Institute and Faculty of Actuaries

IFoA Life Conference 2024

14–16 October, Manchester Central

Institute and Faculty of Actuaries

GenAI agents: how LLMs will evolve from AI chatbots to AI actuaries

Daniel Ramsay and Arlen Galicia Carreon

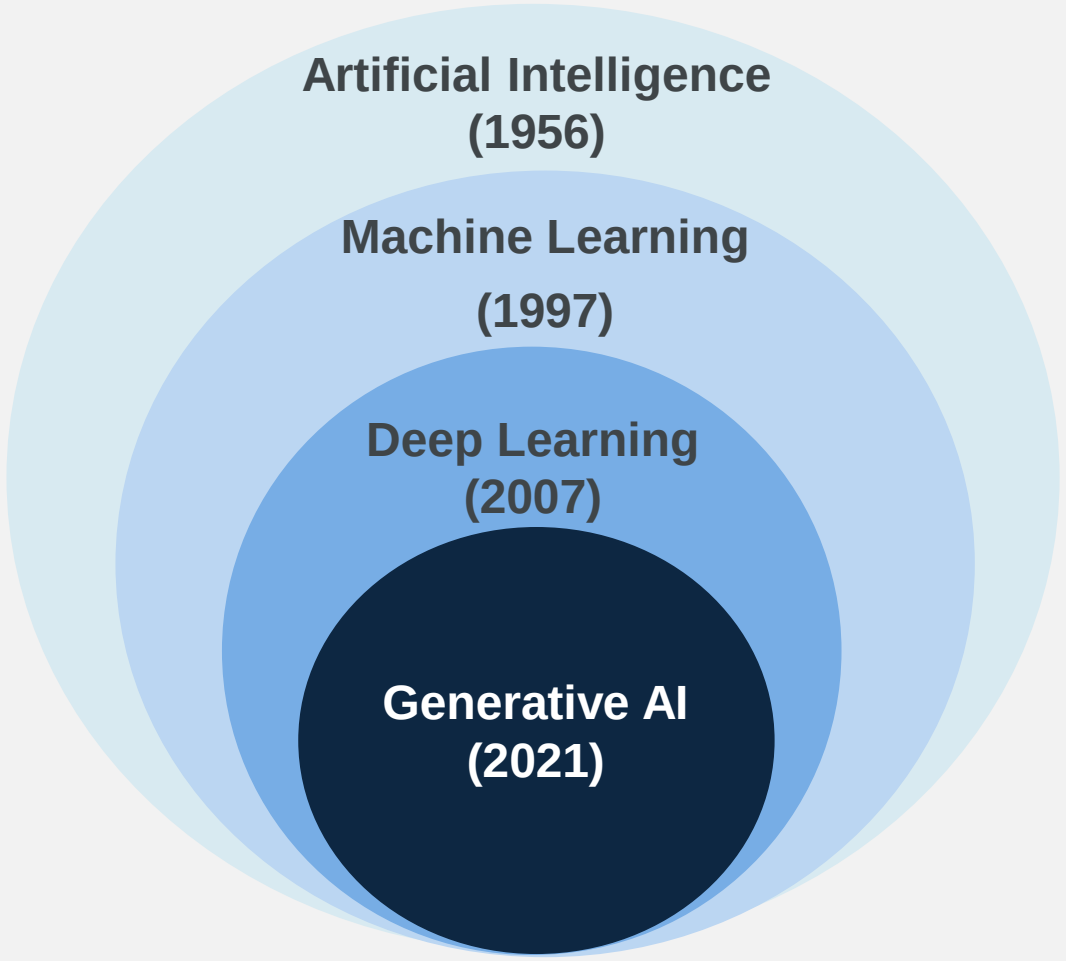
IFoA Life Conference 2024

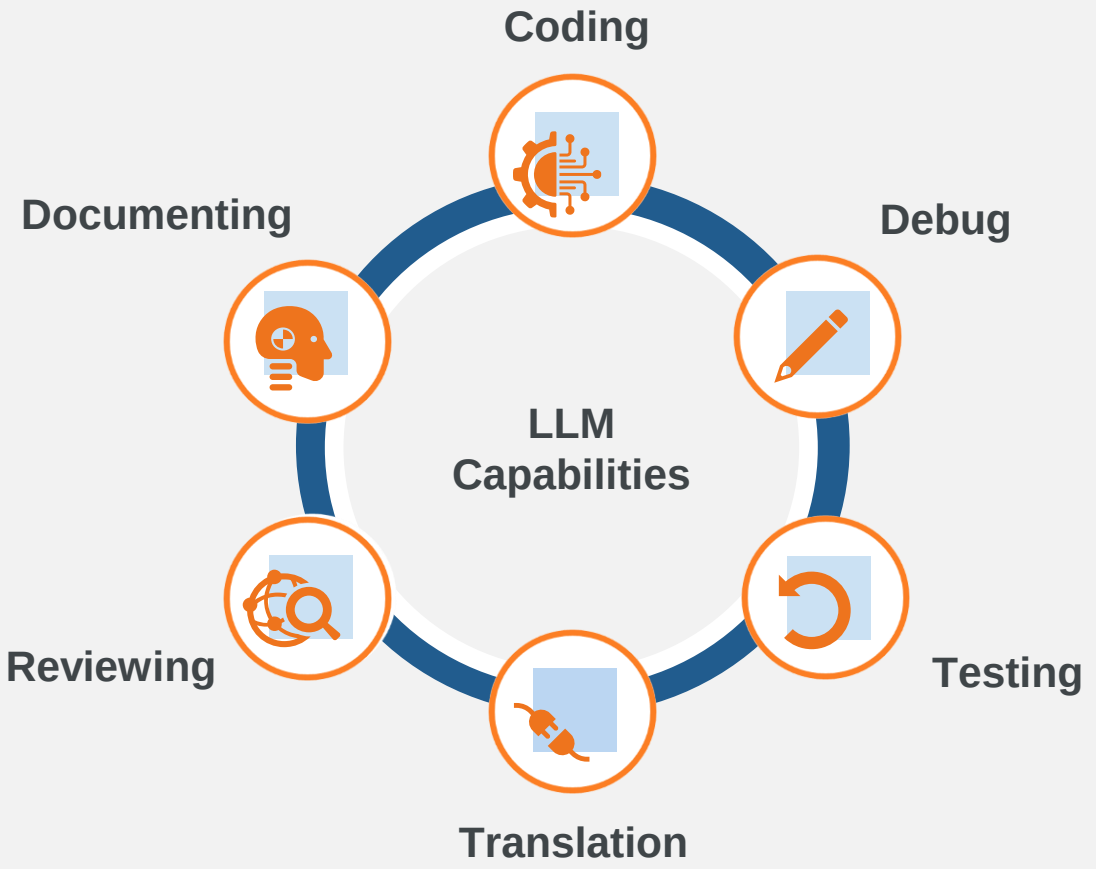
Agenda

- Introduction to LLMs
- What is an AI agent?
- Techniques to Empower LLMs
- Use Cases
- Future Implications

Introduction to LLMs

Is intelligence just next token prediction?

