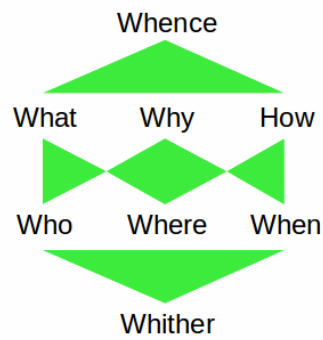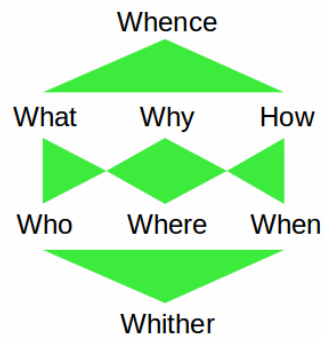# Kenneth Baclawski
John Sowa
Ravi Sharma
Gary Berg-Cross
Ram D. Sriram
Janet Singer
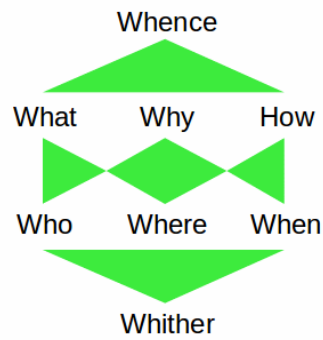
29 January 2020

Outline

- Theme
- Fall Series
- Main Series
  - Invited Speakers
  - Synthesis Sessions
  - Symposium

- Organizer Presentations
  - John Sowa
  - Ravi Sharma
  - Gary Berg-Cross
  - Ram D. Sriram
- Communiqué
- Logistics

Ontology Summit 2020: Knowledge Graphs

Theme

- Whence knowledge graphs?

  - Closely related to ontologies and semantic networks

  - Emerged in the last few years to be an important semantic technology and research area.

- What are they?

  - Structured representations of semantic knowledge, stored in a graph

  - Lightweight versions of semantic networks

- Why?

  - Scale to massive datasets such as the entire World Wide Web

- How are they developed and used?

  - Industry is devoting a great deal of effort

  - Critical to the functions of intelligent virtual assistants such as Siri and Alexa.

- Who (communities) are using them?

  - Ontologies, Big Data, Linked Data, Artificial Intelligence, Deep Learning, and many others.

Ontology Summit 2020: Knowledge Graphs
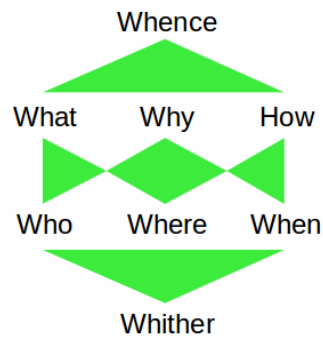
Fall Series

- **Jans Aasman**
  - Why Knowledge Graphs Hit the Hype Cycle and What they have in common

- **John Sowa**
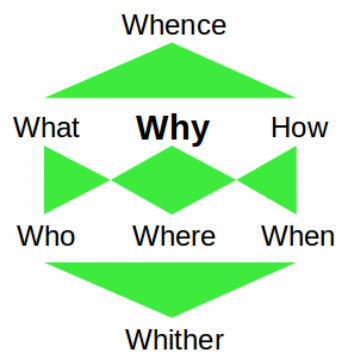 - Knowledge Graphs: Past, Present, Future

- **Elise Stickles**
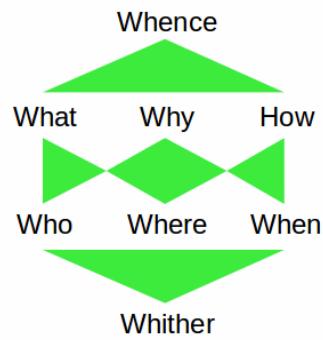 - MetaNet: Deep semantic automatic metaphor analysis

Ontology Summit 2020: Knowledge Graphs

Main Series

- The sessions are classified by relevance to the "W" questions
    - Who, Where and When are grouped together as "Use Case".
- Each session will be convened by one of the summit organizers
- Next week (5 February) **Chaitanya Baru** will be speaking
    - Ram will say more about this.
- On 12 February **John Sowa** will be speaking
    - John will tell us more about this.
- On 19 February **Matthew West** "From Data to Business Value"
    - See next slide.
- On 26 February **Anirudh Prabhu** "Insights from Knowledge Graphs"
    - Gary will tell us more about this.

