



Actuarial Digital Twin

with Ontology-Driven Graph Database and Agentic AI

Dr. Scarlett Bae

RNA Analytics

- 1. Industry Pain Points**
- 2. Can AI Solve the Pain Points? The Reality Check**
- 3. Our Solution: Actuarial Digital Twin (ADT)**
 - Layer 1-1: Ontology
 - Layer 1-2: Graph Database
 - Layer 2: Agentic AI

Appendix



The Post-Implementation Reality: Survival, Not Success



Reporting Surge

After the introduction of new accounting standard like IFRS 17 and solvency regime, actuarial reporting and analysis demands have increased exponentially.



Escalating Costs

Computational and Human resource costs continue to rise, increasing operational burden.



Key Person Risk

Over-reliance on specific experts for an area such as modeling creates operational risk.



Manual Work

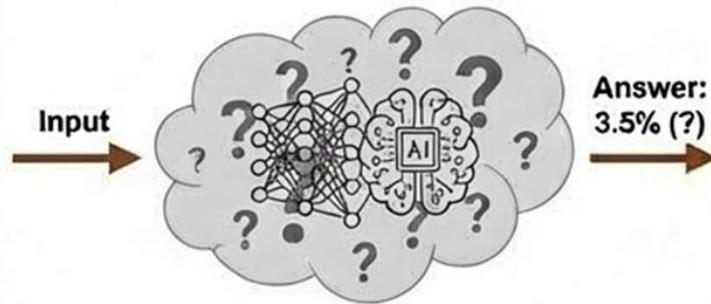
Spreadsheet-centric work increases labour time and human error.

IFRS 17 was just one step in the transformation journey... significant appetite to invest in modernisation

2. Can AI Solve the Pain Points? The Reality Check



Standard LLM



The Hallucinating Poet

Description: Excels at text generation but has "mathematical gaps." High risk of hallucinations.

Failure Example: May plausibly present non-existent regulations due to hallucination effects.

Standard RAG

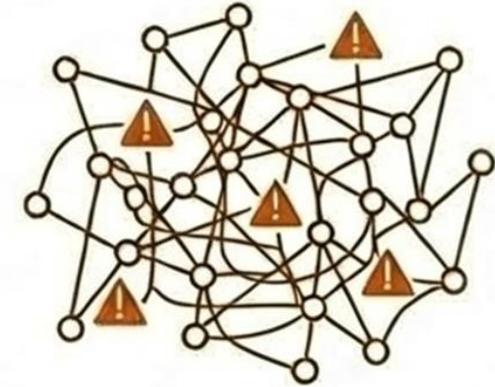


The Disconnected Librarian

Description: Simple keyword matching based on document chunk similarity searches.

Failure Example: May fail to distinguish between 2025 regulations and 2026 amendments.

Unconstrained GraphRAG



The Hairball

Description: Automatically generates random entity connections. Highly noisy relationship networks. Impossible to audit (Lack of audit trail). Failure Example: A single incorrect connection can contaminate the entire logic.

In regulatory insurance area, 'Maybe' is not an option. 1+1 must always equal 2.