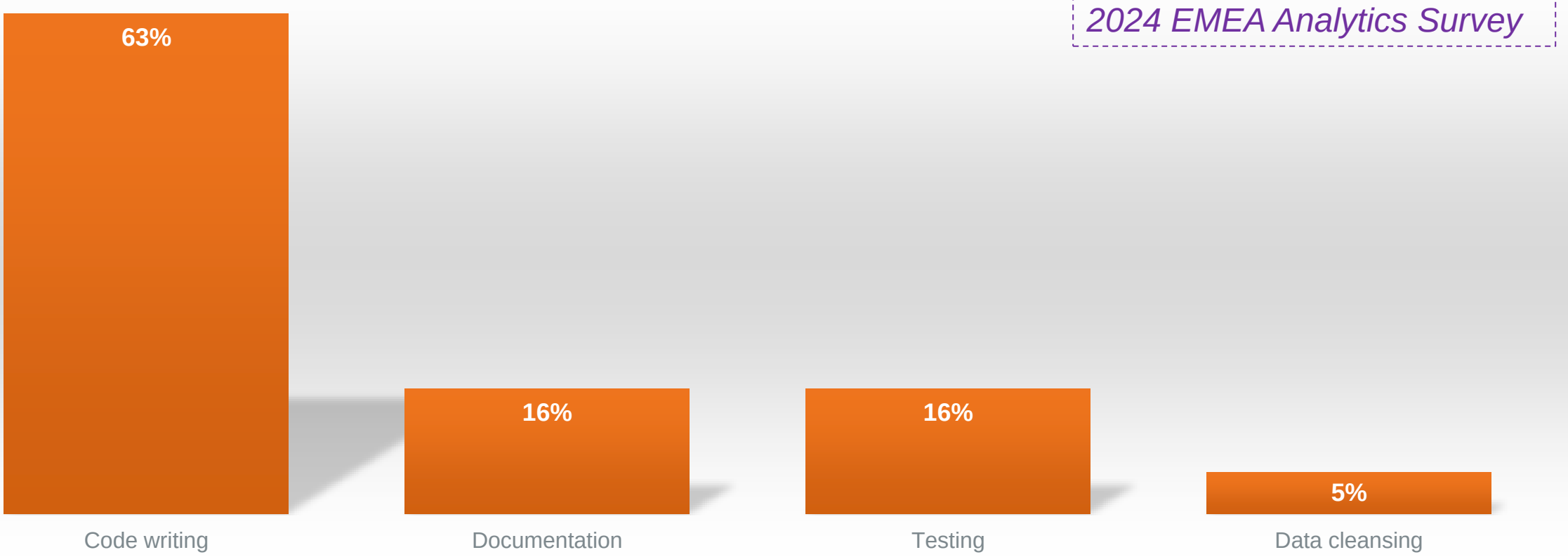




Applications of GenAI

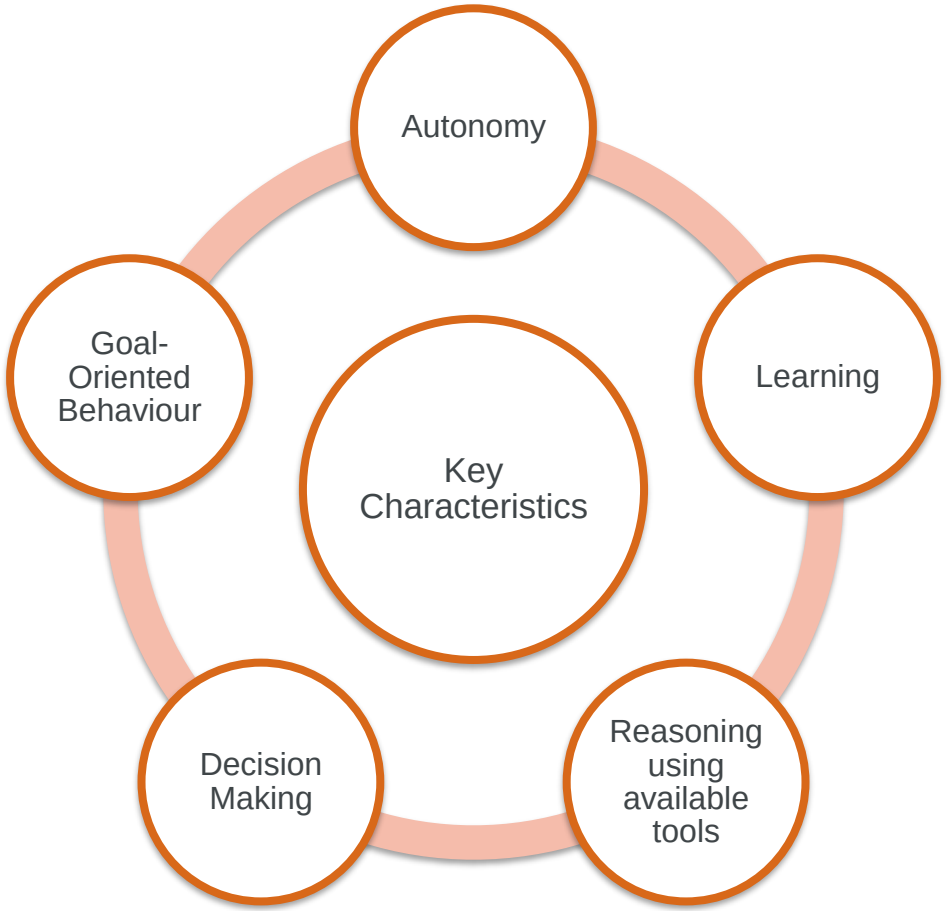
wtw

2024 EMEA Analytics Survey



What is an Artificial Intelligence (AI) Agent?

- Interacts with its environment
- Collects data
- Uses the data to perform self-determined tasks to meet predetermined goals/tasks
- Operates autonomously, making decisions independently



AI Agents Roles Examples - 2024

Developers	Writers	Insurance Assistants	Financial Analysts	HR Assistants	Research Assistants
Code generation and competition	Content generation	Underwriting	Data Analyst	Resume screening	Healthcare and medicine
Debugging and testing	Editing and proofreading	Claims Processing	Trading Strategy Developer	Payroll automation	Environmental Science
Code Review and refactoring	Personalised content	Document Capturing	Trade Advisor	Interview scheduling	Robotics and engineering
		Customer Service	Risk Advisor	Personalised training programs	
		Credit Risk Assessment		Performance monitoring	
		Fraud Detection			

Source1: https://research.aimultiple.com/agentic-ai/
Source2: https://learn.deeplearning.ai/courses/multi-ai-agent-systems-with-crewai/lesson/15/mutli-agent-collaboration-for-financial-analysis-(code)

Use case #1: Documentation

Overview

This model is designed to project various financial and actuarial metrics over time for a portfolio of insurance policies. It includes calculations for mortality rates, survival probabilities, annuity payments, expenses, premiums, claims, benefits, investment income, and best estimate liabilities. The model takes into account different time periods, including commencement and maturity periods, and applies various discounting and investment rate calculations to ensure accurate financial projections.

The model is structured to handle complex insurance products, including those with guaranteed and non-guaranteed annuity payments, single premiums, and various types of claims. It also incorporates detailed timing mechanisms to project values on a monthly, half-monthly, and annual basis. The calculations are performed prospectively, meaning they rely on future cashflows and rates to determine current values.

Conventions

The following conventions are used throughout the model to ensure consistency and clarity in the calculations:

- **Variable Naming:** Variable names are structured to be descriptive and human-readable. For example, "total_cashflow" refers to the total cashflow, and "discount_rate" refers to the discount rate used in the model.
- **NO_AVG:** The value NO_AVG is used to indicate that a variable should not be included in the average calculation. This is typically applied when the time period is outside the valid range for a particular calculation.
- **In-Force (IF):** The term "IF" in variable names generally refers to whether a policy is in-force or not, rather than indicating the life status of the policyholder.
- **Adjusted Age:** The adjusted age of a policyholder may be rounded up or down depending on the basis used. If it is not clear how the adjustment was applied, it is stated as such in the variable description.
- **Time Periods:** The model uses various time periods, including commencement and maturity periods, to determine the validity of

Use case #2: Model migration

Annuity_Excel_Model_NO_HIDE_NEW_NAMES.xlsm — Confidential • Saved to this PC

group	age_exact_issue_1	sex1	smoker_stat_1	age_exact_issue_2	sex2	smoker_stat_2	prem_initial	annuity_pmt_curr	annuity_pmt_freq	gteed_term	elapsed_months	index_ann_pmt	annuity_timing	joint_life_status
1	35	F	A	29			1940.4	388.08	4	12	1	5	arrears	Single
2	26	M	A	27			2695	539	12	30	24	5	advance	Single
3	36	M	S	41			1940.4	388.08	1	12	10	0	advance	Single
4	27	M	A	25	F	A	646.8	129.36	2	60	41	5	advance	First death
5	33	F	A	33	M	A	1352.4	270.48	2	24	23	5	advance	Last survivor
6	54	F	A	59			2371.6	474.32	2	20	6	4	arrears	Single
7	49	F	N	42			646.8	129.36	4	48	12	5	arrears	Single
8	26	F	A	23			1940.4	388.08	4	12	11	1	advance	Single
9	51	F	A	50	M	N	2156	431.2	4	12	11	0	arrears	Last survivor
10	34	F	S	35			1940.4	388.08	4	36	25	5	advance	Single
11	40	F	A	35			1940.4	388.08	4	12	3	5	advance	Single
12	27	F	S	35	M	S	2371.6	474.32	4	12	9	0	arrears	First death
13	55	F	N	62	M	N	1617	323.4	4	96	78	1	advance	First death
14	24	F	A	27			2371.6	474.32	4	12	2	6	advance	Single
15	26	M	A	25			0	30	12	48	39	1	advance	Single

