PODD - Towards An Extensible, Domain-agnostic Scientific Data Management System

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An Ontology-Driven Approach In a Phenomics Setting

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- Data volume
  - High-throughput & high-resolution processes
- Data evolution
  - Changes in model & data

Data Management Requirements

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- Collection
- Distribution & sharing
- Access control
- Archival & versioning
- Discovery & analysis
- Repurposing

PODD Goals

An extensible & domain-independent data management architecture

Related Models & Systems

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- Models
  - Functional Genomics Experiment Model (FuGe)
    - UML & database based
  - Ontology for Biomedical Investigations (OBI)
    - 26,000+ OWL classes & 10,000+ axioms

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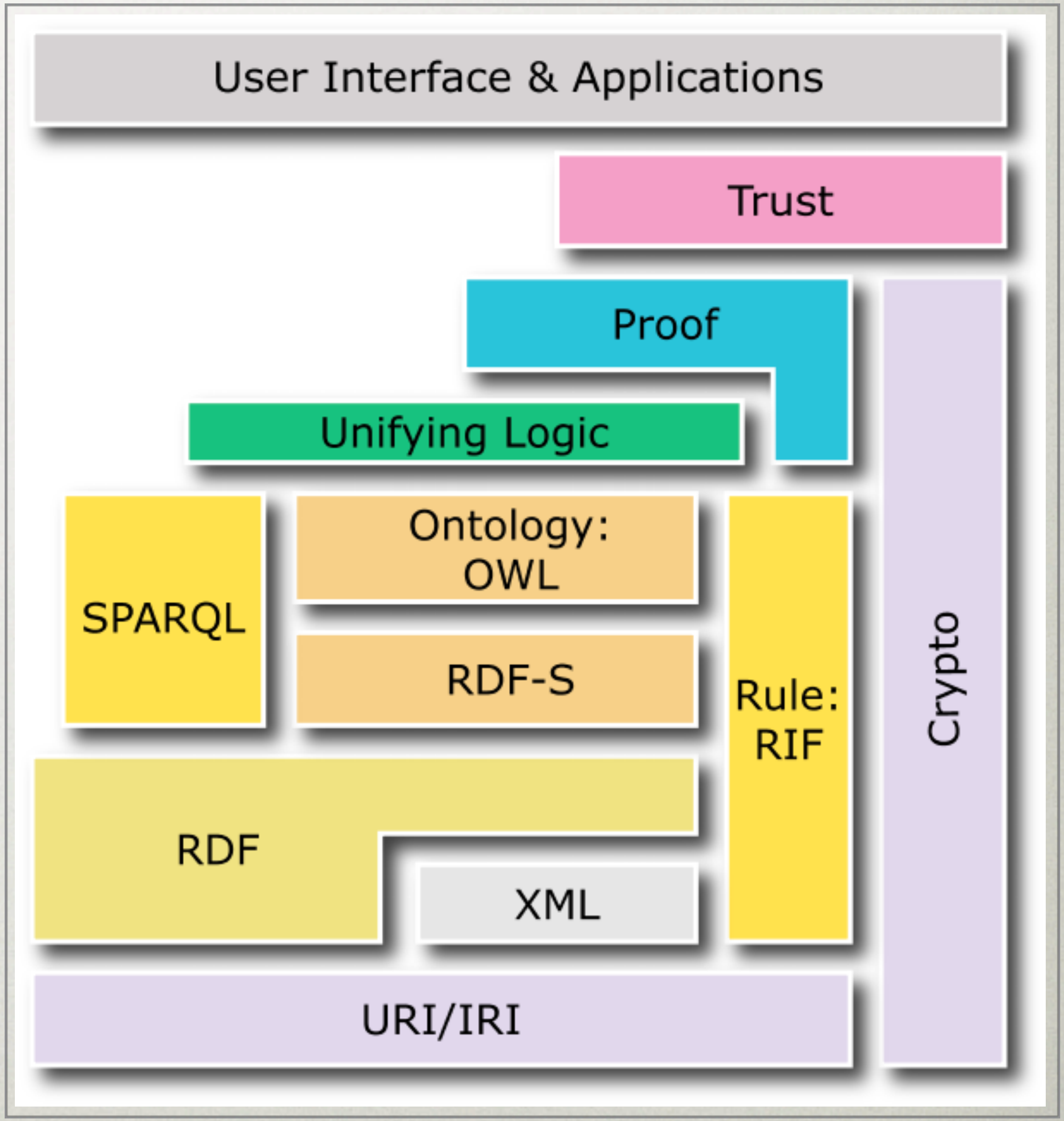
- Systems
  - VIVO: ontology-based institutional research repository
  - PhonemicDB: a multi-organism phenotype-genotype database
  - Fedora Commons, Apache JackRabbit: digital content repository systems

