Agents for Enterprise Workflows

CS294/194-196 Large Language Model Agents
Lecture 7 — October 21st, 2024

Nicolas Chapados
ServiceNow Research

Alexandre Drouin
ServiceNow Research

Who are we?

Nicolas Chapados
ServiceNow Research

Alexandre Drouin
ServiceNow Research

servicenow

Safe harbor notice for forward-looking statements

This presentation may contain "forward-looking" statements that are based on our beliefs and assumptions and on information currently available to us only as of the date of this presentation. Forward-looking statements involve known and unknown risks, uncertainties, and other factors that may cause actual results to differ materially from those expected or implied by the forward-looking statements. Further information on these and other factors that could cause or contribute to such differences include, but are not limited to, those discussed in the section titled "Risk Factors," set forth in our most recent Annual Report on Form 10-K and Quarterly Report on Form 10-Q and in our other Securities and Exchange Commission filings. We cannot guarantee that we will achieve the plans, intentions, or expectations disclosed in our forward-looking statements, and you should not place undue reliance on our forward-looking statements. The information on new products, features, or functionality is intended to outline our general product direction and should not be relied upon in making a purchasing decision, is for informational purposes only, and shall not be incorporated into any contract, and is not a commitment, promise, or legal obligation to deliver any material, code, or functionality. The development, release, and timing of any features or functionality described for our products remains at our sole discretion. We undertake no obligation, and do not intend, to update the forward-looking statements.

AGENDA

Background	Defining Agents Enterprise workflow concepts
API Agents	Architecture TapeAgents
Web Agents	Web Agent Concepts WorkArena BrowserGym and AgentLab
Agents in the Workplace	Automating enterprise workflows Agents and the future of work
Resources to Dig Further	

AGENDA

Background	Defining Agents Enterprise workflow concepts
API Agents	Architecture TapeAgents
Web Agents	Web Agent Concepts WorkArena BrowserGym and AgentLab
Agents in the Workplace	Automating enterprise workflows Agents and the future of work
Resources to Dig Further	

LLM agents are LLM-powered entities able to autonomously plan and take actions to execute goals over multiple iterations.

servicenow

LLM-Based Agents

Reinforcement Learning Agents

- Require long training runs in sandboxed environments
- Limited action space
- Low generalizability to radically new tasks
- A Minecraft agent can't send emails

LLM-Based Agents: Zero-Shot Task Solvers

- LLMs can display some commonsense, since they have lots of world background knowledge
- General-Purpose LLMs have probably been trained on the documentation of your software

Two kinds of LLM Agents

API agents

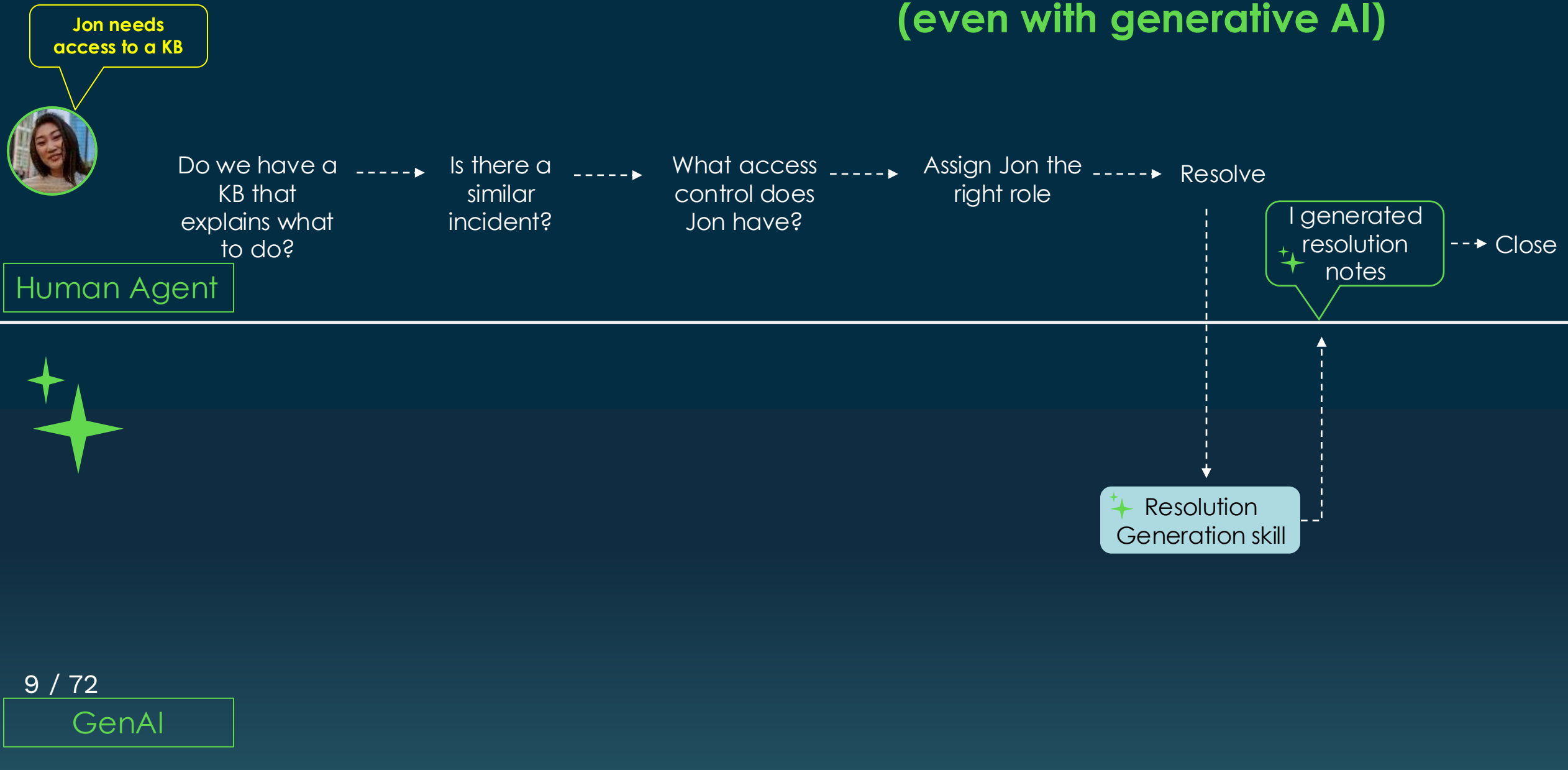
- Observations: API call results, search history, user-uploaded images, chat history
- Actions: API calls, search calls, responses to the user
- Pros: Lower latency, lower risks
- Cons: needs appropriate APIs

Web agents

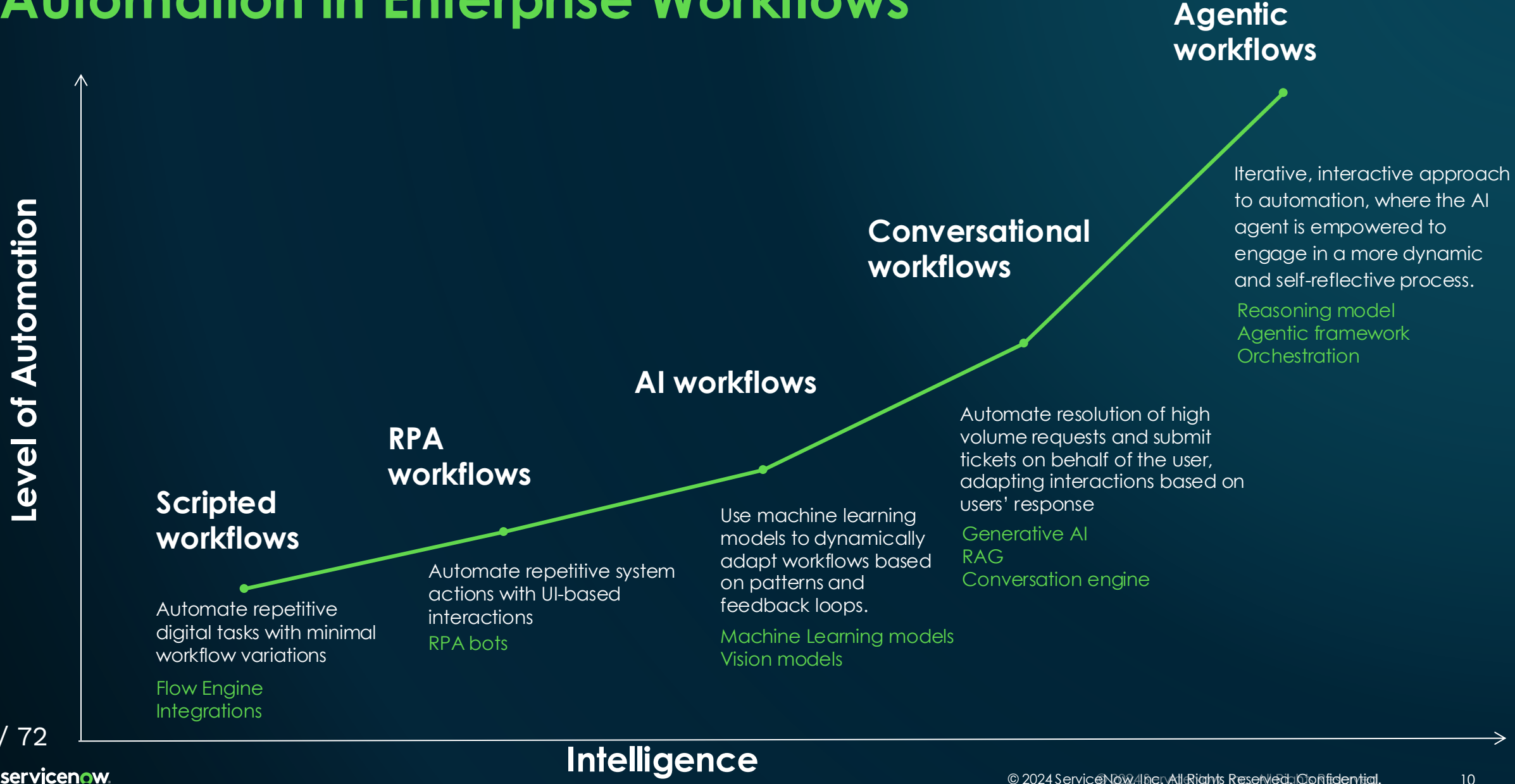
- Observations: what human would see + accessibility tree / raw DOM
- Actions: enter text in fields, clicks
- Pros: can do anything
- Cons: higher latency, higher risks

Today's Enterprise Workflows Remain Quite Manual

(even with generative AI)



Automation in Enterprise Workflows



servicenow

Agents solve for the Millions of Low-Value/Low-Volume Tasks

Today's automation workhorses for high-value or high-volume tasks

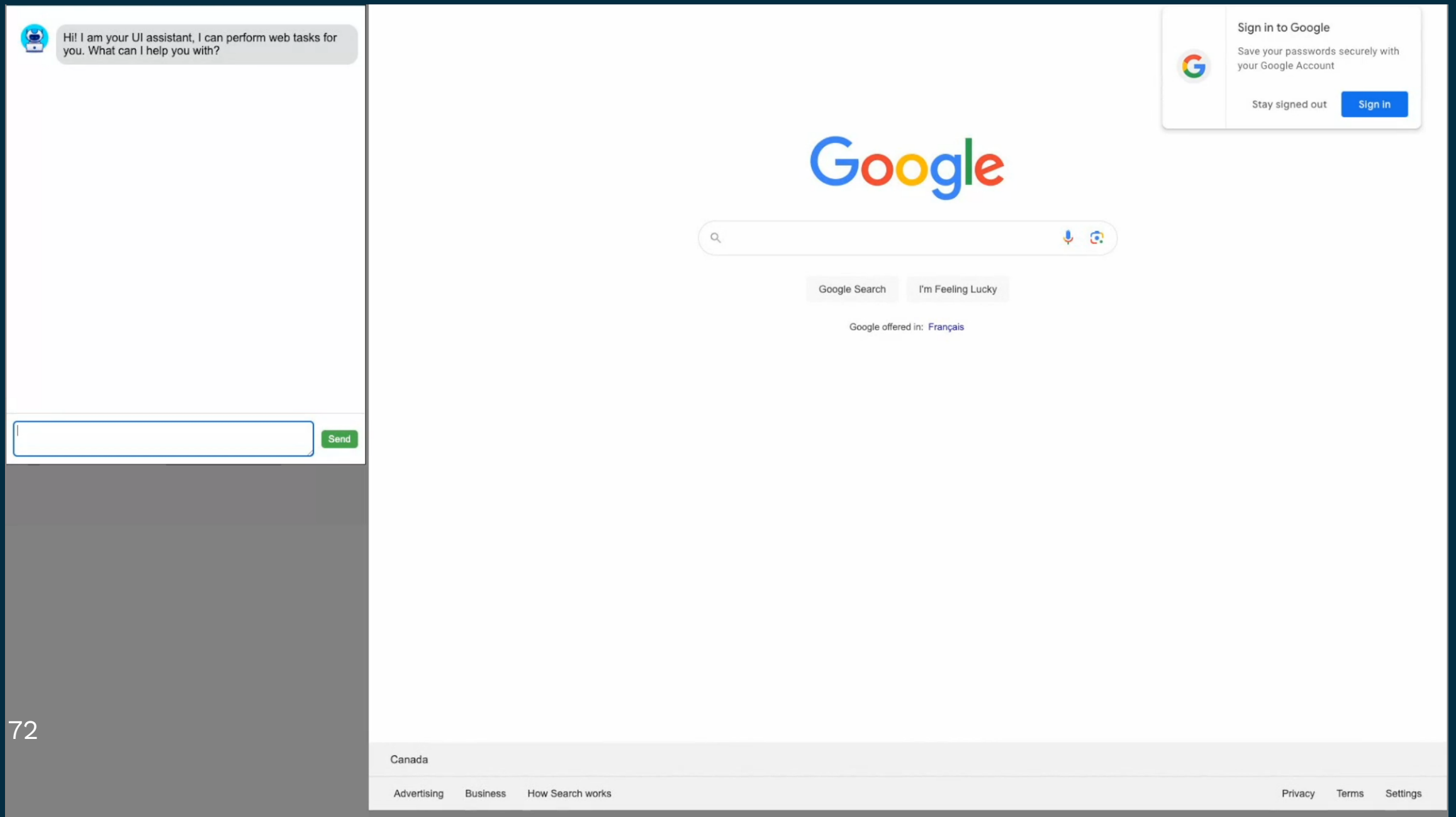
- Robotic Process Automation
- Low-Code / No-Code

What About?

- Scheduling tweets
- Sorting email
- Updating CRM
- Filling out time sheet
- Arranging 15-person meeting across 4 organizations

Demo: Directions to GTC

(original video is 4x longer with long pauses)

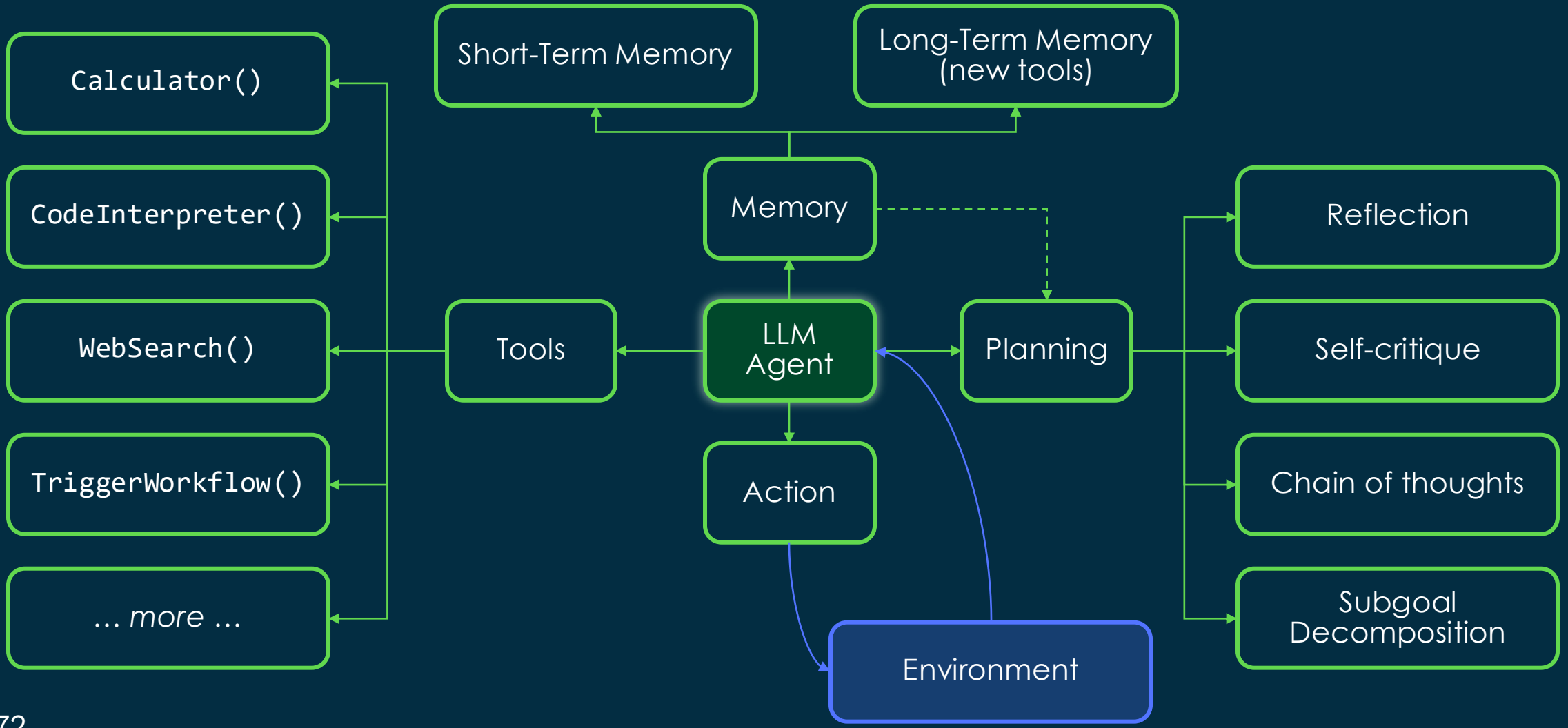


AGENDA

Background	Defining Agents Enterprise workflow concepts
API Agents	Architecture TapeAgents
Web Agents	Web Agent Concepts WorkArena BrowserGym and AgentLab
Agents in the Workplace	Automating enterprise workflows Agents and the future of work