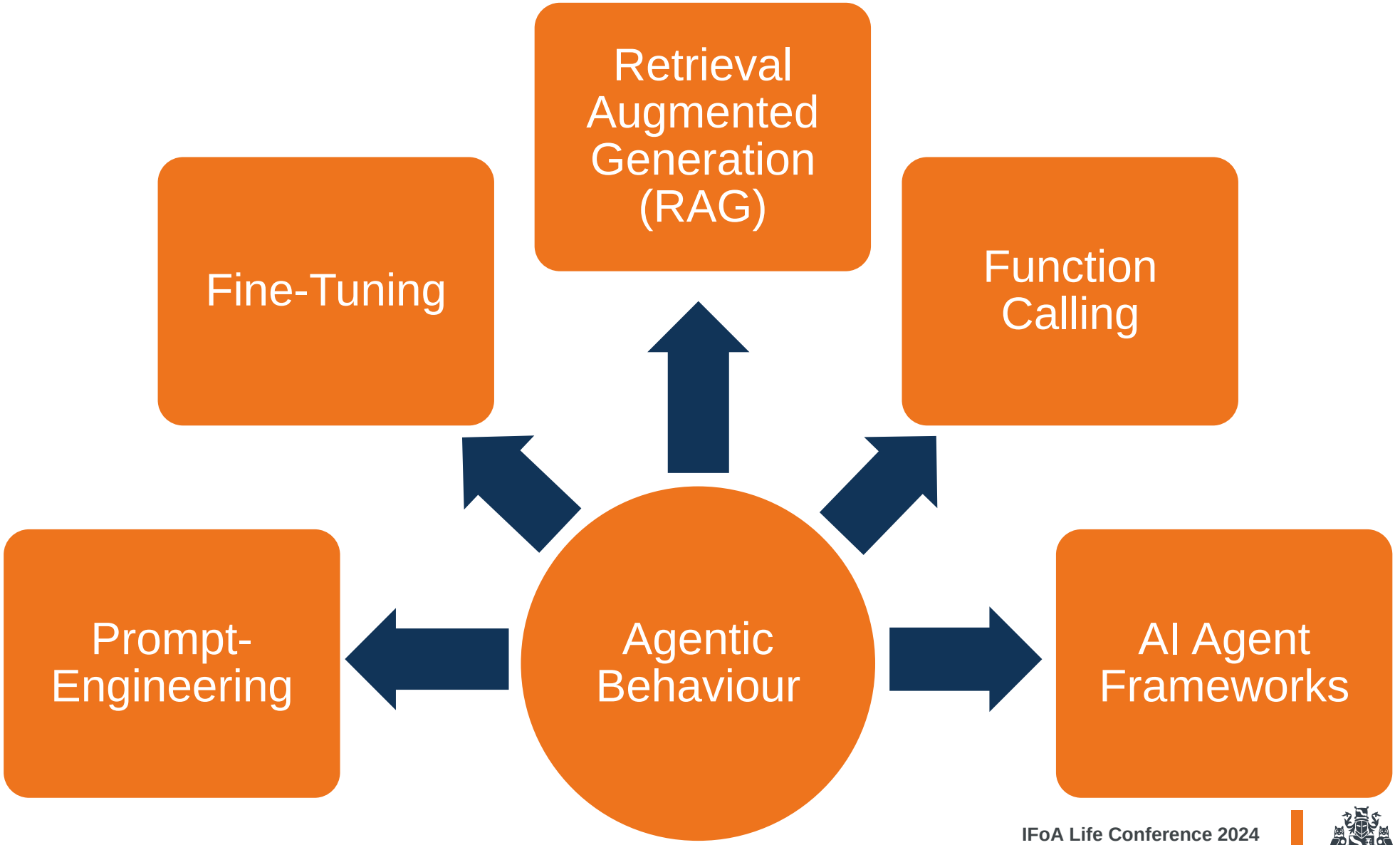
Data | Assumptions | Calc | Comparison | <Match>

Institute
and Faculty
of Actuaries

Techniques to Empower LLMs

IFoA Life Conference 2024

AI Agent Components



Prompt-Engineering

Optimising Inputs for Better Results.

1. More rules
2. Few-shot learning
3. Self-reflection
4. Chain of thought

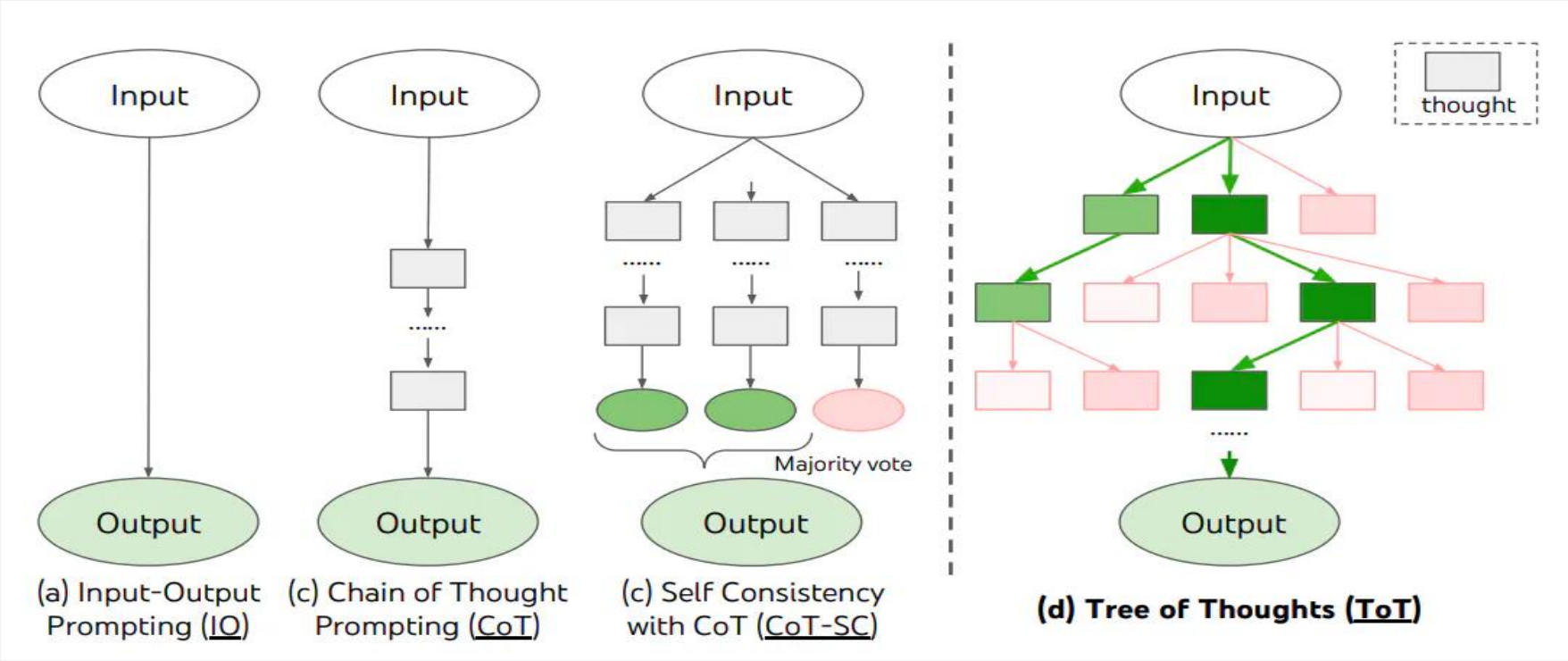


Figure 1: Yao, Shunyu, et al. "Tree of thoughts: Deliberate problem solving with large language models." Advances in Neural Information Processing Systems 36 (2024), Schematic illustrating various approaches to problem solving with LLMs, https://proceedings.neurips.cc/paper_files/paper/2023/file/271db9922b8d1f4dd7aaef84ed5ac703-Paper-Conference.pdf

Fine-Tuning

Configuring AI Models for Specific Tasks.