3. Our Solution: Actuarial Digital Twin (ADT)



ADT System Architecture

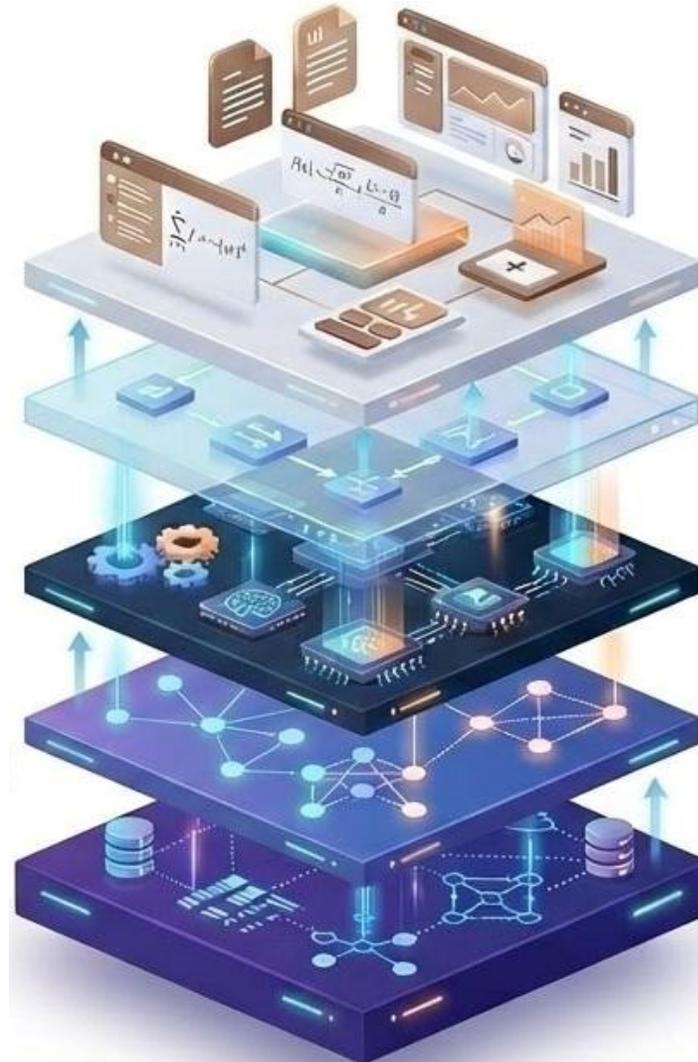
Result Outputs

Layer III: Actuarial Engine
(The Actuarial Layer)

Layer II: Agentic AI
(The Cognitive Layer)

Layer I: Ontology-Driven Graph DB
(Relational & Permanent Memory)

Source Data Inputs



Benefits



Mathematical Reliability: Produces auditable results through precise calculations using the Actuarial Engine.



Automation: Intelligent Agents automatically execute complex business processes.



Speed: Derives rapid insights through advanced Natural Language Processing (NLP)



AI-Ready Data: Represents actuarial domain knowledge through a structured network of relationships.



Ontology-Based Glass Box Architecture



Ontology:

A rigorous blueprint defining the relationships between actuarial concepts, formulas, and regulations.



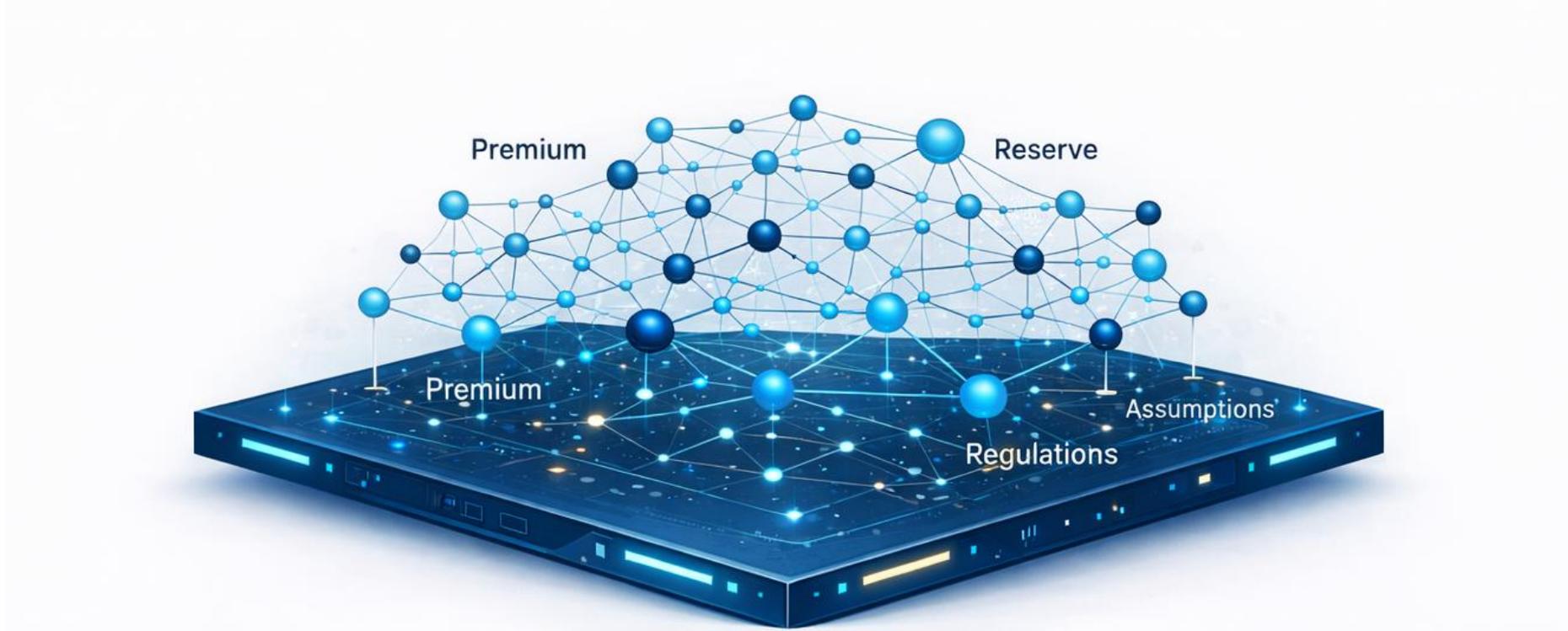
Semantic Consistency:

Instead of generating text, the AI traverses established mathematical dependencies.



Glass Box:

All data sources and calculation paths are fully traceable.



Relationship-Centric Storage

Intuitive modeling and efficient storage of complex data links.



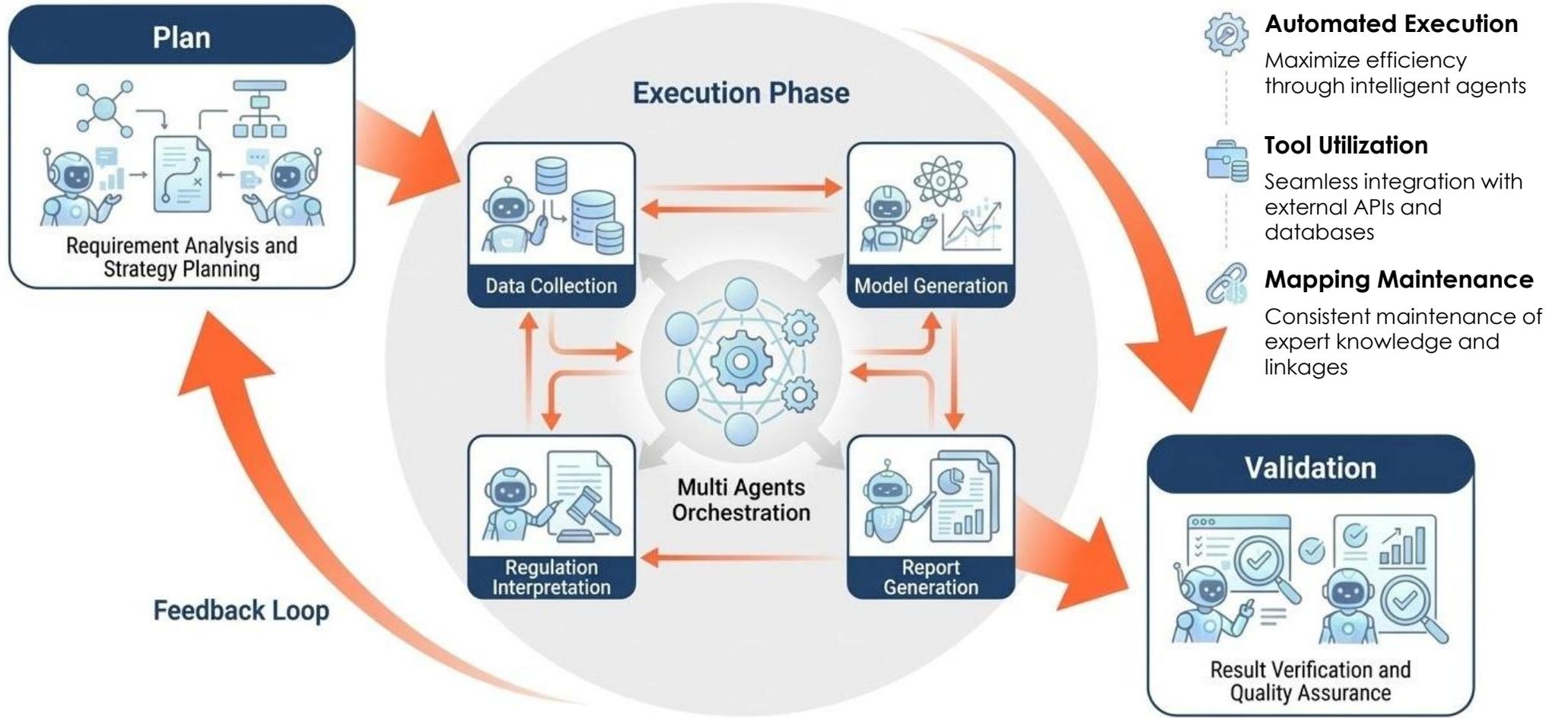
Real-time Navigation

Instant exploration and analysis of large-scale connected data.



