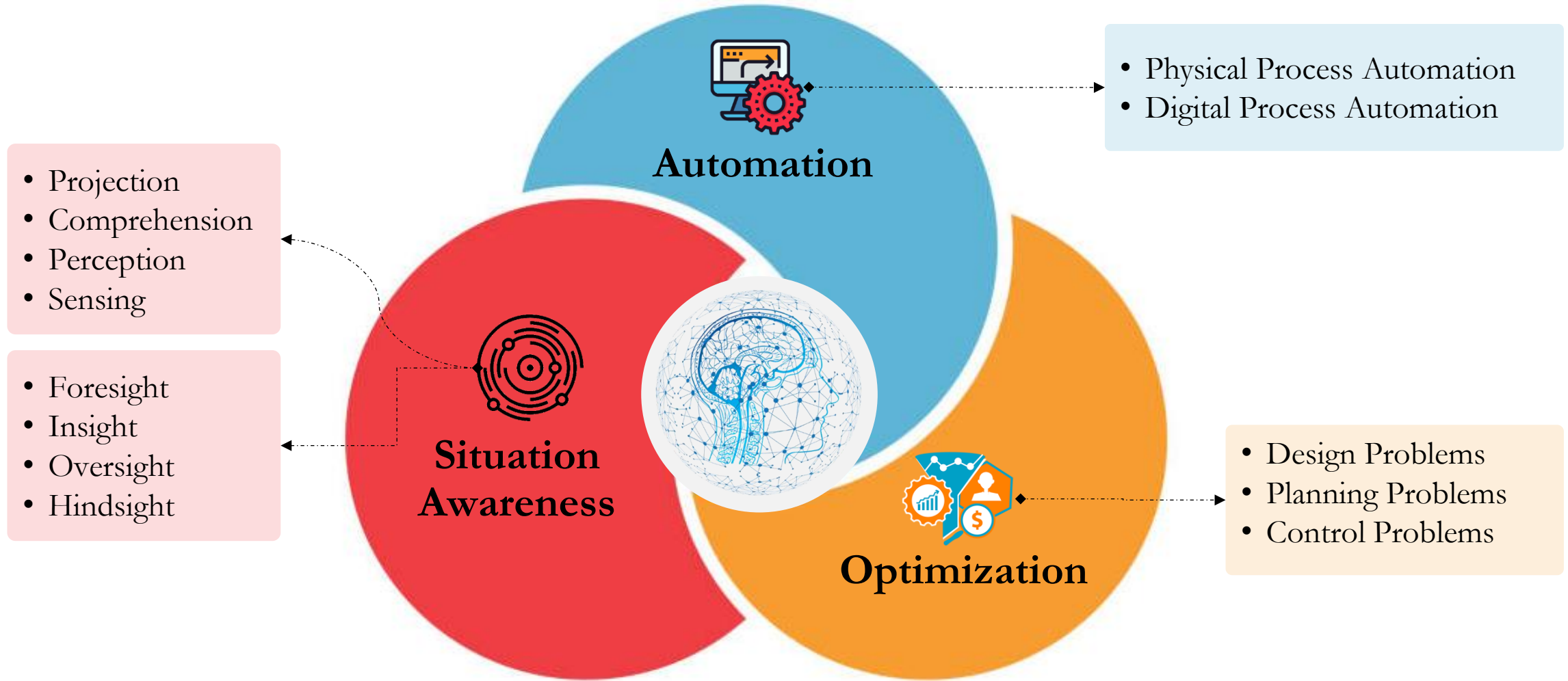
Inspection Assistant

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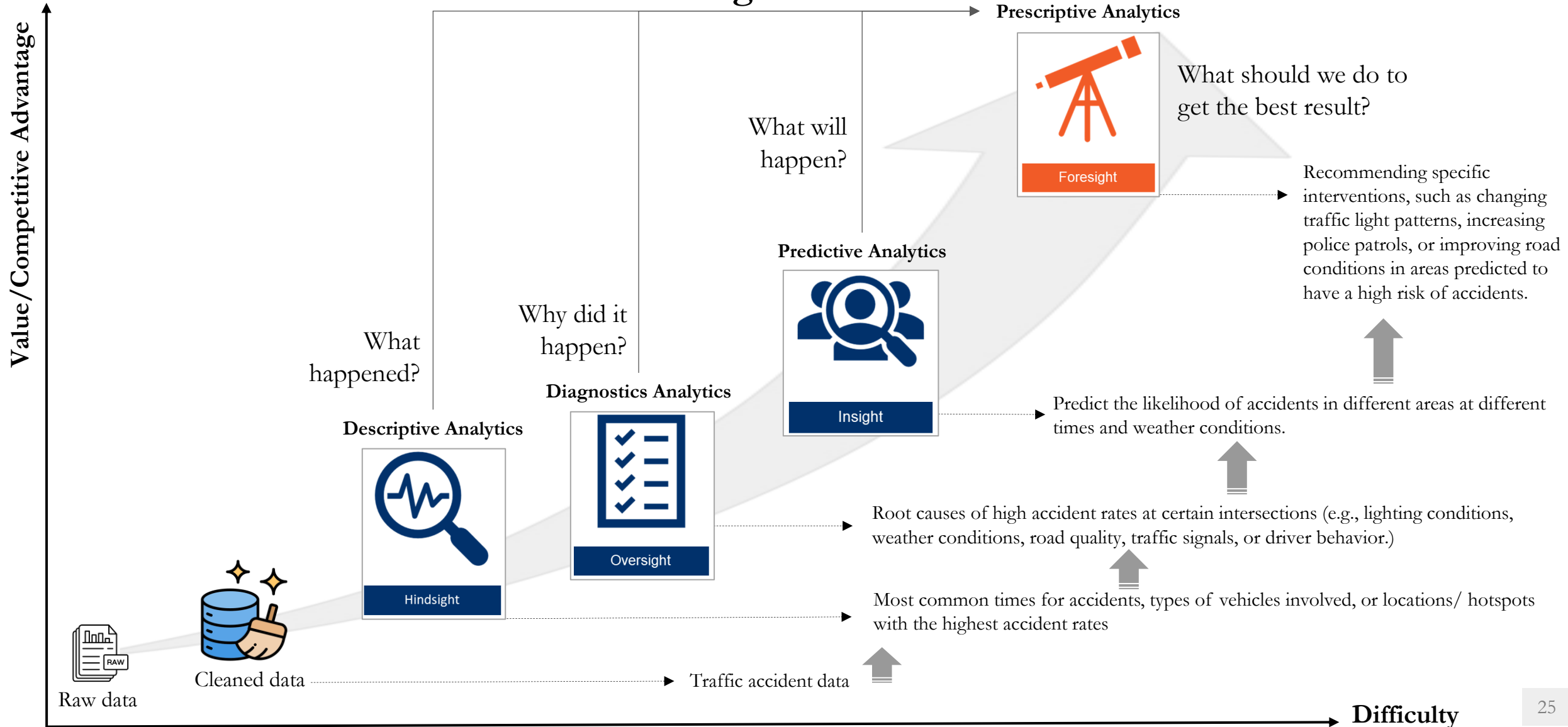


