HOW TO BUILD A SOFTWARE AGENT?

Ph.D. Esteban Guerrero
esteban@cs.umu.se

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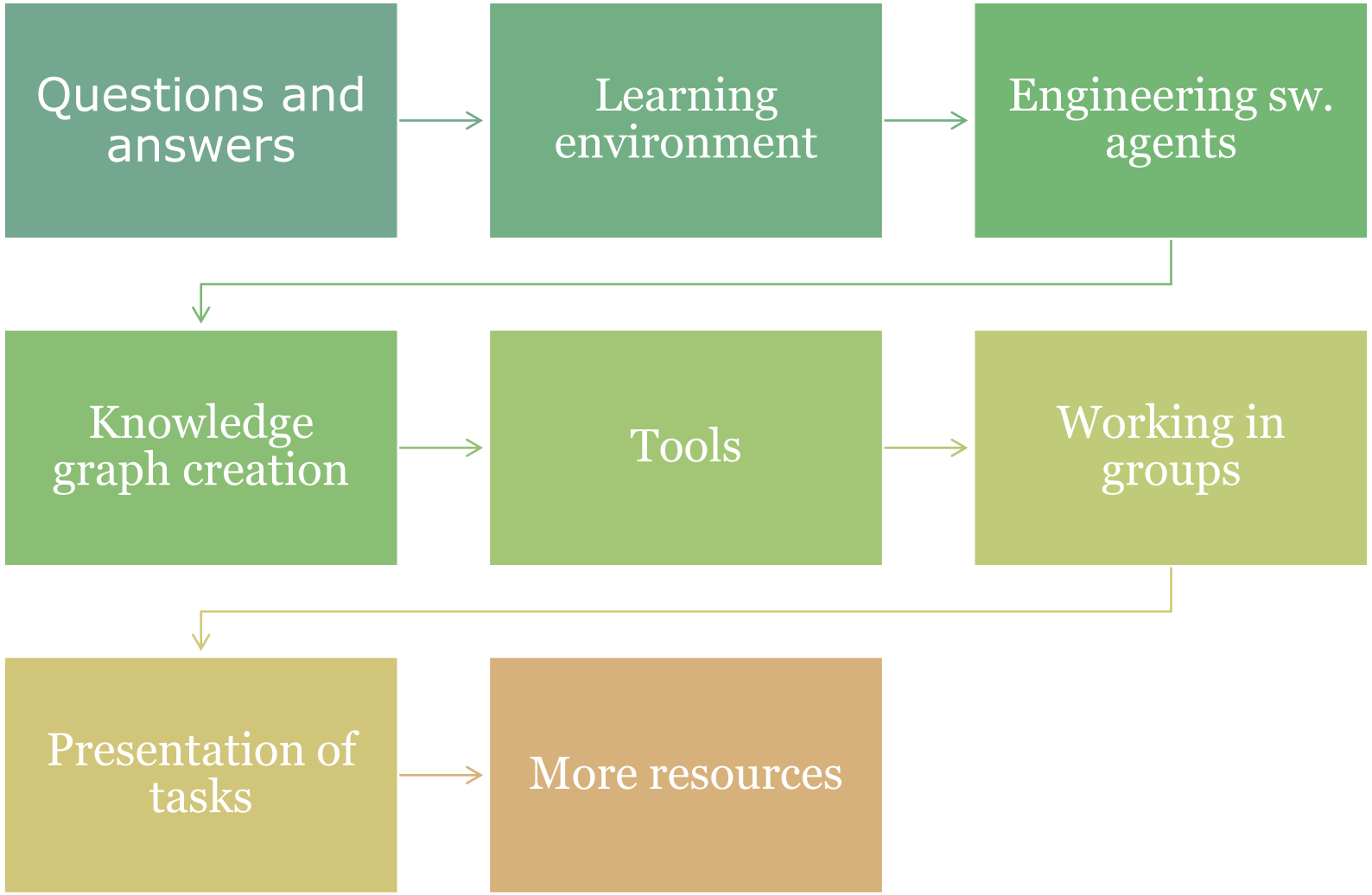
CONTENT


Questions and answers
Learning environment
Engineering sw. agents
Knowledge graph creation
Tools
Working in groups
Presentation of tasks
More resources

QUESTIONS?