Ontology Summit 2020: Knowledge Graphs

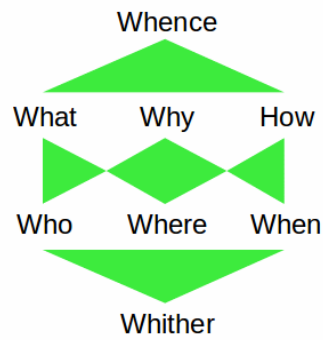**Matthew West** (Why) "From Data to Business Value"

- Some questions to be considered:
  - What is information for? (entertainment, decisions)
  - How does information support decisions?
  - How do you discover your information requirements systematically?
- Critical properties of information
  - Information needs to be fit for purpose, so IM is a Quality Management process
- Applying QM to information
  - The information management landscape
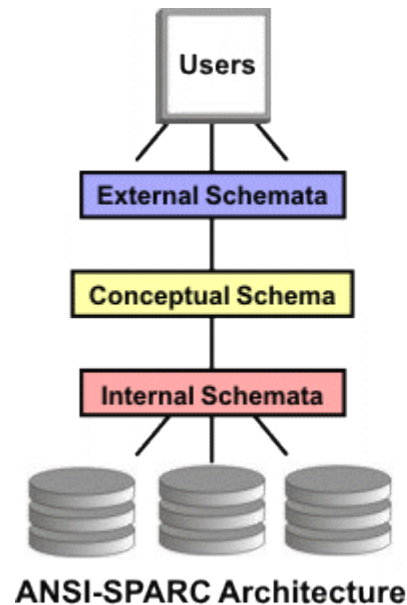 - Information management maturity (how to implement Information Quality Management)

Ontology Summit 2020: Knowledge Graphs

Whence we came, by John Sowa

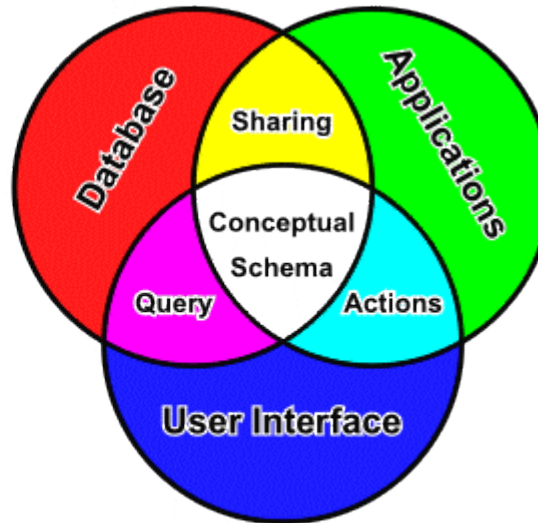## History of knowledge representation in graphs and diagrams.

- 3rd Century AD: Tree of Porphyry for representing ontologies.

- 1897 to 1911: Peirce's existential graphs for logic – first-order, higher-order, metalanguage, modality, and natural language approximations.

- 1950s: Dependency graphs for linguistics by Lucien Tesniére.

- 1960s: Early semantic networks by Masterman, Quillian, Schank...

- 1970s: Logic graphs by Shapiro, Hendrix, Woods, Brachman, Sowa...

- 1980s: Expert systems, database conceptual schema, Cyc project, Shared Reusable Knowledge Base Project (SRKB)...

- 1990s: Applications with databases, statistics, neural networks...

Ontology Summit 2020: Knowledge Graphs
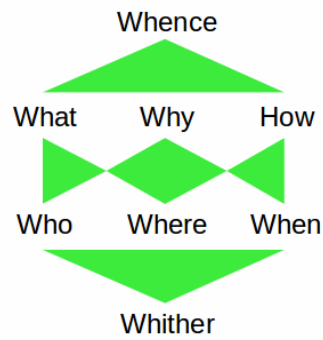
Conceptual Schema for Databases
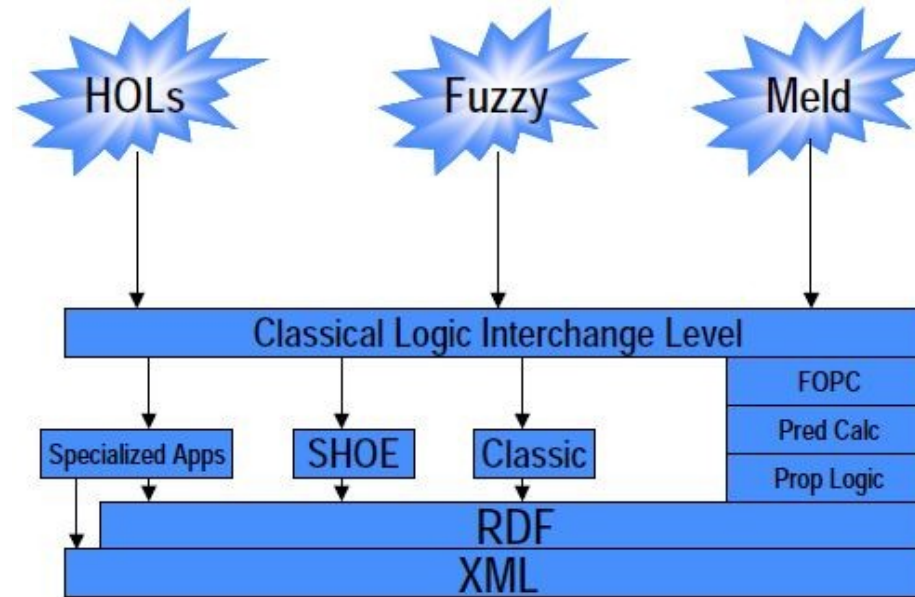

ANSI-SPARC Architecture

An Application System

The ANSI/SPARC three-schema design (1978).