Common Patterns for AI Use Cases



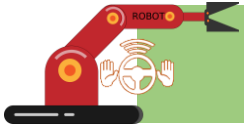
Common Patterns for AI Use Cases

» Situational Awareness: The 4 Lines of Sight



Common Patterns for AI Use Cases

» Automation



Physical Process Automation

- Mobility platform manufacturing (robotic welding, assembly and painting, automated material handling, automated quality inspection)
- Automated public transport
- Automated people movers (APM)
- Smart parking systems
- Smart intersections
- Self-flying vehicles
- Self-driving vehicles

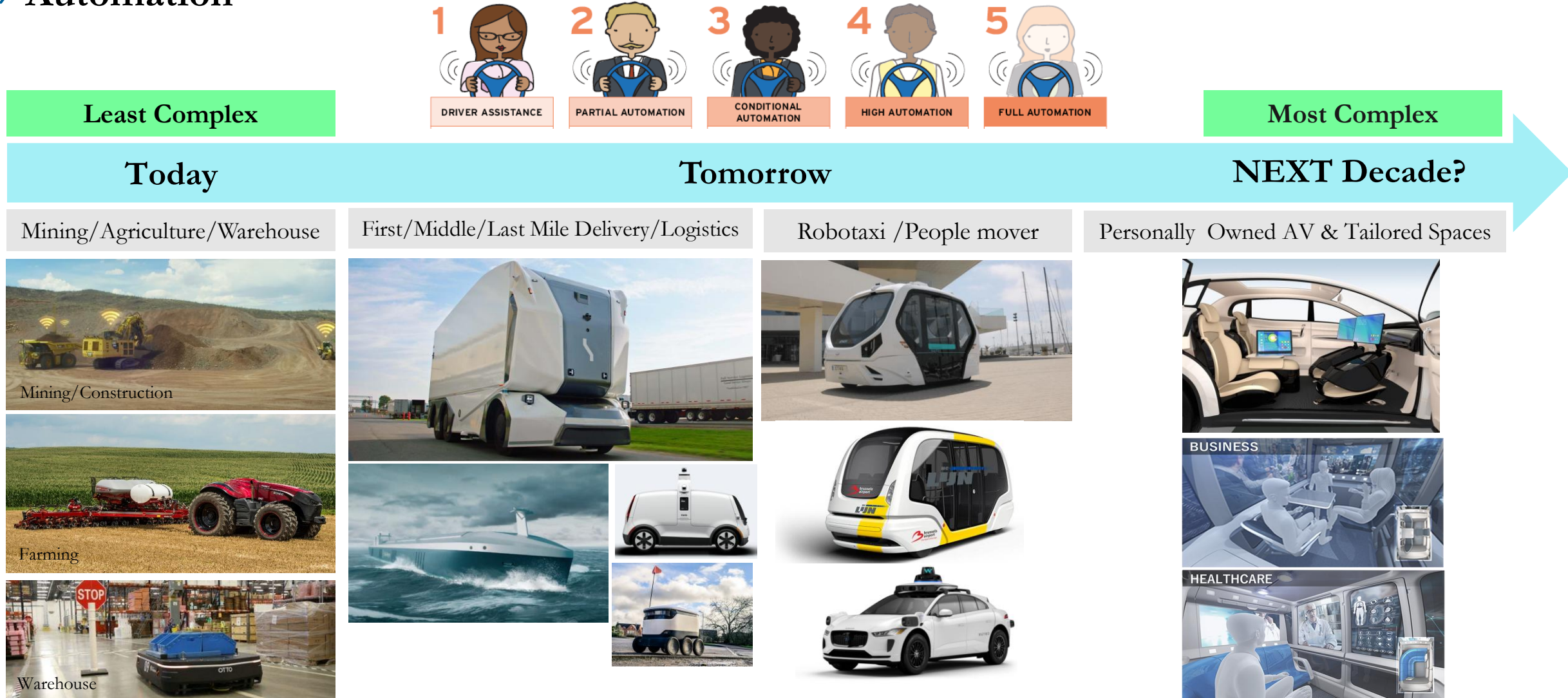


Digital Process Automation

- Robotic Process Automation (RPC)
- Streamline content creation
- Intelligent agent assistants/ Conversational agents (Chatbot such as Retail Support Bots)
- Q&A engines
- Recommendation engines to generate personalized recommendations.
- Digital Go-to-Market (online booking and online shopping, etc.)
- Digital twins

