The Semantic Web, linked data, knowledge graphs

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Big Data for Labour Market Intelligence
For ETF Online capacity development programme
Module 2 – session 7

16 November 2022
Themes

- Diversity is to be welcomed.
- Interoperability is a necessity.
- Technical choices have consequences.

These are big themes, which require broad brush strokes, but the details matter.
Context: Diversity & the Requirement for Interoperability
A View of a Labour Market

Photo: CC BY-SA 3.0, by Vgrigas from Wikimedia
File:Pam Robertson, Grade 12A Teacher at Sinenjongo High School, Joe Slovo Park, Cape Town, South Africa-3320.jpg
# Diversity

<table>
<thead>
<tr>
<th>Actor</th>
<th>Interests</th>
<th>Interact with</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employers</td>
<td>Filling work roles with the right people, recruitment, advancements, payroll …</td>
<td>Employees, applicants, other employers, professional orgs, government …</td>
</tr>
<tr>
<td>Education Organizations</td>
<td>Programme design, course management, assessment, accreditation …</td>
<td>Students, applicants, employers, government, QA orgs…</td>
</tr>
<tr>
<td>Professional Organizations</td>
<td>Frameworks for roles, career paths …</td>
<td>Individuals, employers, education &amp; QA orgs …</td>
</tr>
<tr>
<td>QA Organizations</td>
<td>Accrediting program design and assessment against competencies</td>
<td>Education and Professional organizations</td>
</tr>
<tr>
<td>Government</td>
<td>Economy, legislation, regulation …</td>
<td>All</td>
</tr>
</tbody>
</table>
Key Points

➔ The labour market involves a diversity of different actors, each with their own concerns, practices and uses for data.

➔ Interoperability is facilitated when a common standard is used.

➔ Common standards are possible when there are common concerns, practices and uses for data.

There is not (and should not be) a common standard across the whole of the labour market.

There is, however, still a need to share data.
The technical basis of the semantic web, linked data and knowledge graphs
RDF: Resource Description Framework

- W3C Recommendations from 1999 onwards.
- Early 2000's focus on the "semantic web": ontologies, knowledge representation and logical inferencing.
- 2006 onwards focus on "linked data" and interoperability.
- 2012 onwards focus on "knowledge graphs" and data mining.

RDF: Resource Description Framework

Subject - predicate - Object

Everything can be identified with URIs:


"People think RDF is a pain because it is complicated. The truth is even worse. RDF is painfully simplistic, but it allows you to work with real-world data and problems that are horribly complicated."

Dan Brickley, Schema.org and Google; Libby Miller, BBC (source)
RDF and Semantics

Therefore: Socrates is Greek
Knowledge Graphs

- Add more data
- The object of one statement can be the subject of another.
- Link the statements into a "graph".
- Start answering questions like "how many Greeks are interested in Philosophy"
URIs and Linked Data

- Uniquely identify everything with a URI

Image is the Google "knowledge panel" from a search for Socrates.
URIs and Linked Data

- Uniquely identify everything with a URI
- Allows disambiguation
  - Q: when is Socrates not Greek?
  - A: when Socrates is Sócrates <https://www.wikidata.org/entity/Q102331>, not Σωκράτης: <https://www.wikidata.org/entity/Q913>

Image is the Google "knowledge panel" from a search for Socrates.
## URIs and Linked Data

- Uniquely identify everything with a URI
- Allows disambiguation
  - Q: when is Socrates not Greek?
  - A: when Socrates is Sócrates
- Can follow the link for more data
- Human language independent

Image is the Wikidata entry for Socrates name in various languages.
Recap: Standards and interoperability

If organizations are using similar data for similar things, and they want to cooperate, they can use the same data standard to share data (interoperate)

- HR department can send job vacancy data to Recruiting partner
- Publisher can supply data about learning resources to a school

Within each domain IT systems implement the relevant standards.

BUT: different standards are appropriate for different domains

- HR standard to describe salaries and skills required for job
- LMS standard to describe courses and learning outcomes
Different standards in RDF use the same meta-model (i.e. statements as triples involving subject - predicate - object, identified with URLs.)

Here green, orange and blue statements represent data from three different RDF standards.
RDF allows mixing and matching

Terms from different standards can be used together.