Ontologies

Ontologies



Source: Steve Bratt, <steve@w3.org>

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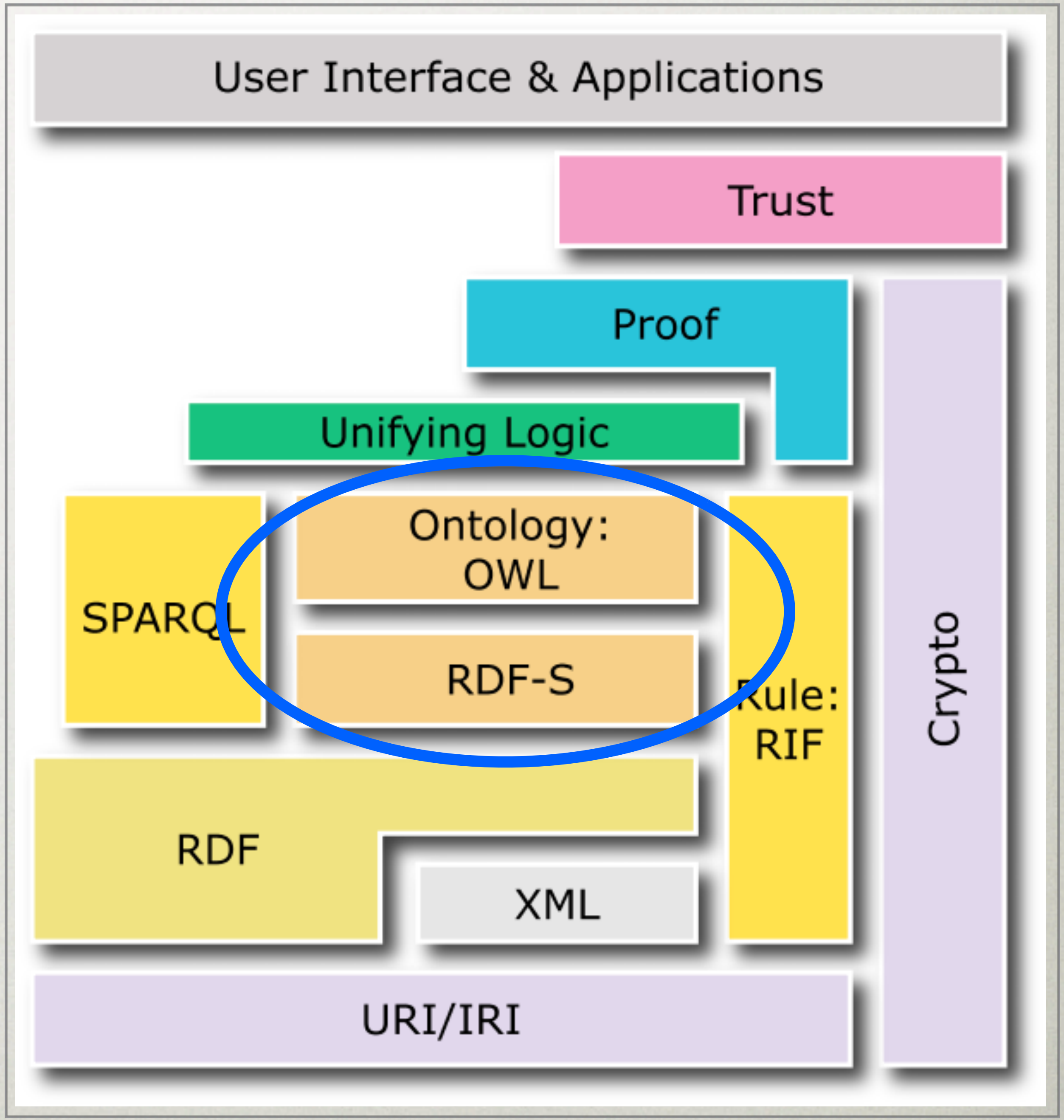