- **The conceptual schema is the equivalent of an ontology.**
- **It specifies the common semantics of all the interfaces.**
- **For more info, see http://jfsowa.com/ikl/.**

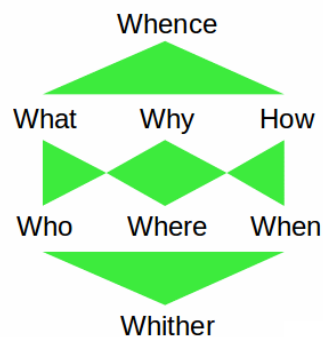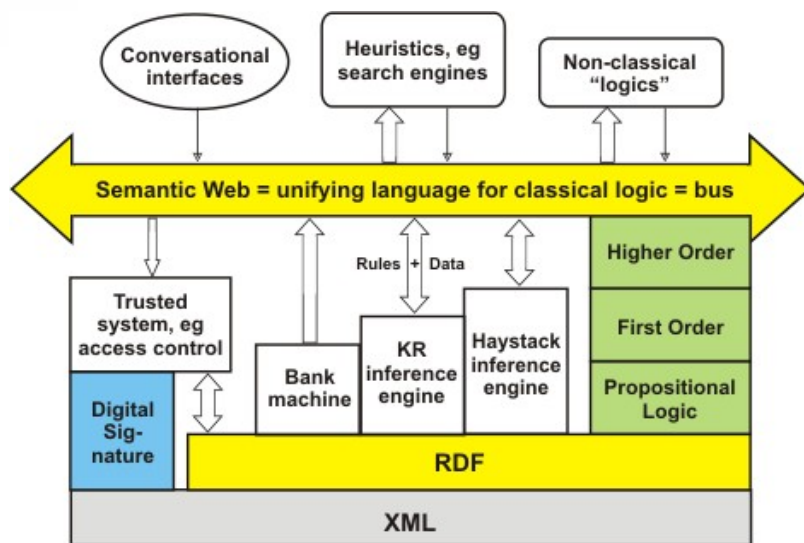**Ontology Summit 2020: Knowledge Graphs**

DAML Requirements

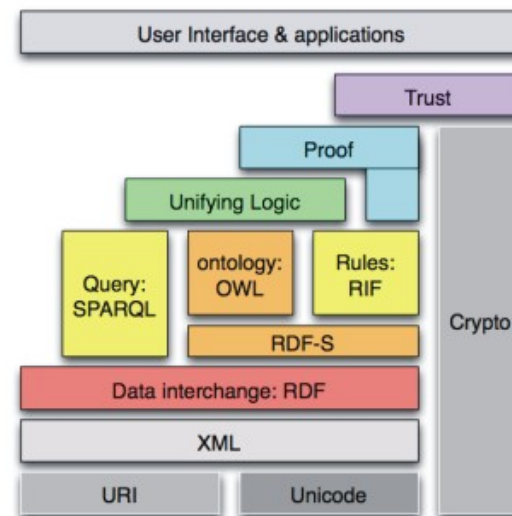A diagram from the original DARPA specifications.

- The interchange level must support higher-order logic, fuzzy logic, and a meld of various representations.
- SHOE is a simple ontology. Classic is similar to OWL.

Ontology Summit 2020: Knowledge Graphs
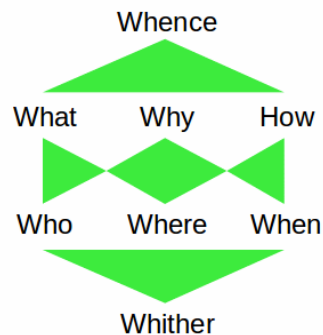
Semantic Web Layer Cakes

As proposed (2000)

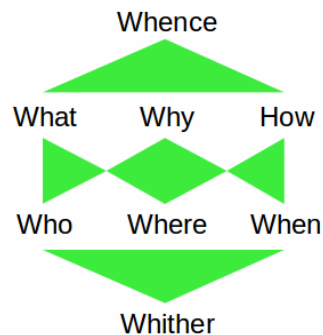As delivered (2005)

The proposal met the requirements.

- But the version of 2005 was more limited, less flexible.
- No support for HOL, fuzzy logic, other representations.
- Decidability is a restriction that was not in the requirements.

Ontology Summit 2020: Knowledge Graphs

Future Challenges and Possibilities

Knowledge graphs are more readable and flexible.

- They explore new technology developed in the past 15 years.

- Important goalsl: A humanly readable notation for anything derived from the WWW by new technology, such as DNNs.

- Flexability is essential, decidability is meaningless.

- Some versions could be mapped to and from RDF.

- Others are closer to natural languages.

