Knowledge Graph Architecture for the Enterprise

by Dean Allemang
Module 0. About the Course (7 min)

Module 1. Definitions and Business Case (55 min)
- *History of Knowledge Graphs*
  - Knowledge Graphs on the Web
  - Knowledge Graph of Banking (abridged)
    - Semantic Web Description of Banking: EBF, abnarmo, CTFC, ECFR, Cornell
    - Semantic Web Description of Banking (abridged)
    - Knowledge Graph of Banking Summary
  - Use Case for Knowledge Graphs
  - Berners-Lee Quote
  - Industrial Scale Semantic Web – Finance Part 1 & 2
  - Industrial Scale Semantic Web – Chemistry Part 1 & 2
  - How Can We Share Meaning?
    - Sharing Terminology Part 1 & 2
    - Linking Terminology
    - Describing Terminology
    - Describing Terminology in FIBO Part 1 & 2
  - Ontologies Refer to One Another
  - Semantic Services in an Enterprise Knowledge Graph Part 1 & 2
- *Knowledge Graphs in Various Industries - Finance*
  - Semantic Enterprise Data Integration
  - Role of FIBO in Semantic Data Integration
- *Knowledge Graphs in Various Industries – Media*
  - Steps in Movie Production
- *Knowledge Graphs in Various Industries – Agriculture*
  - Managing Agricultural Publications Using AGROVOC
  - AGROVOC
- *Knowledge Graphs in Various Industries – Pharmaceuticals*
  - CDISC – Clinical Data Interchange Standards Consortium
- *Data Management Challenges in the Enterprise*
  - Data Management Landscape – a Metaphor Part 1 & 2
  - Map of the Enterprise Data Jungle
  - How the WEB was Won

Module 2. Knowledge Graph Supporting Technologies (40 min)
- *Features of Graph Data Systems*
  - What is a Graph? Part 1 & 2
  - Other Words for Graphs
  - Why Graphs?
- *Approaches to Graphs as Data*
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- Graphs as Linked Tables
- Graphs with Attributes
- Linked Identities

**Property Graph Data Capabilities**
- What are Graphs Good at?
- Entity Resolution
- Entity Resolution Example
- Entity Resolution with Graphs Part 1-3
- Fraud Detection
- Path Analytics Part 1 & 2

**Graph Data Queries**
- Complex Data is a Bowl of Spaghetti Part 1-4
- Various Query Languages

**Graph Data Visualization**
- Graph Data Visualization
- Small, Detailed Displays
- Small Detailed Graphs
- Large Uniform Graphs Part 1 & 2
- Connected Subgraphs

**Graph Data Systems**
- Graph Data Systems
- What Does a Graph Data System Do?
- Data Applications
- Multi-Modal Databases
- Multi-Modal Vendors
- Graph Data Standards

**Standardizing Data**
- Why Standardize Data? Part 1 & 2
- Graph Data Standards
- Well-Known Non-Graph Data Standards: Relational Database
- Well-Known Non-Graph Data Standards: Documents
- Graph Data Standards: Semantic Web
- Graph Data Standards: Property Graph

**Module 3. Semantic Technology Fundamentals (58 min)**

- Knowledge Graph Stack
- RDF Brings Data Together
  - RDF Basic – Data as “Triples”
  - Distributing Tabular Data
  - Column-by-column?
  - Row-by-row?
  - Cell-by-cell?
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- Triples in RDF
- Tabular Data as a Graph
- Combining Data on a Web Site

- **RDFS Enhance Data with Types & Properties**
  - RDF Schema Language (RDFS)
  - Example Classes/Subclasses, Domains/Ranges Part 1 & 2

- **OWL Provides Precision Logic to Describe Models**
  - OWL Example

- **SPARQL Lets you Ask Questions About the Data**

- **Example Knowledge Graph Capabilities Using Semantic Web Standards**
  - Components of the Sample Knowledge Graph
  - Using FIBO for Semantic Data Integration (simple example)
  - AML/KYC Data
  - Data as RDF
  - Semantic Federated Queries
  - FIBO + RDFS Provides Information About Types
  - Inferences Using FIBO and RDFS
  - Semantic Federated Queries
  - FIBO Contribution
  - Data Including FIBO Metastatement about Inverses

- **Using SKOS for Knowledge Management**
  - SKOS Organizes Terminology
  - SKOS – Simple Knowledge Organization System Part 1
  - The Role of SKOS in Enterprise Data
  - SKOS Organizes Terminology
  - Vocabulary for Use and Defining Data Elements
  - Vocabularies for Enterprise Data Management Part 1 – 3
  - FIBO as Master Vocabulary
  - Who Uses SKOS?
  - SKOS Example: Agrovoc

- **The Meaning of Meaning**
  - How Do We Express Meaning?
  - Sample Data
  - Expressing Meaning in Words: Part 1 – 3
  - Expressing Meaning as Reference
  - Expressing Meaning as Structure
  - Expressing Meaning with a Graph
  - Explaining the Swap Record
  - Expressing Meaning as a Structured Graph Part 1 – 4
  - What Role did the Ontology Play in Meaning?