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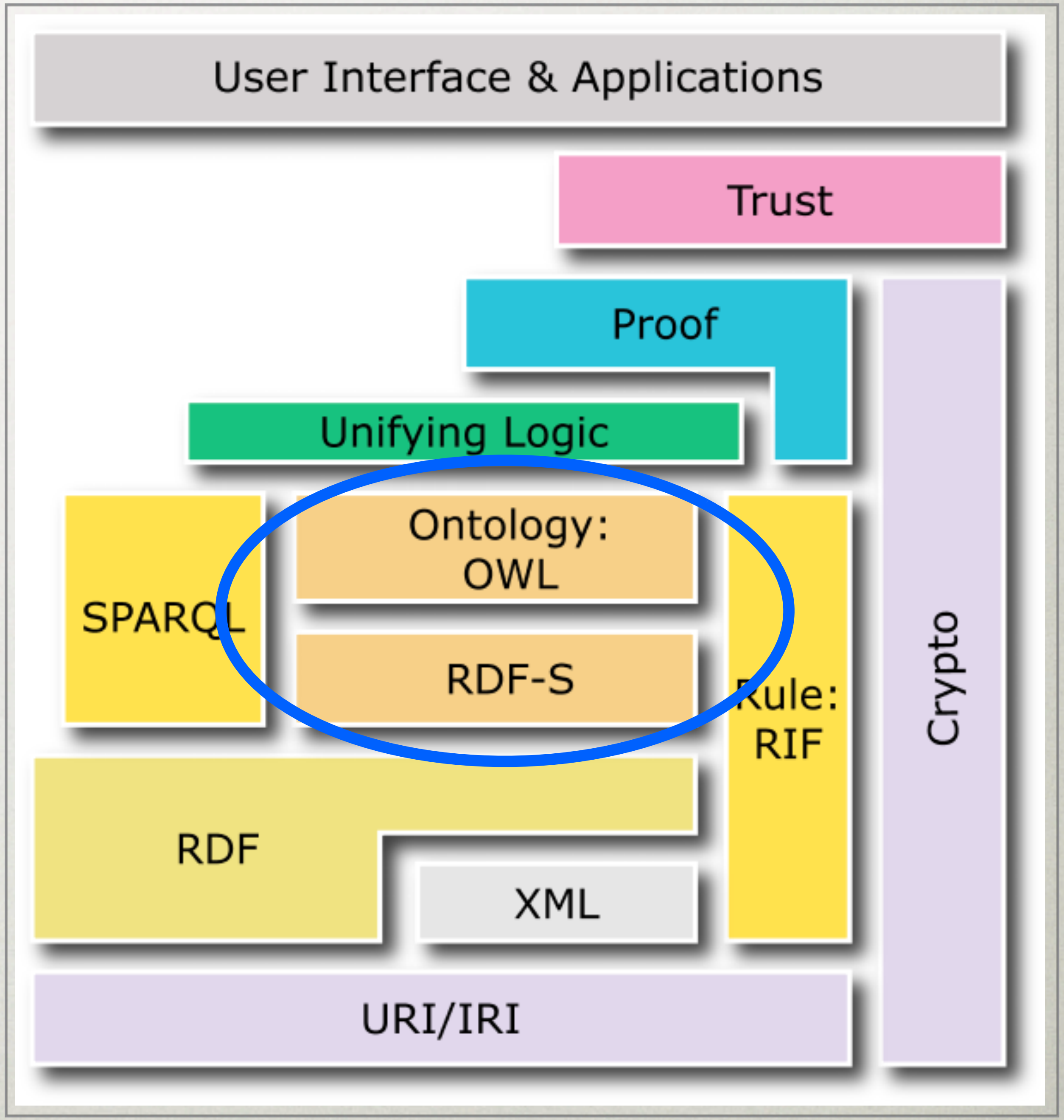
Ontologies

- Expressed in OWL (& RDF Schema)
  - Provides syntax & **semantics** - enables reasoning
  - Expressivity vs decidability



