THE UNIVERSITY OF WESTERN AUSTRALIA

NTLP

UWA System Health Lab
systemhealthlab.com

An ontology for maintenance procedure documentation to support Industry 4.0 software applications

TLP Community of Interest Workshop,
2021 Model-Based Enterprise Summit,
NIST, April 12 - 16, 2021

Presented By:
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WO number:	
Completed by:	
Date completed:	

2M Mech Insp Leak Detection Pumps [equipment ID & model ID omitted]

Reason for maintenance and relevant background information
[reason for maintenance omitted]

Tools, equipment and materials required		
Item/Material (Items/materials not already on task list	Un	Quantity

Reference documentation	
Document ref.	Description

Specific known job hazards / Previous safety event lessons
• Harm to persons by electrical, mechanical and chemical impacts • Guards of moving parts must not be removed when the pumps are running. [additional hazards omitted]

Document history		
Date	Changes Made	By who

Approval		
Approval Date	Owner Role	Name
Approval Date	Reviewer Role	Name

If you feel the execution steps below do not meet the intent of this PM or is missing important steps/checks then please provide feedback to the relevant engineer.

Work Execution				
Task	Job Description	Limits	Required Action	Corrective Action Taken
1	Check that suction and discharge points are clear of obstruction and supply	Obstruction free	Check that suction & discharge valves are clear Check that suction & discharge piping are clear	

If you feel the execution steps below do not meet the intent of this PM or is missing important steps/checks then please provide feedback to the relevant engineer.

Work Execution			
Task	Job Description	Limits	Corrective Action Taken
1	Ensure natural gas equipment / system is isolated		
2	Replace natural gas min flow line [equipment ID omitted].  [Image of equipment omitted]  [Image of equipment omitted] Note: valve is welded into in to pipework		
3	NDT welds		
4	Repaint piping valve as required		

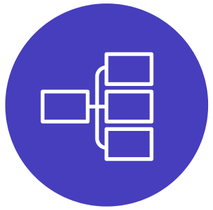
In the event that you are unable to complete all the corrective work please escalate to your supervisor in order to agree a course of action.

EXAMPLE MAINTENANCE PROCEDURE DOCUMENT FROM AN AUSTRALIAN PROCESS PLANT

Background

Current Problems

Documents are diverse in **content** (i.e. different engineers write procedures in different ways)

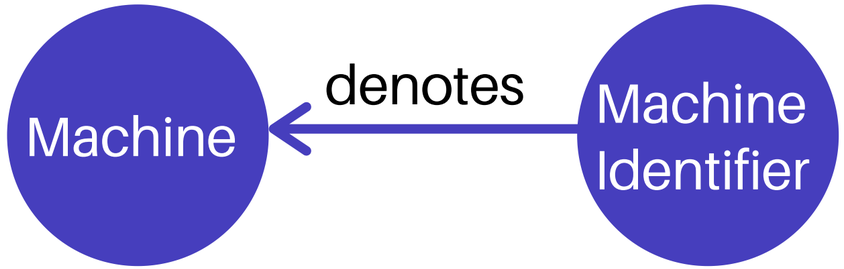


Documents are diverse in **structure** (i.e. in PDF templates that change over time)

What is an ontology?