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BEFORE START…

- Any question about the lecture?
- Any suggestion or petition?

Go to **www.menti.com** and use the code **63 46 25 7**

ABOUT OUR LEARNING ENVIRONMENT

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ESTEBAN GUERRERO

- Current position: Researcher
- Topic: Formal and applied methods of Artificial Intelligence for autonomous multi-agents systems
- Education:
  - Ph.D. in Computing Science, Umeå University. Sweden.
  - Ph. Lic. in Computing Science, Umeå University.
  - M.Sc. Master's degree in Computer Science, Malmö University. Sweden.
  - M.Sc. Master's studies in Telematics Engineering, University of Cauca. Colombia.
  - B.Eng. Bachelor degree in Electronic and Telecommunications Engineering, University of Cauca. Colombia.
- Industrial experience:
  - 4 years R&D engineer in a telecommunications company.

STAR-C: Sustainable behaviour change for health supported by person-Tailored, Adaptive, Risk-aware digital Coaching in a social context

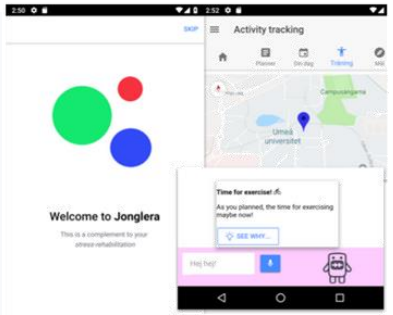
Partners: **Department of Computing Science**, **Department of Epidemiology and Global Health**, **Department of Culture and Media Studies** and **Department of Social Work** Umeå University

Project period:
2018-12-01 – 2024-11-30

Funding agency:
FORTE

Budget:
14'940.000 SEK (Swedish krona)

Research subject: Public health and community medicine

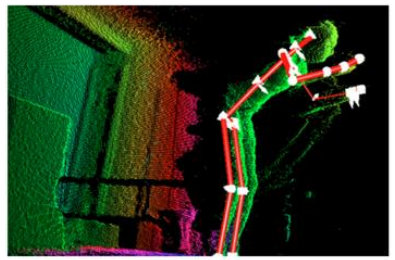


Jonglera - an agent-based coaching system for stress management

Partners: **Computing Science** dept. and dept. of **Psychology**, Umeå University
Key words: multi-agent system; argumentation theory; coalitions; stress; psychology
2017-2019

Autonomous adaptation of software agents in the support of human activities

Partners: **Computing Science** dept. Umeå University Sweden and **Human Performance and Technology Lab**., National Taiwan University, Taiwan



Intelligent skiing coach

Partners: **Computing Science** dept. and **Umeå School of Sport Sciences**, Umeå University
Key words: 3D camera; machine learning; multi-agent system; biomechanics
2017-

Towards a *trusted* intelligent coach

Partners: **Computing Science** dept. and **Umeå School of Sport Sciences**, Umeå University
Key words: 3D camera; machine learning; multi-agent system; biomechanics
2018-