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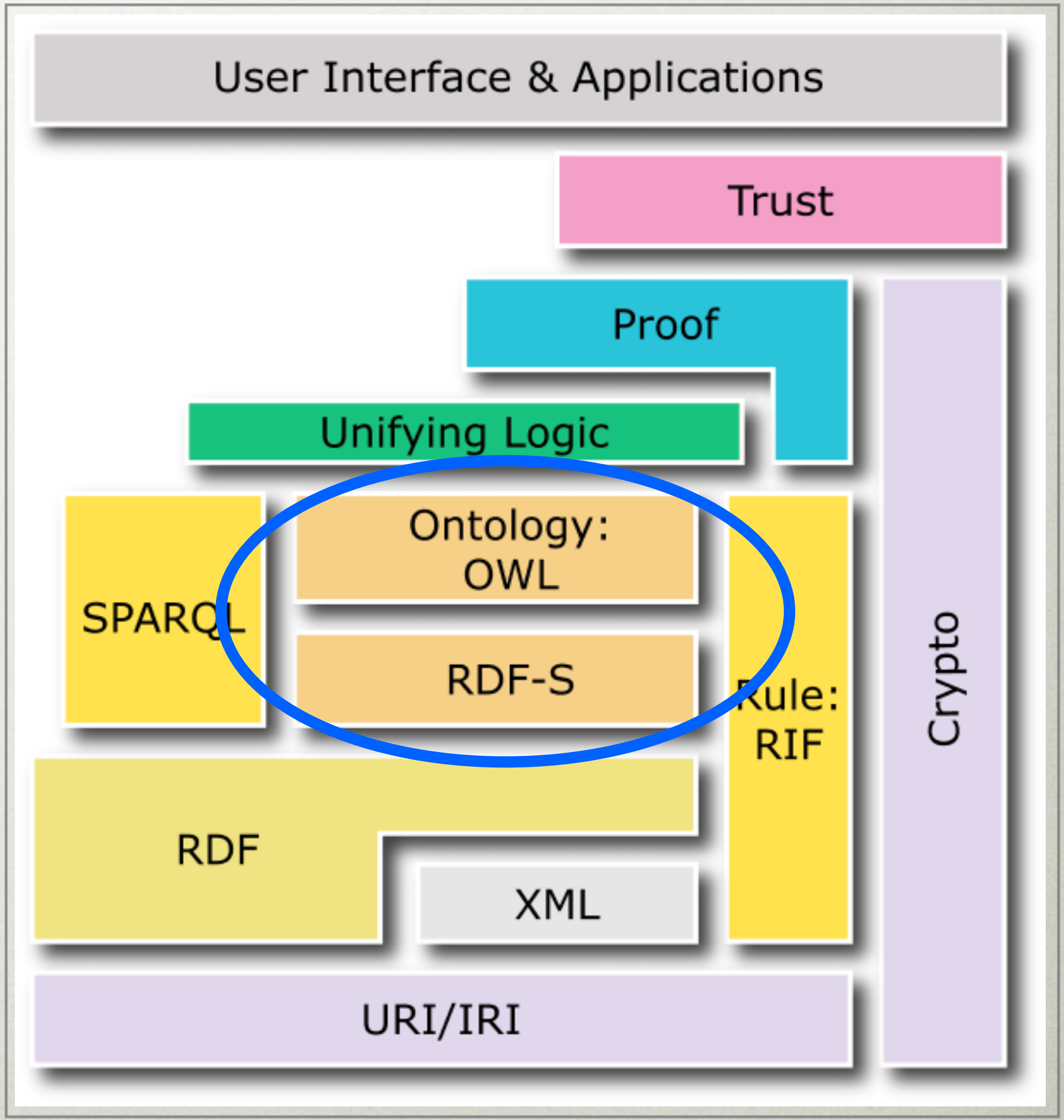