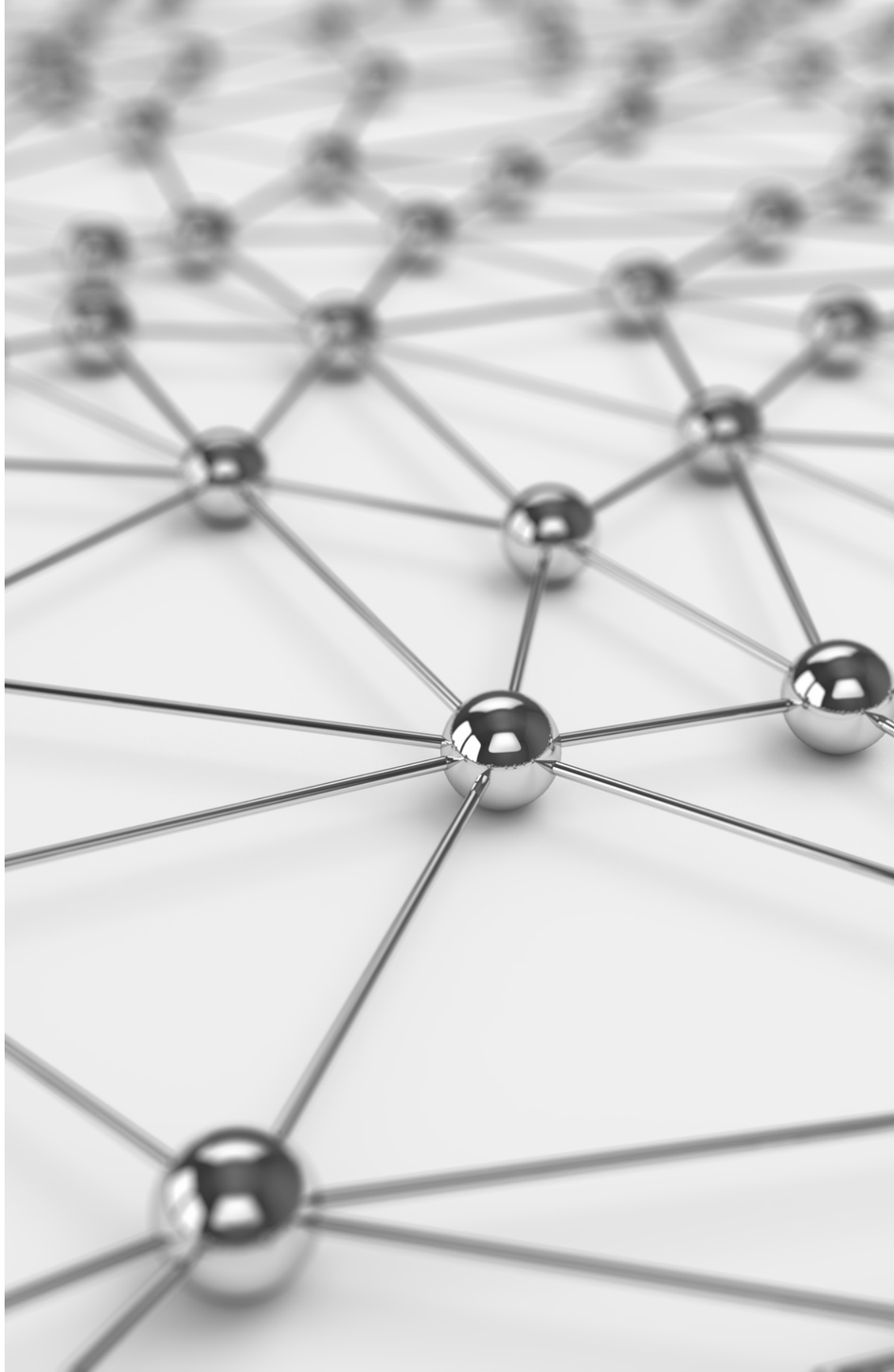
*"'a **formal, explicit** specification of a **shared** conceptualisation of concepts within a domain."* [1]

In essence, data is assigned **classes** (or concepts) and place (formal and explicit) restrictions on the **relationships** between those classes.