- And some are used to represent a kind of conceptual schema.

- It's premature to specify a standard, since the range of possible applications is still unknown.

Ontology Summit 2020: Knowledge Graphs

Ravi Sharma
What are Knowledge Graphs?

- No Single Agreed Definition

- Jans Asman, Franz – Allegrograph

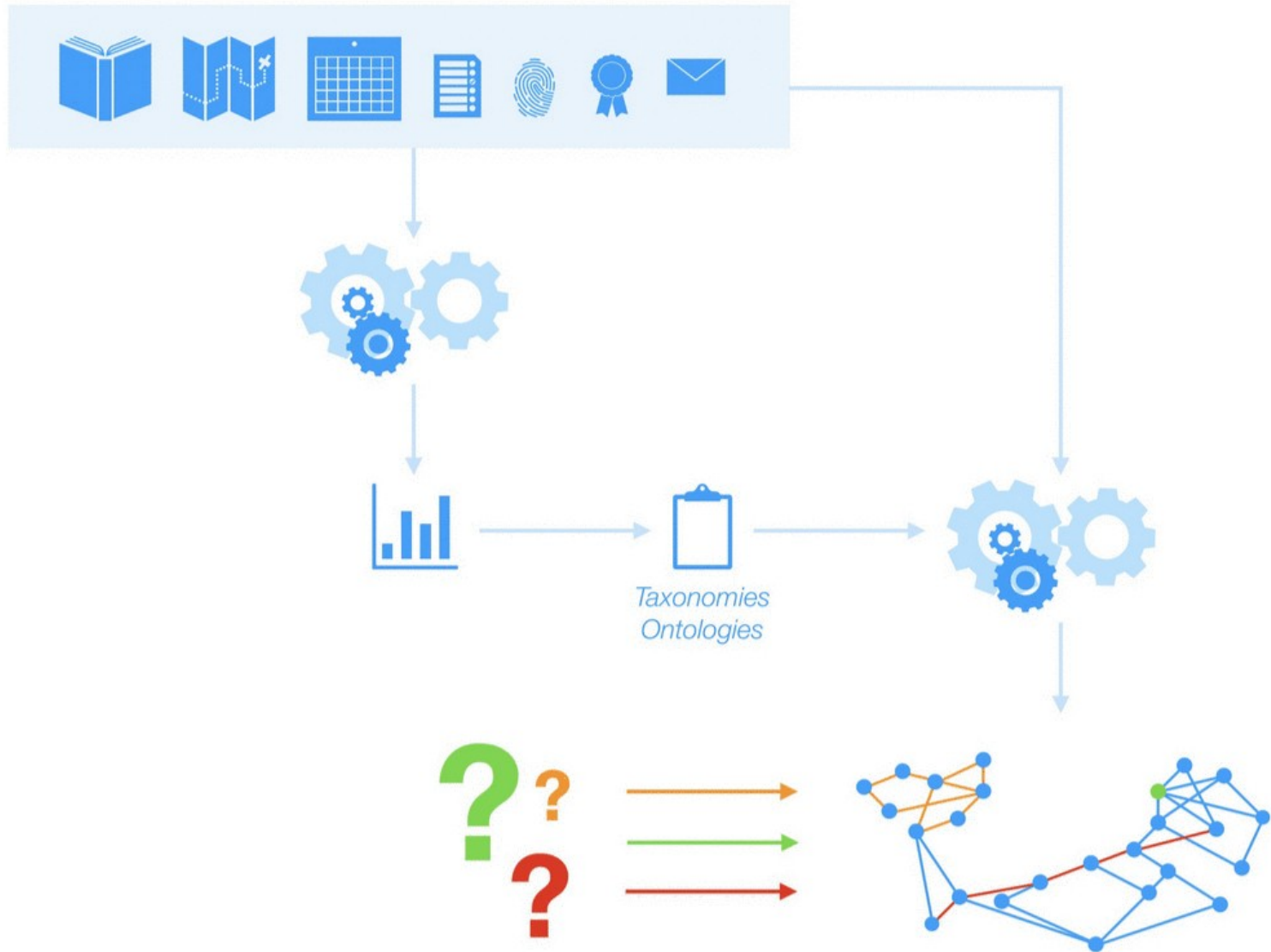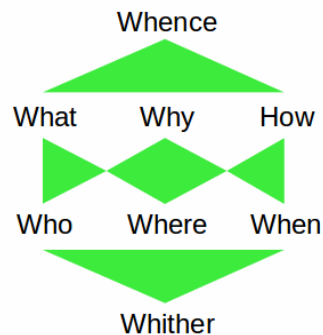 - A system that tries to know and learn everything it can about an entity (for a purpose e.g. Product, Process) and includes A (semantic) graph, ontologies, taxonomies and Identity management and a smart integration of silos of information and often includes ML, NLP, Text Classifier, etc.   (http://bit.ly/34jSlmJ, Slide 36)