Resources to Dig Further

LLM-Based Single Agents: Typical Architecture



Source: https://lilianweng.github.io/posts/2023-06-23-agent

TapeAgents: towards a holistic framework for agent development and optimization

Frameworks that address agent development needs

- Resumable sessions
- Low-code components
- Fine-grained control
- Concurrency
- Streaming

LangGraph, AutoGen, Crew:

- Agent == resumable modular state machine

Frameworks for data-driven agent optimization

- Structured agent configuration
- Structured agent logs
- Optimization algorithms

DSPy, TextGrad, Trace:

- Agent == code that uses structured modules and generates structured logs

Holistic Frameworks

TapeAgents:

Agent ==

Resumable modular state machine

… with structured configuration

… that makes granular structured logs

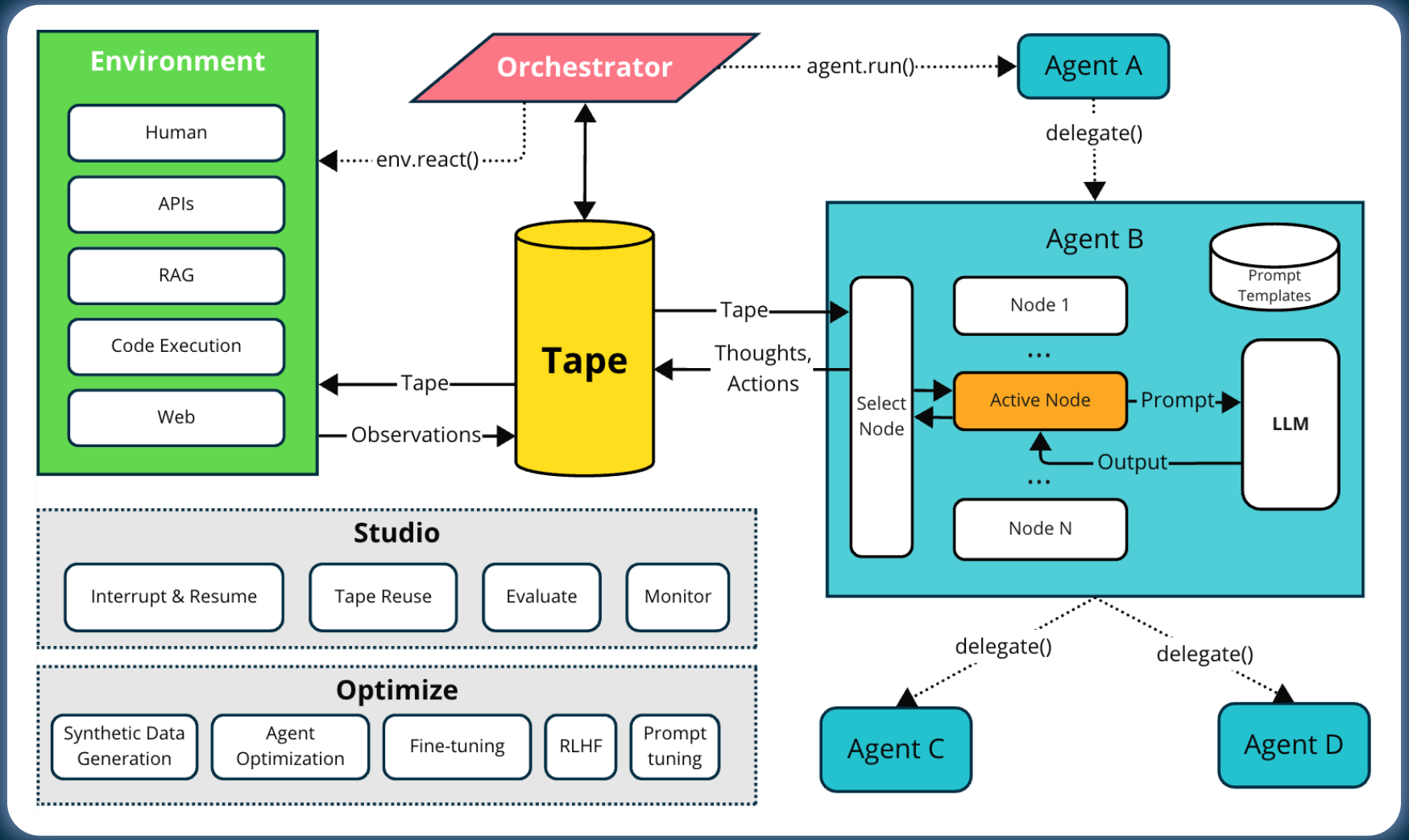
… that can make fine-tuning data from logs

… and reuse other agent's logs

servicenow

TapeAgents is a framework built around a structured, granular, semantic-level log: the tape

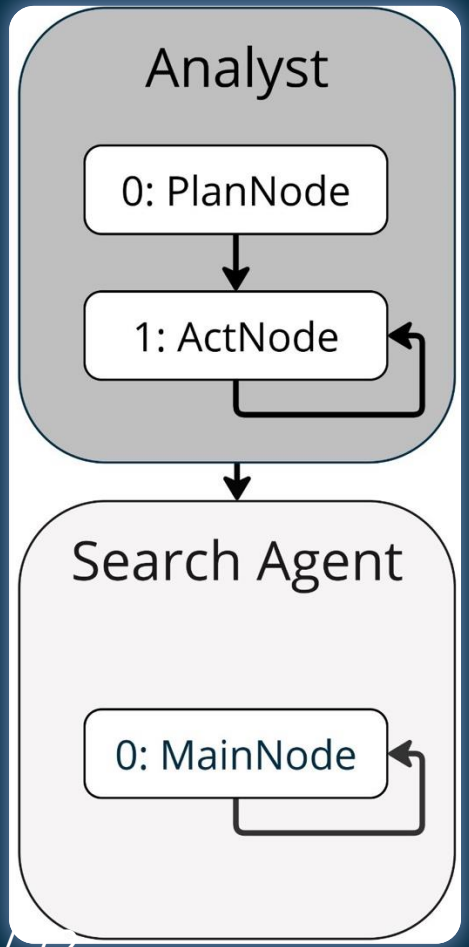
- Agent reads the tape, reasons, writes thoughts and actions to the tape
- Environment executes actions from the tape, write observations to the tape
- Apps use the tape as session states
- Dev tool use tapes to facilitate audit
- Algorithms use tapes to tune agent prompts
- Agents make finetuning data from tapes



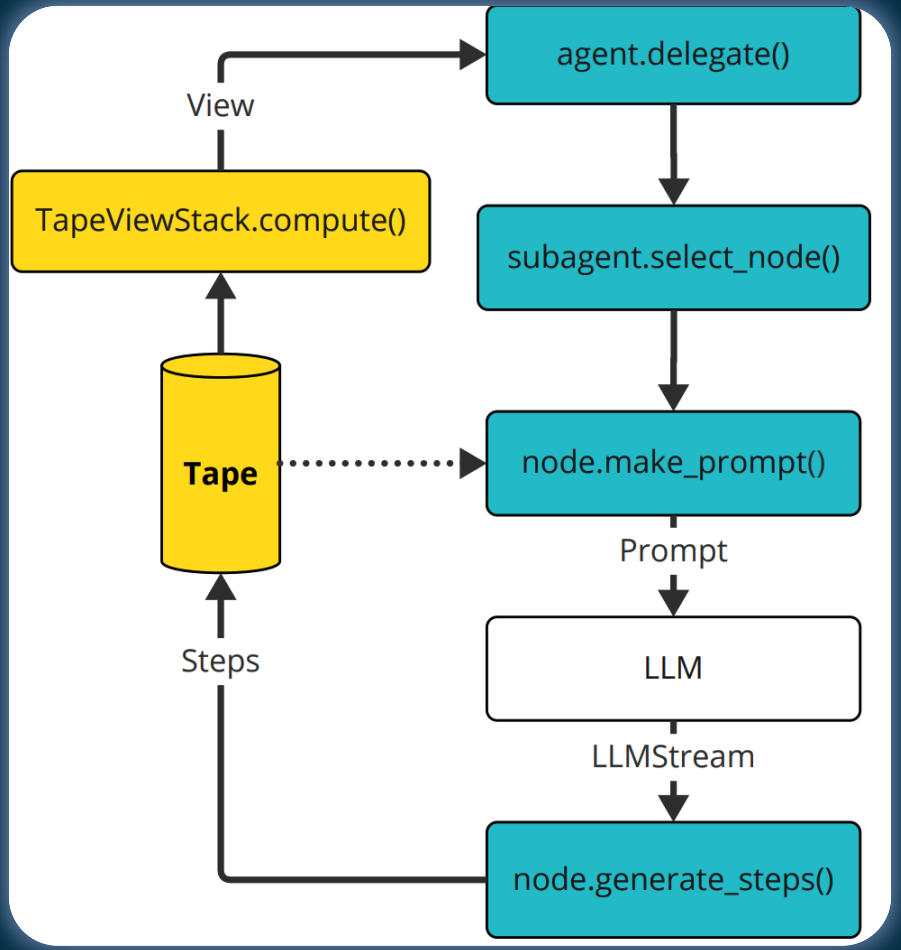
servicenow

Agent reasoning loop: example

Simple two-agent structure (problem-specific)



TapeAgents execution model



Environment

[0] User

```
Tell me about Vulcan in 3 sentences
```

analyst.PlanNode

▶ Prompt 109 tokens | Completion 114 tokens

[1] Thought: AssistantThought

▶ 1. Use the `functions.get_stock_ticker` tool to find the sto...

analyst.ActNode

▶ Prompt 212 tokens | Completion 0 tokens

[2] Thought: SetNextNode(1)

[3] Action: ToolCalls

```
get_stock_ticker(company_name='Vulcan')
```

Environment

[7] Observation: ToolResult

▶ [('2023-09-18', 211.69000244140625), ('2023-09-22', 200.6199...

analyst.ActNode

▶ Prompt 1297 tokens | Completion 0 tokens

[8] Thought: SetNextNode(1)

[9] analyst calls search_agent

```
Vulcan Materials Company overview and recent news
```

search_agent.SearchAgentMainNode

▶ Prompt 21 tokens | Completion 0 tokens

[10] Action: ToolCalls

▶ get_search_results(query='Vulcan Materials Company overview'...

[11] Thought: SetNextNode(0)

servicenow

[0] User

```
kind: user

Tell me about Vulcan in 3 sentences
```

▶ **Prompt 1681 characters**

▶ **Completion**

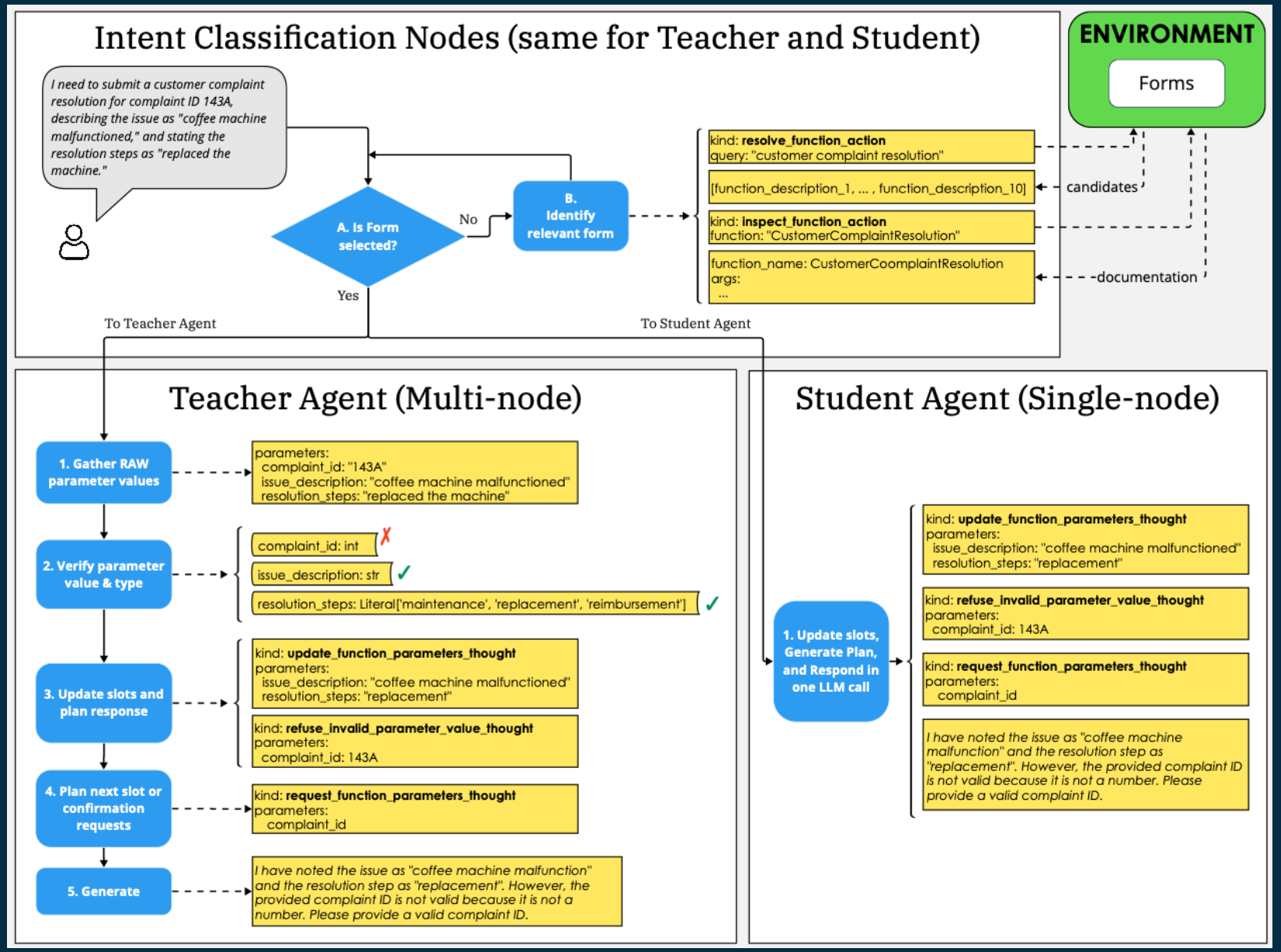
[1] Thought: AssistantThought

```
by: Agent
kind: assistant_thought

To help the user learn about Vulcan, I will:

1. Use the `functions.get_stock_ticker` tool to find the stock ticker symbol for
Vulcan.
2. Use the `functions.get_stock_data` tool to retrieve recent stock price data
for Vulcan using the ticker symbol obtained in step 1.
3. Summarize the information about Vulcan, including its stock ticker and recent
stock performance, in a concise manner.
```

▶ **Prompt 2045 characters**

▶ **Completion**

TapeAgents allows the optimization of a Student Agent from the tapes of a Teacher Agent



servicenow

MAKING COST-EFFECTIVE

G R E A D T H

(CONVERSATIONAL) AGENTS

servicenow

MAKING COST-EFFECTIVE

(CONVERSATIONAL) AGENTS

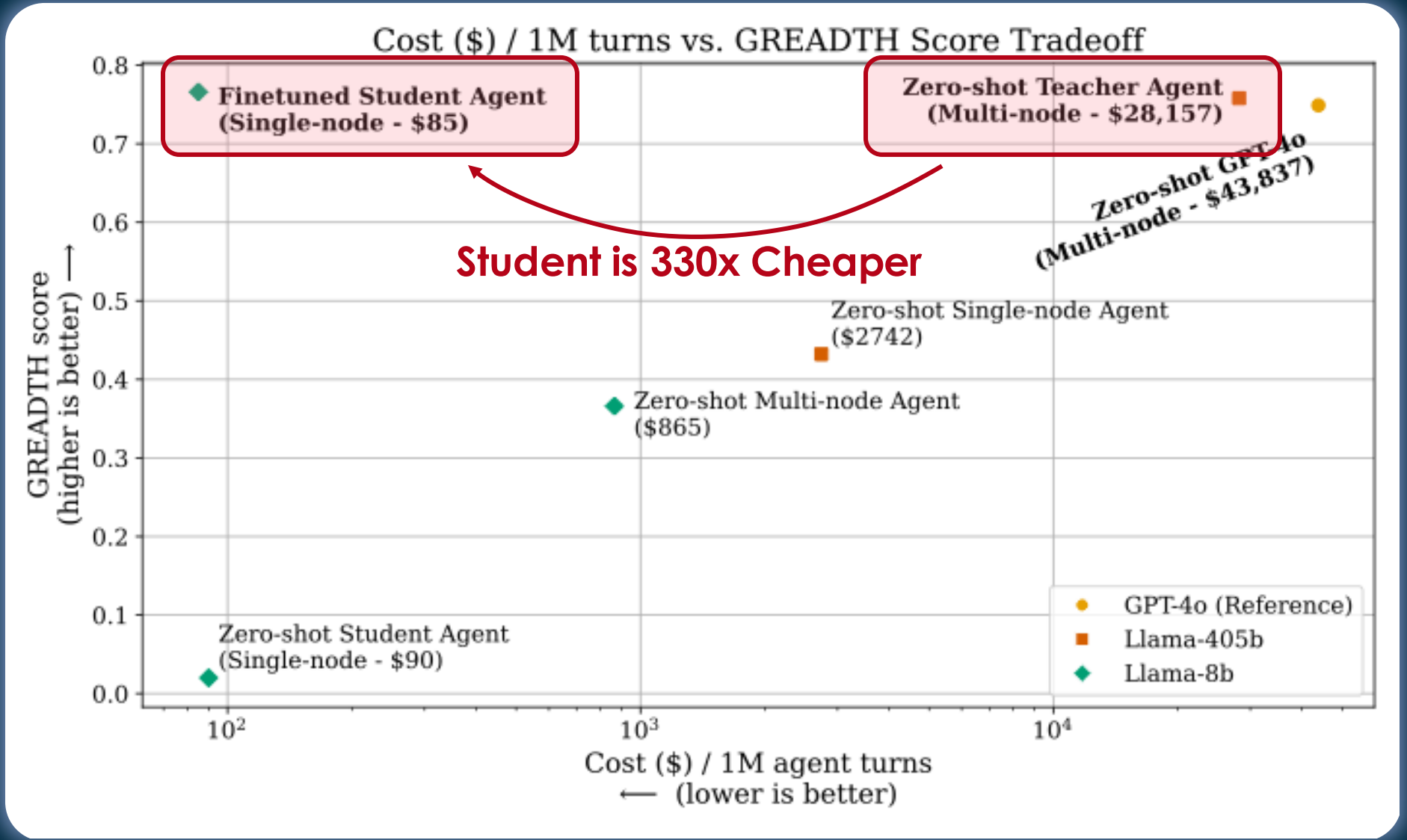
servicenow

Case Study: Cost-Effective Form-Filling Assistant

- **Task:** conversational assistant that routes the user to the right form and helps fill it
- **Constraints**: 5-star conversational experience at low compute cost
- **3 training domains:** `FlyCorp, BigBankCorp, CoffeeCorp`
- **3 testing domains:** `DriveCorp, LuxuryCorp, ShopCorp`
- **Metric: GREADTH**
  - Grounded, Responsive, Accurate, Disciplined, Transparent, Helpful
- Method:
  - Generate synthetic tapes with 19 user agents and a 5-node LLAMA-405B Teacher
  - Finetune 1-node LLAMA-8B Student
- Outcome: student matches GPT-4o performance at 300x lower cost

Table 3: *GREADTH Form Filler experiment results.* *The Teacher[1] is a multi-node agent with Llama 3.1 405B Instruct FP8 as its LLM. The Student[2] is a single-node agent with Llama 3.1 8b Instruct as its LLM. We also evaluate the multi-node agent with GPT-4o and with Llama 3.1 8B Instruct as its LLM, as well as the single-node agent with Llama 3.1 405B Instruct for comparison. The metrics are computed over 1524 partial dialogues from the test domains. Read full analysis in Section 5.4.*

Agent (LLM+Nodes)	G	Re	A	D	T	H	GREADTH Score (Human Raters)
Reference Comparison (GPT-4o-2024-08-06)							
Multi-node (0-shot)	91.3%	87.1%	91.4%	92.7%	94.3%	87.2%	**74.9%**
Llama-3.1-405B-Instruct							
Teacher[1]: Multi-node (0-shot)	89.8%	85.0%	87.9%	91.6%	92.5%	86.5%	**75.8%**
Single-node (0-shot)	74.2%	72.0%	76.8%	67.3%	78.9%	61.9%	**43.2%**
Llama-3.1-8B-Instruct							
Multi-node (0-shot)	75.5%	57.7%	72.4%	74.0%	76.3%	60.3%	**36.6%**
Student[2]: Single-node (0-shot)	18.8%	6.2%	10.9%	11.6%	9.4%	12.7%	**2.0%**
Student[2]: Single-node (finetuned)	92.1%	86.4%	90.2%	94.4%	95.1%	87.1%	**76.6%**



servicenow

Agentic Frameworks: How Does TapeAgents Compare?

