Knowledge Graphs: https://graphwise.ai/fundamentals/what-is-a-knowledge-graph/

What Is a Knowledge Graph?

The heart of the knowledge graph is a knowledge model – a collection of interlinked descriptions of concepts, entities, relationships and events where:

- Descriptions have formal semantics that allow both people and computers to process them in an efficient and unambiguous manner;
- Descriptions contribute to one another, forming a network, where each entity represents part of the description of the entities related to it;
- Diverse data is connected and described by semantic metadata according to the knowledge model.

Key characteristics

Knowledge graphs combine characteristics of several data management paradigms:

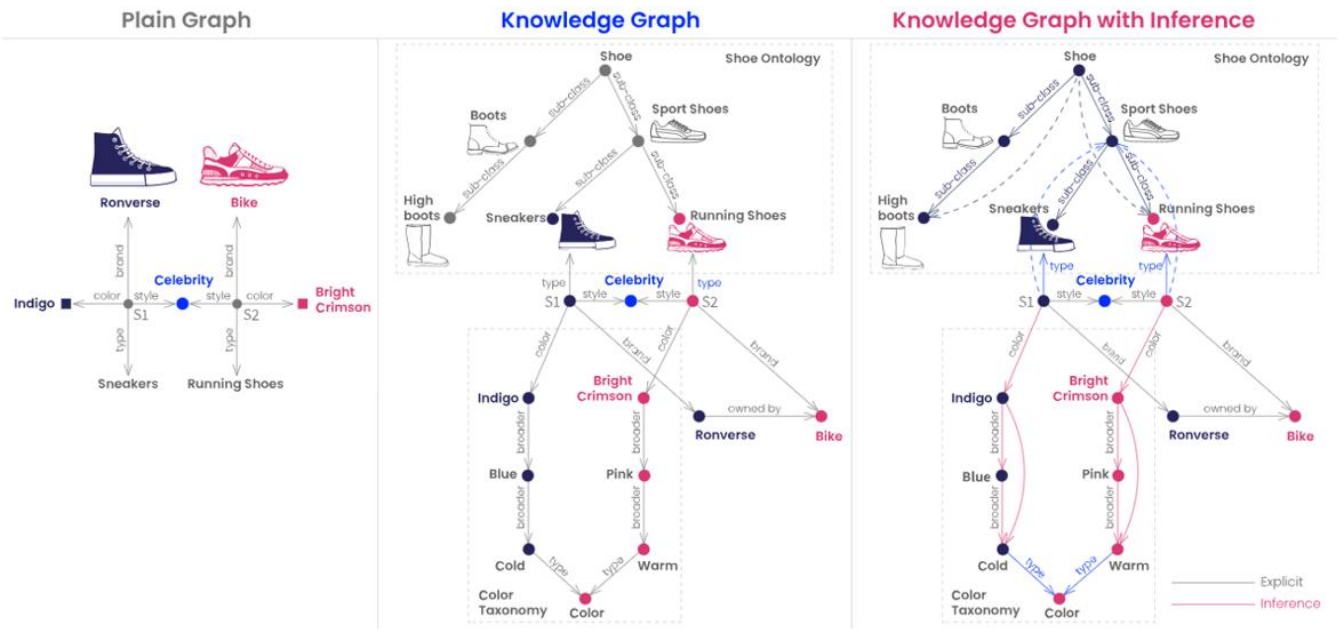
- **Database**, because the data can be explored via structured queries;
- **Graph**, because they can be analyzed as any other network data structure;
- **Knowledge base**, because they bear formal semantics, which can be used to interpret the data and infer new facts.