- Nicola Rohrseitz

  - A Knowledge Graph is a set of datapoints linked by relations that describe a domain, for instance a business, an organization, or a field of study. Knowledge Graphs are secondary or derivate datasets. Creating a Knowledge Graph is a significant endeavor because it requires access to data, significant domain and Machine Learning expertise, as well as appropriate technical infrastructure. (http://bit.ly/2ZWVmqa)

Ontology Summit 2020: Knowledge Graphs

Nicola Rohrseitz KG Architecture

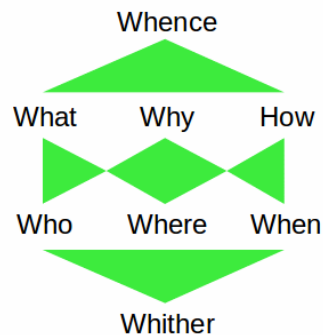**Ontology Summit 2020: Knowledge Graphs**

Ravi Sharma
What are Knowledge Graphs?

- Julian Aijal

  - A knowledge graph acquires and integrates information into an ontology and applies a reasoner to derive new knowledge. A knowledge graph is a programmatic way to model a knowledge domain with the help of subject-matter experts, data interlinking, and machine learning algorithms. (http://bit.ly/2IwjVTu)

- Nickel, Murphy, Tresp and Gabrilovich

  - A Review of Relational Machine Learning for Knowledge Graphs (https://arxiv.org/abs/1503.00759)

  - Knowledge graphs provide semantically structured information that is interpretable by computers — a property that is regarded as an important ingredient to build more intelligent machines.

Ontology Summit 2020: Knowledge Graphs

Ravi Sharma
What are Knowledge Graphs?

- Michael K Bergman
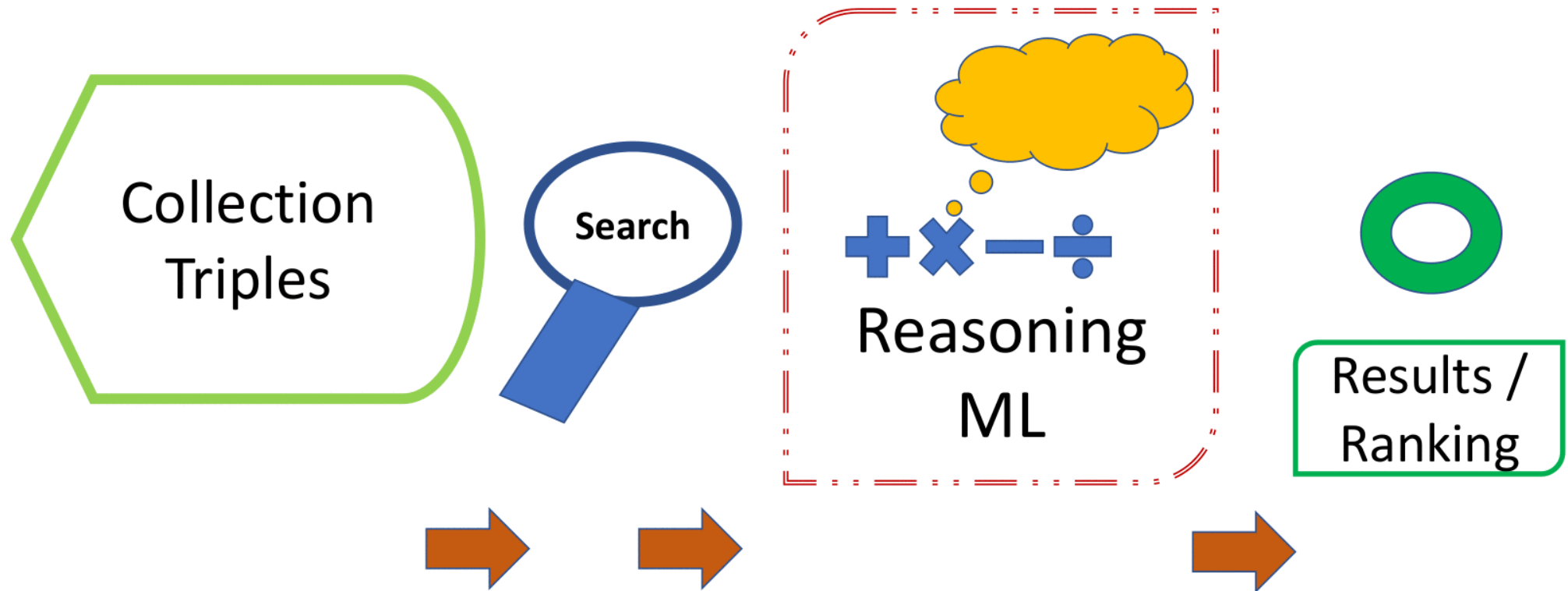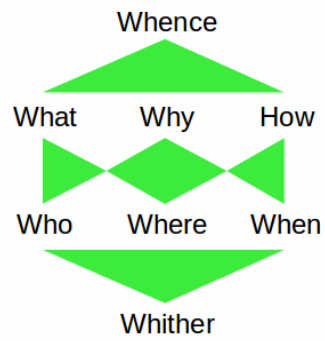
  - What is a Knowledge Graph? One finds there are some 99 references on Google as a whole and some 22 academic papers on Google Scholar. Aligns with Charles S. Peirce - His view of knowledge, not all who label things as knowledge graphs embrace this precise understanding. Term KG has been in use since 1970's and there were 10 definitions of KG in 2019. About the most we can say about knowledge graphs in general, in keeping with their constituent terms, is that they are a representation of knowledge (however defined) in the structural form of a directed (mostly acyclic) graph. In this diversity, KGs are not much different than ontologies, with a similarly broad and contextual use. it appears far superior to the label 'ontology' as a means of describing these knowledge structures to the general public. (http://bit.ly/307PEBs and http://bit.ly/2RAbE6X)