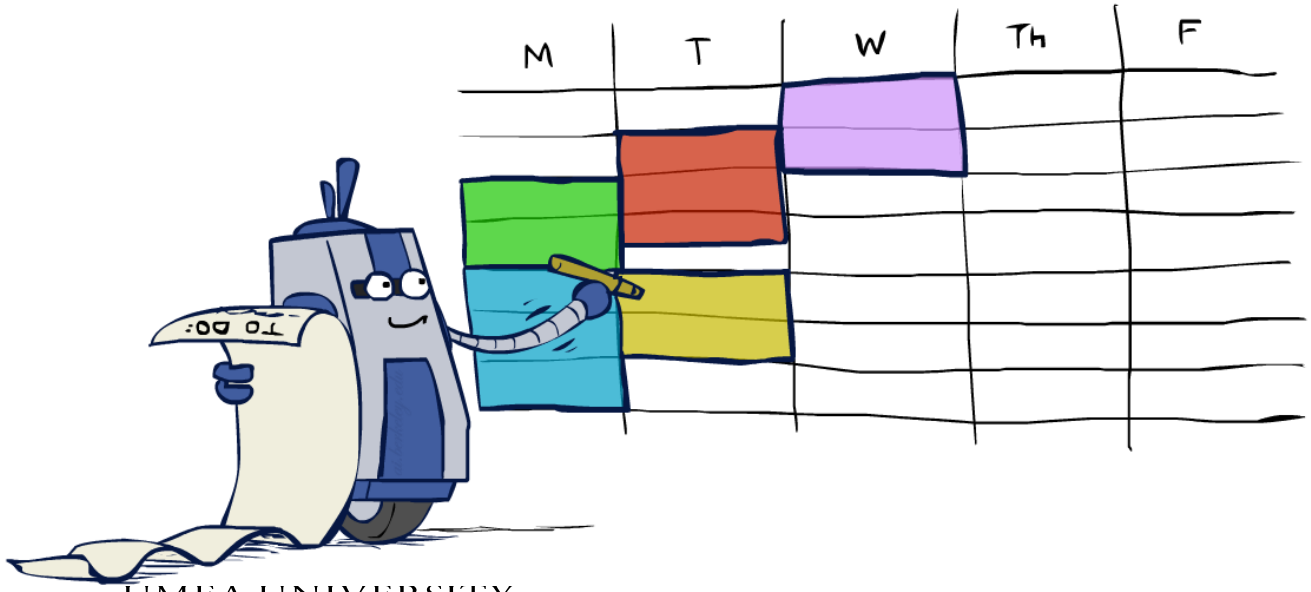
Mobile sports science platform

Partners: **Computing Science** dept. and **Umeå School of Sport Sciences**, Umeå University
Key words: mobile application; multi-agent system; sensors;
2016-2017

https://people.cs.umu.se/esteban/

OUR COMMUNICATIONS

- Top ~~5~~ 4:
  1. Email esteban@cs.umu.se
  2. Canvas tools, chat, discussions, etc.
  3. UmU Play video comments (https://play.umu.se)
  4. YouTube video comments
  5. ~~Scheduled office visits~~



Artwork: Ketrina Yim, UC Berkeley CS188 Artificial Intelligence.

WHAT ABOUT YOU?

What experience in software tools do you have?

Open https://www.menti.com/

Code 3093764

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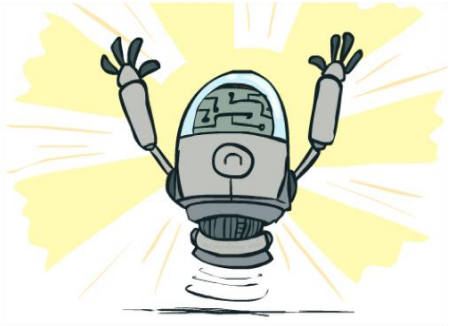
Artwork: Ketrina Yim, UC Berkeley CS188 Artificial Intelligence.

