
# Digital Twins in Finance – An Example

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# Wherefore Digital Twins in a Financial Institution (FI)

A digital twin is a virtual representation of an object or system that spans its lifecycle, uses real-time data, knowledge representation, simulation, machine learning and reasoning to assist just-in-time decision making.

# Why would an FI be interested in Digital Twins ?

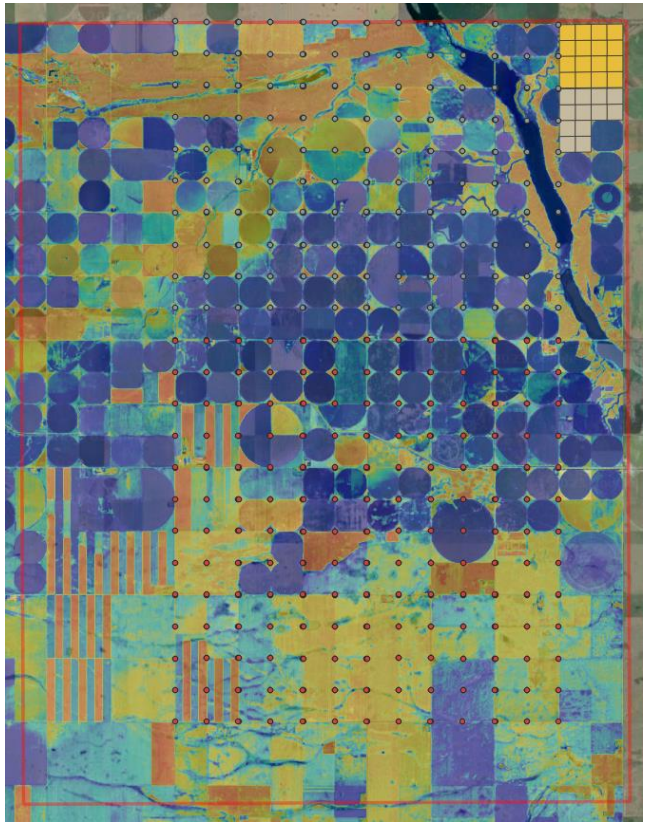
- Financial Institutions (Fis) transform **massive amounts of data** (800 million transactions a day). Drawing insights from this data tends to be targeted, leaving much of the value of the data unexploited.
  - The **scope** of modelling an entire FI is a more than human challenge.
  - "What if" (simulation) **scenarios are limited** by predetermined queries.
  - **Choosing the data** for analytics limits the bounds of the simulation and excludes scenarios an analyst may not have considered.
- Analytics in an FI tend to work in **silos** (credit cards, mortgage, asset management etc.). Assembling a view of the gestalt has been beyond current technology.
- FI's internalize analytics and lose opportunities to include **external data** and analytics.
- 92% of a typical FI's data includes a **location aspect** and yet the use of spatial analytics has been limited to showing points on a map.
- FI data is almost always temporal. **Spatio-temporal** analytics are not being used.

# What would an FI want from a digital twin ?

- If a bank changes the 5-year fixed mortgage rate for Canada, what will be the effect on climate change ?
- For each of an FI's customers, what is the carbon debt directly incurred per transaction ?
- For each of an FI's agriculture clients, calculate and predict fine grained GHG sequestration figures and crop yield including financial effects of climate change per field
- How prepared are FI personnel and clients for natural (and unnatural) disasters (simulation and prediction) ?
- Improve detection of illegal activities (for example money laundering and fraud)
- Optimize location selection for branches, communities and facilities
- Simulate country wide supply chains, predict the effect of disturbances and propose healing of a supply chain. Ultimately self healing supply chainms.
- Study movement of people in space and time to understand motivations and imperatives

# Our Digital Twin Use Case

- **The bank's second largest business domain is Agriculture**
  - The Bank's core principles feature a mandate to *help clients thrive and communities prosper*.
  - The bank trains financial advisors specifically in agriculture
    - Some advisors are also farmers
- **The goal of Flamel (code word) was to solve one or more complex competency questions using digital twins that would help farmers thrive. And to explore, learn and problem solve the technology.**
- A farmer enters a bank branch for an appointment with his/her financial advisor. They review cash, investments, loans, crop insurance, mortgages and in closing, the advisor offers critical and immediately useful insights to the farmer.