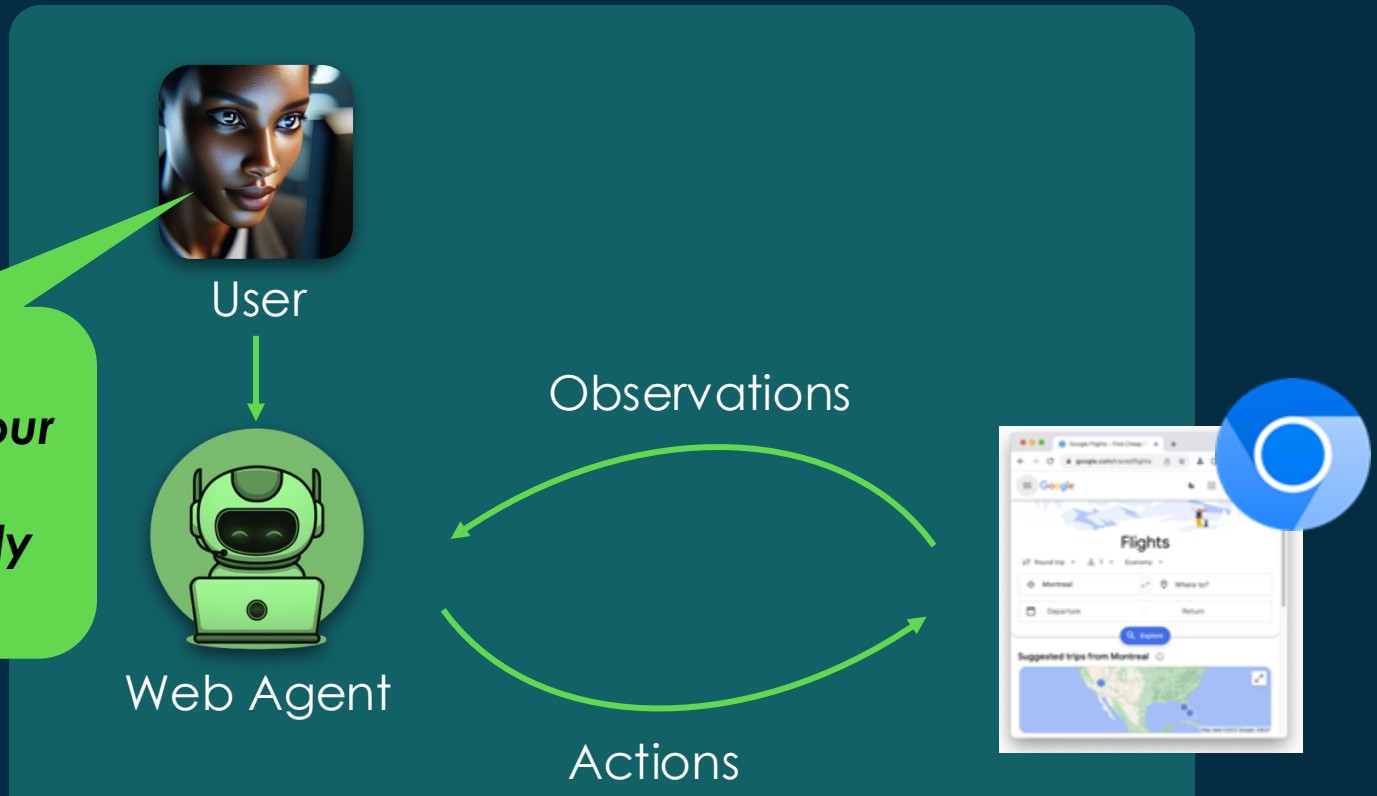
	Development				Optimization		
Method	**Building from Components while Allowing Finegrained Flow Control**	**Native Streaming Support**	**Concurrent LLM Calls**	**Resumable State Machine Agents**	**Log Reuse Across Agents**	**Structured Logs and Agent Configurations for Data-Driven Agent Optimization**	**Making Training Text From Semantic-Level Logs**
DSPy	✓	✗	✓	✗	✗	✓	▲
LangGraph	✓	✓	✓	✓	▲	▲	✗
AutoGen	▲	▲	✗	▲	✗	▲	✗
TapeAgents (Ours)	✓	✓	✗	✓	✓	✓	✓

Table 5: *TapeAgents vs Other Frameworks.* *TapeAgents stands out in features it offers to the practitioner to the support them throughout the LLM Agent development cycle. In this figure, we use the cross sign (✗) to indicate that major core changes would be required for the framework support the feature. Triangle sign (▲) indicates partial support of a feature, meaning that practitioner would have to do extra effort or accept associated limitations to achieve the respective functionality. Check sign (✓) indicates that the framework natively supports a feature. TapeAgents's only weakness in this table is the lack of Concurrent LLM Calls, see Section 7 for a discuss of how we intend to tackle it.*

AGENDA

Background	Defining Agents Enterprise workflow concepts
API Agents	Architecture TapeAgents
Web Agents	Web Agent Concepts WorkArena BrowserGym and AgentLab
Agents in the Workplace	Automating enterprise workflows Agents and the future of work
Resources to Dig Further	

What is a Web Agent?



servicenow

Web Agents Act on the Web on Behalf of Human Users

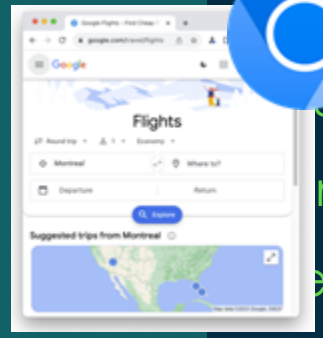
User

Book me a world-wide tour for my rock band next July and August

Web Agent

Observations

Actions



Involves

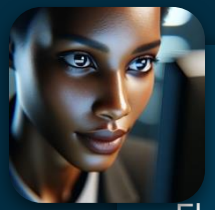
- Task / goal understanding
  ural language)
- ational awareness
- ng-term planning
- etailed action execution

servicenow

Making a basic Web Agent

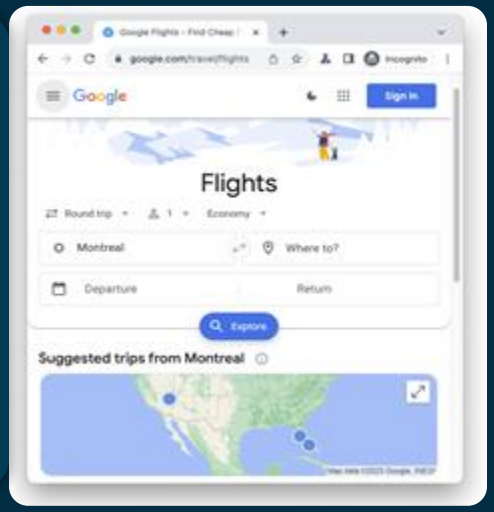
Prompt

- Task Description
- Web Page as text
- Action Space



Task

Fly me to Yellowstone for the next long weekend



LLM

Answer

- Action 1
- Action 2

Execute actions

- Python + Playwright

servicenow

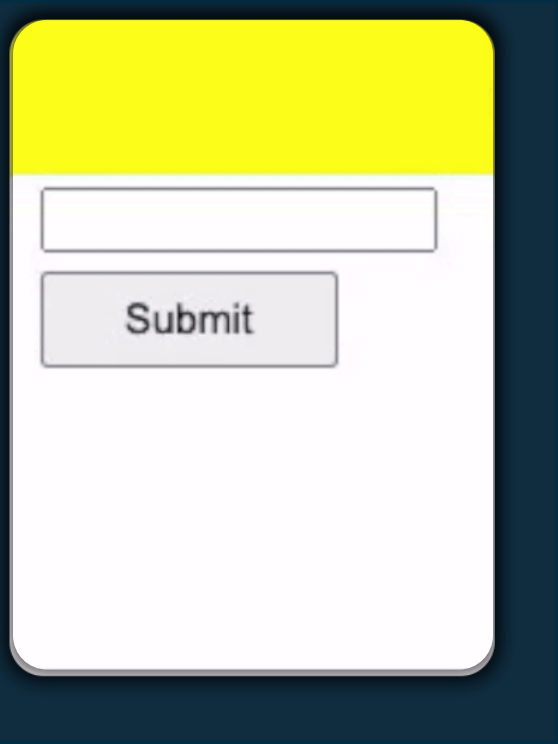
You can do this by prompting an LLM

Example prompt (simplified):

```
Task:
- Enter "Enola" into the text field and press Submit.

DOM (Web Page):
<html>
<body>
...
</body>
</html>

Action space:

# Fill out a form field
fill(backend_id: str, value: str)

# Click an element
click(backend_id: str)

# Move the mouse to a location
mouse_move(x: float, y: float)

Answer Format:
<action>
Your actions
</action>
```

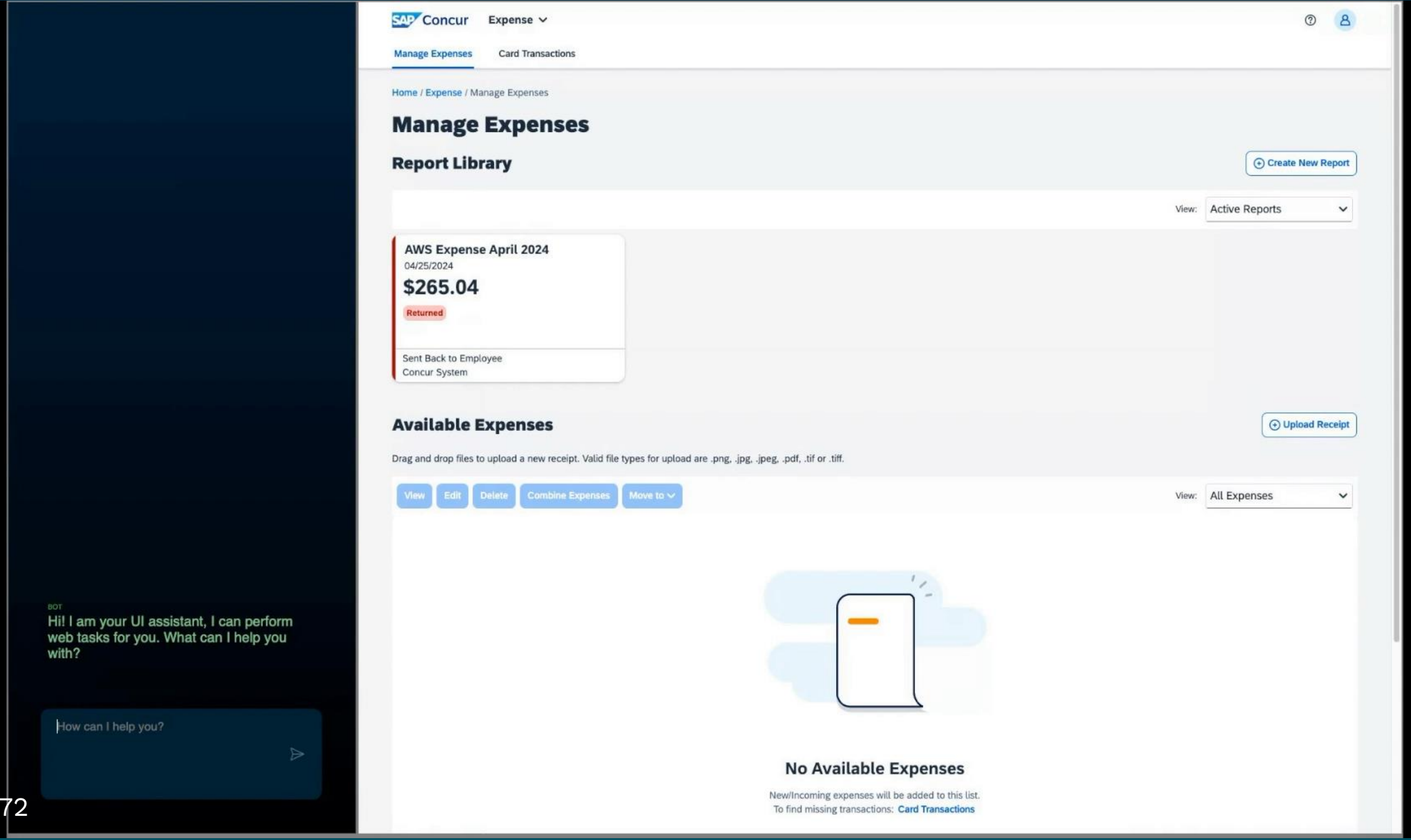
LLM response:

```
<action>
fill('14', 'Enola')
click('15')
</action>
```