LLMs have a vast language knowledge, they lack specialization in expert topics

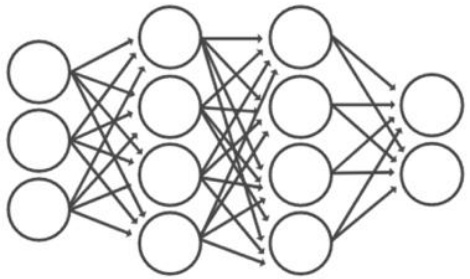
Custom Knowledge Base

IFRS17 rules
Solvency II rules
Other regulation
...

Model learns from domain-specific data and task-specific examples making it more effective for targeted applications

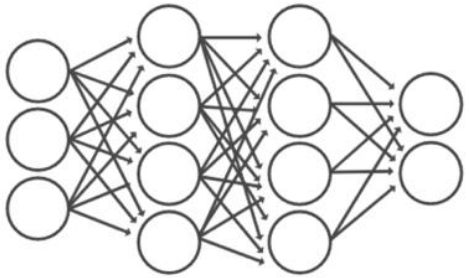
Raw Text Data

Pre-Training



Pre-trained LLM

Fine-tuning



Fine-Tuned LLM

Specialized LLM – deeper understanding of the nuances of the domain.

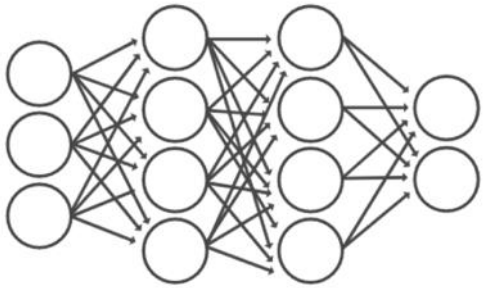
Retrieval Augmented Generation (RAG)

Enhancing AI Responses by Leveraging External Data Sources.