Module 4. Knowledge Graph Enterprise Framework (35 min)
• Application Vs. Enterprise Data
• The Enterprise Data Jungle
• Sustainable Extensibility
• Enterprise Data Community
• Prerequisites for Distributed Data
• Common Reference
  o Shared References are Everywhere
  o Linked Open Data Cloud
• Connecting References
• Semantic Alignment
  o Semantic Alignment by Common Reference
• Things vs. Strings
  o Things vs. Strings Part 1 & 2
• Tools and Components
  o Graph Databases
  o Property Graphs
    ▪ Property Graphs Part 1 & 2
    ▪ Some Cool Things You Can Do With Property Graphs
    ▪ Graph Matching Example: Recommendation Engine
    ▪ Graph Matching Example: Recommendation Engine Part 1 & 2
  o Triple Stores
    ▪ Input Triples Part 1 & 2
    ▪ Query Triples
    ▪ Update / Delete Triples
    ▪ Persistent Data
    ▪ Connection to Other Data Stores
    ▪ Some Cool Things You Can Do With Semantic Graphs
    ▪ Semantic Middleware
  o Shared Strengths
  o Differentiators
• Applications of Knowledge Graphs
  o Knowledge Graph Application Categories
  o Data Catalog
    ▪ Represent Metadata as a Graph
    ▪ Mapping Tables / Columns to Ontologies
  o Smart Data Lake
    ▪ What Makes a Data Lake Smart?
    ▪ Smart Data Lake Examples
  o Future-Proof Data
  o Smart Markup
    ▪ Steps in Movie Production
Module 5. Modeling Methodology and Architecture (33 min)

- *Modeling Methodology and Architecture*
  - Durable Data Part 1 & 2
  - Iterative Modeling & Content Development
  - Recipe for Modeling Failure
  - Recipe for Success
  - Use Cases for Knowledge Graphs
    - Scope of a Model
    - Scope Examples
    - How to Address Scope-Use Cases
    - Anatomy of a Use Case
    - Example: Estimate Cost of Loans
    - Example: Estimate Cost of Television Distribution
    - Using Use Cases for Scoping: TV Show Example
    - Using Use Cases for Scoping: Loan Example

- **Terminology Sources**

- **Guidelines for Terminology**
  - Definition Guidelines (Based on ISO 704)
    - Example of Refined Definitions
  - Conceptual Modeling
    - Basics of Conceptual Modeling Part 1 & 2
    - Steps in Domain Analysis
    - Example of Domain Analysis – Bonds Part 1 & 2
    - Example of Domain Analysis: SKOS
    - Statements in SKOS: Part 1 & 2
    - Modeling Statements in SKOS
    - Combining Modeling Approaches
    - Combining SKOS and OWL
  - Ontology Testing and Evaluation
    - Types of Ontology Testing
    - Logic Errors: Unsatisfiable Class
    - Logic Errors: Unsatisfiable Property
  - Application Testing and Evaluation
    - Competency Questions and Data Mapping
    - Competency Questions and Data Mapping Example
    - Series Data
    - Mapping Data
    - Application Level Testing - Recap
  - Iteration
    - Fixing Issue
    - Mapping Data
    - Adjust and Repeat
  - Methodology Take-Aways
Module 6. Implementation Fundamentals of Knowledge Graph (47 min)

- Example Implementation
- Incremental Development
- Knowledge Graph Implementation
- Presentation Approach
- Select a Use Case
  - Use Case Selection
  - Refine Use Case
  - Selecting Use Case in the Example: Part 1 & 2
- Inventory Data Sources
  - Existing Data Reflect Business Reality
  - Example Inventory
  - Find Legacy Ontologies
  - Ontologies are Everywhere
  - Finding Ontologies in Our Example: Parts 1-4
  - Formalize the Ontologies
  - Ontologies in the Example
- Draw on Reference Ontologies
  - Reference Ontologies
  - Reference Ontologies in the Example part 1-3
- Identify Controlled Vocabulary
  - Internal vs External Controlled Vocabularies
  - Controlled Vocabularies in the Example: Part 1 & 2
- Map Metadata to Ontologies
  - Mapping of Ontology to Metadata
  - Mapping Metadata in the Example Part 1 & 2
  - Metadata Applications
- Materialize Data as Needed
  - Materialize Data
  - Complex Structural Materialization
- Build Queries to Respond to Business Questions
  - Queries Drive Application
  - Example Query
  - Semantic Middleware
- Repeat from Step 3 with New Data
- How Can This Fail?
- Summary: Incremental Development