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# Criteria for Competency Questions (CQs)

## 1. Realistic and has business value

- Technically, we want the CQs to require some reasoning and computation, not just data queries on the knowledge graph

## 2. Provide opportunities to demonstrate practical and valuable technical capabilities including

- Digital twin – simulation, feedback to real life
- Ontologies
- Other forms of AI (e.g. machine learning, knowledge graph analytics, location intelligence)

## 3. Simple enough for delivery in the first Flamel prototype

- The first Flamel prototype may give a “simpler” answer to the CQ combined with discussions on what it takes to provide a more sophisticated answer in the future.
- The “simpler” answer should be designed/implemented such that the system can be extended to provide a more sophisticated answer in the future (modular).

# CQs at a Glance

1. When should each farm field be irrigated to maintain best crop production?
2. When should irrigation cease for each farm field to minimize water wastage?
3. Who is likely to inherit the farm?

Bonus CQs

1. What is the value to the farmer of the residual sequestered carbon on his farm per annum?
2. Per farm, what is the risk of a crop failure due to drought, sufficient to justify an insurance claim?

# *Flamel* POC Entailment

Flamel is a fully functional and populated digital twin that can answer several critical agriculture competency questions.

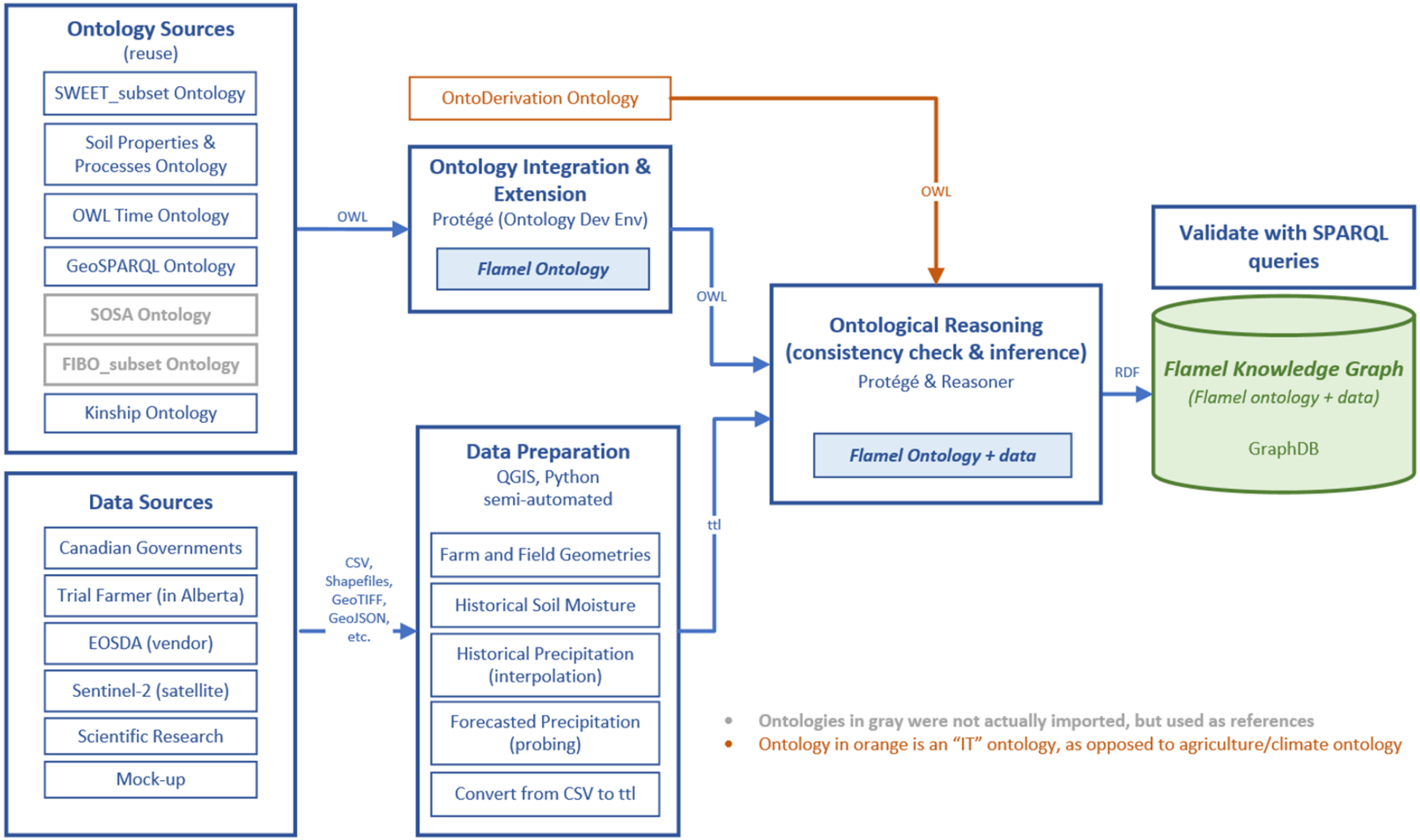
- Researched and qualified **hundreds of data sources**
- Processed and analyzed **geospatial data** including matching varying spatial and temporal resolutions.
- Created and validated our own **ontology** using reasoners
- Reused, federated, and extended **8 published ontologies**
- Flamel ontology (our ontology) contains over **15,000 axioms**
- Used an ontology reasoner to check consistency and infer **new knowledge**
- API access to **real time satellite** and historical data
- Triggered access to **real time forecasts**
- Built a **knowledge graph** using the Flamel ontology and data.
- Designed, created, and integrated digital twin **active agents**; used World Avatar as a base.
- Used newly published **Derived Information Framework** to capture data provenance and coordinate agents
- Used SPARQL and enabled **GeoSPARQL** for asking questions of the digital twin
- Used **Prolog** within the digital twin – enabled logical reasoning and learning within the twin. The twin can learn and predict from new data