User request

Please explain…

LLM



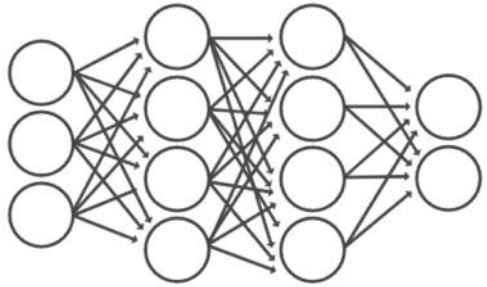
Embeddings knowledge database

IFRS17 rules
Solvency II rules
Other regulation
…

Collection of most relevant knowledge

Use this information…

LLM

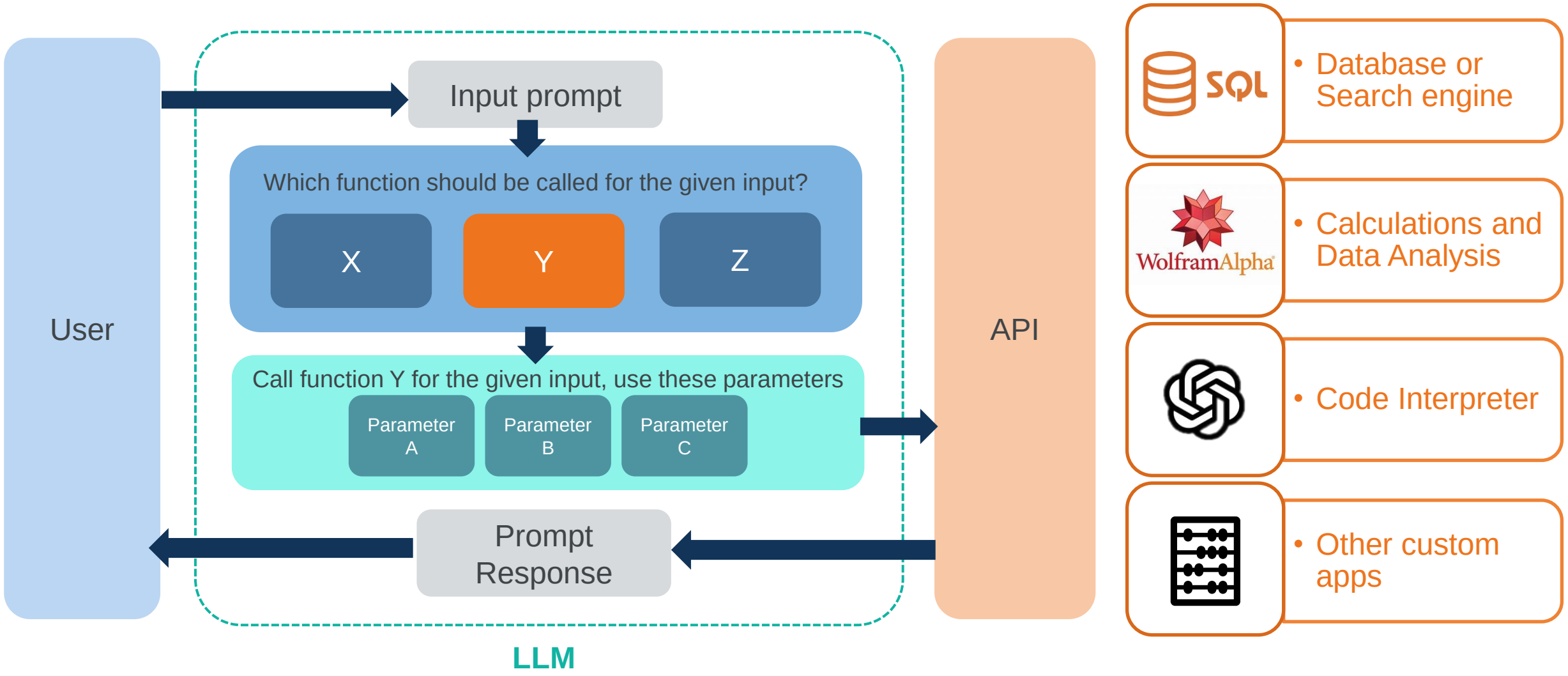


Text output

IFRS17 requires you do…
This
That
…

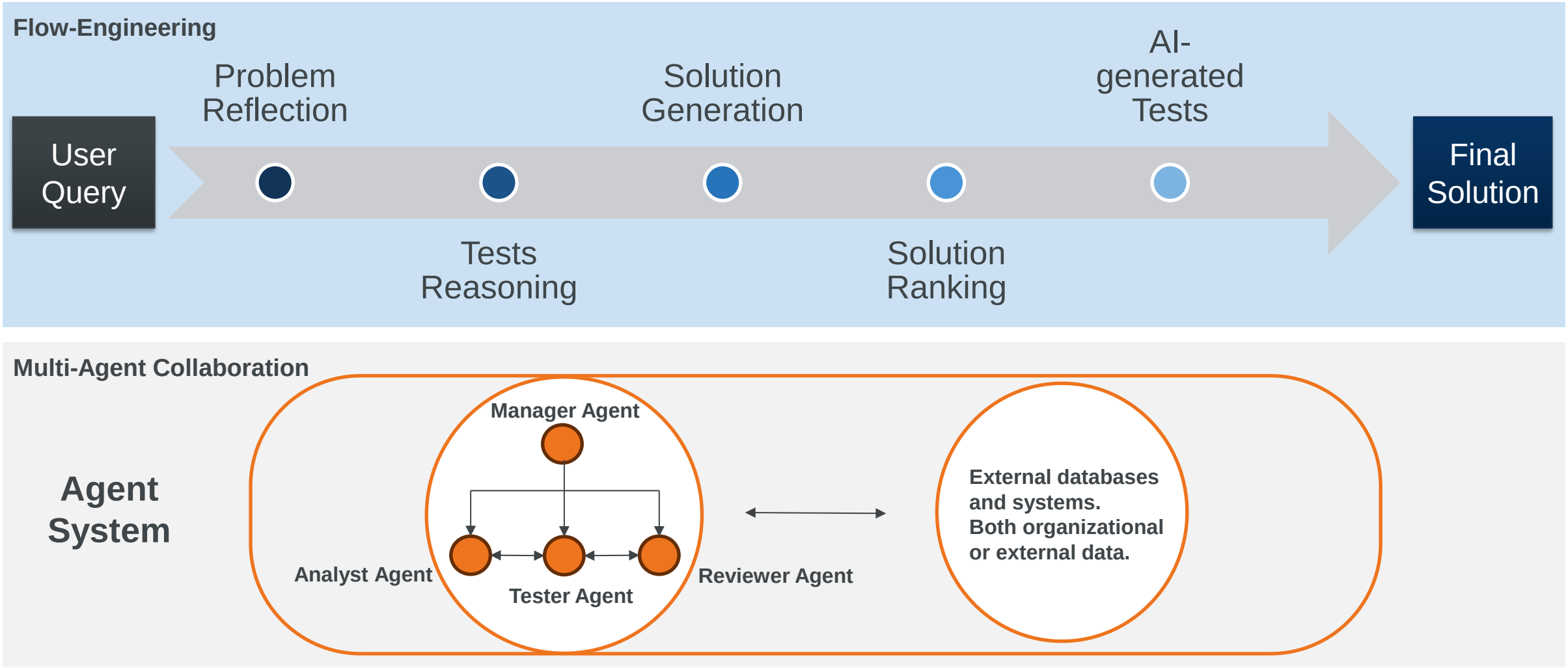
Function Calling

Executing Specific Tasks Through API Calls

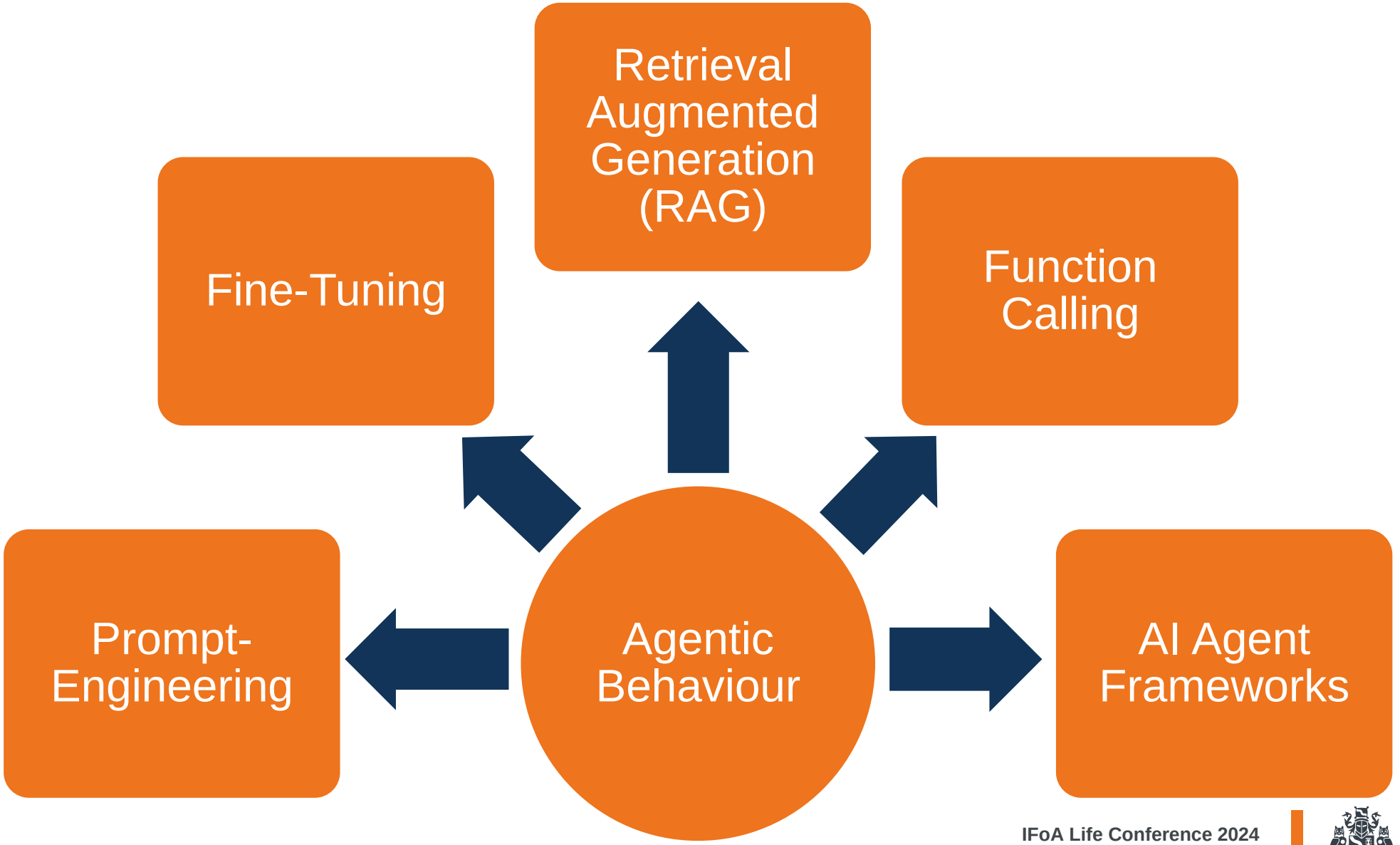


AI Agent Frameworks

Giving AI the ability to plan



AI Agent Components



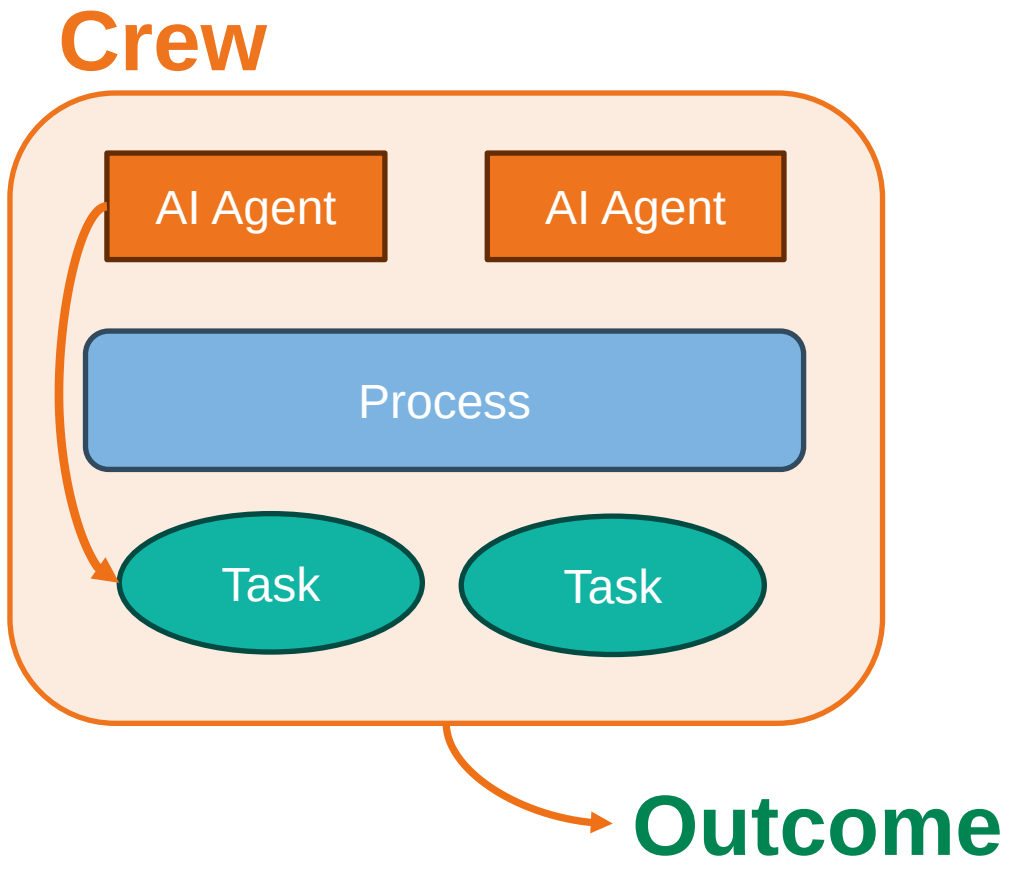
Institute
and Faculty
of Actuaries

Multi-agent Customer Support System

IFoA Life Conference 2024

Creating Agents

Using Open-Source Multiagent Framework CrewAI



Role Playing, Focus and Cooperation

Agent 1

```
support_agent = Agent(
    role="Senior Support Representative",
    goal="Be the most friendly and helpful "
         "support representative in your team",
    backstory=(
        "You work at WTW (https://www.wtwco.com/en-gb) and "
        " are now working on providing "
        "support to {customer}, a super important customer "
        " for your company."
        "You need to make sure that you provide the best support!"
        "Make sure to provide full complete answers, "
        " and make no assumptions."
    ),
    allow_delegation=False,
    verbose=True
)
```