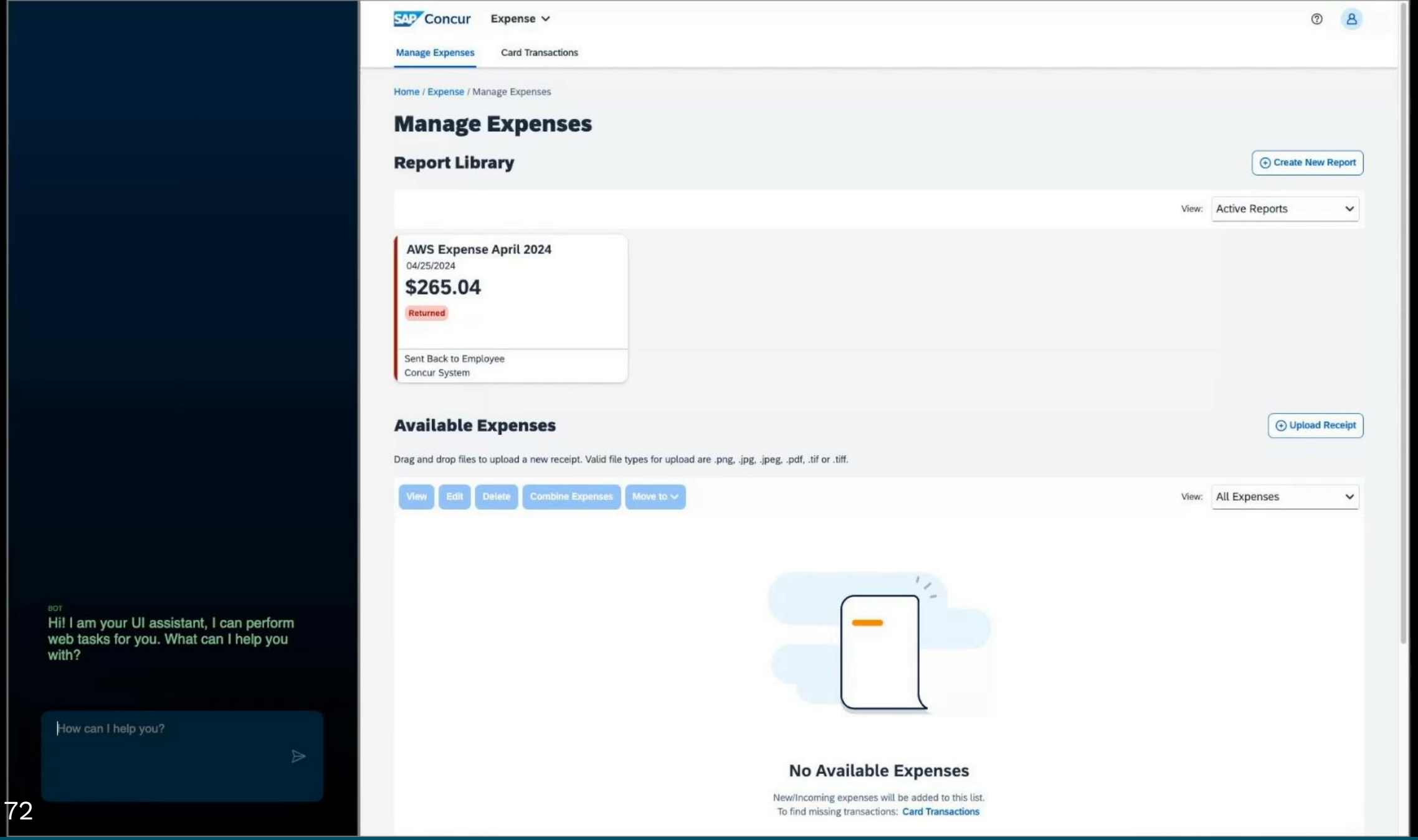
servicenow

ReAct



Agent: GPT-4 + ReAct

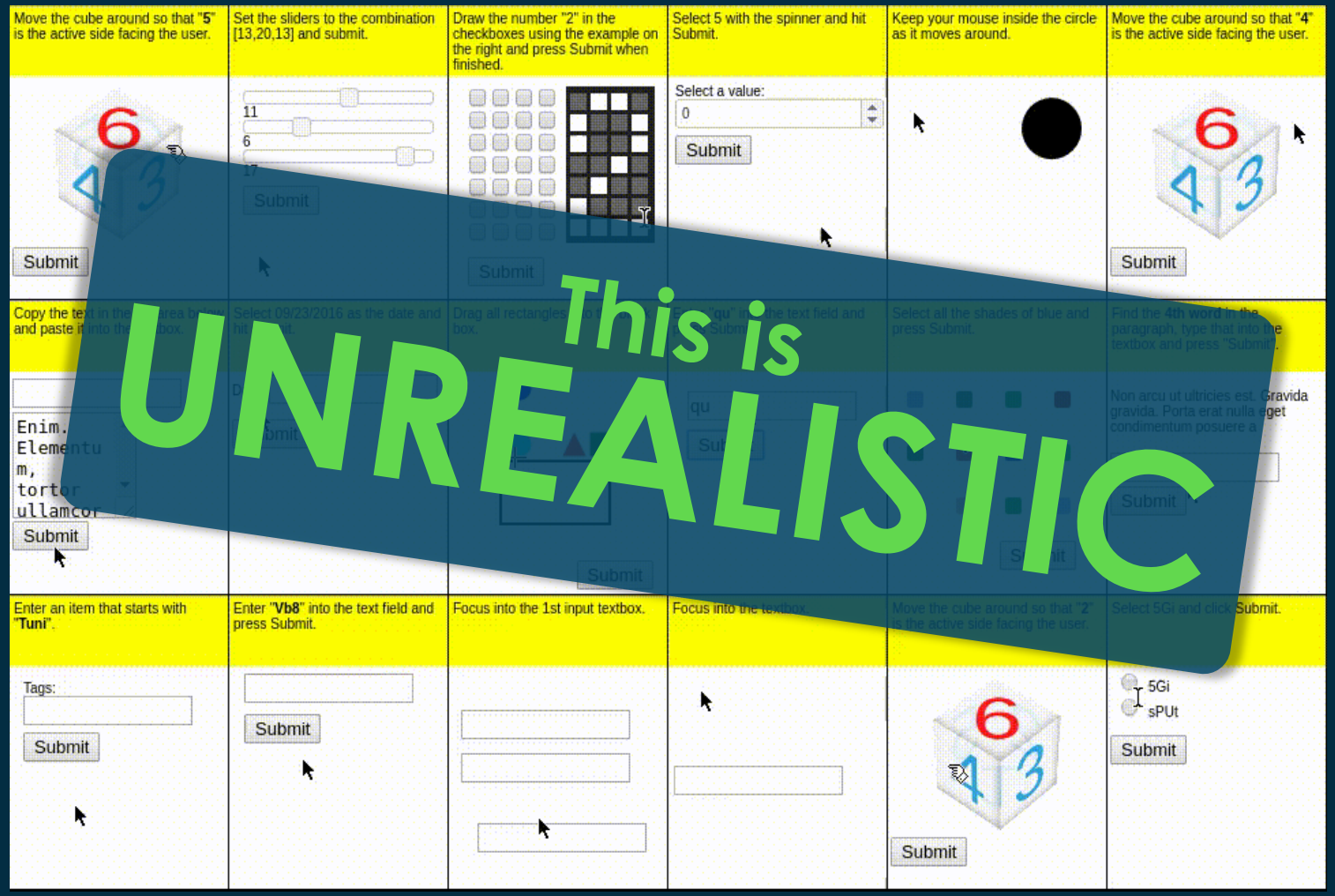
ReAct



Agent: GPT-4 + ReAct

NOTE: 8x speedup

How do we evaluate web agents?



Source: https://miniwob.farama.org/index.html (MiniWoB++)

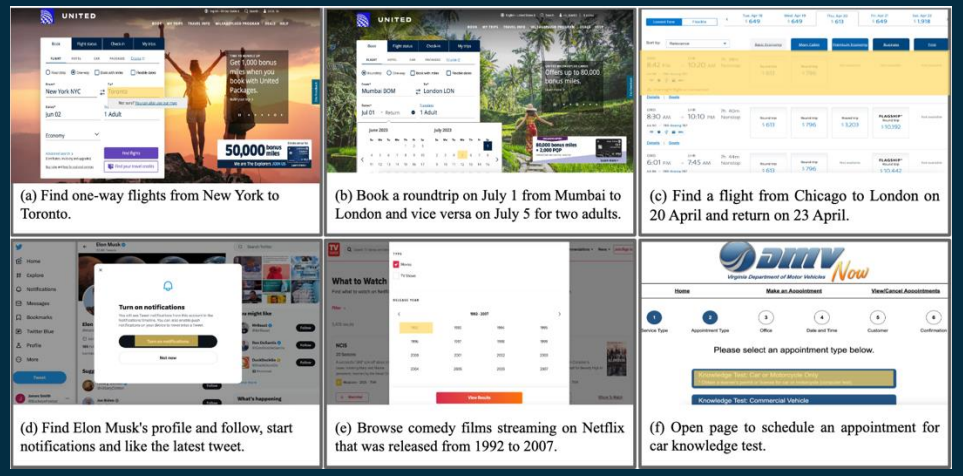
servicenow

Realistic Trace-based Benchmarks

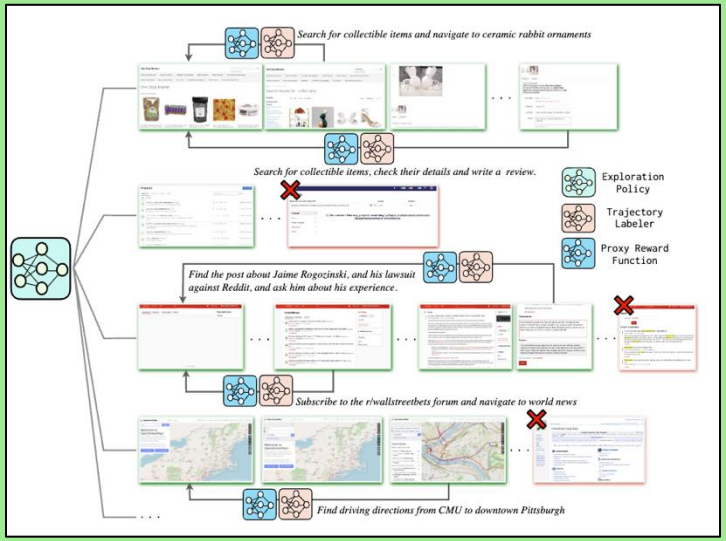
Thousands of ~~human-generated~~ observation-action traces

- ✅ Real websites
- ❌ Evaluation based on "gold traces" (what about alternative solutions?)
- ❌ Traces can be memorized

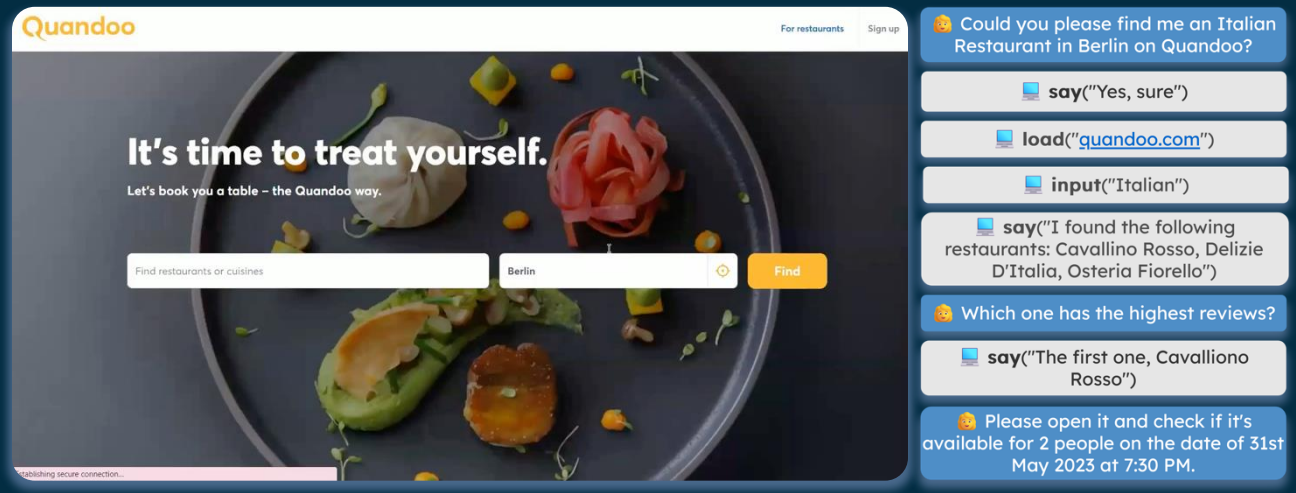
Mind2Web (Deng et al., 2023)



NNetNav (Murty et al., 2024)



WebLINX (Lù et al., 2024)



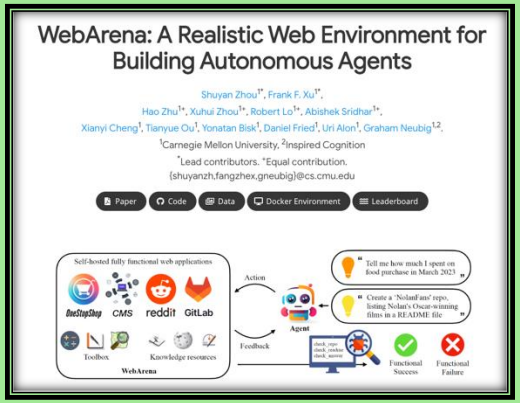
servicenow

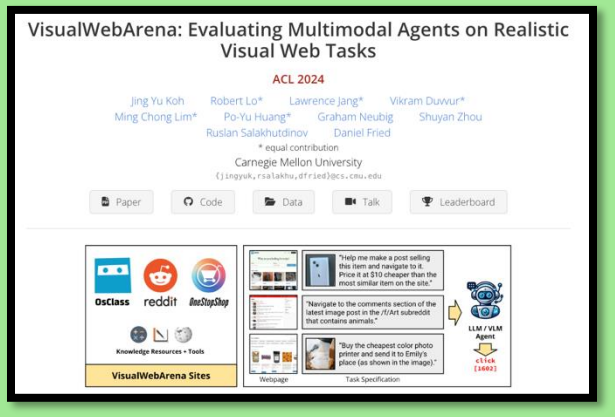
Realistic Live Environment Benchmarks

Evaluate end result rather than sequence of actions (e.g., database state)

- ✅ Agnostic to action trace
- ✅ Low memorization risk (no traces)

Sandboxed environments





Tasks performed on locally hosted server

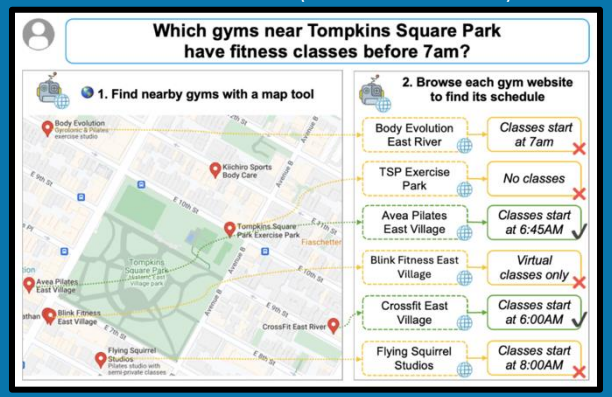
- ✅ High bandwidth (for parallel experiments)
- ❌ Limited to open-source software
- ❌ Complex local setup (e.g., Docker)

Tasks performed on a remote server

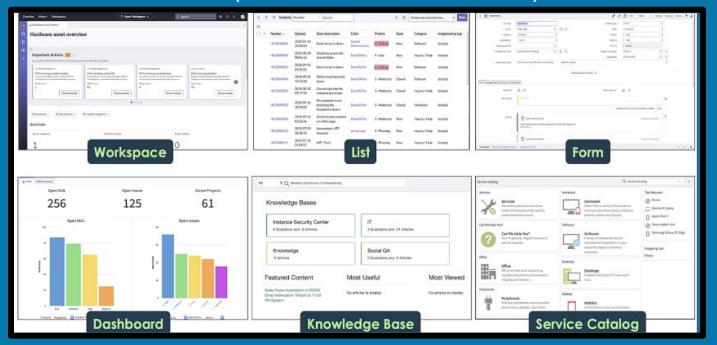
- ✅ More realistic (supports any website, latency)
- ✅ No need for complex local setup
- ❌ Can be unreliable (network issues)

Open Web Environments

AssistantBench (Yoran et al., 2024)



WorkArena (Drouin, Gasse et al., 2024)

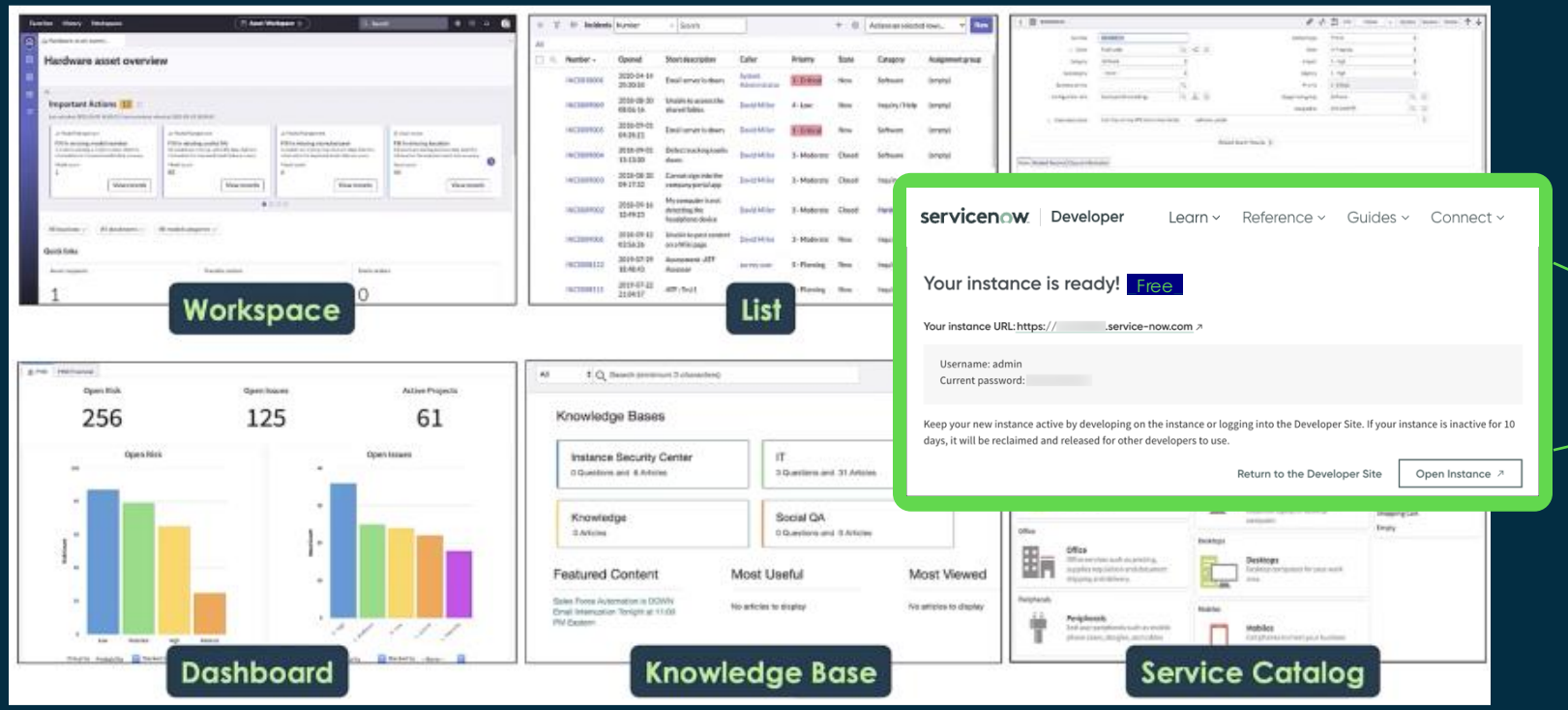


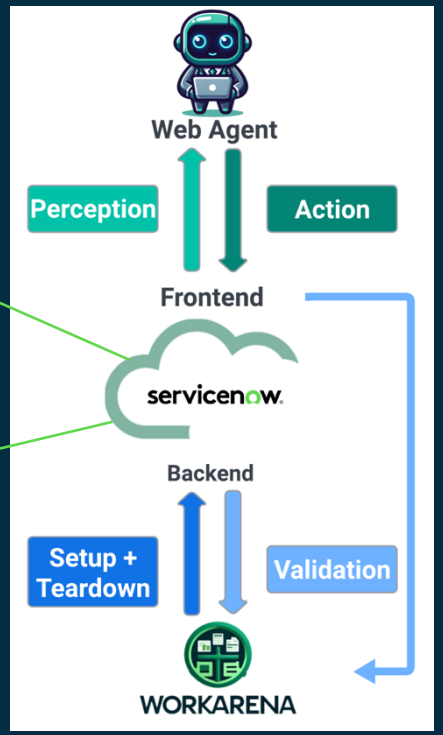
servicenow

WorkArena

```
pip install browsergym-workarena
```

An open-source benchmark of ~600 work-related tasks built on the ServiceNow platform





Tasks span basic UI interactions and complex realistic workflows

Open Web

Service Catalog

Search catalog

Services

Services
Document production services. Create and produce high-quality, professional documents.

Hardware

Hardware
Order from a variety of hardware to meet your business needs, including phones, tablets and laptops.

Shopping Cart

Empty

Can We Help You?

Can We Help You?
Your IT gateway. Report issues and submit requests.

Software

Software
A range of software products available for installation on your corporate laptop or desktop computer.

Office

Office
Office services such as printing, supplies requisition and document shipping and delivery.

Desktops

Desktops
Desktop computers for your work area.

Peripherals

Peripherals
End user peripherals such as mobile phone cases, dongles, and cables

Mobiles

Mobiles
Cell phones to meet your business needs.