OUR AGREEMENTS

Social

- Respect
- Dialogue
- Inclusiveness



COVID related

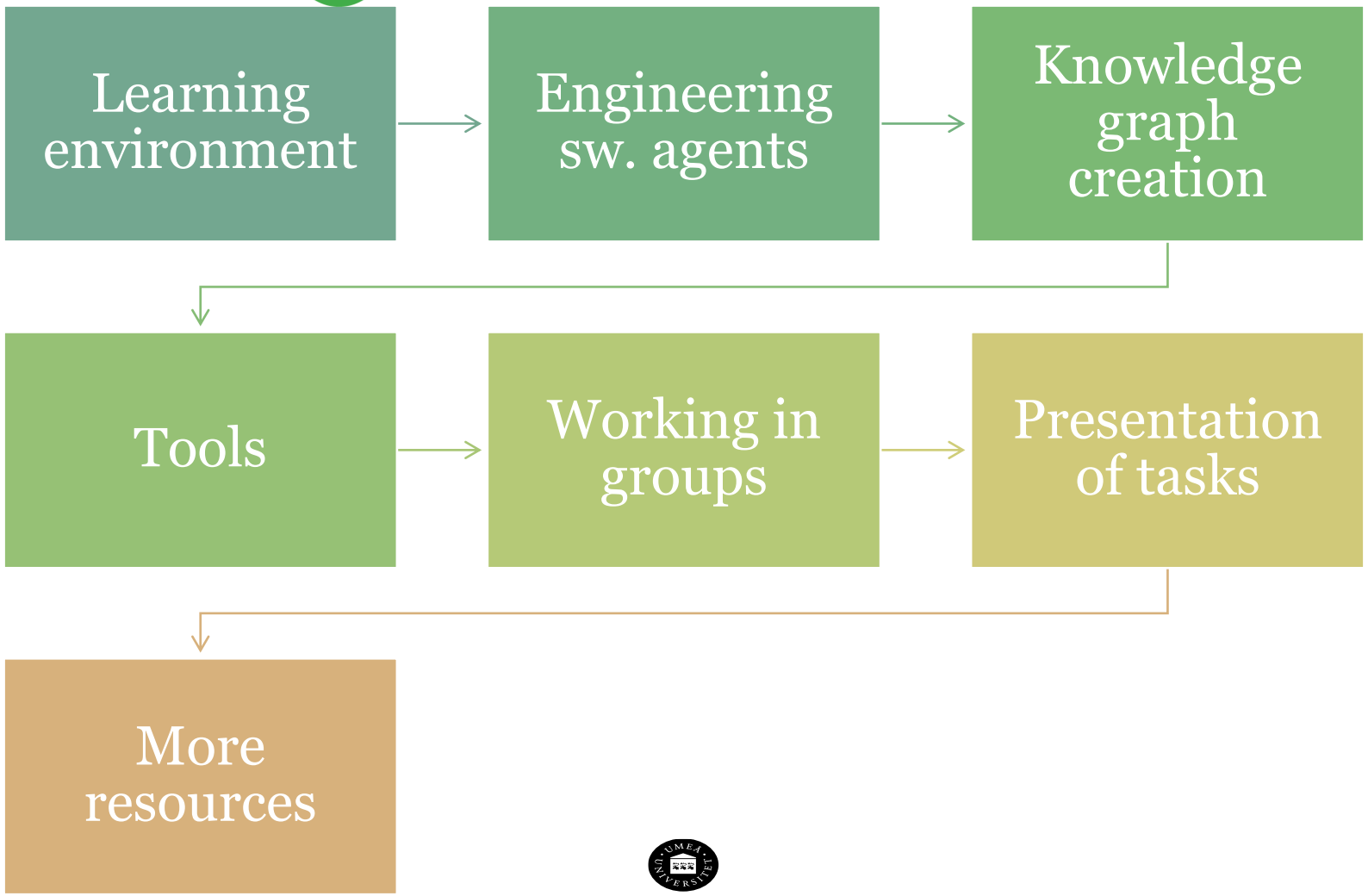
- In physical laboratories sessions (if any) take measures https://support.cs.umu.se/covid-information/info
- If person is infected, contact ISE2020 course teachers

OUR AGREEMENTS

Technical

- Design/development attribution
- Design/development agreement
- Design/development acknowledgement
- Plagiarism has strong consequences https://www.umu.se/en/student/we-can-assist-you/your-rights-and-responsibilities/cheating-and-plagiarism/
- No Wizard-of-Oz in final projects (Adobe XD, Figma, Sketch, Balsamiq, etc.), only in the presentation of the initial design