Agent 2

```
support_quality_assurance_agent = Agent(
    role="Support Quality Assurance Specialist",
    goal="Get recognition for providing the "
    "best support quality assurance in your team",
    backstory=(
        "You work at WTW (https://www.wtwco.com/en-gb) and "
        "are now working with your team "
        "on a request from {customer} ensuring that "
        "the support representative is "
        "providing the best support possible.\n"
        "You need to make sure that the support representative "
        "is providing full"
        "complete answers, and make no assumptions."
    ),
    verbose=True
)
```

Source: CrewAI & Deeplearning AI

Creating Tasks

Task 1

```
inquiry_resolution = Task(
    description=(
        "{customer} just reached out with a super important ask:\n"
        "{inquiry}\n\n"
        "{person} from {customer} is the one that reached out. "
        "Make sure to use everything you know "
        "to provide the best support possible."
        "You must strive to provide a complete "
        "and accurate response to the customer's inquiry."
    ),
    expected_output=(
        "A detailed, informative response to the "
        "customer's inquiry that addresses "
        "all aspects of their question.\n"
        "The response should include references "
        "to everything you used to find the answer, "
        "including external data or solutions. "
        "Ensure the answer is complete, "
        "leaving no questions unanswered, and maintain a helpful and friendly "
        "tone throughout."
    ),
    tools=[docs
    agent=suppo
)
```

```
[DEBUG]: == Working Agent: Senior Support Representative
[INFO]: == Starting Task: Life Insurance Ltd just reached out with a super important ask:
I need help with my actuarial software I am looking for new solutions, specifically for Life InsuranceWhat actuarial so
ftware do you offer? Can you provide guidance?

Daniel Ramsey from Life Insurance Ltd is the one that reached out. Make sure to use everything you know to provide the
best support possible.You must strive to provide a complete and accurate response to the customer's inquiry.


> Entering new CrewAgentExecutor chain...
I need to provide a detailed and informative response to Daniel Ramsey from Life Insurance Ltd regarding the actuarial
software solutions we offer for Life Insurance.

Action: Read website content
Action Input: {
  "url": "https://www.wtwco.com/en-gb/solutions/products/riskagility-financial-modeller/"
}
```

Task 2

```
quality_assurance_review = Task(
    description=(
        "Review the response drafted by the Senior Support Representative for {customer}'s inquiry. "
        "Ensure that the answer is comprehensive, accurate, and adheres to the "
        "high-quality standards expected for customer support.\n"
        "Verify that all parts of the customer's inquiry "
        "have been addressed "
        "thoroughly, with a helpful and friendly tone.\n"
        "Check for references and sources used to "
        " find the information, "
        "ensuring the response is well-supported and "
        "leaves no questions unanswered."
    ),
    expected_output=(
        "A final, detailed, and informative response "
        "ready to be sent to the customer.\n"
        "This response should fully address the "
        "customer's inquiry, incorporating all "
        "relevant feedback and improvements.\n"
        "Don't be too formal, we are a chill and cool company "
        "but maintain a professional and friendly tone throughout."
    ),
    agent=support_quality_assurance_agent,
)
```

```
[DEBUG]: == Working Agent: Support Quality Assurance Specialist
[INFO]: == Starting Task: Review the response drafted by the Senior Support Representative for Life Insurance Ltd's in
quiry. Ensure that the answer is comprehensive, accurate, and adheres to the high-quality standards expected for custom
er support.
Verify that all parts of the customer's inquiry have been addressed thoroughly, with a helpful and friendly tone.
Check for references and sources used to  find the information, ensuring the response is well-supported and leaves no q
uestions unanswered.


> Entering new CrewAgentExecutor chain...
I need to ensure that the response drafted by the Senior Support Representative for Life Insurance Ltd is comprehensiv
e, accurate, and meets the high-quality standards expected for customer support. I must review the response thoroughly
to ensure all parts of the customer's inquiry have been addressed with a helpful and friendly tone.

Action:
Delegate work to co-worker
```

Source: CrewAI & Deeplearning AI

Crew and Final Outcome

Creating the Crew

```
crew = Crew(
  agents=[support_agent, support_quality_assurance_agent],
  tasks=[inquiry_resolution, quality_assurance_review],
  verbose=2,
  memory=True
)
```

Running the Crew

```
inputs = {
    "customer": "Life Insurance Ltd",
    "person": "Daniel Ramsey",
    "inquiry": "I need help with my actuarial software "
               "I am looking for new solutions, specifically for Life Insurance"
               "What actuarial software do you offer? "
               "Can you provide guidance?"
}
result = crew.kickoff(inputs=inputs)
```

In [12]:
```
from IPython.display import Markdown
Markdown(result)
```

Dear Daniel Ramsey from Life Insurance Ltd,

Thank you for reaching out to us regarding your search for new solutions for actuarial software specifically for Life Insurance. We are pleased to inform you that we offer RiskAgility Financial Modeller (FM) as a fast, flexible actuarial software solution designed to enable life and health insurers and pension companies to run financial models that accurately reflect their products and company.

RiskAgility FM is built with the latest algorithms and software technology to enhance performance and ease of use. It is adaptable to your specific business processes and regulatory reporting needs. The software focuses on delivering key benefits required for modern financial reporting and management, including flexibility to adapt to changing business needs, performance and scalability for quick results, end-to-end integration with other systems, and governance and automation support to reduce model risks.

Moreover, RiskAgility FM offers various advantages such as using the latest algorithms and technology to complete reports faster with lower costs, open data formats and APIs for seamless integration, direct linking of data and assumptions for auditable reporting, modular code for collaborative development, and a powerful and open modelling language for accurate risk management.

Furthermore, RiskAgility FM is used across clients in all six continents to manage risks and meet regulatory reporting needs such as local GAAP, IFRS-17, and LDTI. Additionally, it is complemented with Software as a Service (SaaS) options for pay-as-you-go compute on demand, automated regression testing, and hosting.

If you are interested in learning more about RiskAgility FM or have any further questions, please feel free to contact us for more information or to schedule a demonstration.

Thank you for considering Willis Towers Watson for your actuarial software needs.

Warm regards, [Your Name] Senior Support Representative WTW

Source: CrewAI & Deeplearning AI

Institute and Faculty of Actuaries

Actuarial agents

IFoA Life Conference 2024

Use Case #1: Documentation (1)

1. Cashflow Model C++

annuity_payment_guar (annuity)*

```
if (t <= commence_period_s || t > maturity_period_s)
    return 0.0;

if (t <= gteed_term - elapsed_months) {

    if (eq(annuity_timing, "advance")) {
        if (fmod(pol_month(t), 12. / annuity_pmt_freq) + floor(annuity_pmt_freq / 12) == 1)
            return annuity_payment_if_b(t) / annuity_pmt_freq;
    }
    else if (fmod(pol_month(t), 12. / annuity_pmt_freq) == 0)
        return annuity_payment_if_b(t) / annuity_pmt_freq;
    return 0.0;
}

return 0.0;
```

2. Natural Language Description

The guaranteed annuity payment during the guarantee period at time t. The calculation proceeds as follows:
1. If the time t is less than or equal to the commencement period or greater than the maturity period, the payment is 0.0.
2. If the time t plus the elapsed months is less than or equal to the guaranteed term, the payment is calculated as follows:
    2.1. If the annuity timing is 'advance' and the policy month modulo the annuity payment frequency in months plus the floor value of the annuity payment frequency divided by 12 equals 1, the payment is the annuity payment divided by the annuity payment frequency.
    2.2. Otherwise, if the policy month modulo the annuity payment frequency in months equals 0, the payment is the annuity payment divided by the annuity payment frequency.
3. If none of these conditions are met, the payment is 0.0.
This ensures that the guaranteed annuity payment is only considered within the valid time periods and conditions.