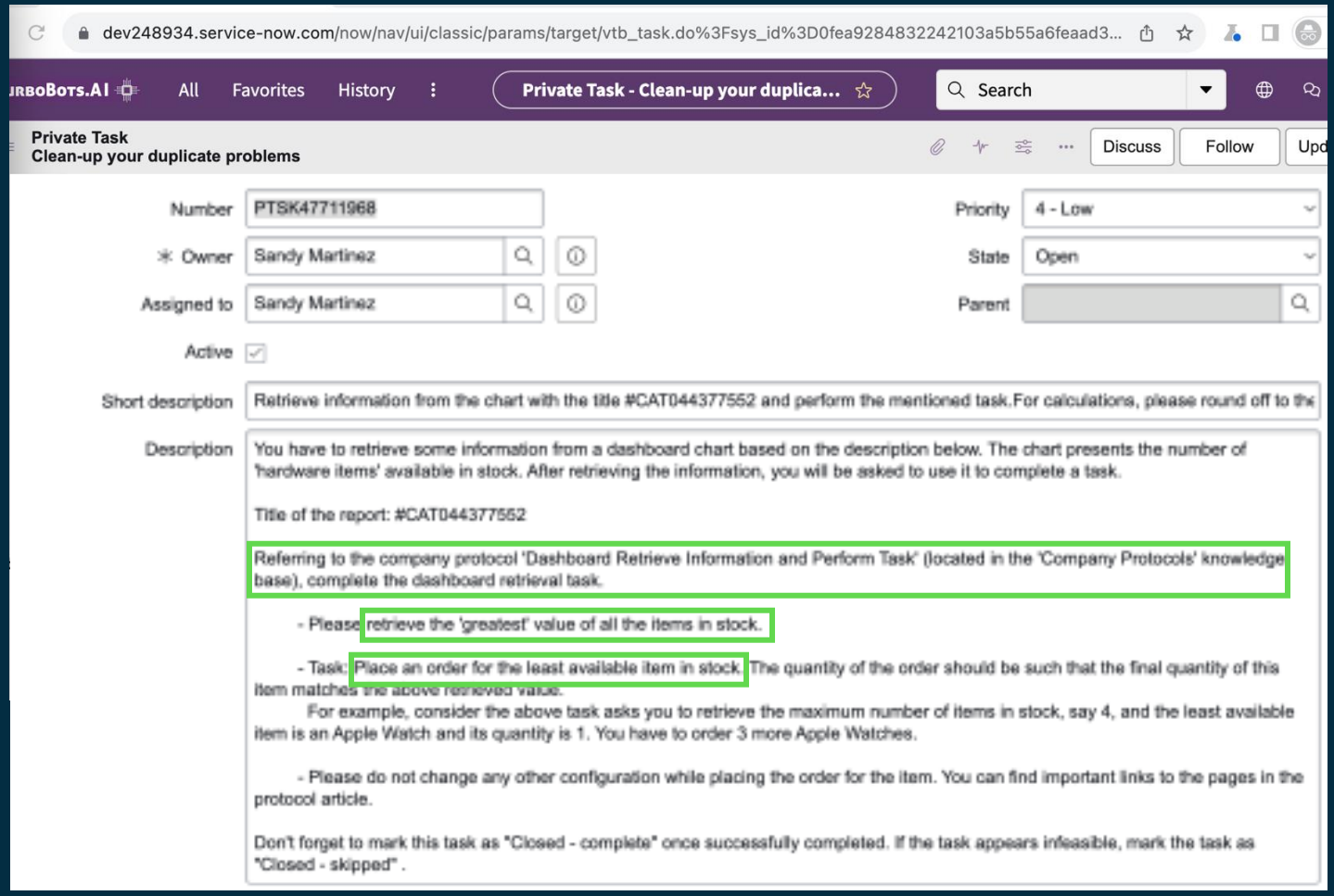
WorkArena++ Towards Realistic Enterprise Workflows

1. Knowledge base

2. Dashboard

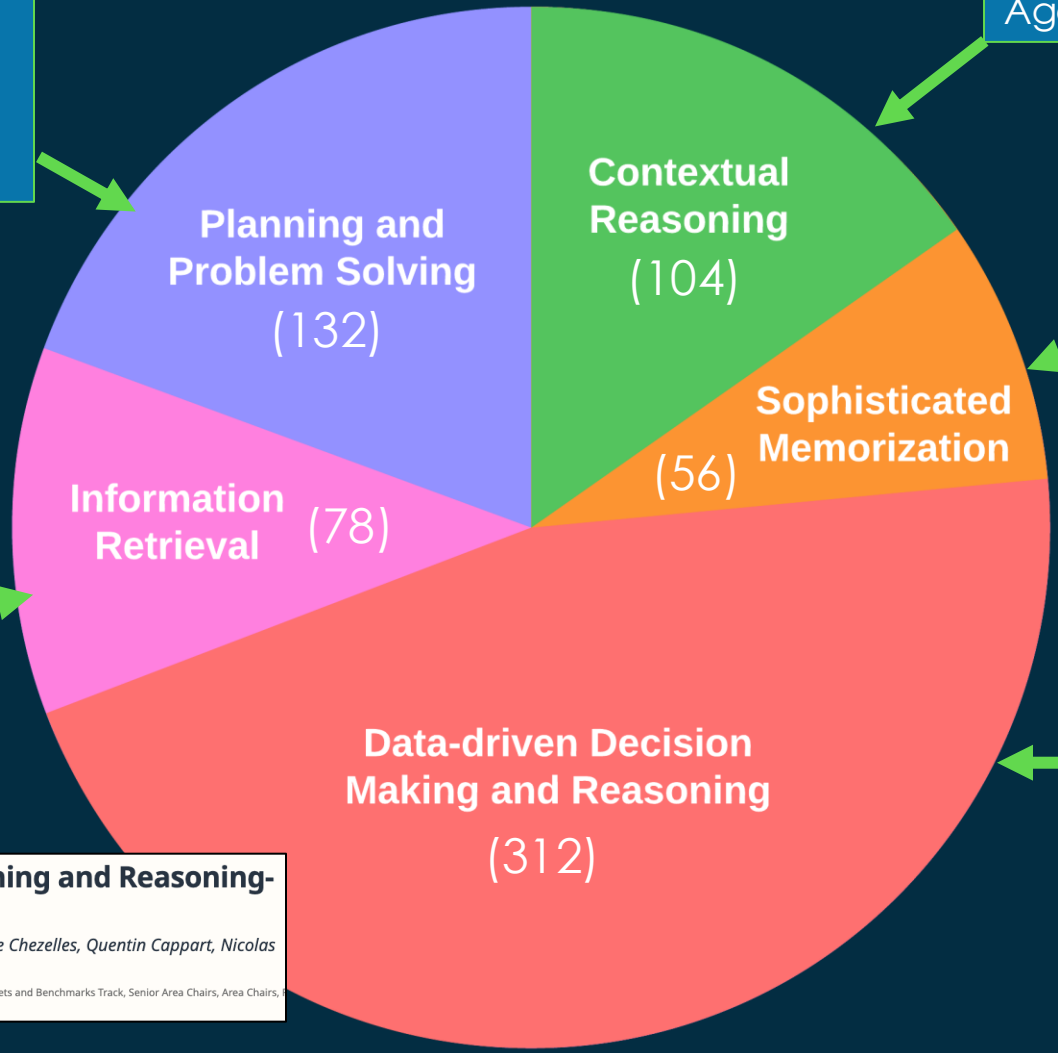
3. Service Catalog

Example: The agent is assigned a ticket and instruction: "Please solve this."



WorkArena++ Towards Realistic Enterprise Workflows

Overview of tasks



Solve a series of enterprise decision-making problems:
- Workload balancing
- Scheduling with constraints
- Assigning work to experts

Some tasks are purposely infeasible. Agent must detect this.

Navigate the platform to gather multiple bits of information and then solve a task:
- Offboard a user

Read dashboards and act:
- Restock IT asset inventory

Search for information in lists, forms, and KBs:
- Find if a user's laptop is under warranty

Read dashboard, make calculations, take action

Budget management: choose where to invest based on expected return

Expense management

WorkArena++: Towards Compositional Planning and Reasoning-based Common Knowledge Work Tasks

Léo Boisvert, Megh Thakkar, Maxime Gasse, Massimo Caccia, Thibault Le Sellier de Chezelles, Quentin Cappart, Nicolas Chapados, Alexandre Lacoste, Alexandre Drouin

Published: 26 Sept 2024, Last Modified: 26 Sept 2024 NeurIPS 2024 Track Datasets and Benchmarks Poster Datasets and Benchmarks Track, Senior Area Chairs, Area Chairs, Authors Revisions BibTeX CC BY 4.0

WorkArena++ is far from being solved

Realistic Workflows

Success rate (higher is better)	Agent Curriculum (full benchmark)					
Task Category (task count)	**GPT-3.5**	**GPT-4o**	**GPT-4o-v**	**Llama3**	**Mixtral**	**Human**
WorkArena L3 (235)						**93.9** ±3.4
Contextual Understanding (32)						87.5 ±11.7
Data-driven Decision-Making (55)						100.0 ±0.0
Planning and Problem Solving (44)						87.5 ±11.7
Information Retrieval (56)						100.0 ±0.0
Sophisticated Memorization (48)						91.7 ±8.0
WorkArena L2 (235)						**93.9** ±3.4
Contextual Understanding (32)						100.0 ±0.0
Data-driven Decision-Making (55)						84.6 ±10.0
Planning and Problem Solving (44)						100.0 ±0.0
Information Retrieval (56)						100.0 ±0.0
Sophisticated Memorization (48)						91.7 ±8.0
WorkArena L1 (33 × 10 seeds)						
MiniWoB (125 × 5 seeds)						
WebArena (812)						

servicenow

WorkArena++ is far from being solved

Realistic Workflows

Success rate (higher is better)

Task Category (task count)	Agent Curriculum (full benchmark) GPT-3.5	GPT-4o	GPT-4o-v	Llama3	Mixtral	Human
WorkArena L3 (235)	**0.0** ±0.0	**0.0** ±0.0	**0.0** ±0.0	**0.0** ±0.0	**0.0** ±0.0	**93.9** ±3.4
Contextual Understanding (32)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	87.5 ±11.7
Data-driven Decision-Making (55)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	100.0 ±0.0
Planning and Problem Solving (44)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	87.5 ±11.7
Information Retrieval (56)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	100.0 ±0.0
Sophisticated Memorization (48)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	91.7 ±8.0
WorkArena L2 (235)	**0.0** ±0.0	**3.0** ±1.1	**3.8** ±1.3	**0.0** ±0.0	**0.0** ±0.0	**93.9** ±3.4
Contextual Understanding (32)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	100.0 ±0.0
Data-driven Decision-Making (55)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	84.6 ±10.0
Planning and Problem Solving (44)	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	0.0 ±0.0	100.0 ±0.0
Information Retrieval (56)	0.0 ±0.0	0.0 ±0.0	3.6 ±2.5	0.0 ±0.0	0.0 ±0.0	100.0 ±0.0
Sophisticated Memorization (48)	0.0 ±0.0	14.6 ±5.1	14.6 ±5.1	0.0 ±0.0	0.0 ±0.0	91.7 ±8.0
WorkArena L1 (33 × 10 seeds)	**6.1** ±1.3	**42.7** ±2.7	**41.8** ±2.7	**17.9** ±2.1	**12.4** ±1.8	
MiniWoB (125 × 5 seeds)	**43.4** ±1.6	**71.3** ±1.5	**72.5** ±1.5	**68.2** ±1.2	**62.4** ±1.6	
WebArena (812)	**6.7** ±0.9	**23.5** ±1.5	**24.0** ±1.5	**11.0** ±1.1	**12.6** ±0.5	

What explains this?

- Failure to plan
- Hallucinated controls
- Incorrect action syntax

servicenow

Benchmark Explosion

- MiniWoB++ (Shi et al., 2017; Liu et al., 2018) **125 tasks**
- WebShop (Yao, Chen et al., 2022) **12 087 tasks**
- WebArena (Zhou et al., 2023) **812 tasks**
- VisualWebArena (Koh et al., 2024) **910 tasks**
- WebLINX (Lù et al., 2024) **2 300 tasks**
- WebCanvas (Pan et al., 2024) **438 tasks**
- WebVoyager (He et al., 2024) **643 tasks**
- AssistantBench (Yoran et al., 2024) **214 tasks**
- WorkArena++ (ServiceNow Research, 2024) **682 tasks**

Call for unification

Get everyone under the same roof for a great Meta-Benchmark

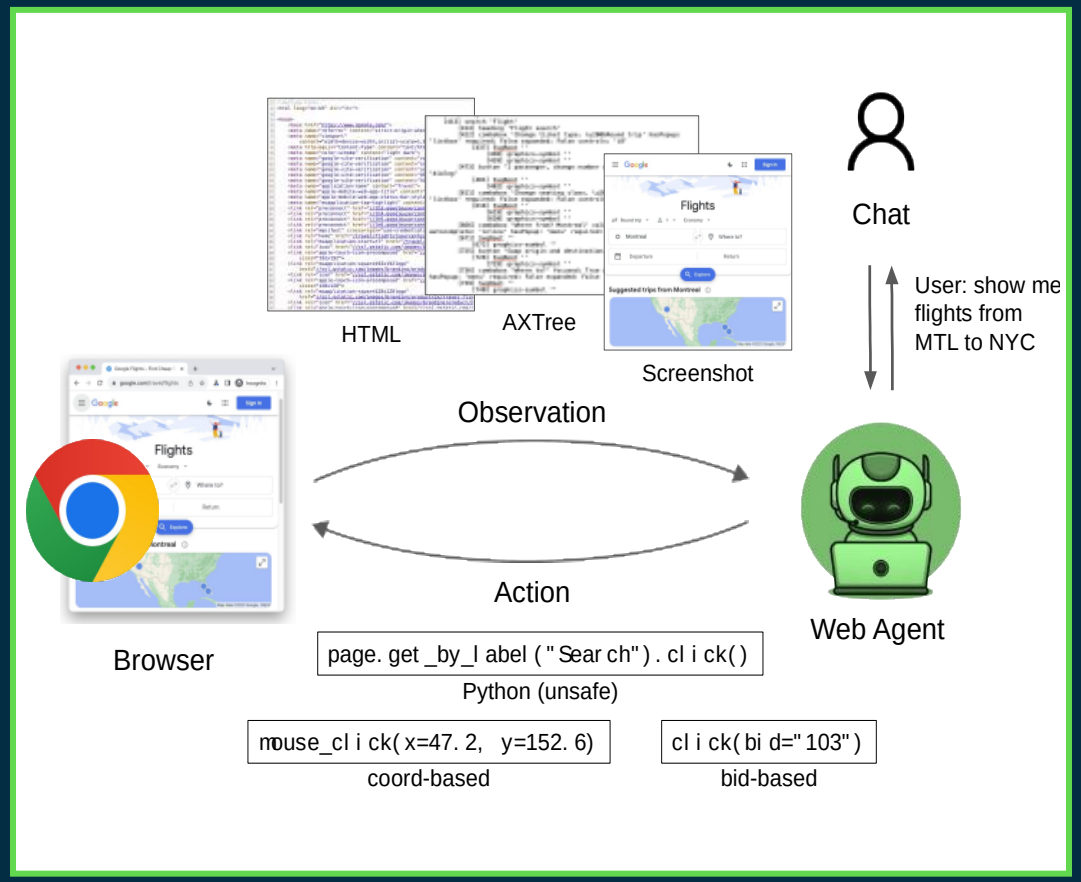
servicenow

BrowserGym

pip install browsergym

A unified evaluation platform

- Standard Observation Space
  - HTML
  - Screenshots
  - Accessibility Tree
  - And more
- Standard Action Space
- Regroups most major benchmarks (thousands of realistic tasks)



servicenow

BrowserGym

pip install browsergym

18:21:38 - BOT
Hi! I am your UI assistant, I can perform web tasks for you. What can I help you with?
18:21:38 - YOU
Please complete the following task.

How can I help you?

Human evaluation for any benchmark!

Private Task - Clean-up your duplica...

Private Task
Clean-up your duplicate problems

Discuss | Follow | Update | Delete

Number: PTSK70688720
Priority: 4 - Low
Owner: Meghan Lewis
State: Open
Assigned to: Meghan Lewis
Parent:
Active
Short description: Clean-up your duplicate problems
Description: Referring to company protocol "Problem List Cleanup" -located in the "Company Protocols" knowledge base- clean-up your problem list (problems assigned to you) by marking duplicates as "Closed - complete" once successfully completed. Otherwise, you can mark the task as "Closed - skipped" .
Additional comments (Customer visible)
Work notes | Post

Activities: 1
Meghan Lewis
Assigned to: Meghan Lewis
Impact: 3 - Low
Opened by: Meghan Lewis
Priority: 4 - Low
State: Open

Human Evaluation Console
Task 1 / 100 --- Elapsed: 5.5 sec.
Validate | Give up | Infeasible
Task not completed. Keep going.