Ontology Summit 2020: Knowledge Graphs

Knowledge Graphs Visualization Attempt

Ontology Summit 2020: Knowledge Graphs

Knowledge Graphs and Ontologies

Random information sources

Processors e.g. ER Extractors

Creation of Triples

Ontologies Semantics AI ML Search

Meaningful and / or Predictive Outcomes and refinements

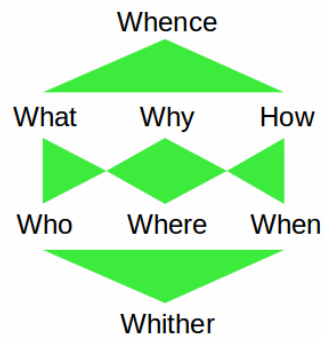**Ontology Summit 2020: Knowledge Graphs**

Insights into Knowledge Graphs: What & How
Gary Berg-Cross and Amit Sheth

- We've had many presentations running up to today on why build these Knowledge Graphs (http://bit.ly/2JMlq1H)

- Enhanced (semantic) applications such as search, browsing, Improve integration of data, including data of diverse modalities and from diverse sources

- Formal Ontologizing offers help to KG work:

  - Quality/expressive knowledge

  - Better knowledge organization,

  - Support for reasoning, and best knowledge practices..

  - **Note also that there are obvious connections to earlier Summits such as the recent CommonSense topic in 2019.**

  - Our speakers will provide some insights of how we build and use KGs.

Ontology Summit 2020: Knowledge Graphs

KGs and the Ontology Spectrum/Gradient

Ontology Summit 2020: Knowledge Graphs

There are many ingredients to a quality KG

- From https://www.researchgate.net/post/What_is_Knowledge_Graphs
  Ajit kumar Roy's What is Knowledge Graphs?
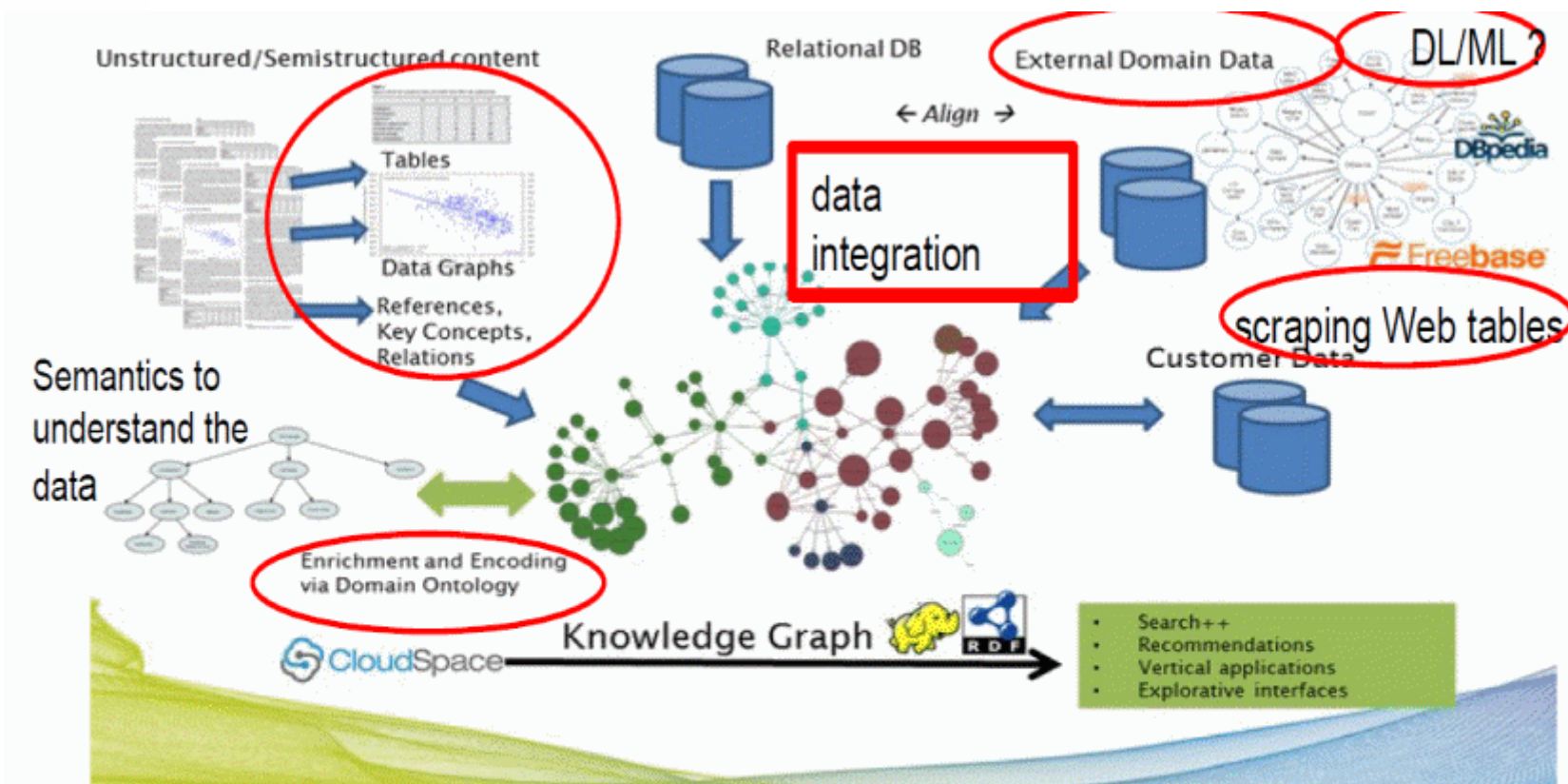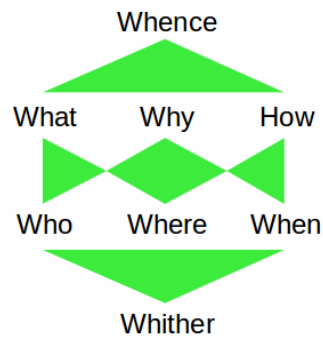
Efforts for communities related to Deep Learning, Knowledge Graphs, and NLP join their forces in order to develop more effective algorithms and applications.