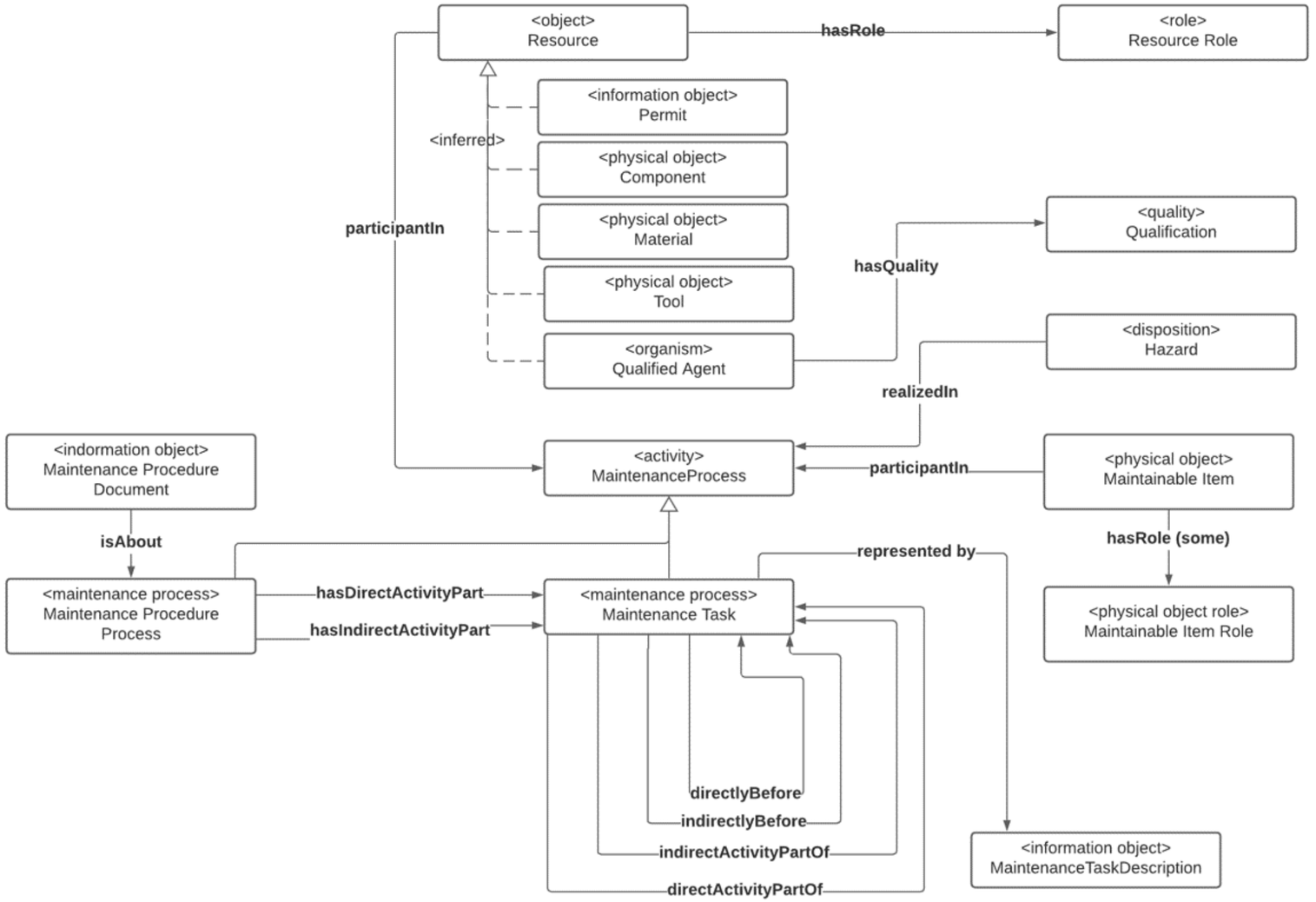


Note that the relationship "denotes" comes from the **shared** information artefact ontology and has its own **definition.** [2]