AgentLab

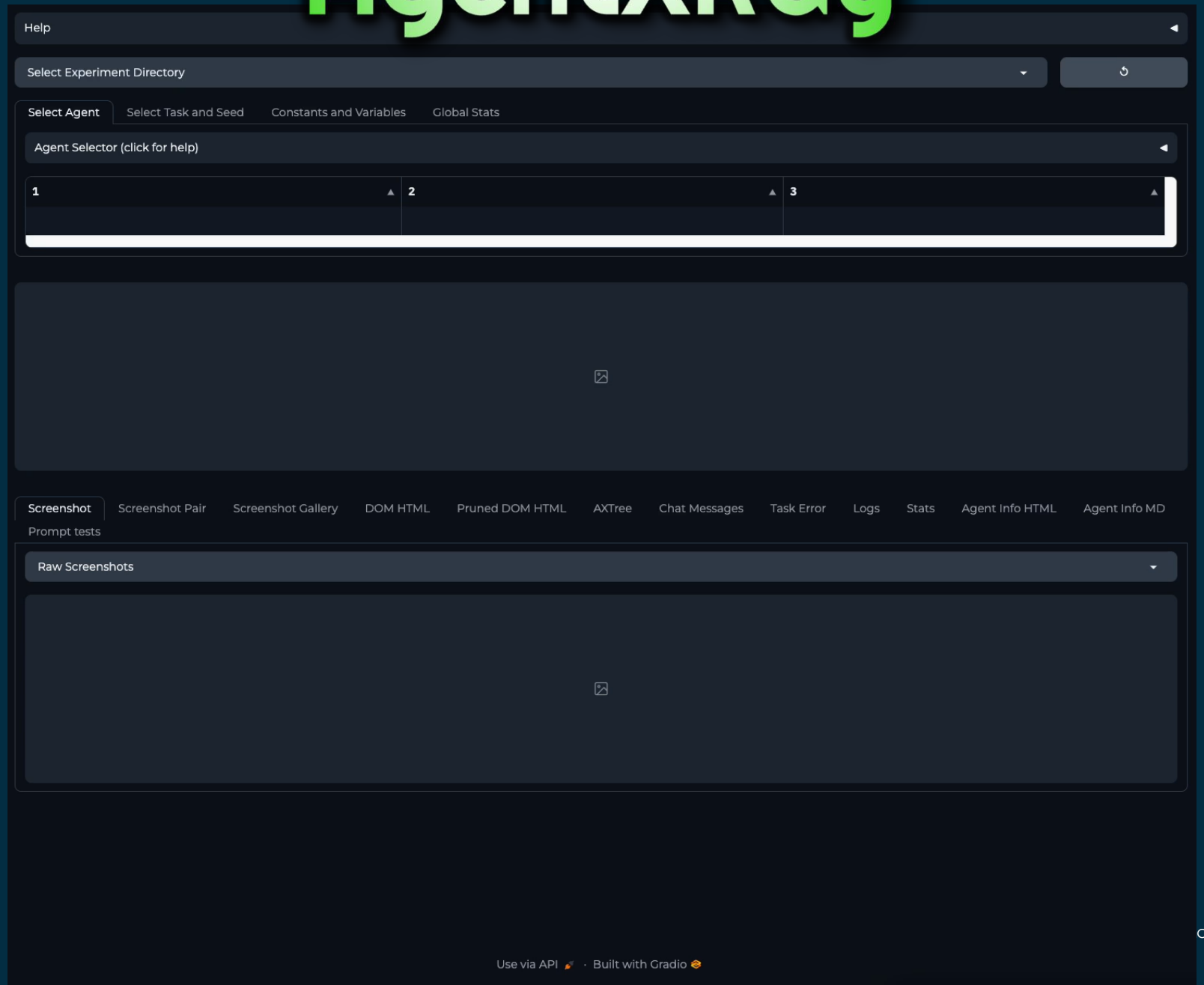
A toolbox for agent design

- Simple building blocks for agents
- Tools to inspect their behavior
- Experimental framework:
  - Easy large-scale evaluation
  - Reproducibility features

```python
class MyAgent(bgym.Agent):

    def get_action(self, obs) -> str:

        action = do_some_reasoning(obs)

        return action


study = run_agents_on_benchmark(MyAgent(), "workarena.l1")

study.run(n_jobs=10, parallel_backend="joblib")
```


servicenow

AgentXRay



servicenow

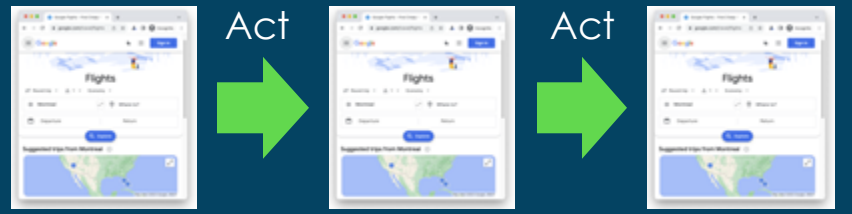
AgentLab

Reproducibility as a priority

Benchmarking on the open web is challenging (dynamic environment)

- Websites are updated
- API-based LLMs change silently
- Python packages evolve

- Standardized observation/action traces



- Experimental journal uploaded to public repo
  Date, versions, agent configuration, traces, etc.

- Leaderboards with scores that are automatically reproduced based on the above

servicenow

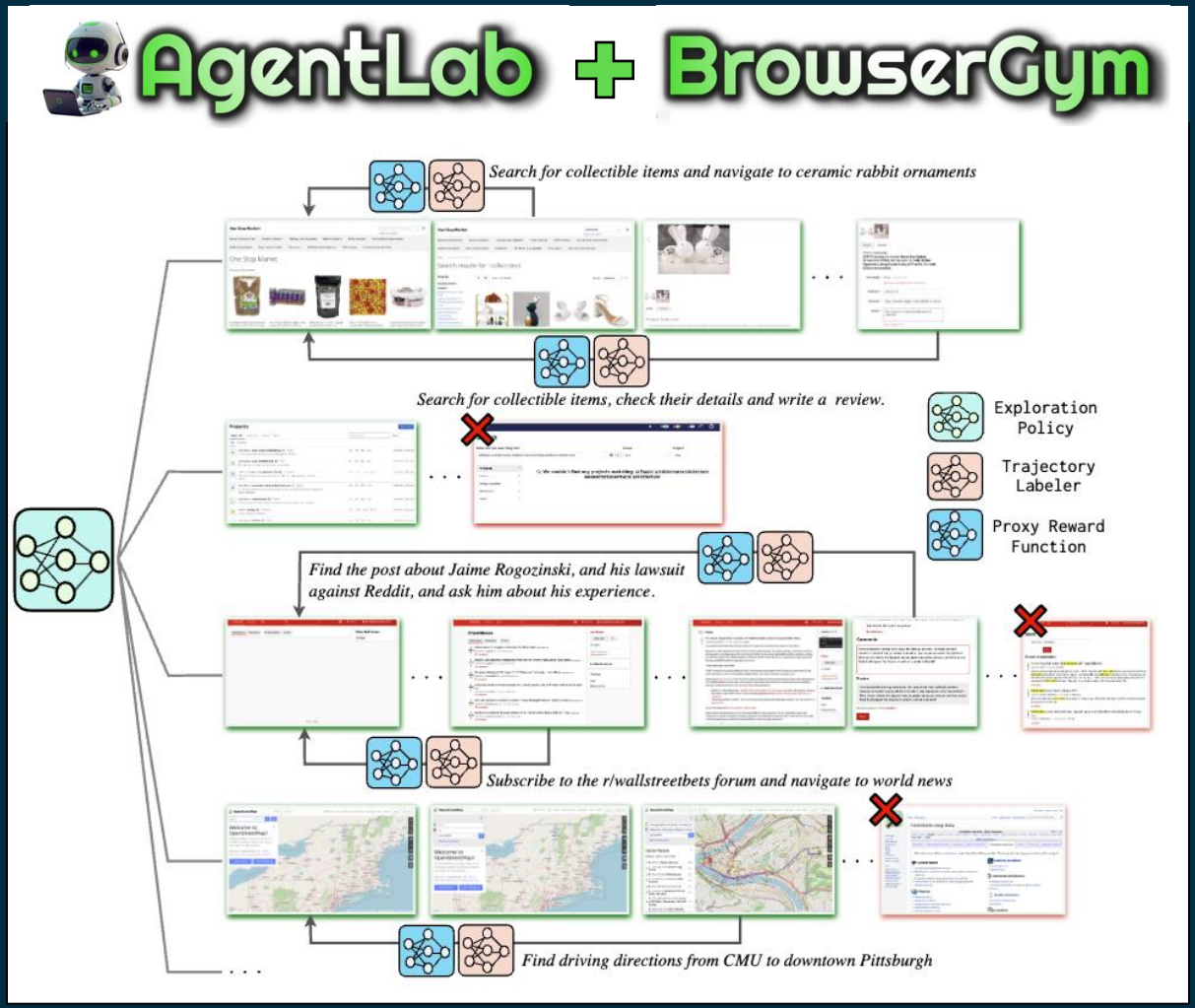
Large Dataset Collection for Web Agents

Opportunity

With mechanisms for:

- Standardized observation and action spaces
- Standardized trace collection
- Public repository for traces

We can collectively gather large-scale finetuning datasets on public benchmarks and on the open web.



Source: Murty et al. (2024)

servicenow

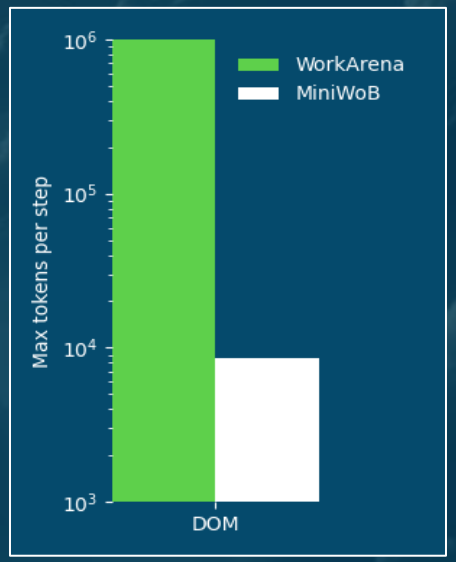
The Challenges for Web Agents Remain tall

*We are, after all, dealing with the **World Wild Web***

Main hurdles

- **Long context understanding**
- Long-term planning
- Learning and adaptability
- Multimodality
- Cost and efficiency
- Safety and alignment

Real-world web pages contain hundreds of thousands of tokens



Retrieval can help (e.g., Dense Markup Ranker; Lù et al., 2024)

servicenow

The Challenges for Web Agents Remain tall

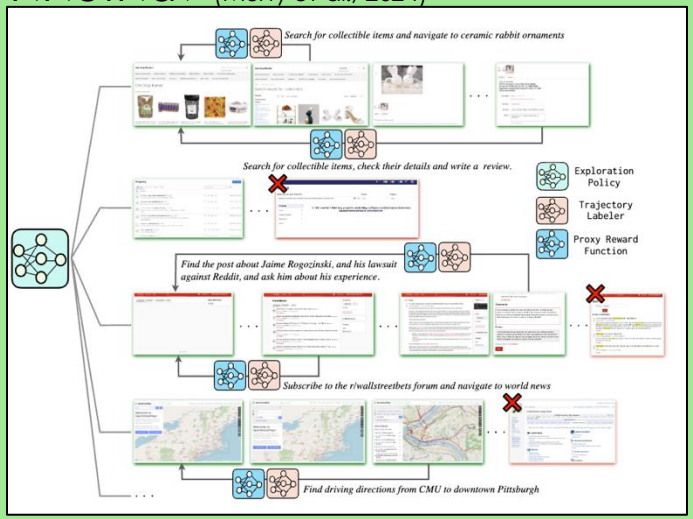
*We are, after all, dealing with the **World Wild Web***

Main hurdles

- Long context understanding
- **Long-term planning**
- Learning and adaptability
- Multimodality
- Cost and efficiency
- Safety and alignment

Sparse rewards and near-impossible test-time exploration

NNetNav (Murty et al., 2024)



Potential solution: automatically gather huge exploratory traces tagged with goal

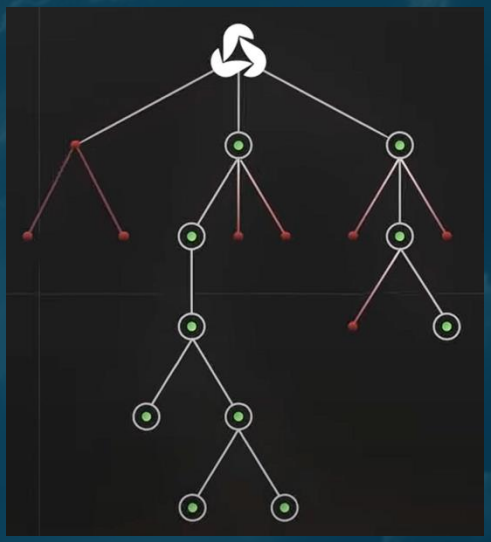
The Challenges for Web Agents Remain tall

*We are, after all, dealing with the **World Wild Web***

Main hurdles

- Long context understanding
- Long-term planning
- **Learning and adaptability**
- Multimodality
- Cost and efficiency
- Safety and alignment

How to efficiently learn from demonstrations and mistakes?



Potential solution: use RL-inspired approaches to finetune agent policy
(Agent Q uses MCTS + DPO; Putta et al., 2024)

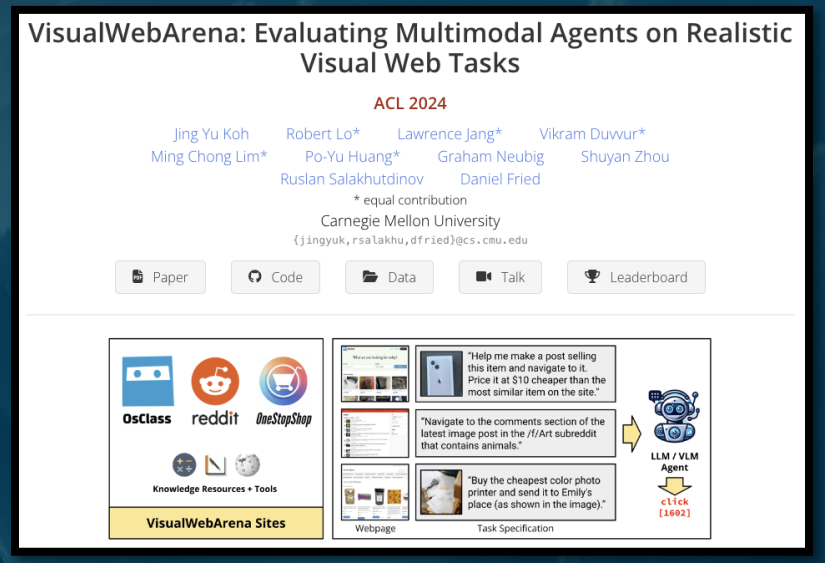
The Challenges for Web Agents Remain tall

*We are, after all, dealing with the **World Wild Web***

Main hurdles

- Long context understanding
- Long-term planning
- Learning and adaptability
- **Multimodality**
- Cost and efficiency
- Safety and alignment

Multimodality can be crucial



Humans rely on vision, but current agents fail to make use of that modality

servicenow

The Challenges for Web Agents Remain tall

*We are, after all, dealing with the **World Wild Web***

Main hurdles

- Long context understanding
- Long-term planning
- Learning and adaptability
- Multimodality
- **Cost and efficiency**
- Safety and alignment

Web Agents must produce more value than they cost to be viable

- Shrinking context size (e.g., retrieval)
- Multi-agent architectures
  - Smaller LLMs that solve low-level tasks (e.g., a "date picker agent")
- Finetuning smaller LLMs to improve their performance

The Challenges for Web Agents Remain tall

*We are, after all, dealing with the **World Wild Web***

Main hurdles

- Long context understanding
- Long-term planning
- Learning and adaptability
- Multimodality
- Cost and efficiency
- **Safety and alignment**

- Website contents can trip over agent LLM guardrails
  - *Text visible to LLM but not human (e.g., white on white)*
  - *Random-character, ascii art and tokenizer attacks*
  - *Even worse for multimodal models*
- 2026's fraudsters
  - *Malicious Chrome plugin detects when you log onto your bank, executes wire transfer abroad*

AGENDA

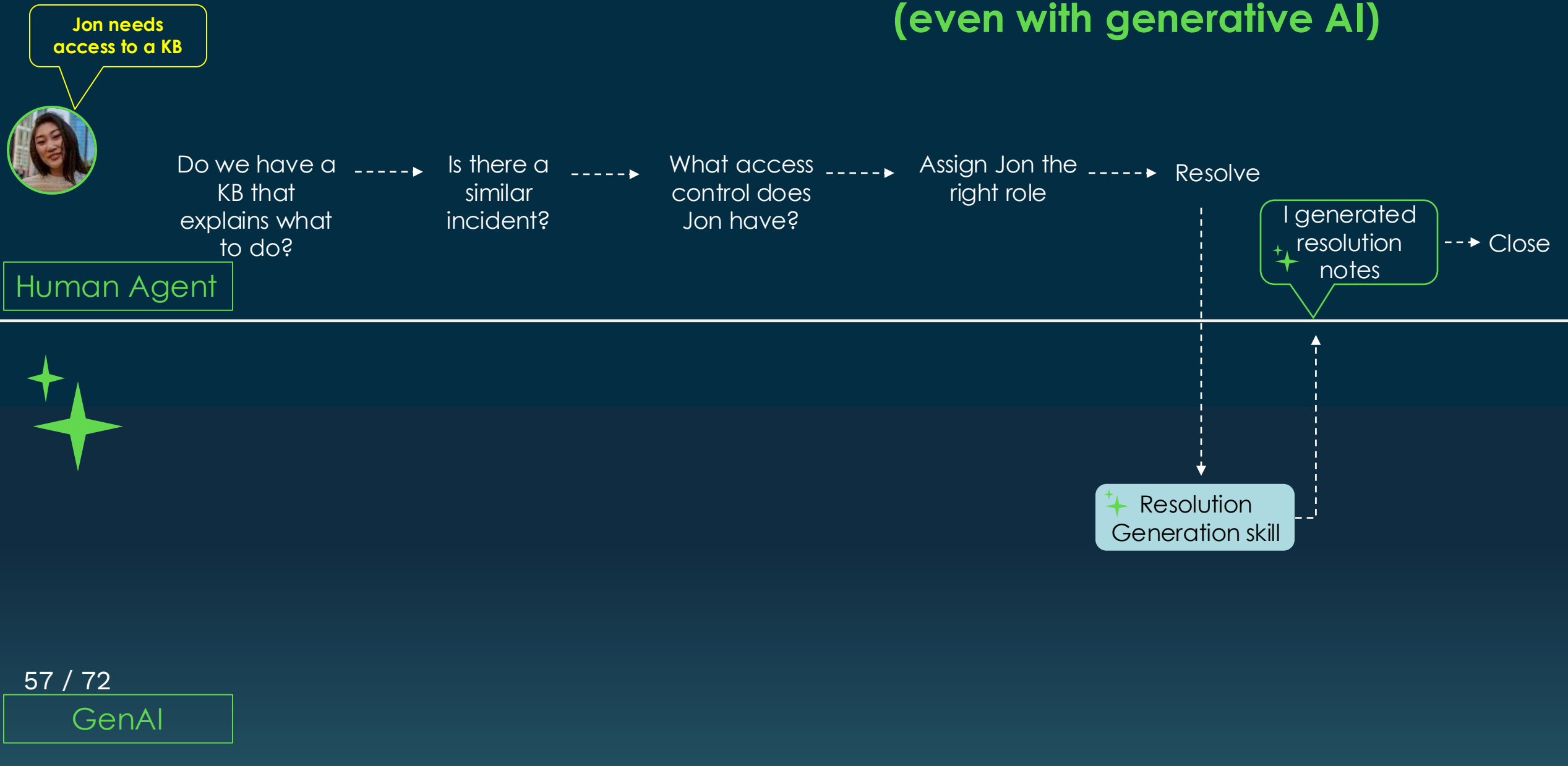
Background	Defining Agents Enterprise workflow concepts
API Agents	Architecture TapeAgents
Web Agents	Web Agent Concepts WorkArena BrowserGym and AgentLab
Agents in the Workplace	Automating enterprise workflows Agents and the future of work

Resources to Dig Further

servicenow

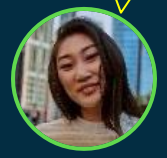
Today's Enterprise Workflows Remain Quite Manual

(even with generative AI)



Access issue – With AI Agents

Jon needs access to a KB



To solve this issue I need to –
1. Find what access Jon has
2. Find KB permissions
3. Give Jon the right access

Can you approve?