Common Patterns for AI Use Cases

» Automation

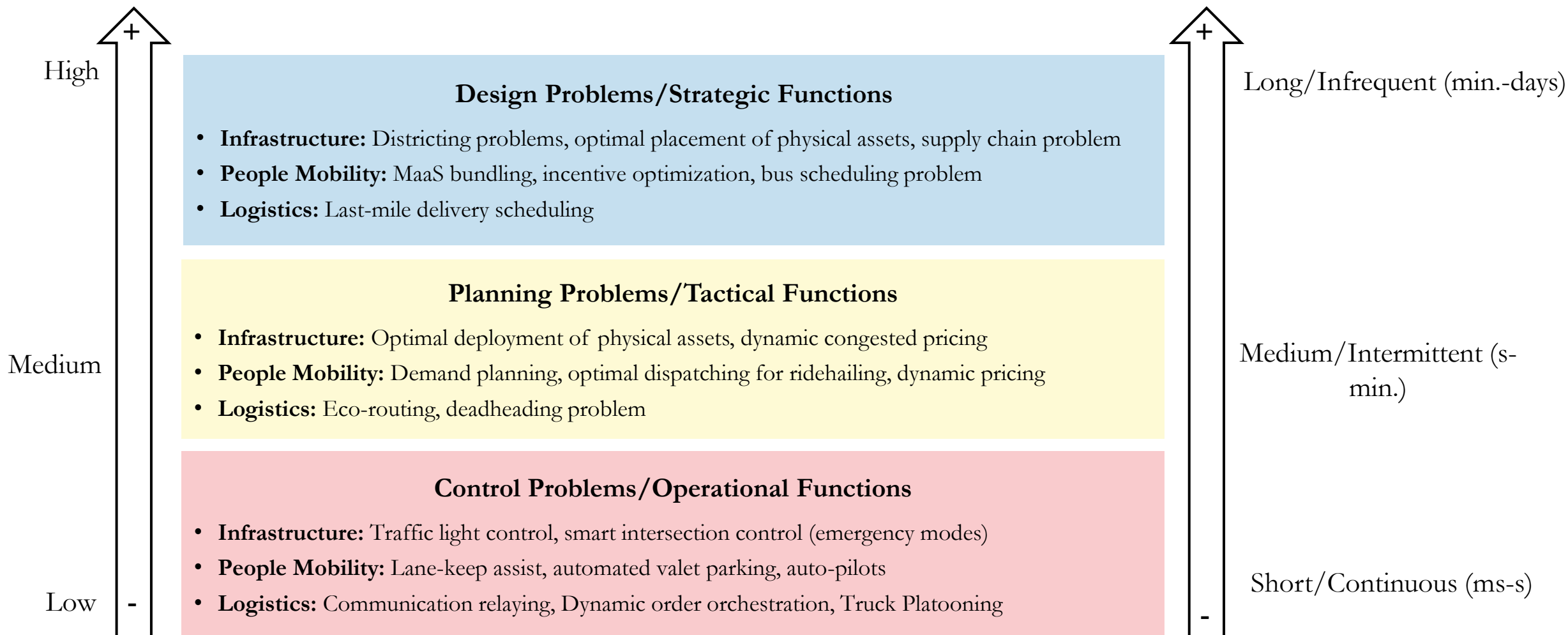


Common Patterns for AI Use Cases

» Optimization

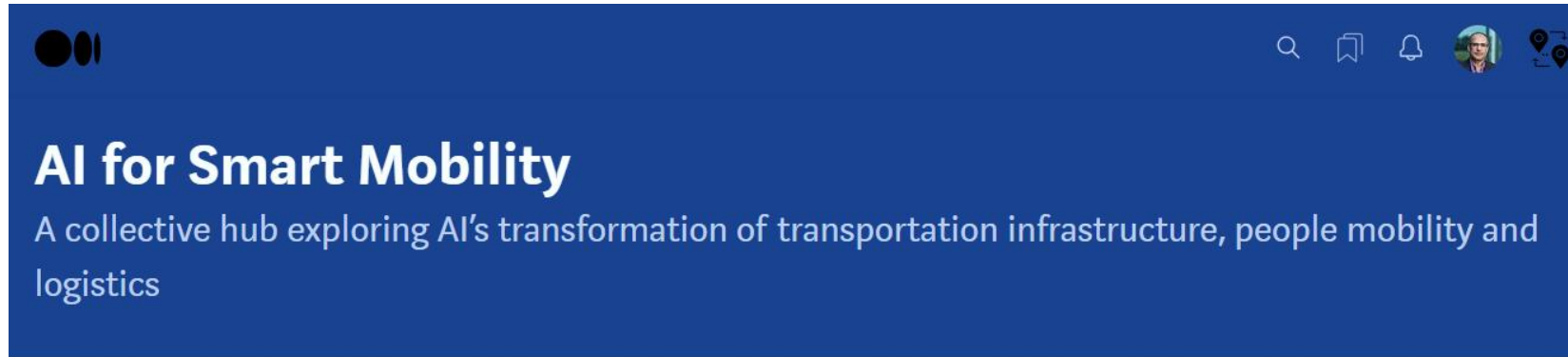
Quality of Solutions

Search Time



Common Patterns for AI Use Cases

» Optimization



Optimizing Traffic Sensor Placement in the City of Toronto

By Yichen Liao, Xinyi Gong and Amir Hossein Mobasheri as part of course project of ECE1724H: Bio-inspired Algorithms for Smart Mobility...

 YICHEN LIAO
Oct 26 · 6 min read



Predicting Ride-Sharing Platform Pricing in New York City with Deep Learning

Yanhao Li, Chen Zhang and Wangwenzan Zhou as part of course project of ECE1724H: Bio-inspired Algorithms for Smart Mobility, University of...

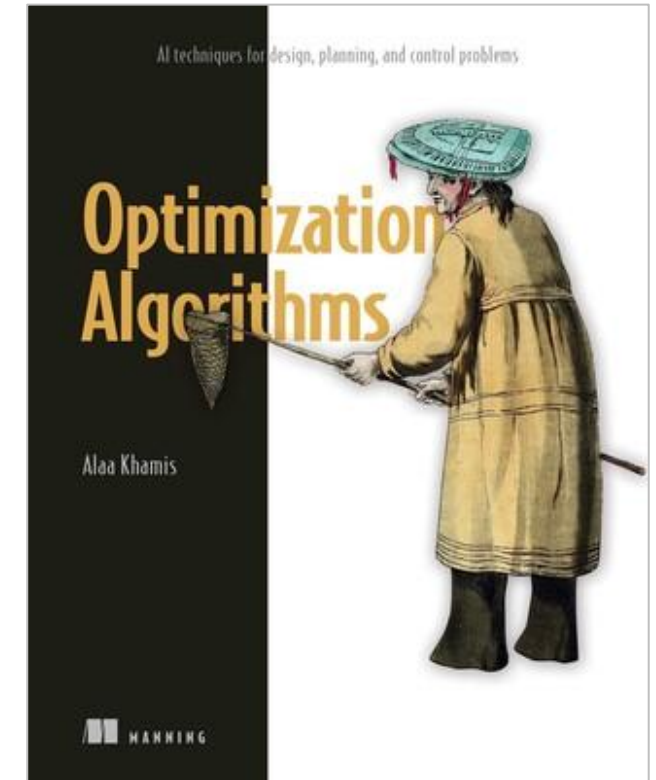
 AllenZhou
Oct 25 · 18 min read



Optimal Placement of Public Parcel Lockers for Last-Mile Delivery

By Tianwei Zhang and Shiuan-Wen Chen as part of course project of ECE1724H: Bio-inspired Algorithms for Smart Mobility, University of...

 Tianwei Zhang
Oct 24 · 9 min read



[Join us](#)  **AI4SM**

Outline

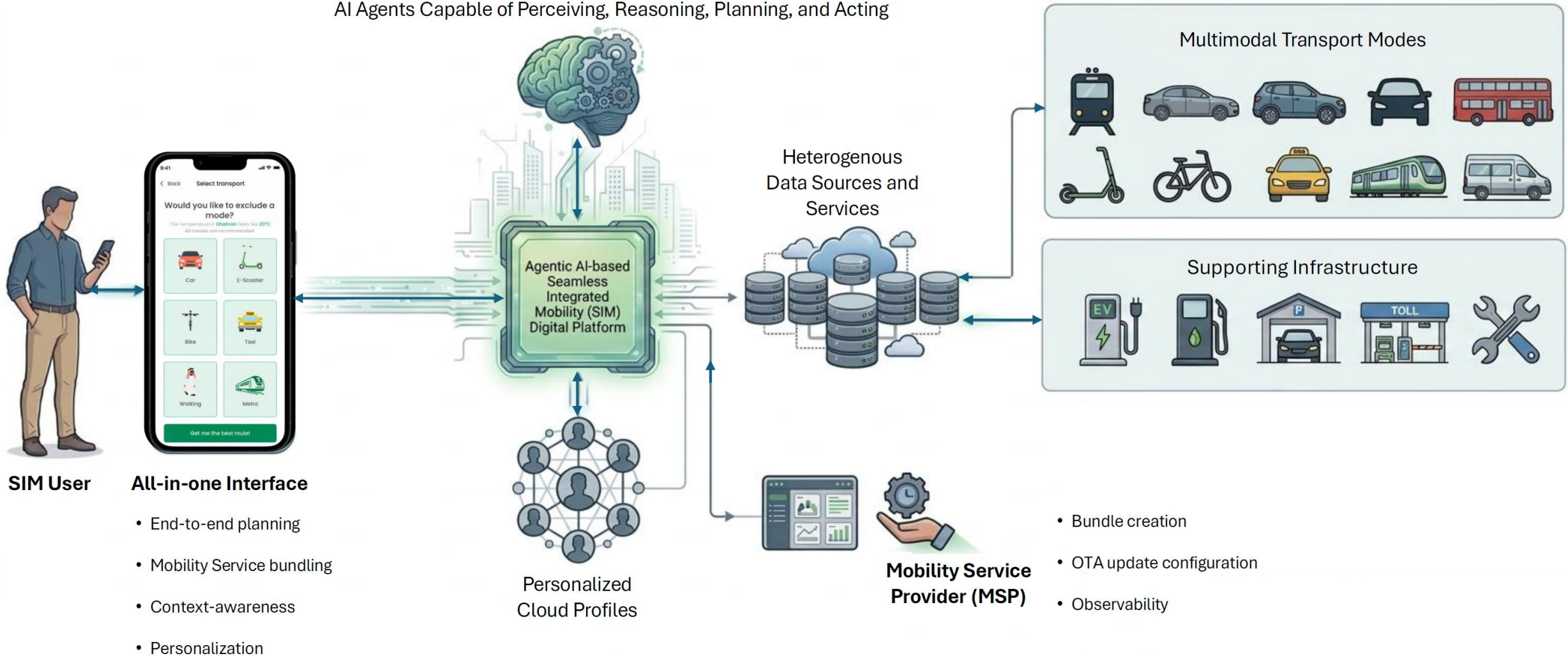
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Use Cases in Smart Mobility and Logistics