# Key Technologies in RBC's Digital Twin

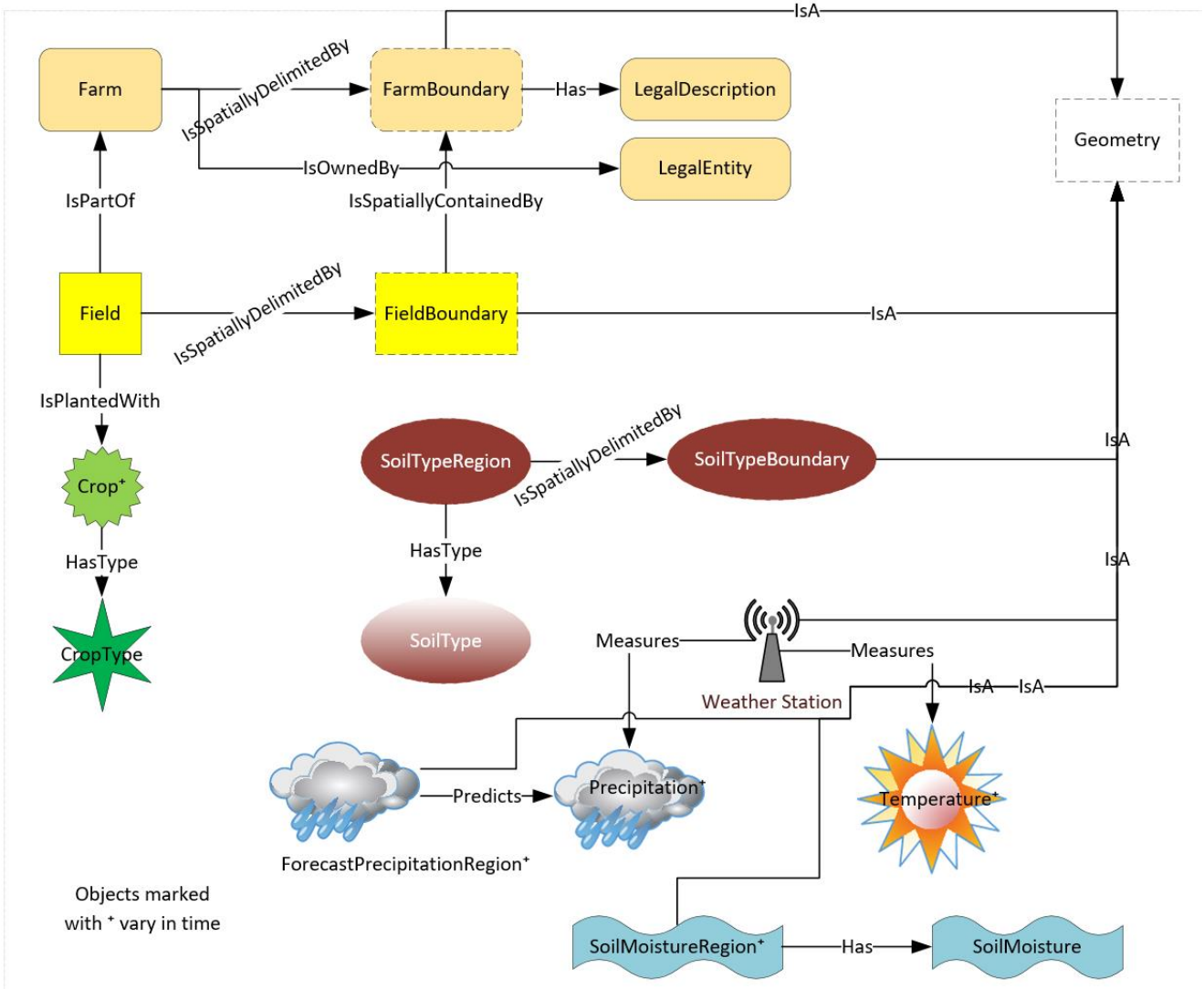
- Differential Privacy
- Synthetic Data
- Knowledge Graph
- Real Time, Just in Time or Static
- Simulation and Prediction
  - Ripples
  - Active agents
  - Embedded models
    - Machine Learning
    - Neural Symbolic AI

- Location Intelligence
  - Geodemographics
  - Imagery Feature Extraction
  - Visualization
- Ontology
  - Reasoning
  - Semi-automated ontology creation

# *Flamel* Structure



# *Flamel* Ontology




- The first use cases of Flamel focus on climate and agriculture – two important priorities for RBC.
- The Flamel ontology represents key concepts in the complex system comprising weather, climate, and agriculture.
- This is a vastly simplified depiction of the Flamel ontology.

# Possible Competency Questions for Flamel Phase 2

1. **Which crop is best suited to each of the parts of a specified field?**
    a. Fields until now have been indivisible but soil types, precipitation patterns, irrigation constraints, terrain limitations, ownership, accessibility (for equipment) all suggest strategically splitting fields is worthwhile.
    b. Because irregular field subdivisions are not conducive to efficient plowing, the subdivisions will need to be reshaped.
2. **What is the most profitable configuration of crops for a particular farmer?**
3. **Ignoring field ownership, for an entire province, which "crops per field" distribution gives the optimum production in CAD.**
    a. This then gets broken down to individual farmers and that allows:
        i. Economies of scale (multiple neighboring fields seeded, dusted, harvested etc as a unit)
        ii. Maximum production for the province improves international domination.
        iii. Improved natural and artificial pollination.
        iv. Best use of government subsidies and incentives
4. **Projecting from history, which combinations of crop and practices have had the most significant effects in either mitigating or exacerbating the consequences of climate change**
5. **When should a farmer initiate harvest for a particular field given market conditions, transport and field readiness ?**

# To InFInity and Beyond

**FIs need Digital Twins for:**

- Fraud and Money Laundering detection
- Self Healing Supply Chains
- Client behavior prediction
- Facility and Services Optimization
- Climate Change (inc financed emissions)
- Location based risk mitigation

**For FIs, Digital Twins need:**

- Federation
- Ontology merging
- Accessible toolsets
- Templates
- Performance optimization
- Orchestration standards

# Questions?