Use Case #1: Documentation (2)

3. Categorise

- Assumptions
- Guarantees
- …
- Expenses

4. Allocate Variables to Sections

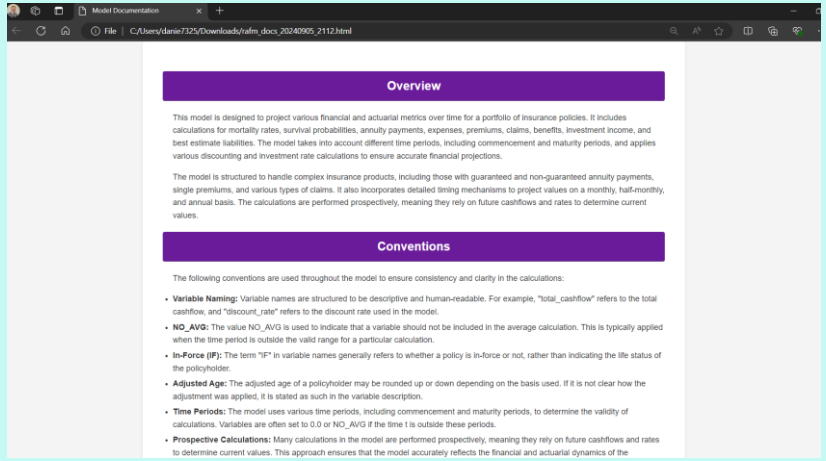
init_comm -> commission
fix_exp_a -> expenses
annuity_guar -> guarantees

5. Write Documentation for Sections

Expenses

Variable Name	Description
Renewal Expense	The renewal expense at time t. The calculation proceeds as follows: 1. If the time t is less than or equal to the commencement period or greater than the maturity period, the expense is 0.0. 2. Otherwise, the fixed renewal expense is calculated as follows: 1. Multiply the fixed renewal expense rate by the number of policies at the beginning of the period. 2. Multiply the result by the survival probability at the half-month. 3. Divide by 12 to convert to a monthly expense. This ensures that the renewal expense is correctly determined based on the number of policies, survival probability, and fixed renewal expense rate within the valid time periods.

6. Write Summary



Use case #1: Documentation

Overview

This model is designed to project various financial and actuarial metrics over time for a portfolio of insurance policies. It includes calculations for mortality rates, survival probabilities, annuity payments, expenses, premiums, claims, benefits, investment income, and best estimate liabilities. The model takes into account different time periods, including commencement and maturity periods, and applies various discounting and investment rate calculations to ensure accurate financial projections.

The model is structured to handle complex insurance products, including those with guaranteed and non-guaranteed annuity payments, single premiums, and various types of claims. It also incorporates detailed timing mechanisms to project values on a monthly, half-monthly, and annual basis. The calculations are performed prospectively, meaning they rely on future cashflows and rates to determine current values.

Conventions

The following conventions are used throughout the model to ensure consistency and clarity in the calculations:

- **Variable Naming:** Variable names are structured to be descriptive and human-readable. For example, "total_cashflow" refers to the total cashflow, and "discount_rate" refers to the discount rate used in the model.
- **NO_AVG:** The value NO_AVG is used to indicate that a variable should not be included in the average calculation. This is typically applied when the time period is outside the valid range for a particular calculation.
- **In-Force (IF):** The term "IF" in variable names generally refers to whether a policy is in-force or not, rather than indicating the life status of the policyholder.
- **Adjusted Age:** The adjusted age of a policyholder may be rounded up or down depending on the basis used. If it is not clear how the adjustment was applied, it is stated as such in the variable description.
- **Time Periods:** The model uses various time periods, including commencement and maturity periods, to determine the validity of

Use Case #2: Excel-to-RAFM (1)

1. Excel workbook

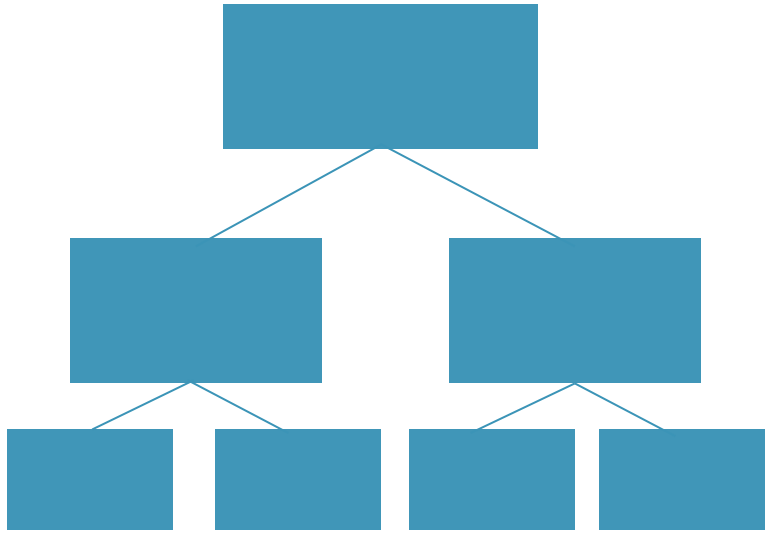
	A	B	C	D	E	F	G	H
1								
2	**valdate**		01/01/2023		**Total BEL**	-466.42		
3	**policyholder**		1					
4	**DOB**		01/01/1940					
5	**sum_assured**		10000					
6	**premium**		1500					
7	**Elapsed months**		1					
8	**maturity period**		120					
9								
10	**month**	**age**	**date**	**mort_rate**	**survival_prob**	**cum_survival_rate**	**risk_premium**	**monthly_expenses**
11	0	83.0000	01/01/2023	0.0077	0.9923	1	76.9931242	4.166666667
12	1	83.0833	01/02/2023	0.0077	0.9923	0.992300688	76.9931242	4.166666667
13	2	83.1667	01/03/2023	0.0077	0.9923	0.984660655	76.9931242	4.166666667
14	3	83.2500	01/04/2023	0.0077	0.9923	0.977079445	76.9931242	4.166666667
15	4	83.3333	01/05/2023	0.0077	0.9923	0.969556605	76.9931242	4.166666667
16	5	83.4167	01/06/2023	0.0077	0.9923	0.962091685	76.9931242	4.166666667
17	6	83.5000	01/07/2023	0.0077	0.9923	0.954684241	76.9931242	4.166666667
18	7	83.5833	01/08/2023	0.0077	0.9923	0.947333829	76.9931242	4.166666667
19	8	83.6667	01/09/2023	0.0077	0.9923	0.94004001	76.9931242	4.166666667
20	9	83.7500	01/10/2023	0.0077	0.9923	0.932802348	76.9931242	4.166666667
21	10	83.8333	01/11/2023	0.0077	0.9923	0.925620411	76.9931242	4.166666667
22	11	83.9167	01/12/2023	0.0077	0.9923	0.91849377	76.9931242	4.166666667
23	12	84.0000	01/01/2024	0.0077	0.9923	0.911422	76.9931242	4.166666667
24	13	84.0833	01/02/2024	0.0086	0.9914	0.904404677	85.93777783	4.166666667
25	14	84.1667	01/03/2024	0.0086	0.9914	0.896632424	85.93777783	4.166666667

2. Identify columns

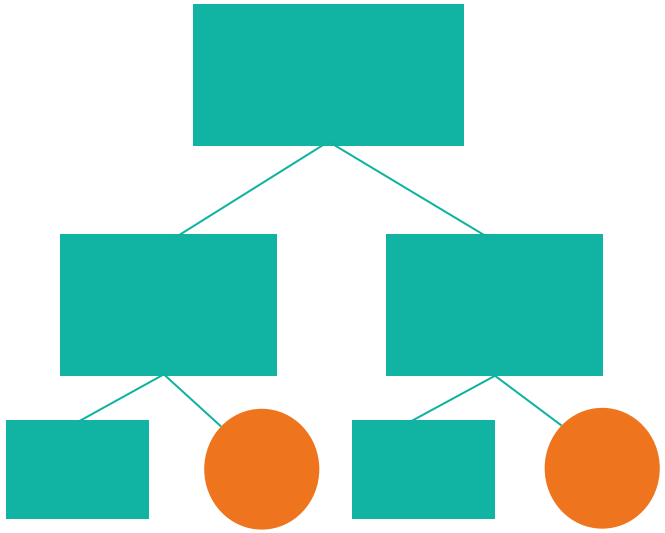
- Commission
- Sum Assured
- Expenses

Use Case #2: Excel-to-RAFM (2)