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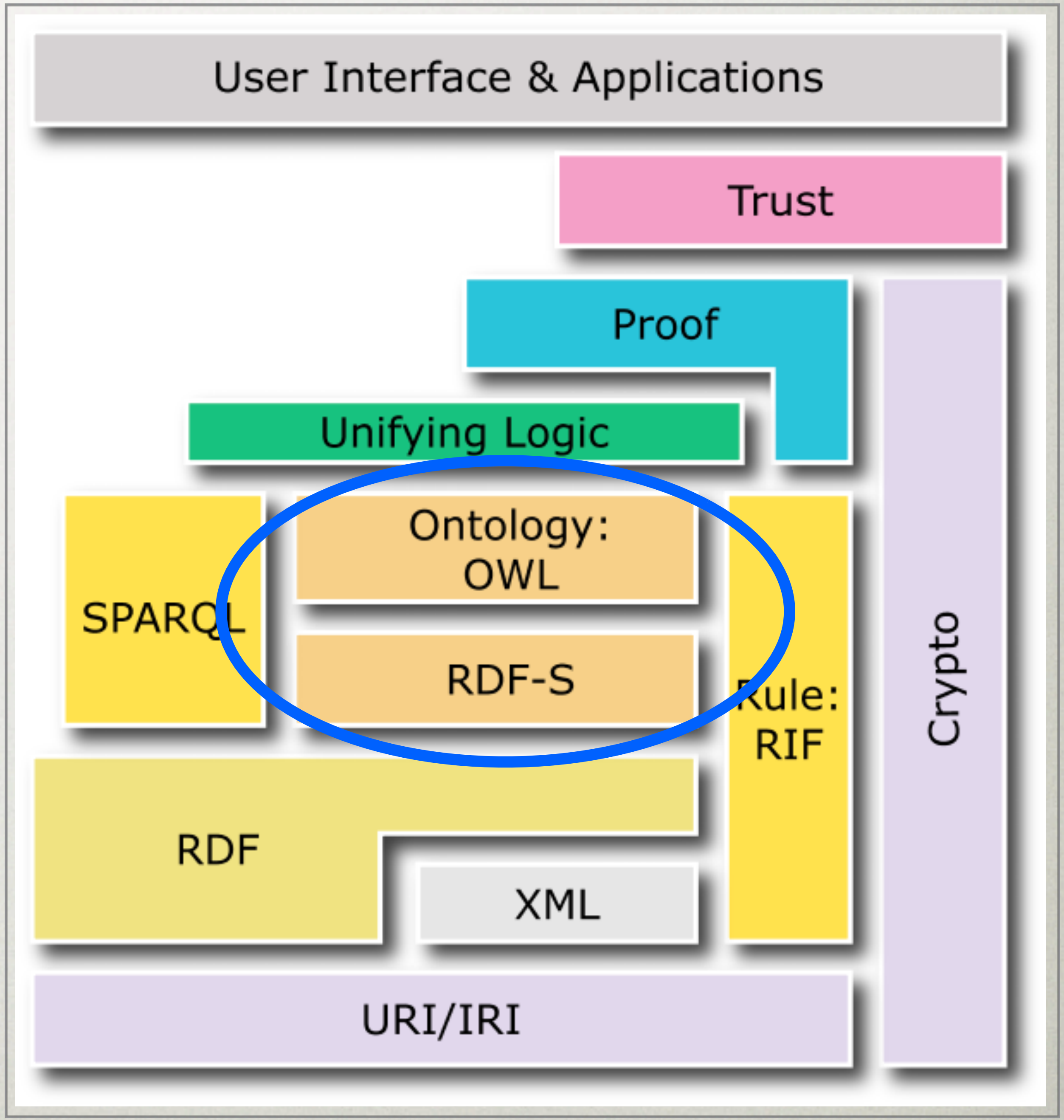
- Designed to be open & interoperable
  - Facilitates sharing, reuse & integration
- Maturing technology stacks
  - APIs, reasoners, triple stores, query engines