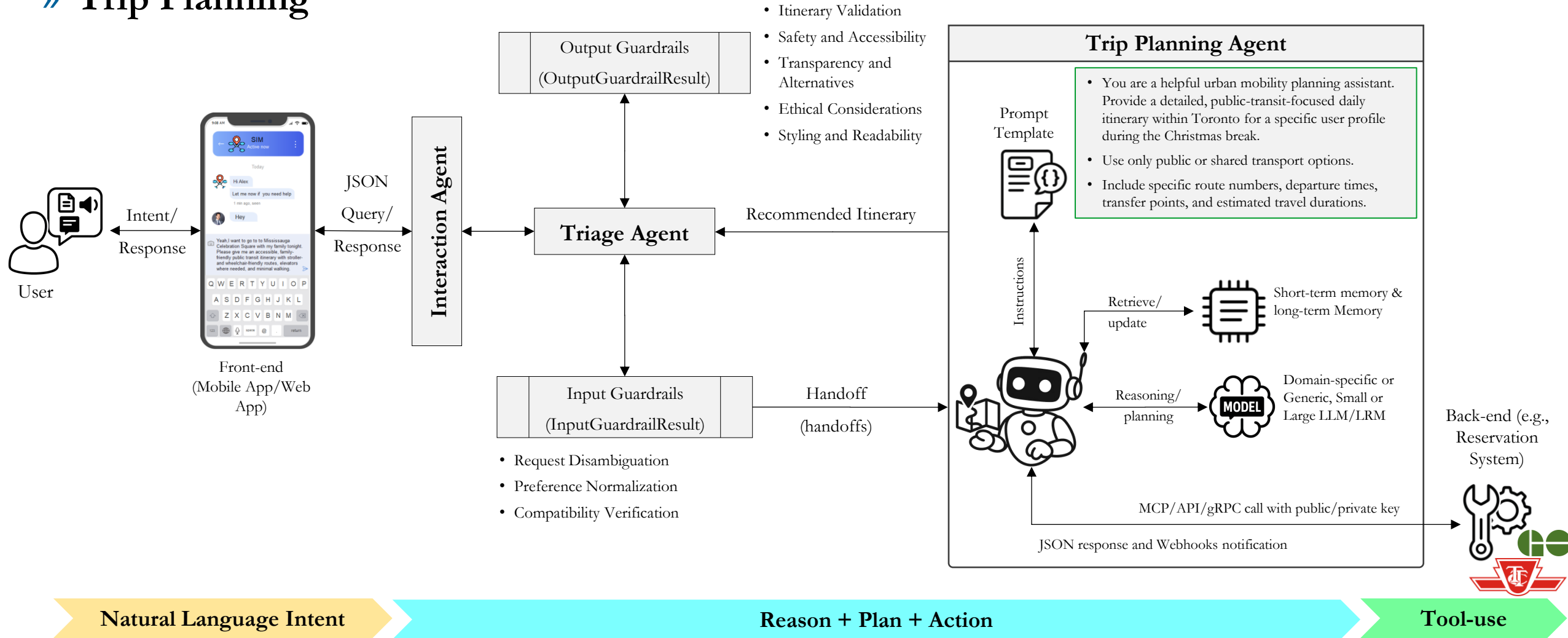
» Agentic AI for Seamless Integrated Mobility

AI Agents Capable of Perceiving, Reasoning, Planning, and Acting



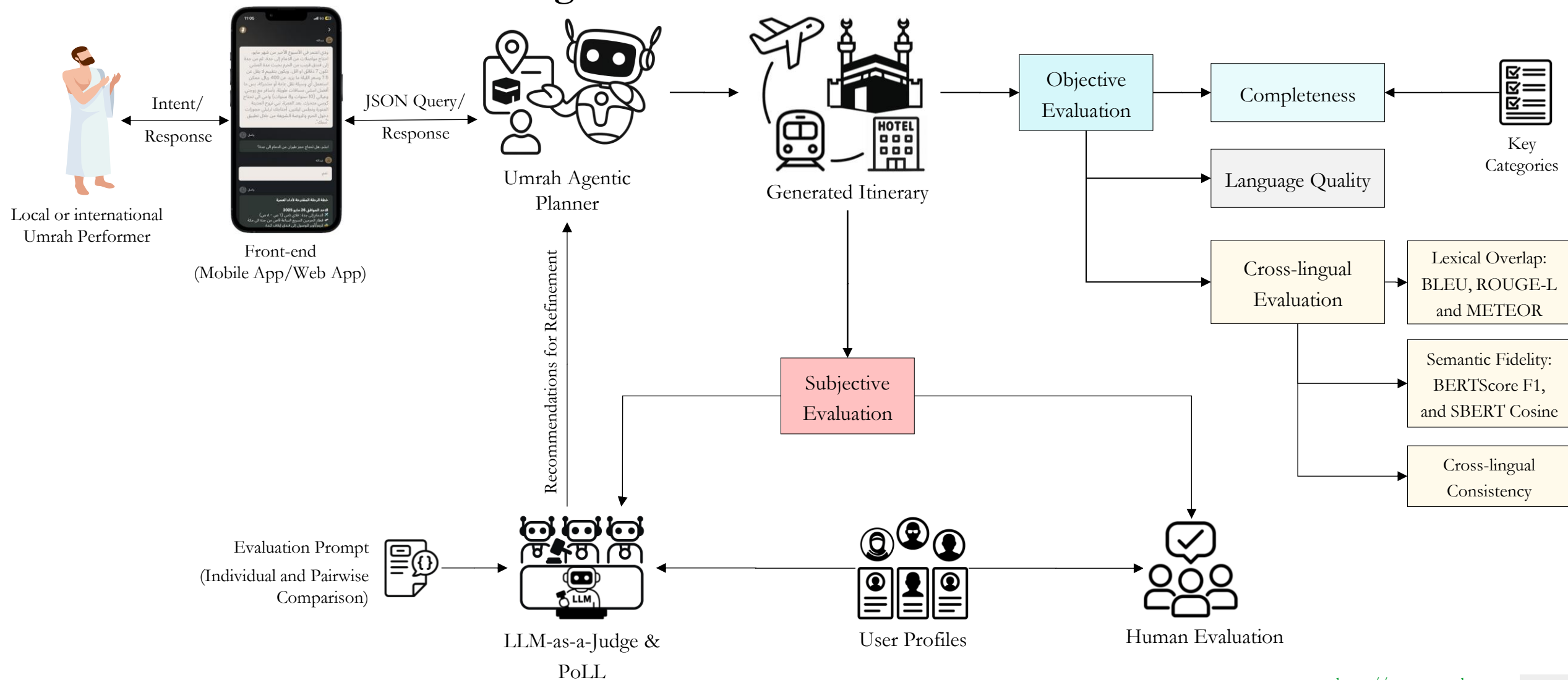
Use Cases in Smart Mobility and Logistics