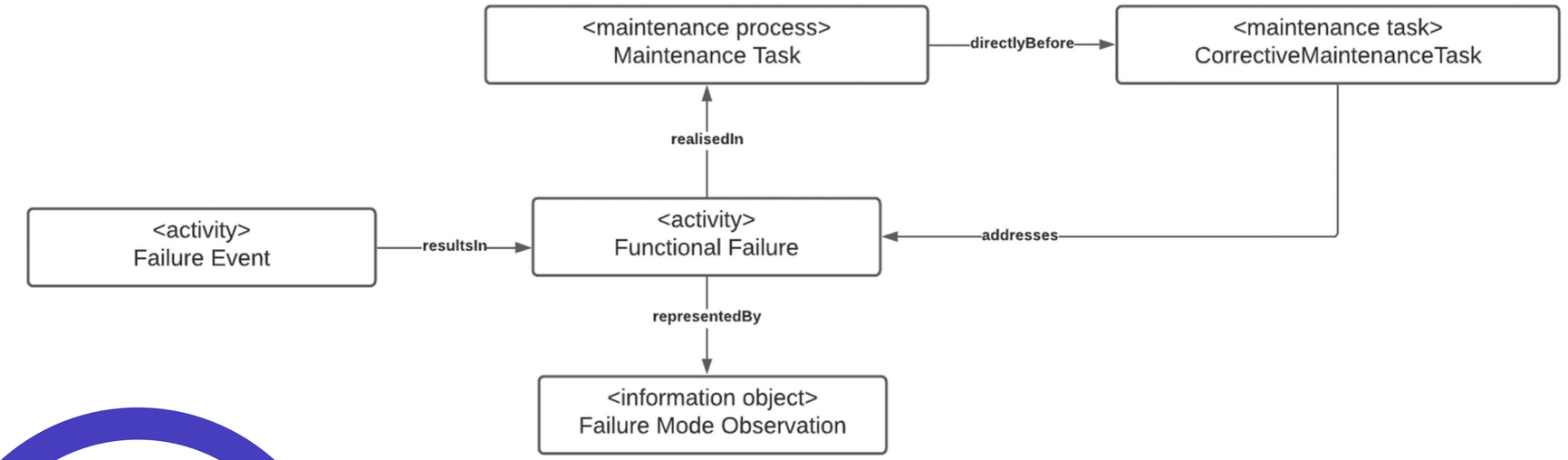
The use of these **definitions** enables **reasoning.**



Module 1: The static procedure ontology



Module 2: The corrective maintenance task ontology

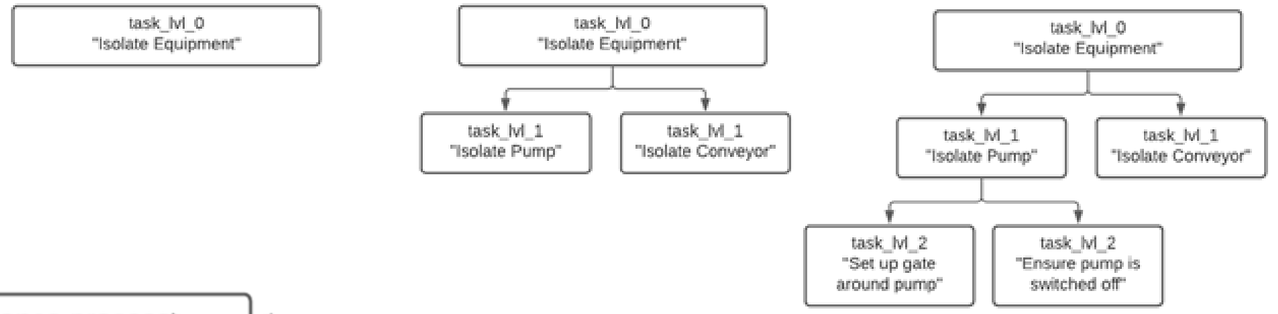


Work Execution			
Task	Job Description	Limits	Corrective Action Taken
1	Ensure natural gas equipment / system is isolated		
2	Replace natural gas min flow line [equipment ID omitted]. [Image of equipment omitted]		