Knowledge graphs, represented in RDF, provide the best framework for data integration, unification, linking and reuse, because they combine:

- **Expressivity**: The standards in the Semantic Web stack – RDF(S) and OWL – allow for a fluent representation of various types of data and content: data schema, taxonomies and vocabularies, all sorts of metadata, reference and master data. The RDF* extension makes it easy to model provenance and other structured metadata.
- **Performance**: All the specifications have been thought out, and proven in practice, to allow for efficient management of graphs of billions of facts and properties.
- **Interoperability**: There is a range of specifications for data serialization, access (SPARQL Protocol for end-points), management (SPARQL Graph Store) and

federation. The use of globally unique identifiers facilitates data integration and publishing.

- **Standardization**: All the above is standardized through the W3C community process, to make sure that the requirements of different actors are satisfied – all the way from logicians to enterprise data management professionals and system operations teams.



Ontologies and formal semantics

Ontologies represent the backbone of the formal semantics of a knowledge graph. They can be seen as the data schema of the graph**.** They serve as a formal contract between the developers of the knowledge graph and its users regarding the meaning of the data in it. A user could be another human being or a software application that wants to interpret the data in a reliable and precise way. Ontologies ensure a shared understanding of the data and its meanings.

When formal semantics are used to express and interpret the data of a knowledge graph, there are a number of representation and modeling instruments:

- **Classes.** Most often an entity description contains a classification of the entity with respect to a class hierarchy. For instance, when dealing with business information there could be classes *Person*, *Organization* and *Location*. Persons and

organizations can have a common superclass *Agent*. Location usually has numerous sub-classes, e.g., *Country*, *Populated place*, *City*, etc. The notion of class is borrowed by the object-oriented design, where each entity usually belongs to exactly one class.

- **Relationship types**. The relationships between entities are usually tagged with types, which provide information about the nature of the relationship, e.g., *friend*, *relative*, *competitor*, etc. Relationship types can also have formal definitions, e.g., that *parent-of* is inverse relation of *child-of*, they both are special cases of *relative-of*, which is a symmetric relationship. Or defining that *sub-region* and *subsidiary* are transitive relationships.
- **Categories**. An entity can be associated with categories, which describe some aspect of its semantics, e.g., *"Big four consultants"* or *"XIX century composers"*. A book can belong simultaneously to all these categories: *"Books about Africa"*, *"Bestseller"*, *"Books by Italian authors"*, *"Books for kids"*, etc. The categories are described and ordered into taxonomy.
- **Free text descriptions**. Often a 'human-friendly text' description is provided to further clarify design intentions for the entity and improve search.
- **What is NOT a knowledge graph?**
- **Not every RDF graph is a knowledge graph**. For instance, a set of statistical data, e.g. the GDP data for countries, represented in RDF is not a KG. A graph representation of data is often useful, but it might be unnecessary to capture the semantic knowledge of the data. It might be sufficient for an application to just have a string 'Italy' associated with the string 'GDP' and a number '1.95 trillion' without needing to define what countries are or what the 'Gross Domestic Product' of a country is. It's the connections and the graph that make the KG, not the language used to represent the data.

Not every knowledge base is a knowledge graph. A key feature of a KG is that entity descriptions should be interlinked to one another. The definition of one entity includes another entity. This linking is how the graph forms. (e.g. A is B. B is C. C has D. A has D). Knowledge bases without formal structure and semantics, e.g. Q&A "knowledge base" about a software product, also do not represent a KG. It is possible to have an expert system that has a collection of data organized in a format that is not a graph but uses automated deductive processes such as a set of 'if-then' rules to facilitate analysis.

Examples of big knowledge graphs

DBPedia: This project leverages the structure inherent in the infoboxes of Wikipedia to create an enormous dataset of 4.58 things (link https://wiki.dbpedia.org/about) and an ontology that has encyclopedic coverage of entities such as people, places, films, books, organizations, species, diseases, etc. This dataset is at the heart of the Open Linked Data movement. It has been invaluable for organizations to bootstrap their internal knowledge graphs with millions of crowdsourced entities.

Wordnet: One of the most well-known lexical databases for the English language, providing definitions and synonyms. Often used to enhance the performance of NLP and search applications.