» Trip Planning



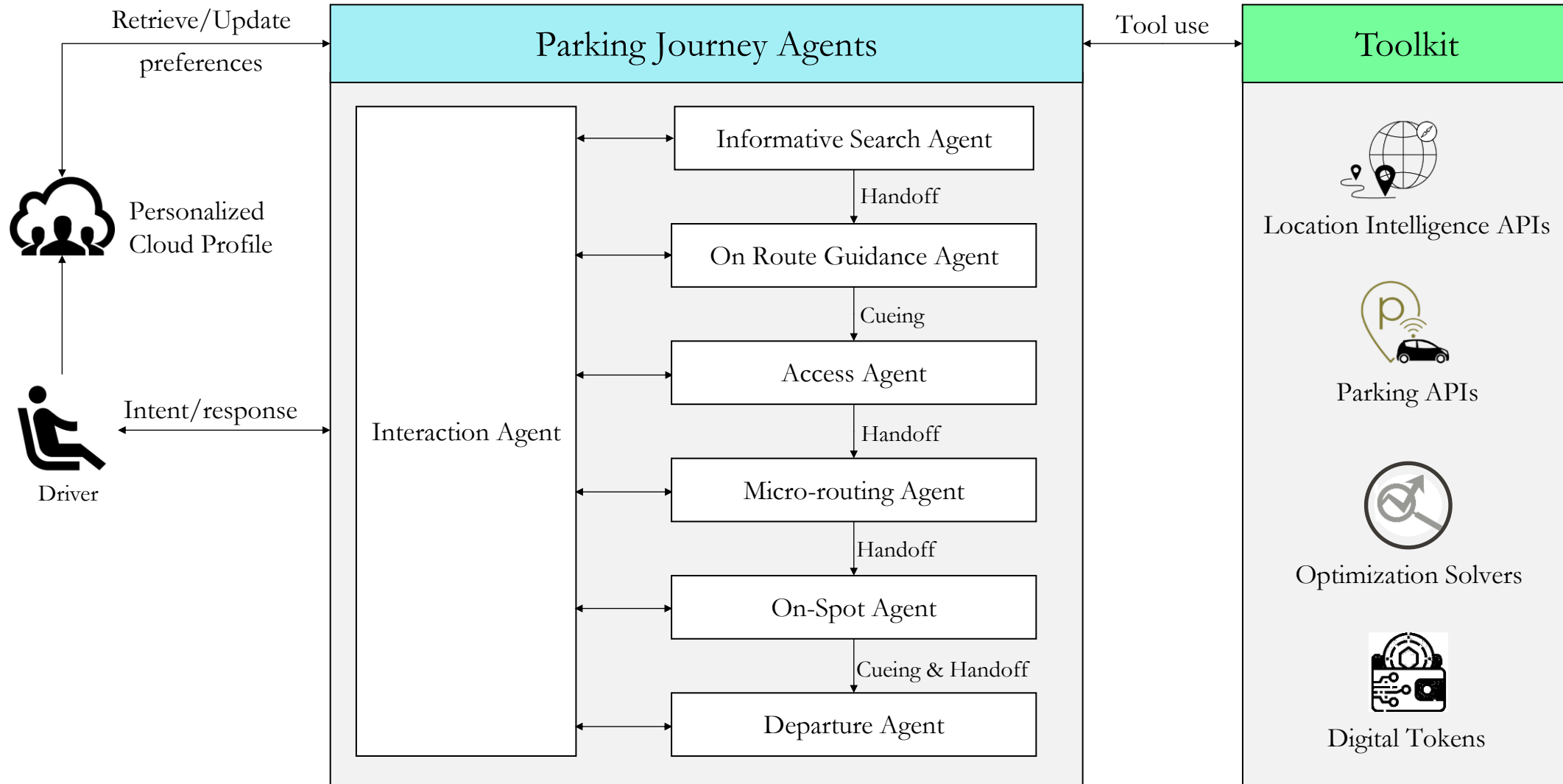
Use Cases in Smart Mobility and Logistics

» Personalized Umrah Planning



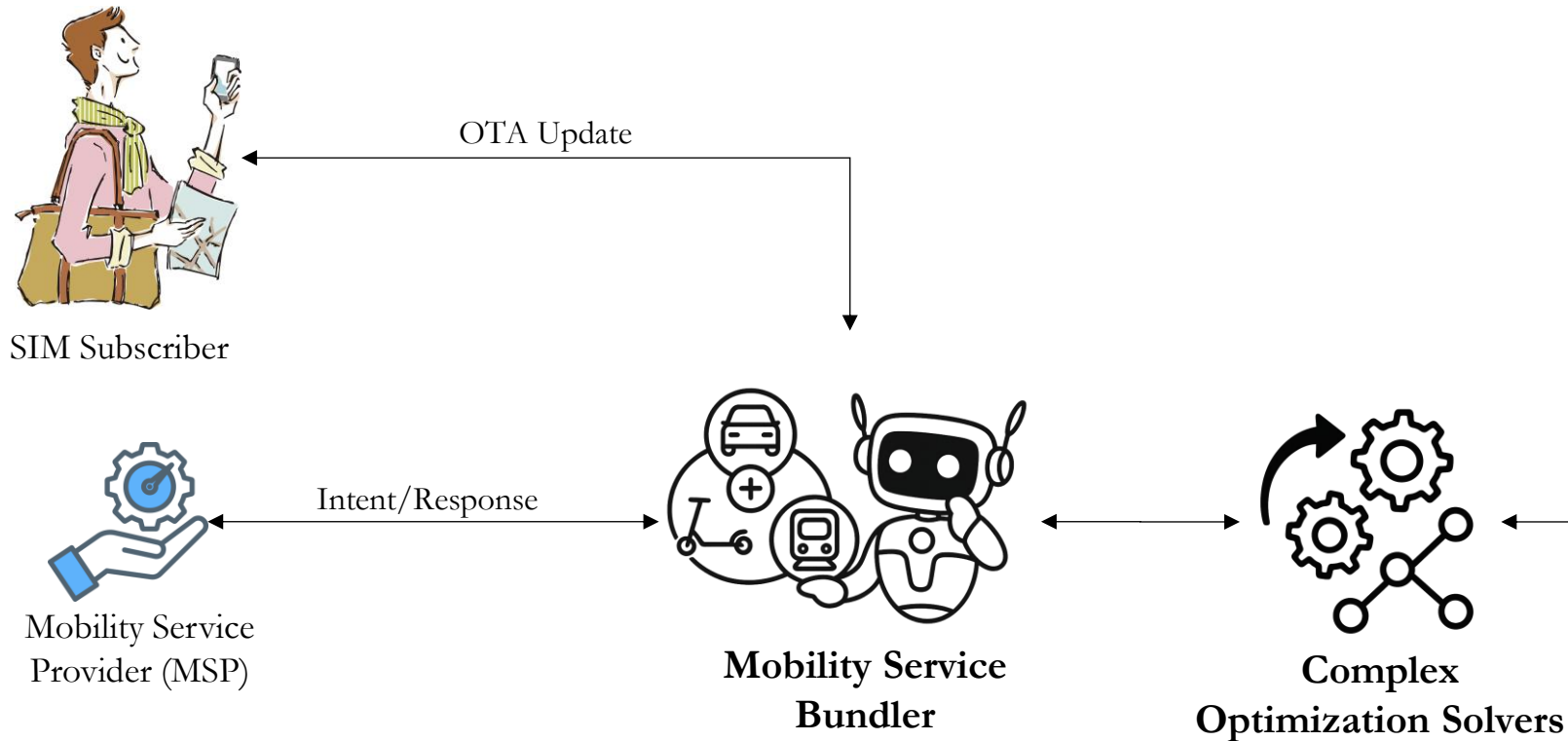
Use Cases in Smart Mobility and Logistics