CONTENT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ENGINEERING AGENTS

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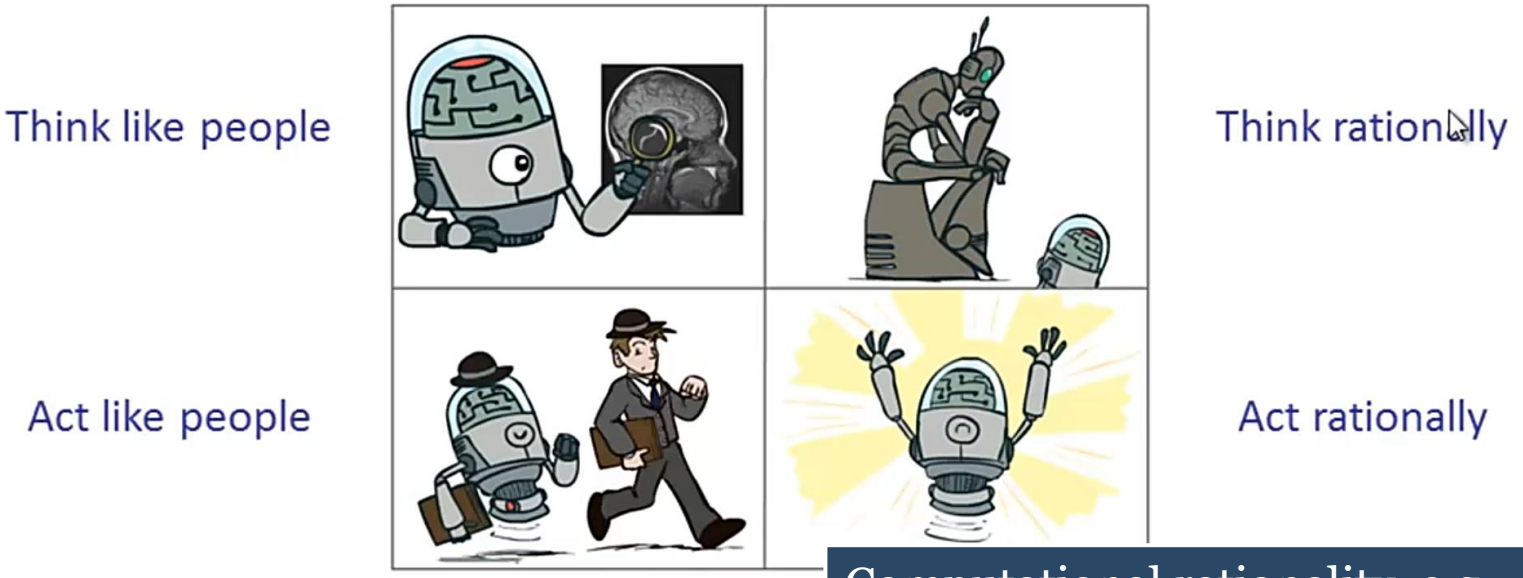
ENGINEERING AGENTS

Recap:

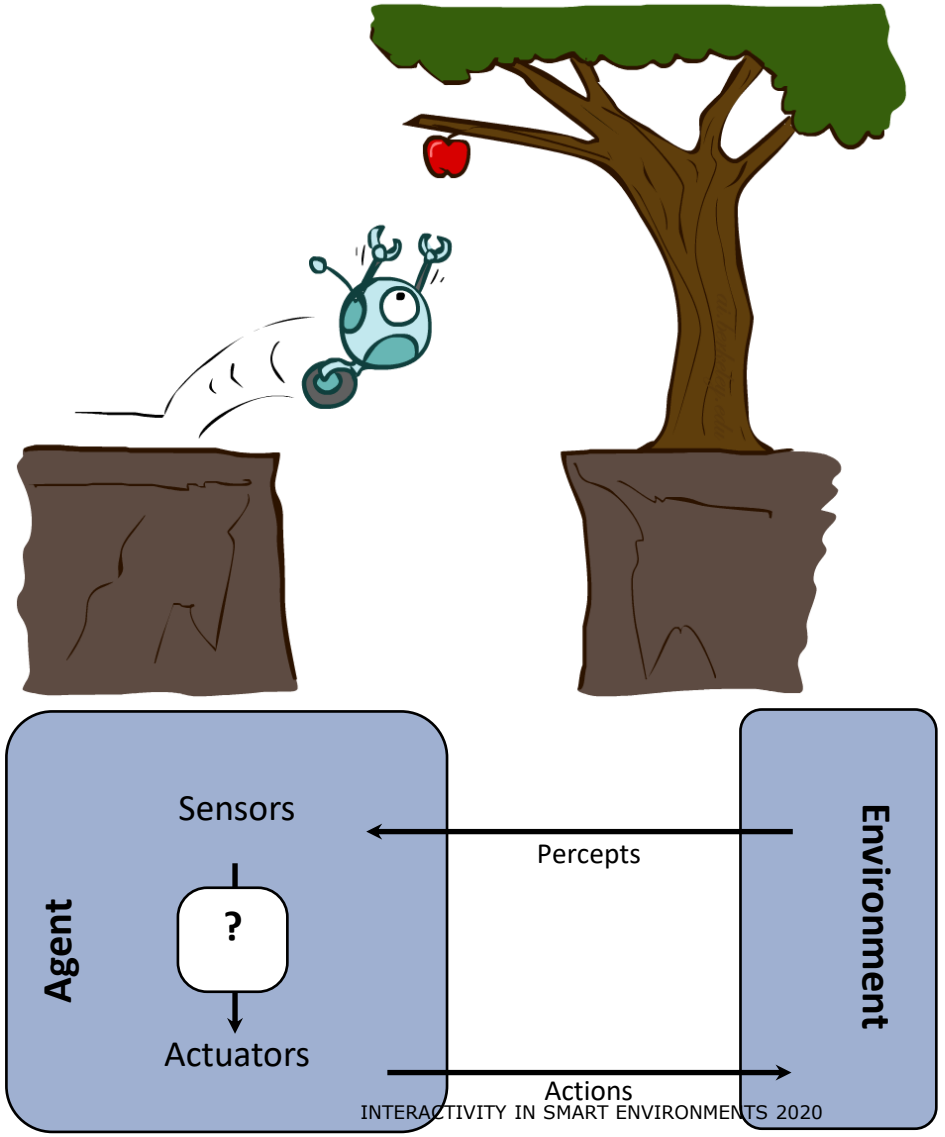
- The Belief-Desire-Intention (original) is a theory to explain and predict the behavior and mental state of people.
- BDI model in (computer science) is used to design software to explain predict behaviour of agents with mental states.