Flexible Scalability

Agile data model adaptation to changing business needs.



Streamlining Modeling Workflow

This approach streamlines the entire actuarial modeling workflow by automating product data extraction and PST (Product Spec Table) generation through the Knowledge Agent, and semi-automating model construction. The Modeling Agent handles code generation and model execution, while human modelers focus on architecture design, validation, and result review. This hybrid human-AI process works collaboratively to significantly reduce development time, improve model accuracy and consistency, and enable modelers to concentrate on high-value tasks.

Knowledge Agent

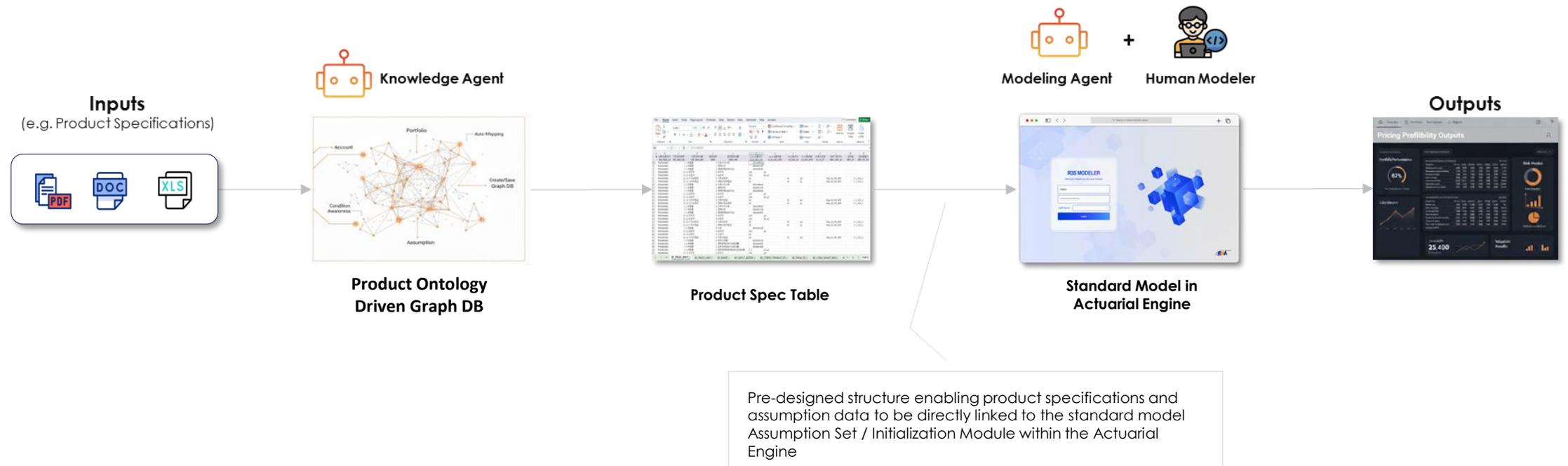
- Automated Product Data Extraction
- PST (Product Spec Table) Generation
- Initial Input Data Structuring

Modeling Agent

- Automatic Modeling Code Generation and Suggestions
- Real-time Compilation and Model Execution
- Error Debugging and Optimization Support