» Frictionless Urban Parking



Use Cases in Smart Mobility and Logistics

» Mobility Service Bundling



MaaS Bundles

Persona-specific Bundles



Professional



Student



Family

Event-specific Bundles



Expo 2030



WorldCup 2034



Umrah

Corporate Bundles



For employees with company-sponsored benefits

Subsidized Bundles



Elderly/with disabilities



Unemployed



Low-income/
Newcomers

SEAMLESS INTEGRATED
MOBILITY



- **Title:** Agentic AI-based Framework for SIM
- **Objective:** Develop as a unified platform that integrates multimodal transportation options.
- **Collaboration:** RCRC, MIT Urban Mobility Lab, VTTI

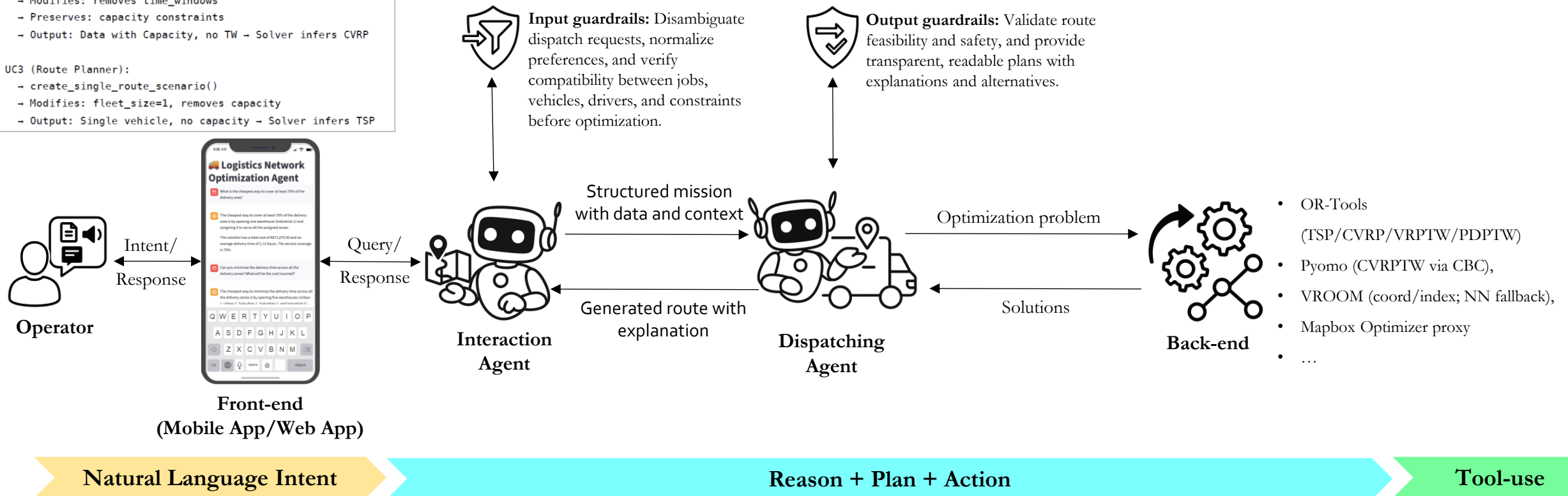
Use Cases in Smart Mobility and Logistics

» Agentic Smart Dispatch

UC1 (Route Dispatcher):
→ `update_waypoint_location()`
→ Modifies: waypoint coordinates ONLY
→ Preserves: time_windows, capacity constraints
→ Output: Data with TW + Capacity → Solver infers CVRPPTW

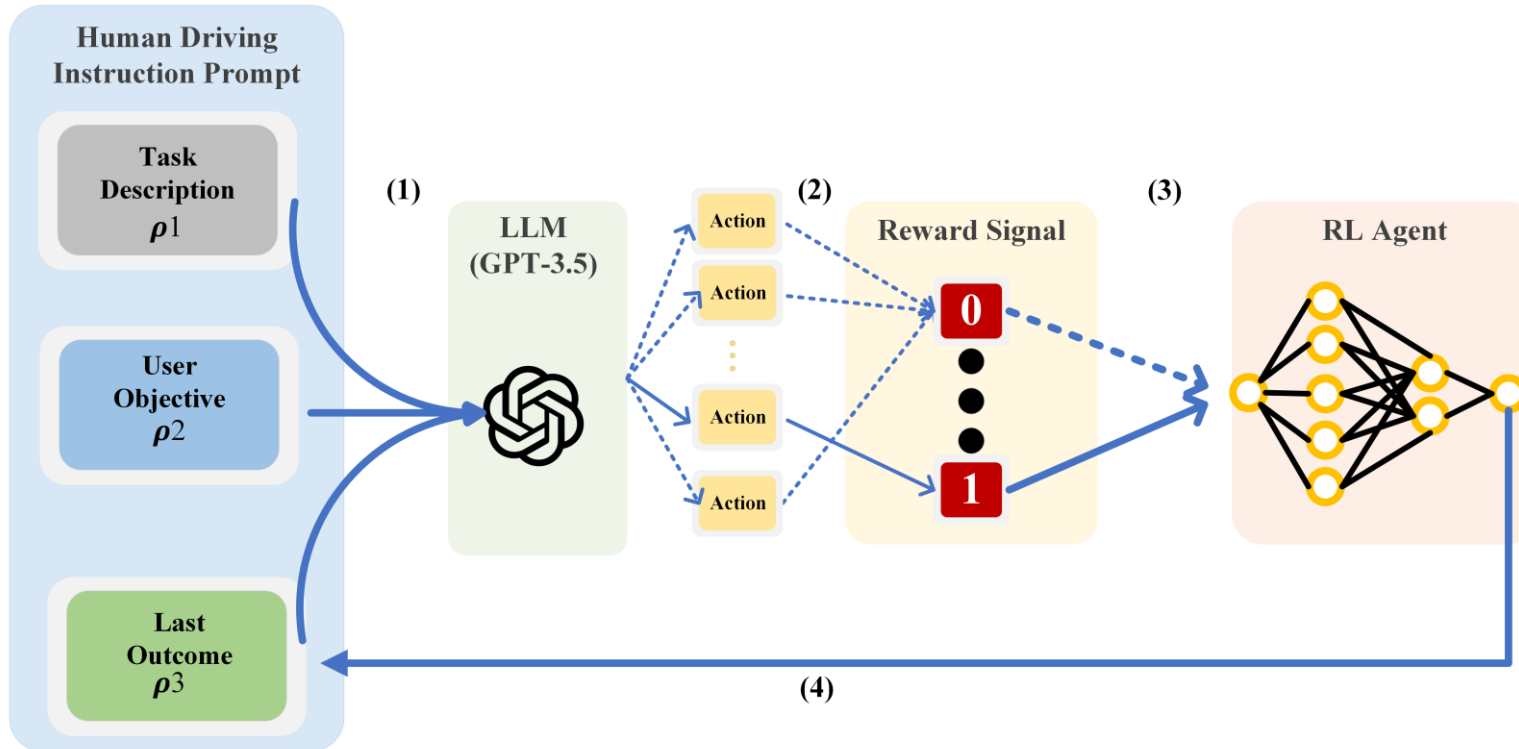
UC2 (Station Manager):
→ `modify_waypoint_constraints()`
→ Modifies: removes time_windows
→ Preserves: capacity constraints
→ Output: Data with Capacity, no TW → Solver infers CVRP