Ontology Summit 2020: Knowledge Graphs

Sessions Plan

- 29 January 2020 Introduction to the Insight Track

- 26 February 2020 Session 1

  - Speaker: **Anirudh Prabhu** (RPI) "Insights from Knowledge Graphs"

  - We gain insight from Reasoners. Visual Analytics Network Science Approach

  - Working under Prof. Peter Fox his research interests include Data Modeling, Semantic E-science, and Data Visualization.

- March ? 2020 Session 2

  - Speaker: **Paco Nathan** (Managing Partner, Derwen, Inc.): The Rich Context Project

- Forum/Email conversations as needed to flesh out possible alternative approaches

Ontology Summit 2020: Knowledge Graphs

Anirudh Prabhu

Visual Analytics

◦ D3js/Visjs
◦ VOWL
◦ iGraph/VisNetwork

Ontology Summit 2020: Knowledge Graphs

Paco Nathan

The Rich Context project intakes metadata from the agencies involved with Administrative Data Research Facility (ADRF) to build a knowledge graph of metadata about dataset usage.

Clip slide

Perspectives

- the ubiquity of linked data

- the tyranny of "thinking relational"

- the primacy of working with graphs (and their math analog, tensors)
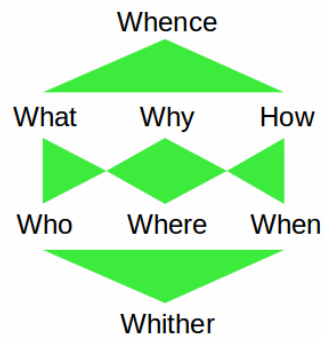
- nouns vs. verbs vs. adjectives (extreme nominalization)

- evolution of hardware, cloud, and cluster topologies

- the power of graph embeddings

http://bit.ly/2tTsm7Z

23

Ontology Summit 2020: Knowledge Graphs

Ram D. Sriram Speakers

- **Chaitanya Baru** (Whence) on 5 February

    - Senior Science Advisor, OIA, NSF

    - Advises NSF on OKN, which is part of NSF's Convergence Accelerator Program (Track 1)

    - Has been very involved in development of above program

- **Ernest Davis** (Why) on 25 March

    - Columbia University and author of Rebooting AI

    - Known for his work on Commons Sense Reasoning

    - Rebooting AI points out the need for representation schemes that will result in common sense reasoning (probably a case for integration of ontologies with deep neural networks)

Ontology Summit 2020: Knowledge Graphs

Ram D. Sriram Speakers

- **Jay Pujara** (Use Cases -- Financial))

  - Research Assistant Professor, USC-ISI

  - Research focuses on knowledge graph construction

  - Conducted tutorials and held workshops at AAAI on knowledge graphs.