RDF has standards to assert equivalence between terms.
RDF allows mixing and matching

- Same knowledge graph as before, but created by mixing and matching terms from different RDF standards
Key Points

RDF:

➔ Stable, mature, open standards framework.
➔ Foundation of the semantic web / linked data / knowledge graphs
➔ Allows you to infer information that is not explicitly in the data
➔ Decentralized: link between datasets
➔ Large, public datasets are possible
➔ Harmonization on a common meta-model: interoperability between different domain standards
Credential Engine: Credential Transparency, CTDL and the Credential Registry
Credential Engine & What It Does

**Our Mission:** Credential Engine is a non-profit whose mission is to map the credential landscape with clear and consistent information, fueling the creation of resources that empower people to find the pathways that are best for them.

**Our Vision:** We envision a future where millions of people worldwide have access to information about credentials that opens their eyes to the full range of opportunities for learning, advancement, and meaningful careers.

**How we accomplish our Mission and Vision:**

- Building common infrastructure and language
- Collaboration
- Empowerment
Credential Engine’s open technologies

Credential Transparency Description Language (CTDL)

Linked open data schema that describes over 800 characteristics of credentials, skills, jobs, and providers.

CTDL Publishing Tools

Providers use the API or any of the publishing system tools to convert information to CTDL, publish to the Registry, and create globally unique identifiers (CTIDs).

Credential Registry

The Registry collects and connects credential, skill, and job data described with CTDL as a linked open data graph to power tools and applications, including the Credential Finder.

Credential Finder

A tool to view and explore the information stored in the Registry.

Technical site: https://credreg.net
Credential Transparency Description Language (CTDL)

An openly licensed common language modeled on World Wide Web Consortium (W3C) specifications for the semantic web to enable transparency and comparability of credential and competency information.

Three Schemas:
1. **CTDL** - Credentials and adjacent classes
2. **CTDL-ASN** - Competencies
3. **QDATA** - Quantitative Data

CTDL Handbook via https://credreg.net
### Certification

**Definition:** Time-limited, revocable, renewable credential awarded by an authoritative body for demonstrating the knowledge, skills, and abilities to perform specific tasks or an occupation.

**Comment:** Certifications can typically be revoked if not renewed, for a violation of a code of ethics (if applicable) or proven incompetence after due process. Description of revocation criteria for a specific Certification should be defined using Revocation Profile.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>URI:</td>
<td><a href="https://purl.org/ctdl/terms/Certification">https://purl.org/ctdl/terms/Certification</a></td>
</tr>
<tr>
<td>Shorthand URI:</td>
<td>cterms:Certification</td>
</tr>
<tr>
<td>Label:</td>
<td>en-US: Certification</td>
</tr>
<tr>
<td>Definition:</td>
<td>en-US: Time-limited, revocable, renewable credential awarded by an authoritative body for demonstrating the knowledge, skills, and abilities to perform specific tasks or an occupation.</td>
</tr>
<tr>
<td>Comment:</td>
<td>en-US: Certifications can typically be revoked if not renewed, for a violation of a code of ethics (if applicable) or proven incompetence after due process. Description of revocation criteria for a specific Certification should be defined using Revocation Profile.</td>
</tr>
<tr>
<td>Type of Term:</td>
<td>rdfs:Class</td>
</tr>
<tr>
<td>Status:</td>
<td>vs:stable</td>
</tr>
<tr>
<td>Subclass Of:</td>
<td>cterms:Credential, cterms:Credential</td>
</tr>
</tbody>
</table>
Example data from the Credential Finder

A.A.S. in Dental Assisting
Ivy Tech Community College of Indiana
Last updated: Dec 22, 2020

About this Credential
Basic information about the Credential

The Dental Assisting program at Ivy Tech is taught by instructors who have all worked as dental assistants in the field. Students will get to study in a state-of-the-art facility learning a variety of skills involving radiography, dental materials, infection control, chairside, and general dentistry as well as dental specialties. For more information about dental assisting, visit the American Dental Assistant's Association website. The Dental Assisting program is a selective admission program. When you apply to the college, you would be accepted into the Healthcare Specialist program with a concentration in Dental Assisting while you complete the prerequisite requirements. The Dental Assisting program accepts a limited number of students each year and there is a separate application process.