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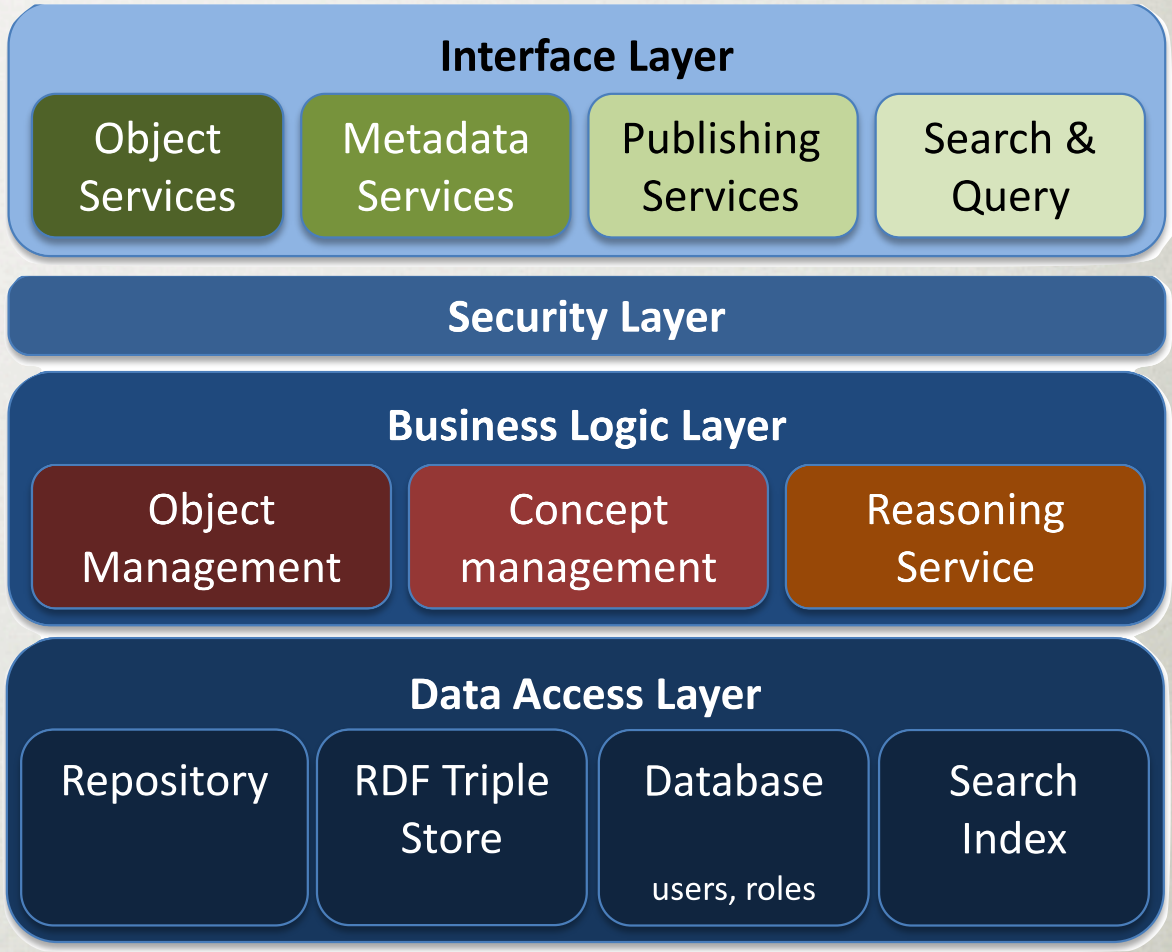
- Ontologies & RDF central to all operations in the data lifecycle
- Aims: improved ***extensibility*** & data ***integration***

The PODD System Architecture

- PODD: **P**henomics **O**ntology **D**riven **D**ata System
- Ontologies the core of the architecture
- Objects represented semantically
  - Semantics (metadata) captured in RDF
- Repository operations on RDF:
  - Ingestion, retrieval, update, query & search, export



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- *Extensibility* through inheritance & versioning
- *Integration* through ontology alignment/ mapping

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Domain concepts	OWL classes
Attributes & relations	OWL restrictions
Domain objects	OWL individuals
Comments, descriptions	OWL/RDF annotations

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- Organizes data *logically*
  - Represented as metadata objects
  - Parent-child relationships
  - References relationships

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- Base ontology: domain independent
- Phenomics ontology: domain specific

PODD Ontologies

Base

$PODDConcept \sqsubseteq \top$

$\top \sqsubseteq \forall\, contains.PODDConcept$

$isContainedBy \sqsubseteq (^{-}contains)$

$PODDConcept \sqsubseteq \leq 1\ isContainedBy$

$\top \sqsubseteq refersTo.PODDConcept$

$$\begin{aligned} Project \sqsubseteq \quad & = 1\ hasProjectPlan \sqcap \\ & \geq 1\ hasInvestigation \sqcap \\ & = 1 hasStartDate \sqcap \\ & \leq 1\ hasPublicationDate \sqcap \\ & \ldots \end{aligned}$$