Create Hierarchy of Dependencies



Identify Assumptions and Code Variables



Assumptions

Code variables

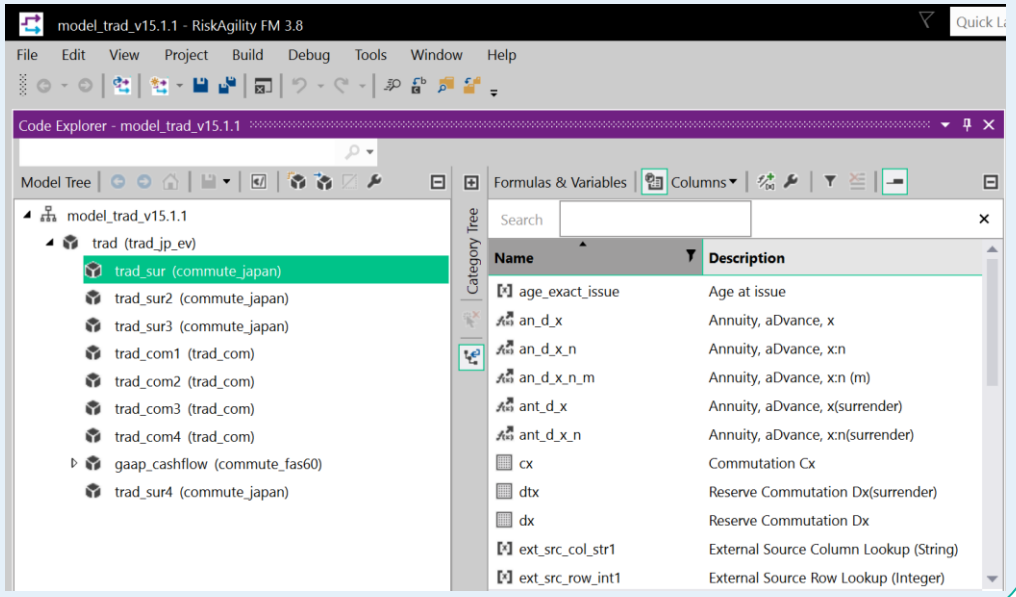
Use Case #2: Excel-to-RAFM (2)

Generate code

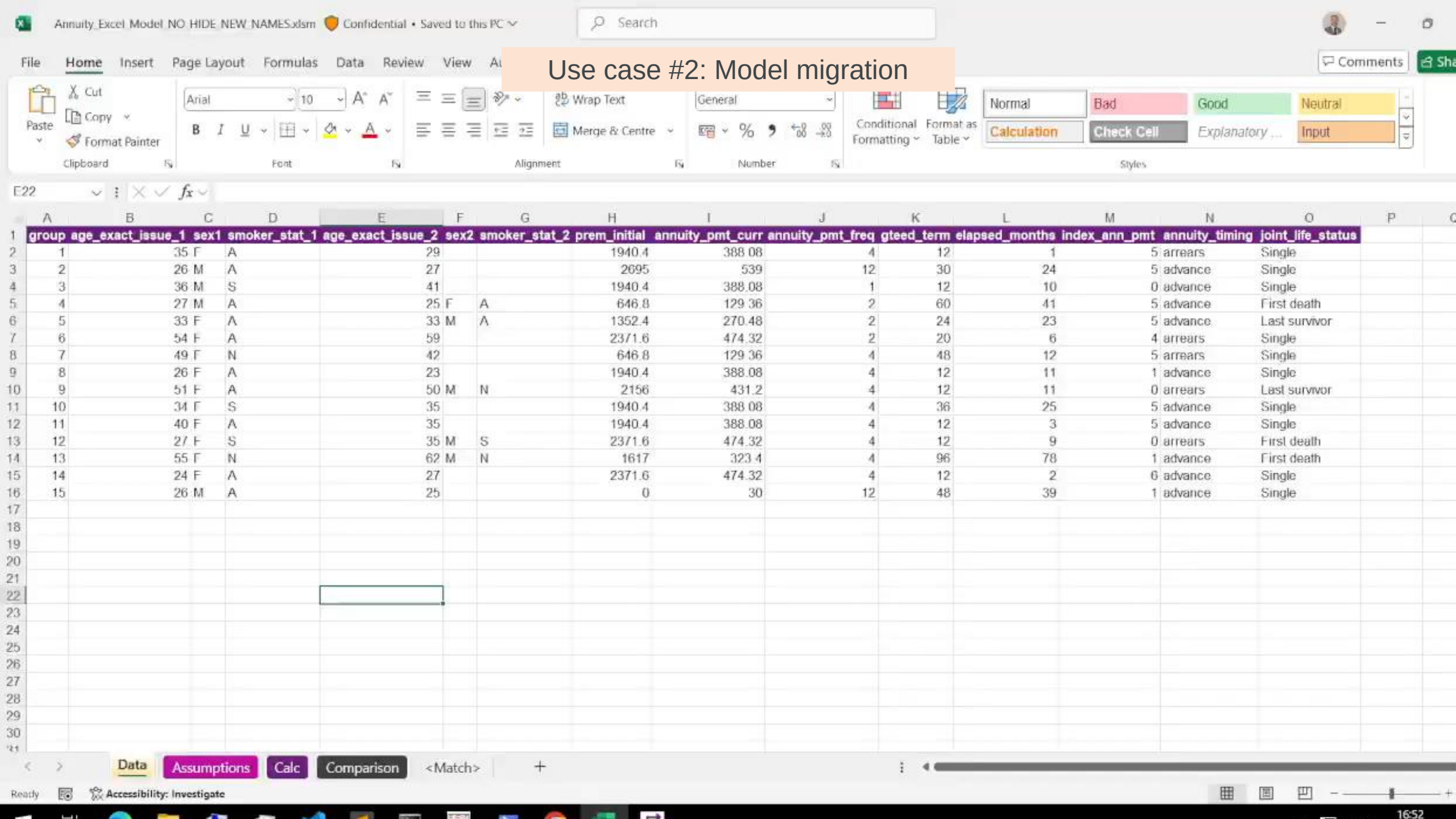
annuity_payment_guar (annuity)*

```
if (t <= commence_period_s || t > maturity_period_s)
    return 0.0;

if (t <= gteed_term - elapsed_months) {

    if (eq(annuity_timing, "advance")) {
        if (fmod(pol_month(t), 12. / annuity_pmt_freq) + floor(annuity_pmt_freq / 12) == 1)
            return annuity_payment_if_b(t) / annuity_pmt_freq;
    }
    else if (fmod(pol_month(t), 12. / annuity_pmt_freq) == 0)
        return annuity_payment_if_b(t) / annuity_pmt_freq;
    return 0.0;
}

return 0.0;
```

Inject into RAFM model



Use case #2: Model migration



group	age_exact_issue_1	sex1	smoker_stat_1	age_exact_issue_2	sex2	smoker_stat_2	prem_initial	annuity_pmt_curr	annuity_pmt_freq	gteed_term	elapsed_months	index_ann_pmt	annuity_timing	joint_life_status
1	35	F	A	29			1940.4	388.08	4	12	1	5	arrears	Single
2	26	M	A	27			2695	539	12	30	24	5	advance	Single
3	36	M	S	41			1940.4	388.08	1	12	10	0	advance	Single
4	27	M	A	25	F	A	646.8	129.36	2	60	41	5	advance	First death
5	33	F	A	33	M	A	1352.4	270.48	2	24	23	5	advance	Last survivor
6	54	F	A	59			2371.6	474.32	2	20	6	4	arrears	Single
7	49	F	N	42			646.8	129.36	4	48	12	5	arrears	Single
8	26	F	A	23			1940.4	388.08	4	12	11	1	advance	Single
9	51	F	A	50	M	N	2156	431.2	4	12	11	0	arrears	Last survivor
10	34	F	S	35			1940.4	388.08	4	36	25	5	advance	Single
11	40	F	A	35			1940.4	388.08	4	12	3	5	advance	Single
12	27	F	S	35	M	S	2371.6	474.32	4	12	9	0	arrears	First death
13	55	F	N	62	M	N	1617	323.4	4	96	78	1	advance	First death
14	24	F	A	27			2371.6	474.32	4	12	2	6	advance	Single
15	26	M	A	25			0	30	12	48	39	1	advance	Single

A glimpse of things to come

Technical Report: Building Genie, https://cosine.sh/blog/genie-technical-report