Looks good. Go ahead

I'm going to assign Jon 'Knowledge' role

Ok

Close

Human Agent

Who can I assign this issue to?

Generate a plan based on relevant KB and similar incidents

What access Jon has?

What are the KB Permissions?

Assign Jon role 'Knowledge'

Document resolution steps

AI Agents Orchestrator

Next-best-action AI Agents

User Access AI Agents

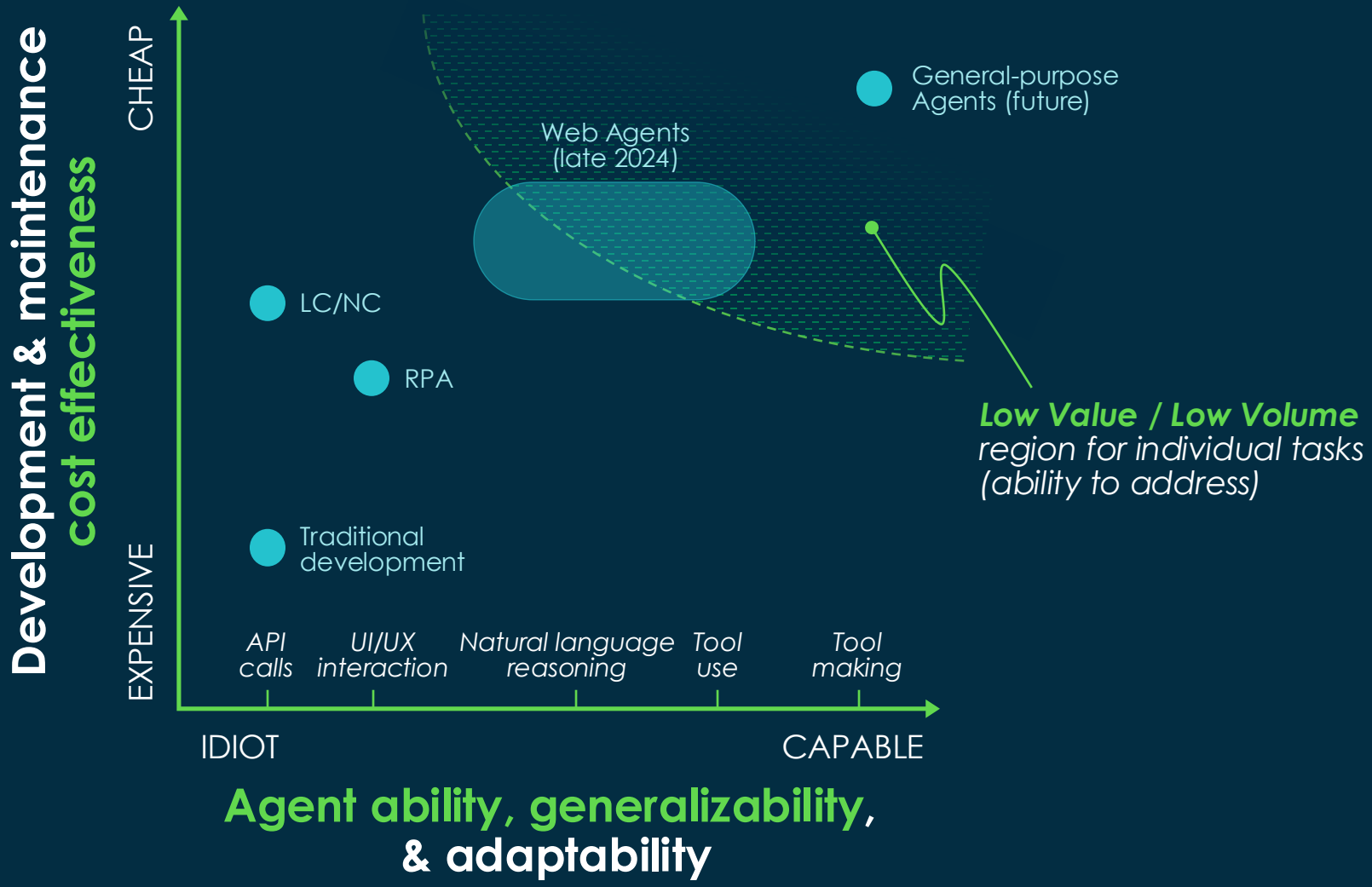
KB AI Agent

User Access AI Agents

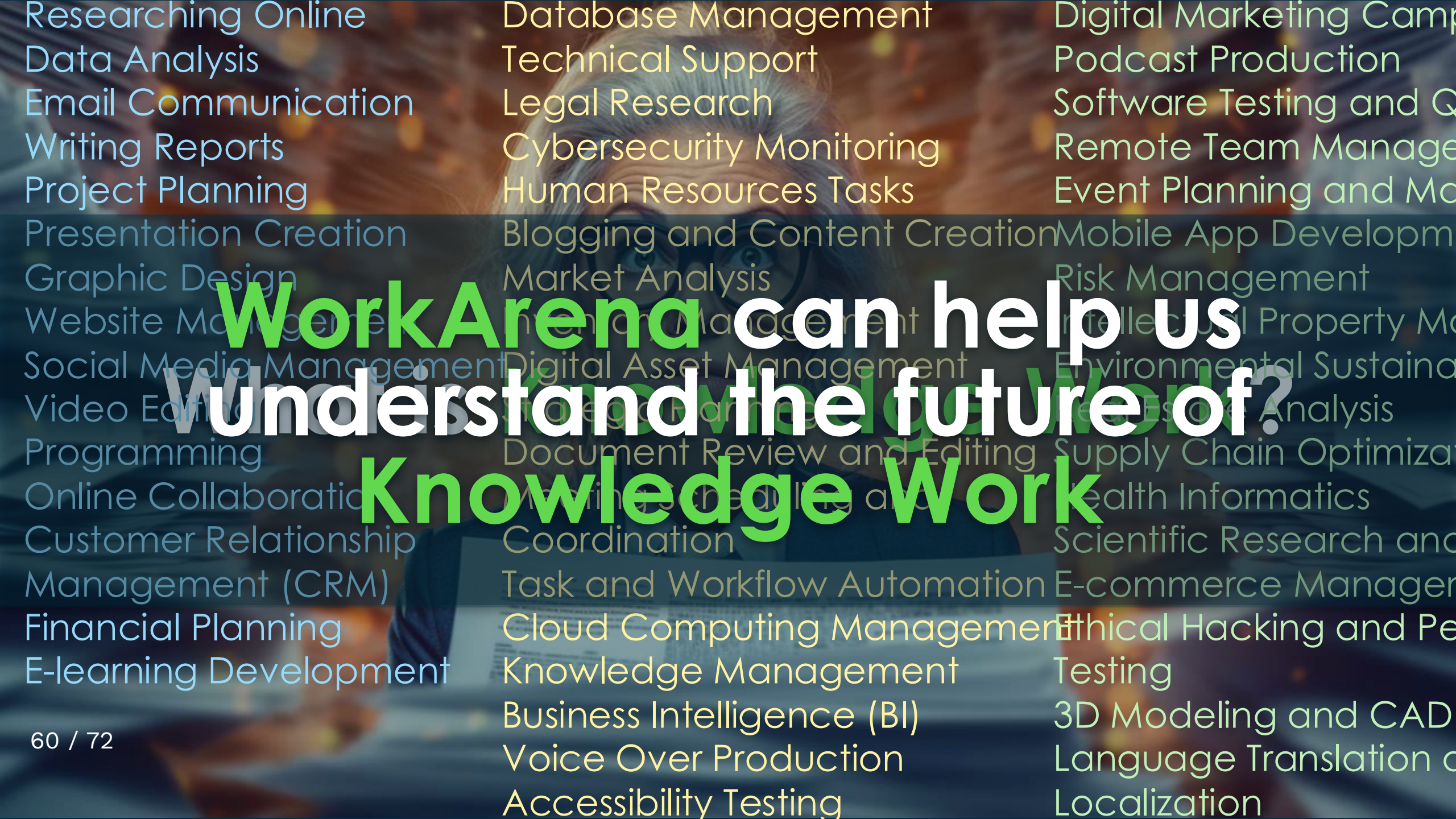
Documenter AI Agents

AI Agents

Web Agents to address Low Value / Low Volume tasks



servicenow


Researching Online
Data Analysis
Email Communication
Writing Reports
Project Planning
Presentation Creation
Graphic Design
Website Management
Social Media Management
Video Editing
Programming
Online Collaboration
Customer Relationship Management (CRM)
Financial Planning
E-learning Development
Database Management
Technical Support
Legal Research
Cybersecurity Monitoring
Human Resources Tasks
Blogging and Content Creation
Market Analysis
Inventory Management
Digital Asset Management
Strategic Planning
Document Review and Editing
Meeting Scheduling and
Coordination
Task and Workflow Automation
Cloud Computing Management
Knowledge Management
Business Intelligence (BI)
Voice Over Production
Accessibility Testing
Digital Marketing Camp
Podcast Production
Software Testing and Q
Remote Team Manage
Event Planning and Ma
Mobile App Developm
Risk Management
Intellectual Property Ma
Environmental Sustaina
Real Estate Analysis
Supply Chain Optimiza
Health Informatics
Scientific Research and
E-commerce Manager
Ethical Hacking and Pe
Testing
3D Modeling and CAD
Language Translation a
Localization
WorkArena can help us understand the future of Knowledge Work

O*NET: Cataloging the Workforce

15-0000				Computer and Mathematical Oc
	15-1200			Computer Occupations
		15-1210		Computer and Information Analysts
			15-1211	Computer Systems Analysts
			15-1212	Information Security Analysts
		15-1220		Computer and Information Researc
			15-1221	Computer and Information Research Sc
		15-1230		Computer Support Specialists
			15-1231	Computer Network Support Specialists
			15-1232	Computer User Support Specialists
		15-1240		Database and Network Administrato
			15-1241	Computer Network Architects
			15-1242	Database Administrators
			15-1243	Database Architects
			15-1244	Network and Computer Systems Admin
		15-1250		Software and Web Developers, Prog
			15-1251	Computer Programmers
			15-1252	Software Developers
			15-1253	Software Quality Assurance Analysts ar
			15-1254	Web Developers
			15-1255	Web and Digital Interface Designers
		15-1290		Miscellaneous Computer Occupatio
			15-1299	Computer Occupations, All Other

Software Quality Assurance Analysts and Testers

15-1253.00

Bright Outlook | Updated 2024

Develop and execute software tests to identify software problems and their causes. Test system modifications to prepare for implementation. Document software and application defects using a bug tracking system and report defects to software or web developers. Create and maintain databases of known defects. May participate in software design reviews to provide input on functional requirements, operational characteristics, product designs, and schedules.

Sample of reported job titles: Automation Tester, Information Technology Analyst (IT Analyst), Quality Assurance Analyst (QA Analyst), Quality Assurance Engineer (QA Engineer), Quality Engineer, Software Quality Assurance Analyst (SQA Analyst), Software Quality Assurance Engineer (SQA Engineer), Software Quality Engineer, Software Test Engineer, Test Engineer

Summary | Details | Custom | Easy Read | Veterans | Español

Contents

Occupation-Specific Information

Tasks

5 of 30 displayed

- Identify, analyze, and document problems with program function, output, online screen, or content.
- Document software defects, using a bug tracking system, and report defects to software developers.
- Develop testing programs that address areas such as database impacts, software scenarios, regression testing, negative testing, error or bug retests, or usability.
- Design test plans, scenarios, scripts, or procedures.
- Document test procedures to ensure replicability and compliance with standards.

Technology Skills

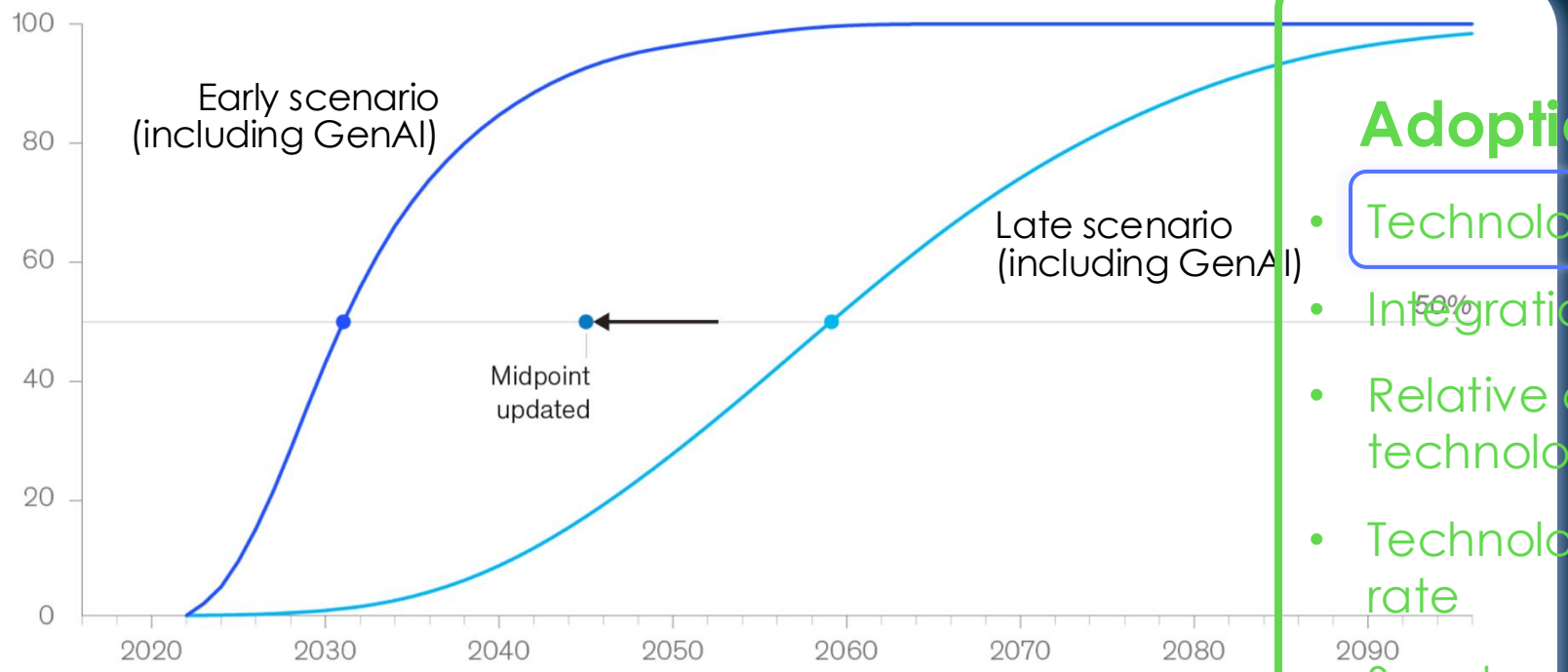
5 of 68 displayed

- **Data base user interface and query software** — Airtable; Apache Hive; Blackboard software; IBM DB2
- **Development environment software** — Apache Kafka; Apache Maven; Apache Subversion SVN; Oracle Java 2 Platform Enterprise Edition J2EE
- **Object or component oriented development software** — Apache Spark; jQuery; Objective C; Scala
- **Program testing software** — Hewlett Packard LoadRunner; IBM Rational Robot; JUnit; Selenium
- **Web platform development software** — Django; Google Angular; React; Spring Framework

servicenow

Source: Bureau of Labor Statistics Standard Occupational Classification and O*NET

Technology adoption takes time and uncertainty for generative AI adoption remains high



[1]Includes data from 47 countries, representing about 80% of employment across the world. 2017 estimates are based on the activity and occupation mix from 2016. Scenarios including generative AI are based on the 2021 activity and occupation mix.
[2]Early scenario: aggressive scenario for all key model parameters (technical automation potential, integration timelines, economic feasibility, and technology diffusion rates.).
[3]Late scenario: parameters are set for later adoption potential.
Source: McKinsey Global Institute analysis

Adoption Drivers

- Technological maturity
- Integration speed
- Relative cost of technology vs labor
- Technology diffusion rate
- Supply constraints (e.g. GPUs, regulatory)

servicenow Source: The economic potential of generative AI: The next productivity frontier (McKinsey)