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& \ldots
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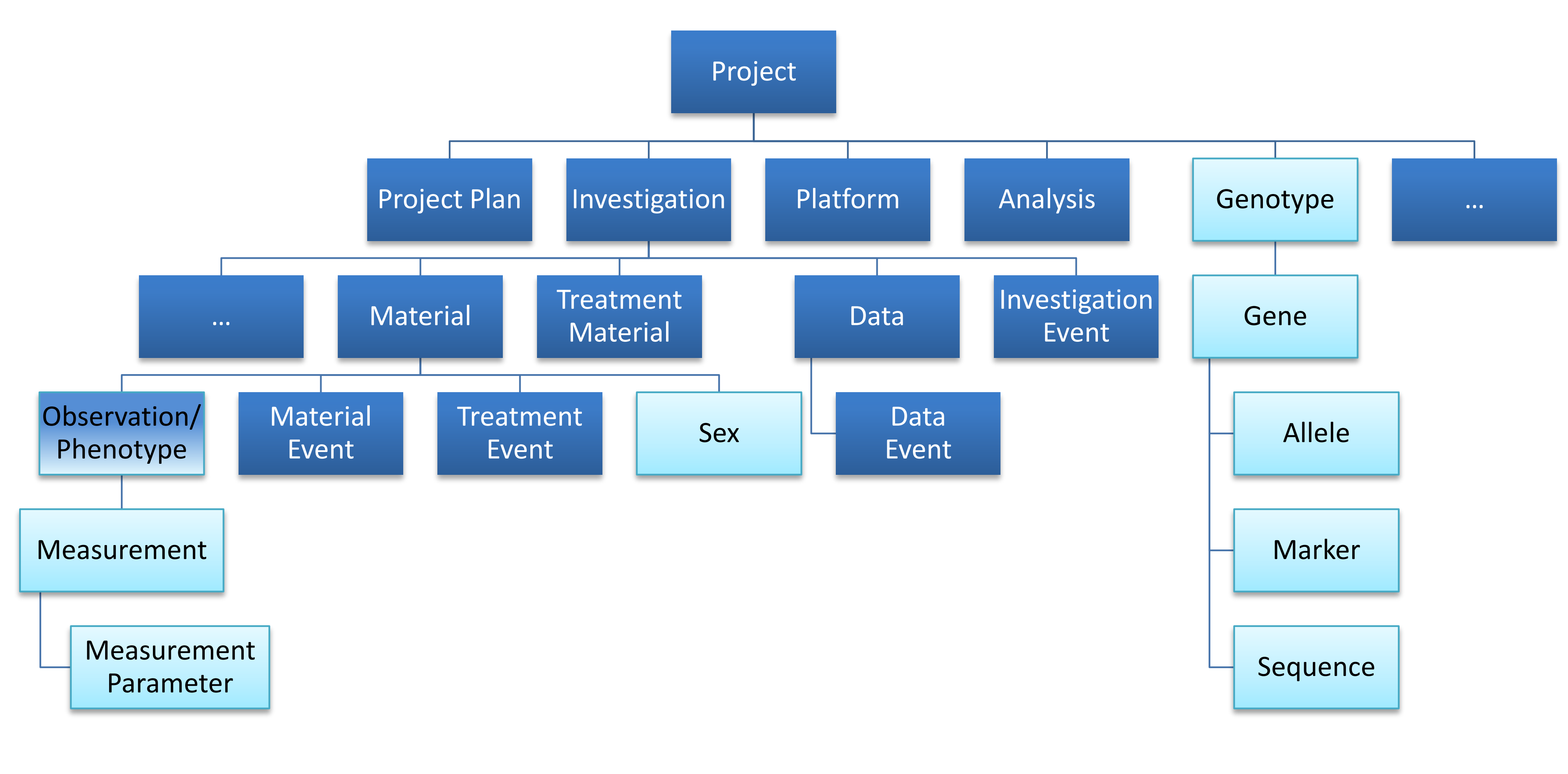
Phenomics

$$
\begin{aligned}
Genotype \sqsubseteq \quad & PODDConcept\ \sqcap \\
& \forall\, hasGene.Gene\ \sqcap \\
& \leq 1\ hasEcotype\ \sqcap \\
& \leq 1\ hasSubspecies\ \sqcap
\end{aligned}
$$

$$
\begin{aligned}
Project \sqsubseteq \quad & \forall\, hasGenotype.Genotype\ \sqcap \\
Material \sqsubseteq \quad & \forall\, hasPhenotype.Phenotype\ \sqcap \\
& \forall\, refersToGenotype.Genotype
\end{aligned}
$$



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- Facilitates extensibility & evolution
    - Ontology reasoning instead of DB integrity constraint checking
    - Data & metadata are all versioned
- System exploration
    - Search, browsing, SPARQL querying, *etc.*

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  - ✓ An ontology-driven architecture for improving extensibility
  - ✓ A set of ontologies as domain models
  - ✓ A system for phenomics data management
- ? Future works
  - ? Ontology/vocabulary mapping
  - ? Annotation of domain objects
  - ? Workflow support

Acknowledgment

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