UC3 (Route Planner):
→ `create_single_route_scenario()`
→ Modifies: fleet_size=1, removes capacity
→ Output: Single vehicle, no capacity → Solver infers TSP



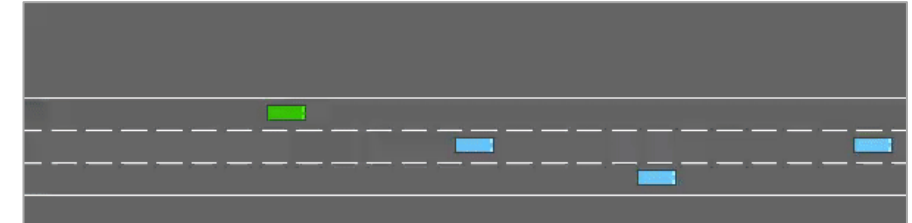
Use Cases in Smart Mobility and Logistics

» Automated Driving

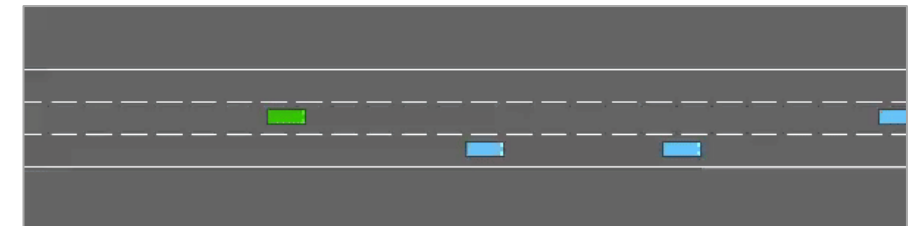


$$R_{\text{total}}(s, a) = \alpha R_{\text{safety}}(s, a) + \beta R_{\text{efficiency}}(s, a) + \gamma R_{\text{LLM}}(s, a)$$

An example of conservative model



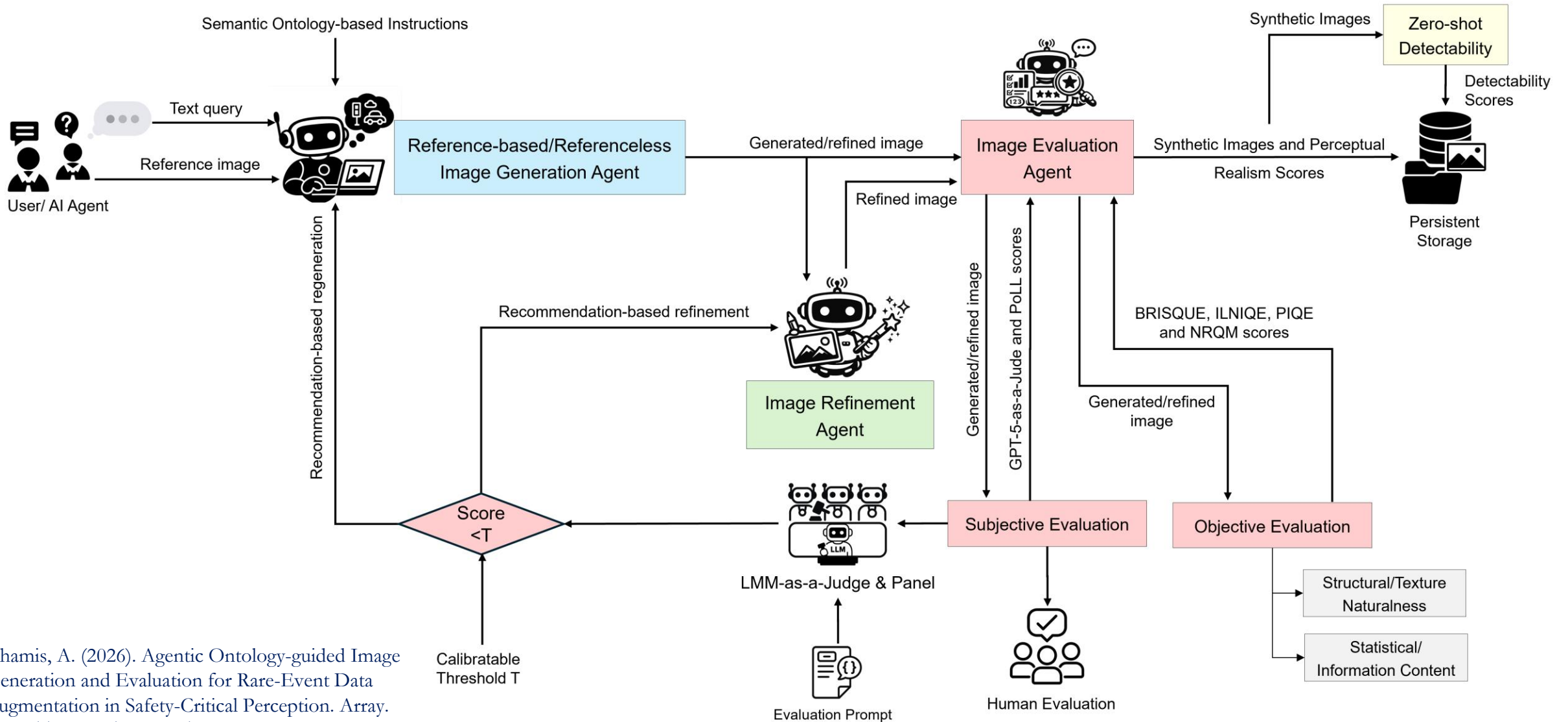
An example of aggressive model



Index	Mean Reward	Lane Change	Speed Up
DQN baseline	0.82824	0.30681	0.42045
Aggressive	0.83888	0.02326	0.83721
Conservative	0.71391	0.01333	0.00666
Base	0.80140	0.10345	0.10345

Use Cases in Smart Mobility and Logistics

» Rare-Event Data Augmentation



Use Cases in Smart Mobility and Logistics

» Rare-Event Data Augmentation



Method	BRISQUE ↓	ILNIQE ↓	PIQE ↓	NRQM ↑
Referenceless OpenAI (Regenerated)	19.47	48.76	34.10	7.39
Referenceless Gemini 3 Pro	9.67	41.31	32.12	8.36
Referenceless Grok 4.20	11.55	42.99	34.48	8.13

Method	LMM-as-a-Judge ↑	Panel of LMMs ↑	Human Evaluation ↑
OpenAI (Regenerated)	4.38	3.90	2.45
Gemini 3 Pro (Referenceless)	4.74	5.00	3.54
Grok 4.20	3.60	4.00	2.31