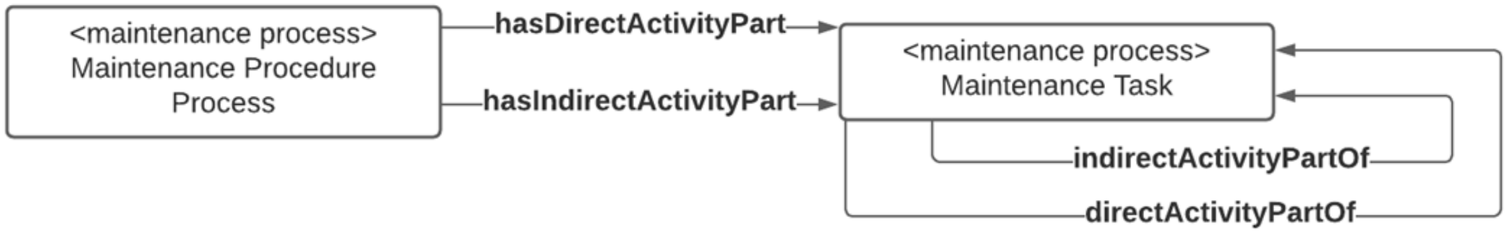
Special Feature 1: The generic task hierarchy

```
prefix po: <http://www.example.org/static-procedure-ontology#>
prefix iso: <http://test.conm/iso/15926/part14/>
select ?taskInProcedure ?parentTask
where {
    ?taskInProcedure po:indirectActivityPartOf po:procedure_process_001 .
    ?taskInProcedure po:directActivityPartOf ?parentTask .
}
```