Related Organization(s)
Organizations that own, offer, or perform other services related to the Credential

Owned and Offered By
Ivy Tech Community College of Indiana

Connections
Relationships between the Credential and other data in the Registry

Related Competencies
Teaches 50 Competencies

All of the information about this credential is directly from credentialfinder.org
Example data from the Credential Finder

All the information about this credential is directly from the Credential Registry as JSON-LD

A.A.S. in Dental Assisting

Registry Info

Raw Metadata:

```json
{
   "@context": "https://credreg.net/ctdl/schema/context/json",
   "@id": "https://credentialengineregistry.org/resources/ce-dd1df89c-5ed7-43ee-be8e-44e799ca6f13",
   "@type": "ceterms:AssociateDegree",
   "ceterms:ctid": "ce-dd1df89c-5ed7-43ee-be8e-44e799ca6f13",
   "ceterms:name": {
      "en-US": "A.A.S. in Dental Assisting"
   },
   "ceterms:ownedBy": [
      "https://credentialengineregistry.org/resources/ce-1abb6c52-0f8c-4b17-9f89-7e9087673106"
   ],
   "ceterms:requires": [
      {
         "@type": "ceterms:ConditionProfile",
         "ceterms:name": {
            "en-US": "Credit Hours"
         },
         "ceterms:assertedBy": [
            "https://credentialengineregistry.org/resources/ce-1abb6c52-0f8c-4b17-9f89-7e9087673106"
         ]
      }
   }
}
```
Key Takeaways

➔ Credential Engine is a not-for-profit organization aiming to collaborate in improving the outlook for education and employability.

➔ CTDL is an RDF-based language for describing Credentials (qualifications) and things related to them.

➔ Data using CTDL can be stored in registries such as the Credential Registry.
CTDL and Verifiable Credentials (briefly)
W3C Verifiable Credentials

- Standard for tamper evident assertions of an individual's achievements.
  - RDF Data Model [https://www.w3.org/TR/vc-data-model/](https://www.w3.org/TR/vc-data-model/)
  - Protocols for privacy-respecting issuing of this data.
- The educational examples in the standard are very scant on detail.
- A W3C Community Group has been looking at education use cases.
- Basis of 1EdTech(*) OpenBadges V3

(* was IMS)
W3C VC Example

```
{
   "@context": [
      "https://www.w3.org/2018/credentials/v1",
      "https://www.w3.org/2018/credentials/examples/v1"
   ],
   "id": "http://example.edu/credentials/3732",
   "type": ["VerifiableCredential", "UniversityDegreeCredential"],
   "issuer": "https://example.edu/issuers/565049",
   "issuanceDate": "2010-01-01T00:00:00Z",
   "credentialSubject": {
      "id": "did:example:ebfeb1f712ebc6f1c276e12ec21",
      "degree": {
         "type": "BachelorDegree",
         "name": "Bachelor of Science and Arts"
      }
   }
}
```

It is not enough to just to say that you have a degree.
CTDL in a W3C VC

```json
"credentialSubject": {
  "id": "did:example:ebfeb1f712ebc6f1c276e12ec21",
  "achievement": [
    {
      "id": "res:ce-49247727-7cbd-4f0e-8179-e51036d1f14a", // the degree achieved
      "type": "ceterms:BachelorDegree",
      "ceterms:name": "{"en-US": "Bachelor’s Degree"},
      "ceterms:requires": [ "res:ce-84958217-1323-46fe-87c8-652120800190",
        "res:ce-8aa6b5b5-095c-4152-89b2-06438129002c" ]
    },
    {
      "id": "res:ce-84958217-1323-46fe-87c8-652120800190", // List of competencies acquired
      "type": "ceasn:Competency",
      "ceasn:codedNotation": "EXKSCI1",
      "ceasn:competencyLabel": "Knowledge of Science",
      "ceasn:competencyText": "Demonstrate a good knowledge of science..."
    },
    {
      "id": "res:ce-8aa6b5b5-095c-4152-89b2-06438129002c",
      "type": "ceasn:Competency",
      "ceasn:codedNotation": "EXKART1",
      "ceasn:competencyLabel": "Knowledge of Arts",
      "ceasn:competencyText": "Demonstrate a good knowledge of arts..."
    }
  ]
}
```

In JSON-LD playground
https://tinyurl.com/2twaddyv
Key Takeaways

➔ CTDL can be used with other RDF languages to provide rich data about the educational and occupational achievements of individuals, a personal knowledge graph

➔ which can be compatible with data from other sources, such as educational offers, job adverts etc.

For more details see our discussion document: CTDL terms and Registry data in Verifiable Credentials (VC / Open Badges 3.0 / CLR 1.1)
Thank You

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