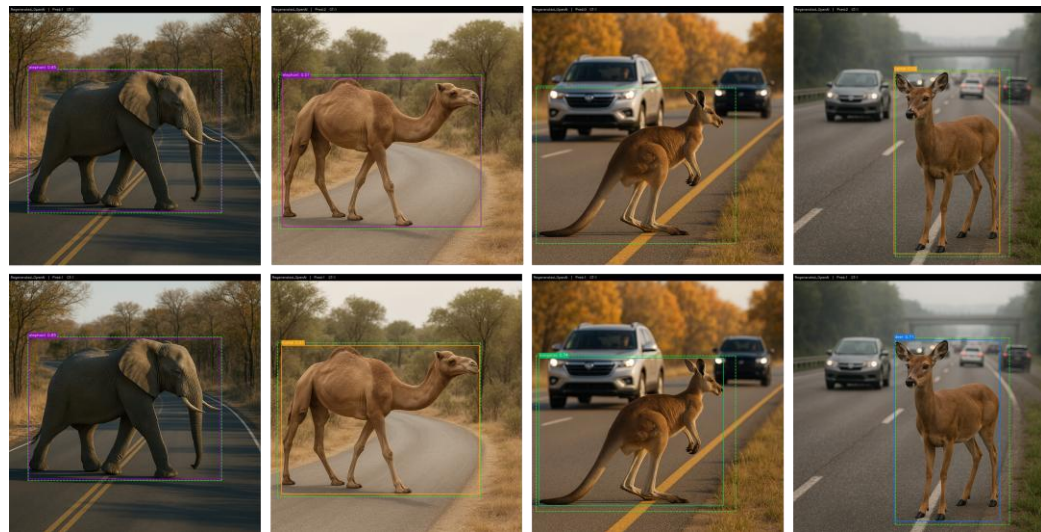
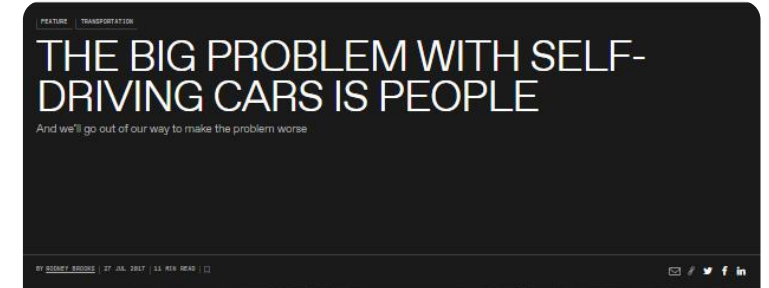
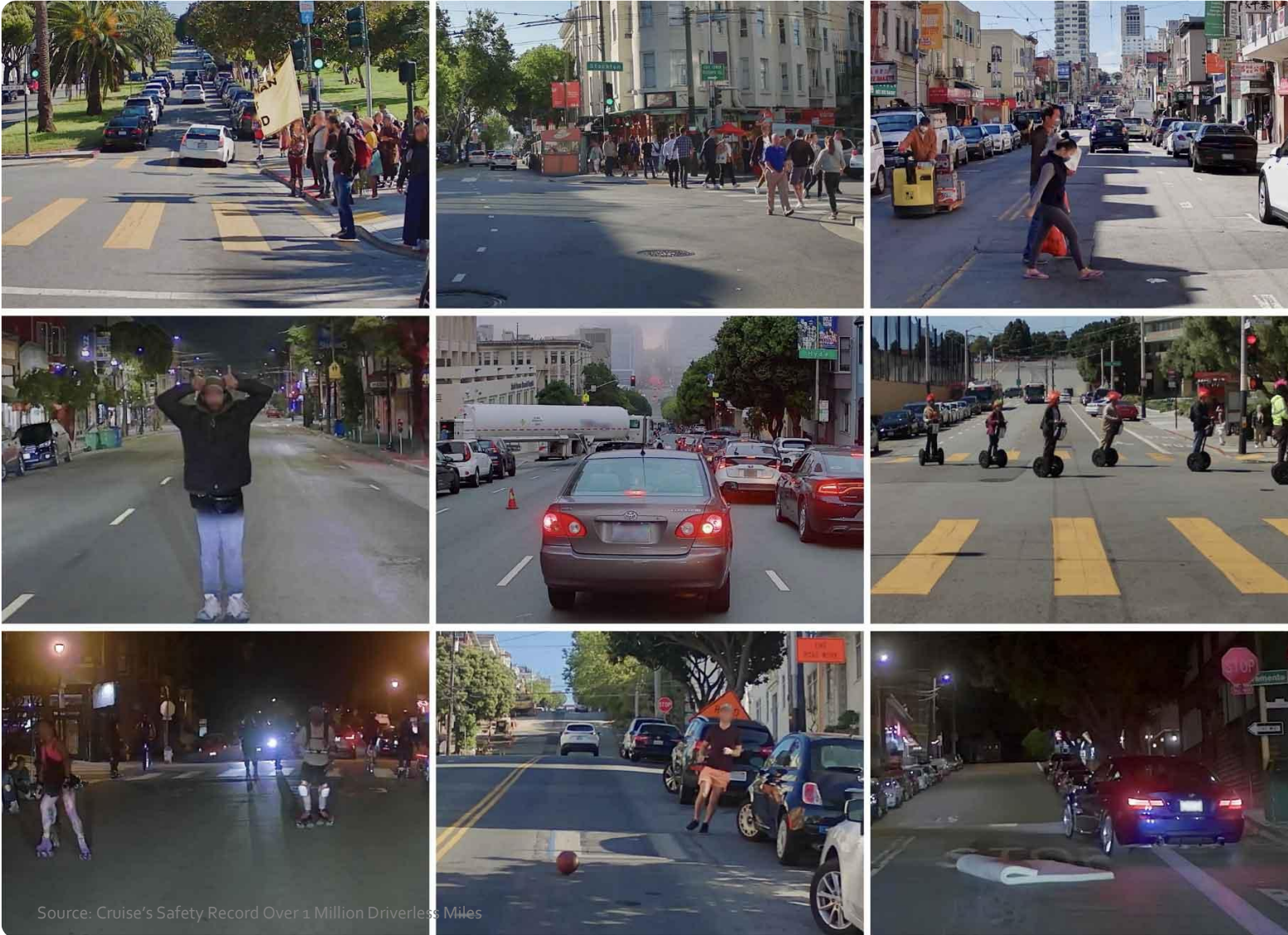


Figure: Examples of generated images using a referenceless ontology-guided approach. (1) GPT-5 synthesis, (b): gpt-image-1 refinement, (c) Recommendation-driven regeneration, (d) Gemini 3 Pro synthesis, (e) Grok 4.20

Khamis, A. (2026). Agentic Ontology-guided Image Generation and Evaluation for Rare-Event Data Augmentation in Safety-Critical Perception. Array. <https://doi.org/10.1016/j.array.2026.100932>. [GitHub](#)

Use Cases in Smart Mobility and Logistics

» VRU Adversarial Behavior Recognition



1. Alaa Khamis, et al. VULNERABLE ROAD USERS' ADVERSARIAL BEHAVIOR RECOGNITION, P104517-PRI-NP-US01.
2. Alaa Khamis, et al. VULNERABLE ROAD USER'S ADVERSARIAL BEHAVIOR OPPORTUNITY AND CAPABILITY, P104518-PRI-NP-US01.
3. Alaa Khamis, et al. RESPONSES TO VULNERABLE ROAD USER'S ADVERSARIAL BEHAVIOR, P104516-PRI-NP-US01.



Thank You

Questions, collaborations, and student enquiries are all welcome.

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