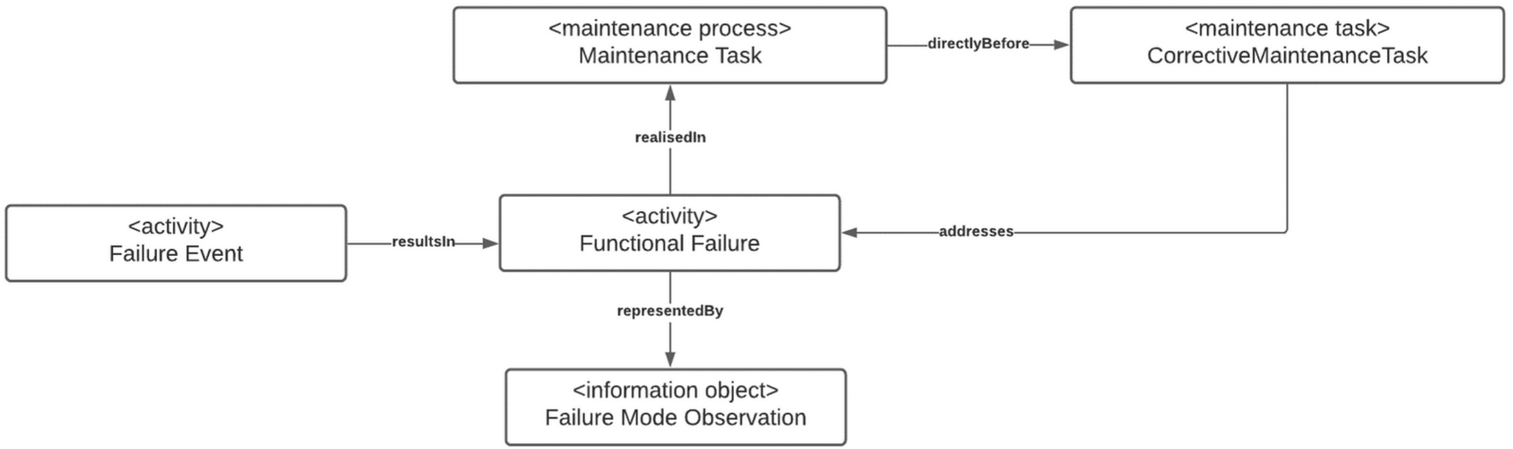
Example data



Ontology component



Special Feature 2: Corrective actions and limits as failure modes



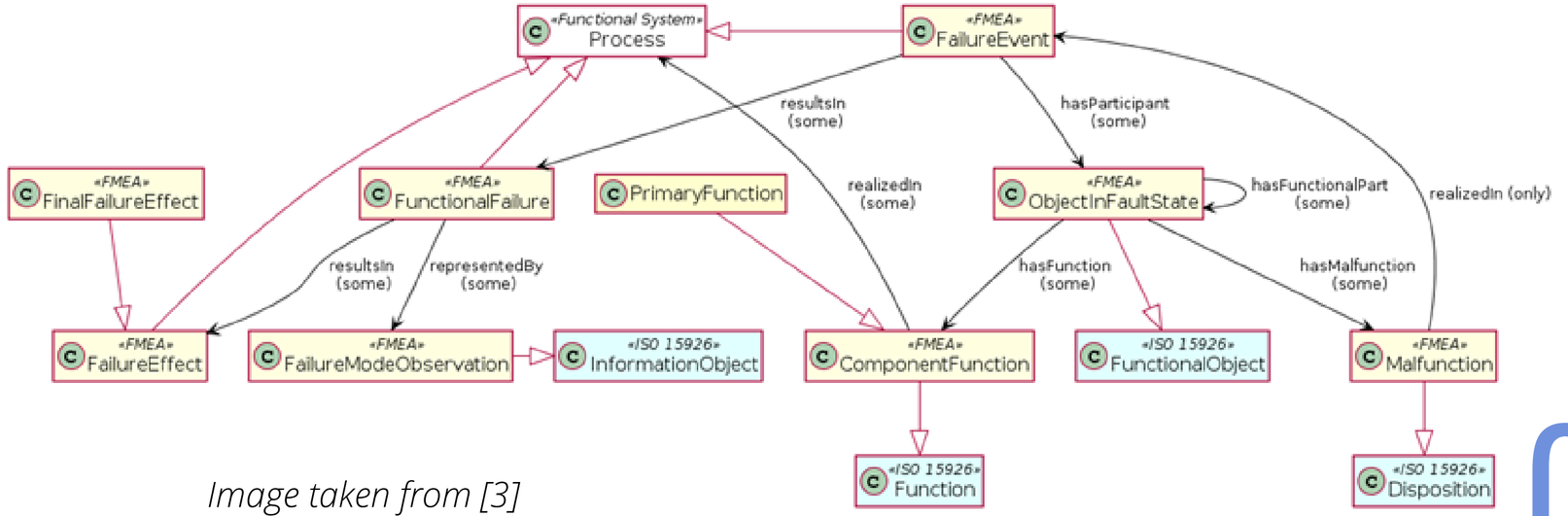


Image taken from [3]

The role of ontologies in TLP

1

SHARED VOCABULARY

Ontologies promote "shared" names for concepts in a domain. Essential for TLP tasks where a tagging schema is required such as in Named Entity Recognition.

2

CONCEPT INTERPERETATION

The formal nature of ontologies ensure that different parties (i.e. humans and machines in TLP) interpret the meaning of concepts in the same way.

3

FACT INFERENCE

Reasoning services enable ontology users to infer new facts from data. For example, in a particular context, a "tool" can become a "resource".

4

DATA INTEGRATION

Ontologies enable us to integrate concepts that may appear disparate. This was the case with Functional Failures in the procedure ontology. This means the TLP pipelines could draw from many data sources to make decisions.

The role of TLP in ontologies

1

DATA POPULATION

TLP algorithms that can "tag" large sets of data according to a concept schema can be used to populate an ontology. For example, a TLP algorithm may be able to recognise a "tool" from task text. This tool can be stored as a "resource" in the ontology.

2

CONVERSATIONAL INTERFACES

Ontologies and TLP can be used **together** to create natural language question answering systems (i.e. a chatbot for maintenance).

Resources

ONTOLOGY EXPLAINED BLOG

https://ontology-explained.com/

THE INDUSTRIAL ONTOLOGIES FOUNDRY

https://www.industrialontologies.org/

MY PHD RESEARCH

https://caitlin2694.github.io/

References

THIS PRESENTATION'S TEMPLATE, IMAGES AND ICONS ARE FROM THE **CANVA** ONLINE DESIGN PLATFORM (https://www.canva.com/).

[1] R. Studer, V. R. Benjamins, and D. Fensel, “Knowledge engineering: principles and methods,”Data & knowledge engineering, vol. 25, no. 1-2, pp. 161–197, 1998.

[2] OBO Foundry. (2021). Information Artifact Ontology
:An ontology of information entities. http://www.obofoundry.org/ontology/iao.html

[3] Hodkiewicz, M., Klüwer, J. W., Woods, C., Smoker, T., & French, T. (2020). Digitalization and reasoning over engineering textual data stored in spreadsheet tables. IFAC-PapersOnLine, 53(3), 239-244.