Assessing Impact: Top-Down vs Bottom-Up

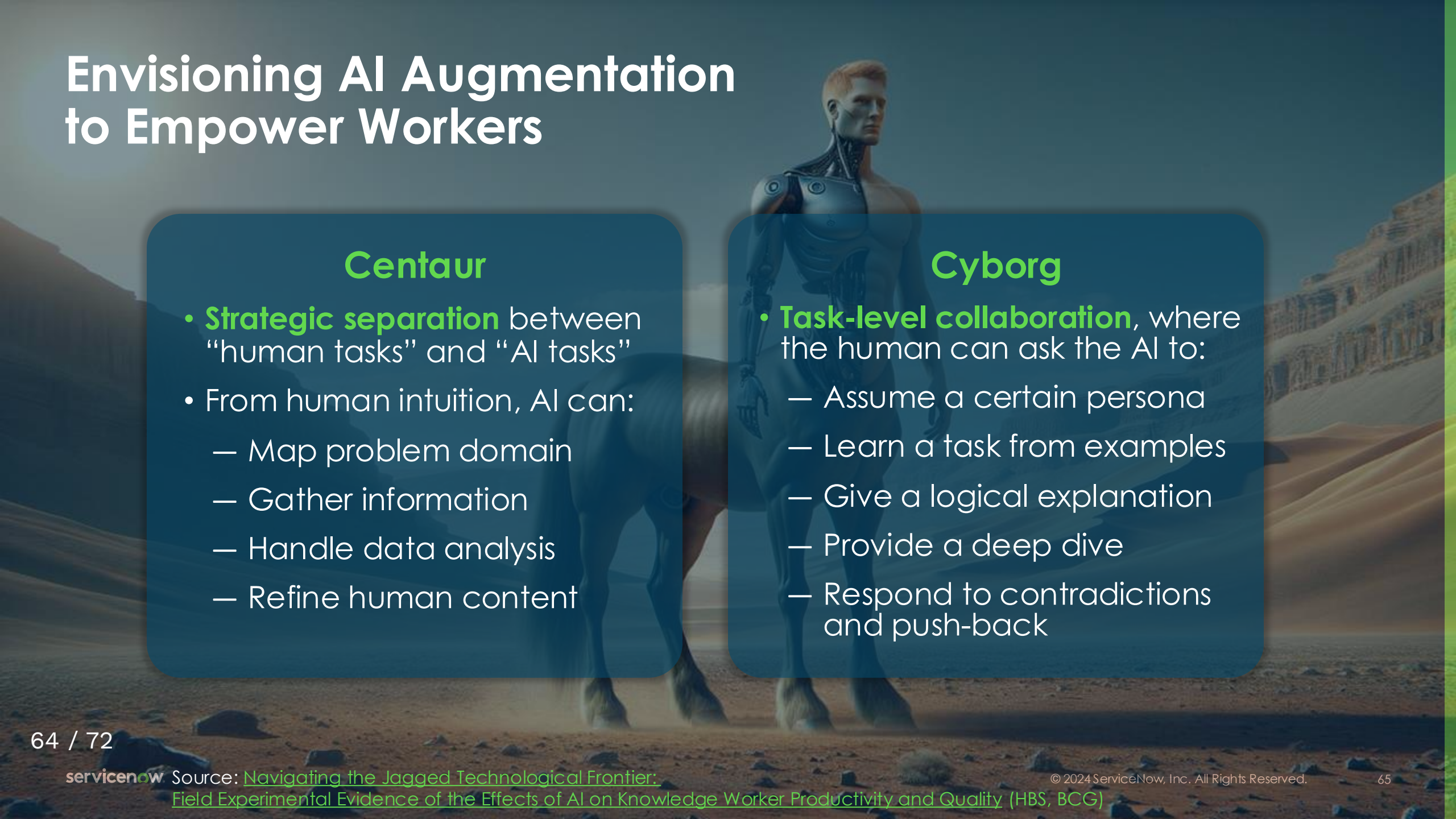
Top-Down Assessment

- Analyze each task for each job in O*NET
- For each, "guess" what the task looks like with AI, and decide if human still needed
- Can be automated (GPT-4)
- Advantage: wide coverage
- Challenge: blurry picture

Bottom-Up Assessment

- Map each task in O*NET to benchmark tasks in a knowledge work proxy such as **WorkArena**
- Track ability of AI to successfully complete the tasks and map back to job automation prob.
- Advantage: detailed picture
- Challenge: spotty coverage

Envisioning AI Augmentation to Empower Workers



Centaur

- **Strategic separation** between "human tasks" and "AI tasks"
- From human intuition, AI can:
  - Map problem domain
  - Gather information
  - Handle data analysis
  - Refine human content

Cyborg

- **Task-level collaboration**, where the human can ask the AI to:
  - Assume a certain persona
  - Learn a task from examples
  - Give a logical explanation
  - Provide a deep dive
  - Respond to contradictions and push-back

Source: Navigating the Jagged Technological Frontier: Field Experimental Evidence of the Effects of AI on Knowledge Worker Productivity and Quality (HBS, BCG)

AGENDA

Background	Defining Agents Enterprise workflow concepts
API Agents	Architecture TapeAgents
Web Agents	Web Agent Concepts WorkArena BrowserGym and AgentLab
Agents in the Workplace	Automating enterprise workflows Agents and the future of work

Resources to Dig Further

LLM Agent Frameworks & Benchmarks

LIBRARIES / FRAMEWORKS

LangChain (Oct)

- *Enables chaining multiple LLM calls for multi-step workflows*
- *Various tools like APIs, databases, and external data sources.*
- *Memory mgmt, allowing context retention across multiple interactions.*

AutoGPT (Mar)

- *Automates tasks with autonomous agents.*
- *Uses a feedback loop to refine outputs based on goals and constraints.*
- *Unlike LangChain, emphasizes autonomous decision-making over structured workflow chaining.*

AutoGen (Sept)

- *Multi-agent framework for building workflows with AI agents.*
- *AutoGen agents can work together, integrating LLMs, tools, and human inputs.*
- *Unlike LangChain and AutoGPT, emphasize multi-agent interaction and human-AI collab*

Crew.ai (Dec)

- *Collaborative agent teams with specific roles and goals.*
- *Sequential and hierarchical processes.*
- *Versatile tools with error handling and caching capabilities.*
- *Allows human oversight & interaction*

2022 2023 2024

BENCHMARKS

ToolBench (May)

- *Evaluate tool use with diverse real-world tasks*
- *8 tasks, e.g.: Open Weather, Trip booking, Google Sheets*
- *Can boost open-source LLMs to 90% success rate, matching GPT-4 in 4 out of 8 tasks*

AgentBench (Aug)

8 environments:

- *operating system*
- *database*
- *knowledge graph*
- *digital card game*
- *lateral thinking puzzles*
- *house-holding*
- *web shopping*
- *web browsing*

MLAgentBench (Oct)

- *13 tasks for ML experimentation, from CIFAR-10 to BabyLM.*
- *Tasks include file operations, run code, output inspection.*
- *Best is Claude v3 Opus 37.5% avg success rate*
- *Challenges: long-term planning, hallucination*

GAIA (Nov)

- *Q&A: need reasoning, multi-modality, tools.*
- *Humans: 92% vs. 15% for GPT-4 with plugins.*
- *466 questions; 166 with detailed traces, 300 retained for leaderboard.*
- *Questions have unambiguous answer.*

LIBRARIES / FRAMEWORKS

Crew.ai (Dec)

- *Collaborative agent teams with specific roles and goals.*
- *Sequential and hierarchical processes.*
- *Versatile tools with error handling and caching capabilities.*
- *Allows human oversight & interaction*

LangGraph (Jan)

- *Graph-based: agent workflows as nodes and edges*
- *Stateful design*
- *Supports human-agent collaboration*
- *Real-time streaming*
- *Allows granular control*

LlamaIndex Workflows (Aug)

- *Event-driven architecture*
- *Provides state management and enables cyclical flows*
- *Supports tools like Arize Phoenix for debugging*

TapeAgents (Oct)

- *Single unifying abstraction (the "tape") which is both a log of events and the state of the system*
- *Enables complex agent optimization such as prompt tuning and distillation from complex teacher to simpler student*

2024

BENCHMARKS

GAIA (Nov)

- *Q&A: need reasoning, multi-modality, tools.*
- *Humans: 92% vs. 15% for GPT-4 with plugins.*
- *466 questions; 166 with detailed traces, 300 retained for leaderboard.*
- *Questions have unambiguous answer.*

SWE-Bench (Apr)

- *Evaluate AI agents on real-world software engineering tasks*
- *2,294 problems from real GitHub issues and PR across 12 popular Python repositories*
- *Code generation, bug fixing, design*
- *Evals on correctness, efficiency, collab*

τ-Bench (Jun)

- *Emulate conversations between a LLM user and a LLM agent provided with domain-specific API tools and policy guidelines*
- *175 tasks from retail and airline domains*
- *Top models still at sub-par performance*

InsightBench (Oct)

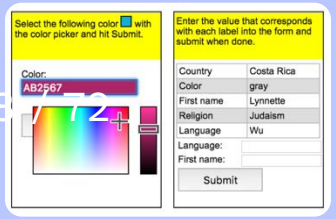
- *Evaluate agents on end-to-end data science workflows, measuring cross-domain generalization*
- *Task planning, execution, reasoning*
- *Incomplete data & ambiguous goals*

Web Agent Research Milestones

2017

World of Bits (WoB)

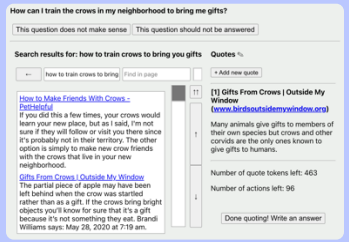
- *First widely available web benchmark*
- *Simplified tasks*
- *100 tasks*
- *Can be solved by RL*



2021

WebGPT (OpenAI)

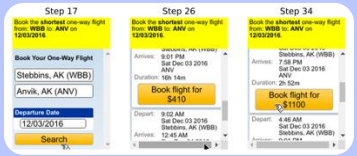
- *Fine-tuned GPT-3 for QA with web browsing*
- *Evaluated on "Explain Like I'm 5" Reddit Qs + TruthfulQA dataset*



2022

Learning to Control Computers (DM)

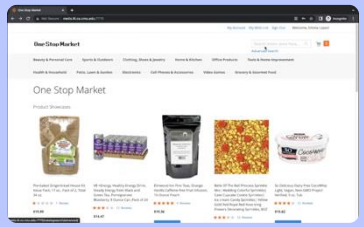
- *Control computers w/ keyboard & mouse from NL instructions*
- *MiniWob++ through RL with computer-human interactions*



2023

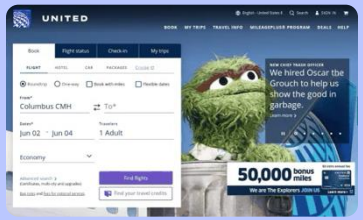
WebArena (CMU)

- *Realistic benchmark, 812 tasks, 6 domains*
- *Long-horizon tasks*
- *Best GPT-4: 11% solve rate vs 78% for humans*



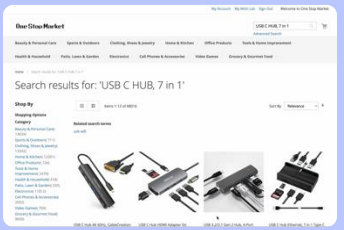
Mind2Web (Ohio)

- *Benchmark of realistic web tasks from NL*
- ***Interaction traces***
- *2,350 tasks from 137 websites, 31 domains*



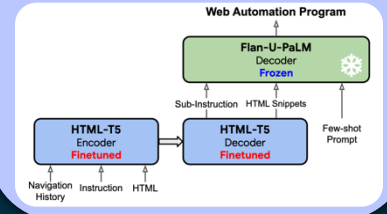
VisualWebArena

- *Benchmark that needs **visual comprehension***
- *Test visual & reasoning skills of web agents*
- *910 tasks, 3 domains*



WebAgent (Google)

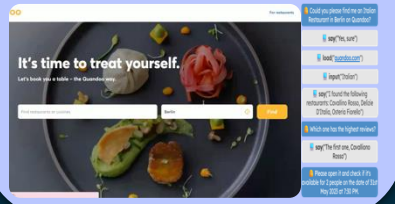
- *Combine 2 LLMs to simplify huge HTML, plan solution, create code talking to web browser; **no pixels***
- *MiniWoB & Mind2Web*



2024

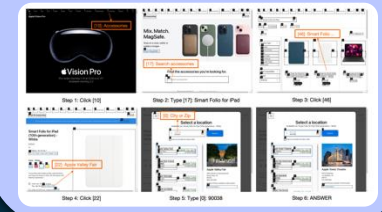
WebLINX (McGill)

- ***Conversational** web agent navigation*
- *2337 expert demos on 155 real-world websites*
- *Visual models not best; fine-tuning is key*



WebVoyager (Tenᶜ)

- *Completes tasks on real websites using **textual+visual** inputs*
- *New benchmark: 15 websites, automatic GPT-4V-based eval.*

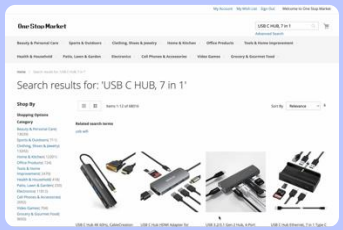


MU)

- mark,
- nains
- sks
- solve
- umans

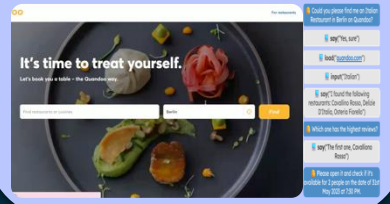
VisualWebArena

- *Benchmark that needs **visual comprehension***
- *Test visual & reasoning skills of web agents*
- *910 tasks, 3 domains*



WebLINX (McGill)

- ***Conversational** web agent navigation*
- *2337 expert demos on 155 real-world websites*
- *Visual models not best; fine-tuning is key*



WorkArena (ServiceNow)

- *Basic tasks that a knowledge worker must carry out*
- *Implemented on the ServiceNow platform*

OSWorld

- *369 computer tasks of real web and desktop apps in open domains*
- *OS file I/O + workflows spanning multiple applications*

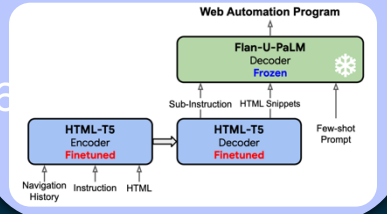
WorkArena++ (ServiceNow)

- *Compositional tasks with much higher difficulty than WorkArena*
- *Today's best models get single-digit performance, with huge room for improvement*

2024

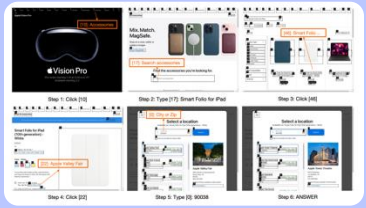
WebAgent (Google)

- *Combine 2 LLMs to simplify huge HTML, plan solution, create code talking to web browser; **no pixels***
- *MiniWoB & Mind2Web*



WebVoyager (Tenȼ)

- *Completes tasks on real websites using **textual+visual** inputs*
- *New benchmark: 15 websites, automatic GPT-4V-based eval.*



WebCanvas (CMU)

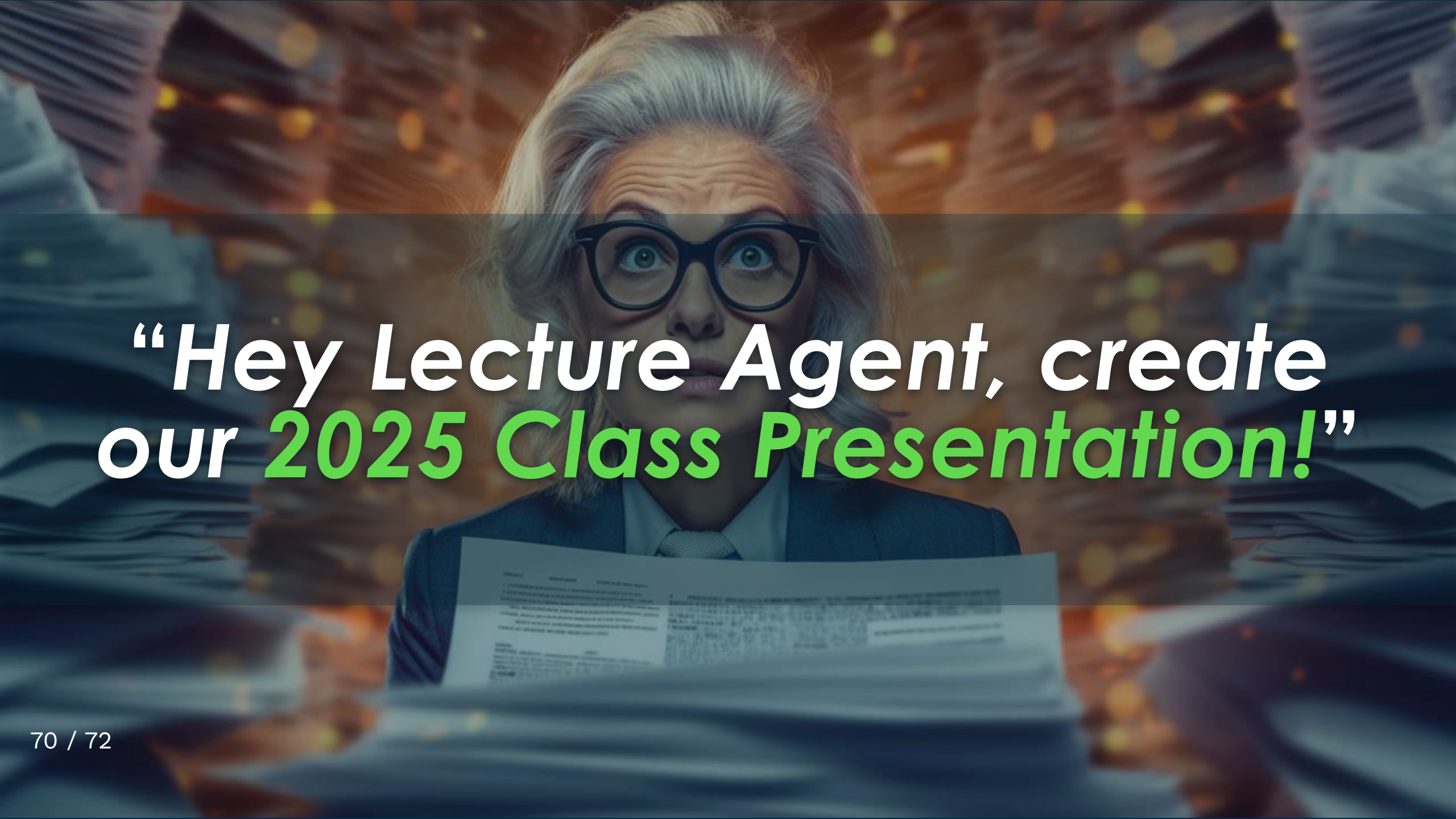
- *Handles dynamic web*
- *Mind2Web-Live, a refined Mind2Web: 542 tasks, 2439 evaluation states*

AssistantBench

- *Diverse web tasks: search, navigation, data extraction, interaction*
- *214 tasks that can be auto-evaluated*

NNetNav (Stanford)

- *Training web agents entirely through synthetic demos*
- *Web trajectory rollouts are processed by an LLM to be retroactively labeled into instruction*


“Hey Lecture Agent, create our 2025 Class Presentation!”

Tape Agents

WorkArena

BrowserGym

AgentLab

Q & A

Many thanks to the following colleagues:

Alexandre Lacoste
Maxime Gasse
Massimo Caccia
Léo Boisvert
Megh Thakkar
Tom Marty
Rim Assouel
Thibault Le Sellier De Chezelles
Dzmitry Bahdanau
Nicolas Gonthier
Gabriel Huang
Ehsan Kamalloo
Rafael Pardinas
Jordan Prince Tremblay
Alex Piché
Torsten Scholak
Oleh Shliazhko
Karam Ghanem
Soham Parikh
Mitul Tiwari
Quaizar Vohra
David Vazquez
Valérie Bécaert


servicenow