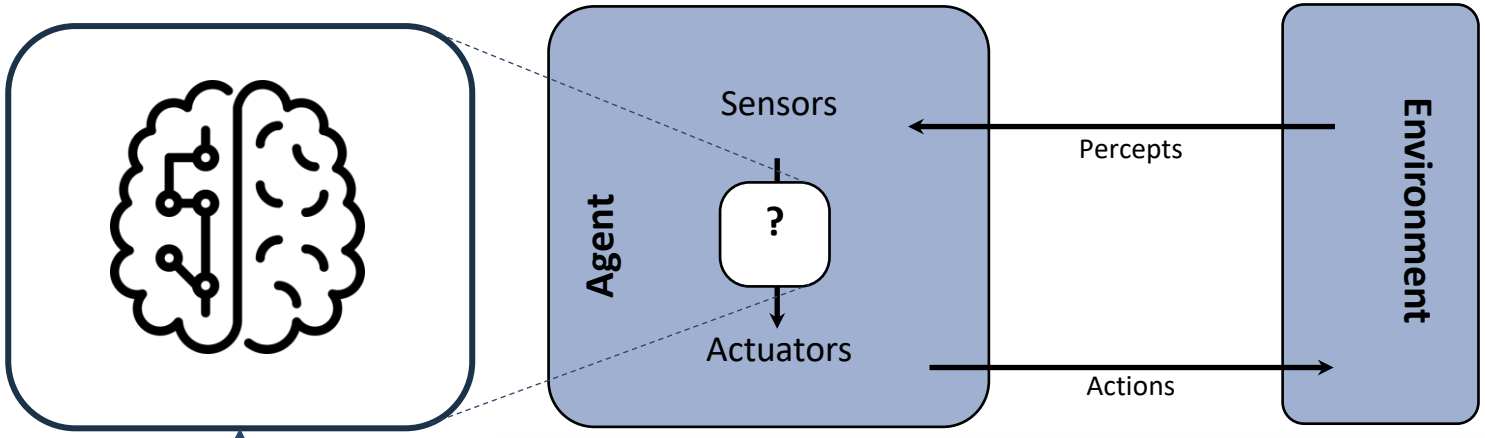
Artwork: Ketrina Yim, UC Berkeley CS188 Artificial Intelligence.

Computational rationality, e.g. maximizing an expected utility

ENGINEERING AGENTS



TOOLS FOR BUILDING AGENT'S MODULES



This lecture focus

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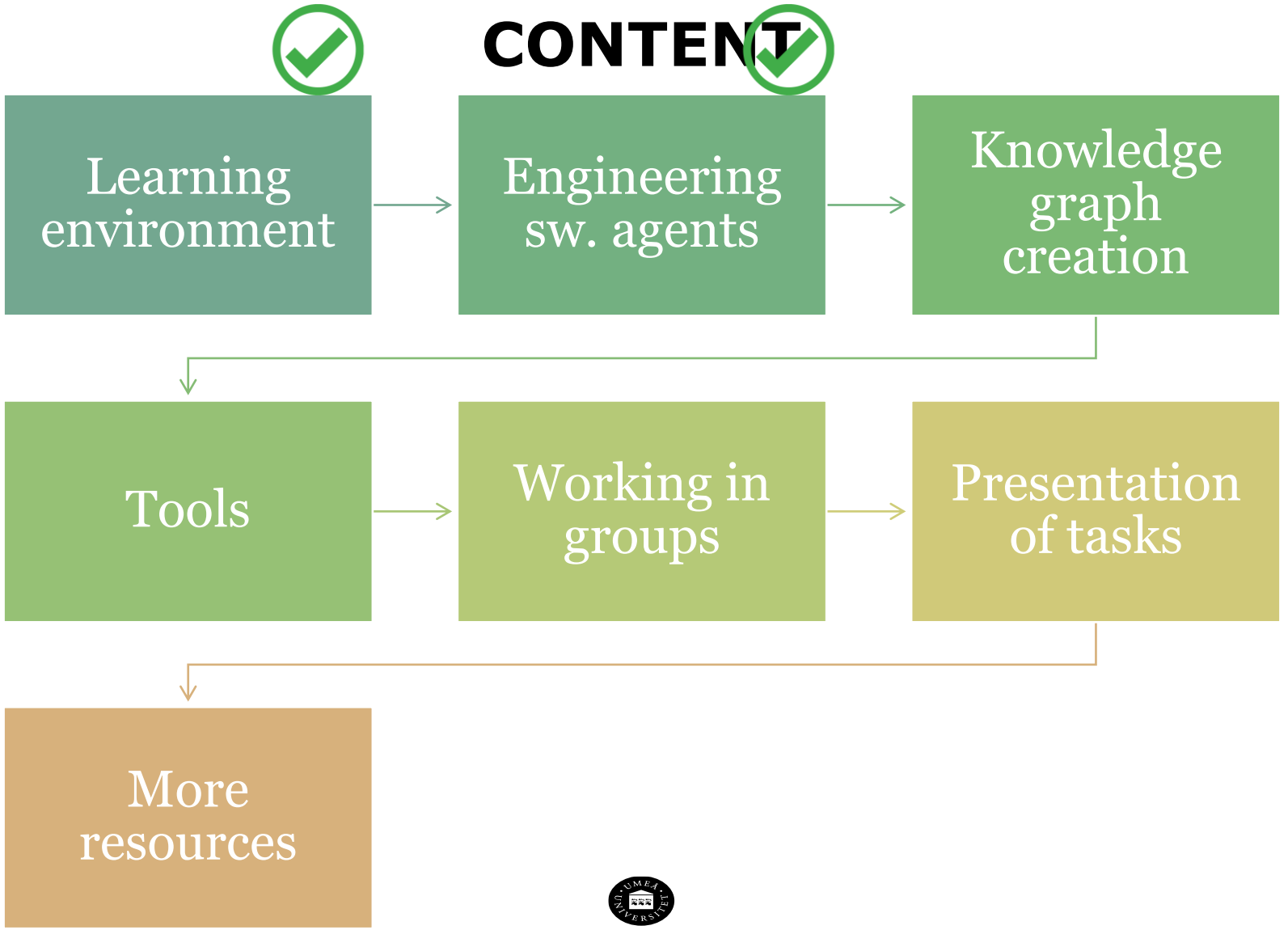
HOW TO IMPLEMENT THIS ARCHITECTURE?