  - Received an NSF OKN Phase I proposal – Leveraging Financial and Economic Data

- **Chris Mungall** (Use Cases – Biomedical)

  - Head, Molecular Ecosystems Biology Group, LBNL, Berkeley

  - Gene Ontology Consortium

  - The Monarch Initiative -- Phenotype comparison across species using ontologies

Ontology Summit 2020: Knowledge Graphs

Ram D. Sriram Speakers

- **Vinay K. Chaudhri** (Use Cases -- Books)

  - Currently at Stanford University

  - Research focuses on science and engineering of large knowledge base systems

  - Developed an intelligent text book in biology using knowledge graphs

  - Also co-investigator in an NSF OKN Phase I proposal on intelligent text books

- **Binil Starly** (Use Cases -- Manufacturing)

  - Directs Data Intensive Manufacturing Lab at NC State Univ.

  - Primary research area – Digital Manufacturing

  - Recipient of NSF's Convergence Accelerator Phase I grant

Ontology Summit 2020: Knowledge Graphs

Ram D. Sriram Speakers

- **Eswaran Subrahmanian** & **Spencer Breiner**

  - NIST work on Category Theory

  - Research focuses on representing KGs using Category Theory

  - Category Theory provides an elegant scheme for representing a wide variety of knowledge (qualitative and quantitative)

Ontology Summit 2020: Knowledge Graphs

Other Potential Speakers

- **Yolanda Gil**, USC-ISI (OKN for Scientific Discovery)

- **Sargur Srihari**, SUNY Buffalo (Probabilistic KGs)

- **RV Guha**, Google (Whence)

- **Lucila Ohno-Machado**, UC San Diego (Biomedical)

- **Sean Gordon**, Portland State Univ (Spatial Decision Support)

- **TN Bhat**, NIST (Generating KGs)

Ontology Summit 2020: Knowledge Graphs

Communiqué

- The results will be captured in the form of a Summit Communiqué

- Several sessions will be devoted to the development of the Communiqué
  - Two Synthesis sessions
  - Two Communiqué sessions

- The Communiqué will be presented at the Symposium
  - To be held around the middle of June 2020

Ontology Summit 2020: Knowledge Graphs

Logistics

- Each session normally lasts one hour
  - 30 minutes for the presentation
  - 30 minutes for discussion
  - Some sessions may be longer (up to 1.5 hours)
- Each session starts at Noon Eastern Time on Wednesday
- Each session has a meeting page on the ontologforum.org wiki

Ontology Summit 2020: Knowledge Graphs

Supplementary Slides

References

- Amit Sheth, Swati Padhee, Amelie Gyrard, 'Knowledge Graphs and Knowledge Networks - The Story in Brief," IEEE Internet Computing, July-Aug 2019

- See also https://www.slideshare.net/apsheth/knowledge-graphs-and-their-central-role-in-big-data-processing-past-present-and-future

- https://www.slideshare.net/knoesis/knowledgeinfused-ai

- Ali, Saqib, et al. "Semantic Knowledge Based Graph Model in Smart Cities." International Conference on Smart City and Informatization. Springer, Singapore, 2019.

- Insights from Kgs https://www.slideshare.net/AnirudhPrabhu/insights-from-knowledge-graphs

- Read about the Rich Context project at https://coleridgeinitiative.org/richcontext

- Chapter 13 - The Future of AI in Rich Context Paco Nathan see http://34.82.145.119:8080/chap13.html

- Paco Nathan   Graph realities https://www.slideshare.net/ConnectedDataLondon/graph-realities

Why a KG Thrust?

- For fluid knowledge about the world using diverse data...but...

- A basis to automate commonsense knowledge & reasoning capabilities?

- In smart cities experience semantics helps but comes up with certain limitations including an incapability to transform semi-structured data into useful knowledge, issues in handling inconsistent data, and inability to process large-scale, multi-source, and complex data of smart cities.

- Example is a Semantic Knowledge Based Graph model to overcomes these limitations such as

    - diverse domain knowledge, handle large knowledge databases

    - automatically classify heterogeneous data by using ML techniques and

    - support intelligent semantic search algorithms in smart cities.

- Results of all this are summarized in the form of a knowledge graph which gives a comprehensive insight into the data. *After Ali, Saqib, et al. "Semantic Knowledge Based Graph Model in Smart Cities." International Conference on Smart City and Informatization. Springer, Singapore, 2019.

Some Issues and Questions

- What knowledge do we need to support this use of KGs?

- What would be the nature of these KGs and their Knowledge representation?

- What is the nature of the k-graph & how axiom-rich (formal) would these be?

- Can we/should we build on Schema.org or the like?

- What quality ontologies are available as part of KG efforts?

- What supporting technologies do we need, including use of rapidly advancing Machine learning (ML) technology which may help in extracting, and developing public knowledge bases from a variety of forms.

- How do manage and maintain KBs of open knowledge as we leverage new input and related sources of informal information such as metadata annotation?

- How to handle big, noisy data for portions of reality described in many contexts?

- How do we handle fitness for many uses in many different contexts?......