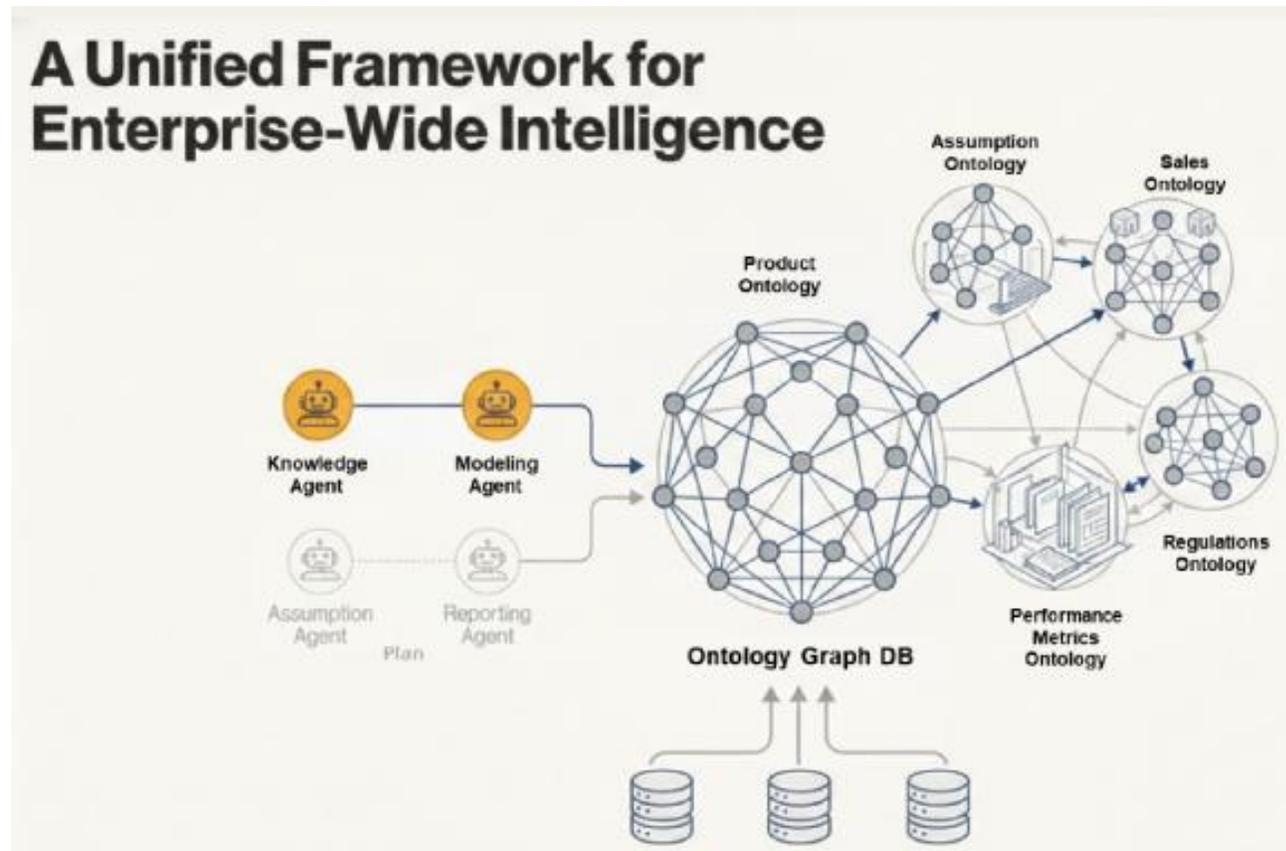
Human Modeler

- Overall Architecture Design and Direction Setting
- Code and Model Output Validation / Review
- Final Decision-Making and Approval



Enterprise-wide Expansion of an Ontology-Driven Graph Database

Insurance product graph databases must first be standardized using an ontology structure. As this ontology-based graph DB expands into other business domains and integrates them into a single logical framework, enterprise-wide data consistency is established. On this foundation, new capabilities such as natural language queries, AI agents, automated modeling, and automated reporting become possible, ultimately evolving into an ontology-based digital twin for insurers. As a result, operational speed, accuracy, and predictive capabilities across all insurance functions are dramatically enhanced.



Ontology-Based Graph Database Implementation

Ontology

- Provides a structured framework that defines entities, metadata, and relationships within a domain
- Enables AI (not just humans) to understand data semantics and perform reasoning
- Reconstructs dispersed product and actuarial data into a unified and integrated structure. When combined with Large Language Models (LLMs), delivers powerful, knowledge-driven AI capabilities

Key Benefits

- Eliminates data silos and enables enterprise-wide integration
- Allows intuitive natural language queries over complex datasets
- Establishes a foundation and scalable knowledge management system for AI platforms

Thank You



The Institute of Actuaries of Japan
Think the Future, Manage the Risk

Dr. Scarlett Bae, Head of AI Consulting at RNA Analytics

Sookyung.bae@rnaanalytics.com