To implement this architecture we need to meet a number of difficult challenges.

For example,

1. How can we **create a knowledge base for our agent**?
2. How can we **make it function in a changing environment** and **maintain focus on its current goal** without losing the ability to change goals in response to important events in its environment?
3. How can we make **it capable of explaining some of these events** and use the explanations to fill gaps in its knowledge base?
4. How can we get it to use its knowledge to **do intelligent planning**?

CONTENT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KNOWLEDGE GRAPH CREATION

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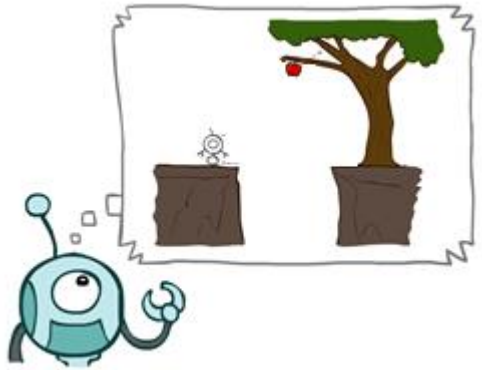
THE AGENT'S KNOWLEDGE

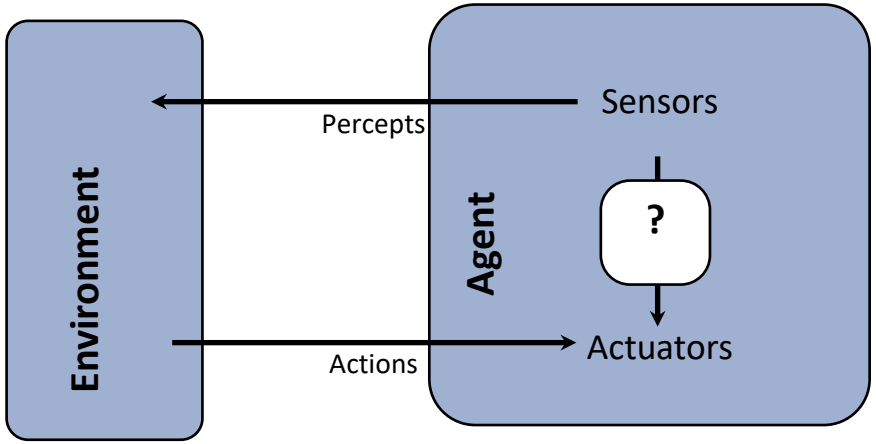
What an agent should have in its mind?

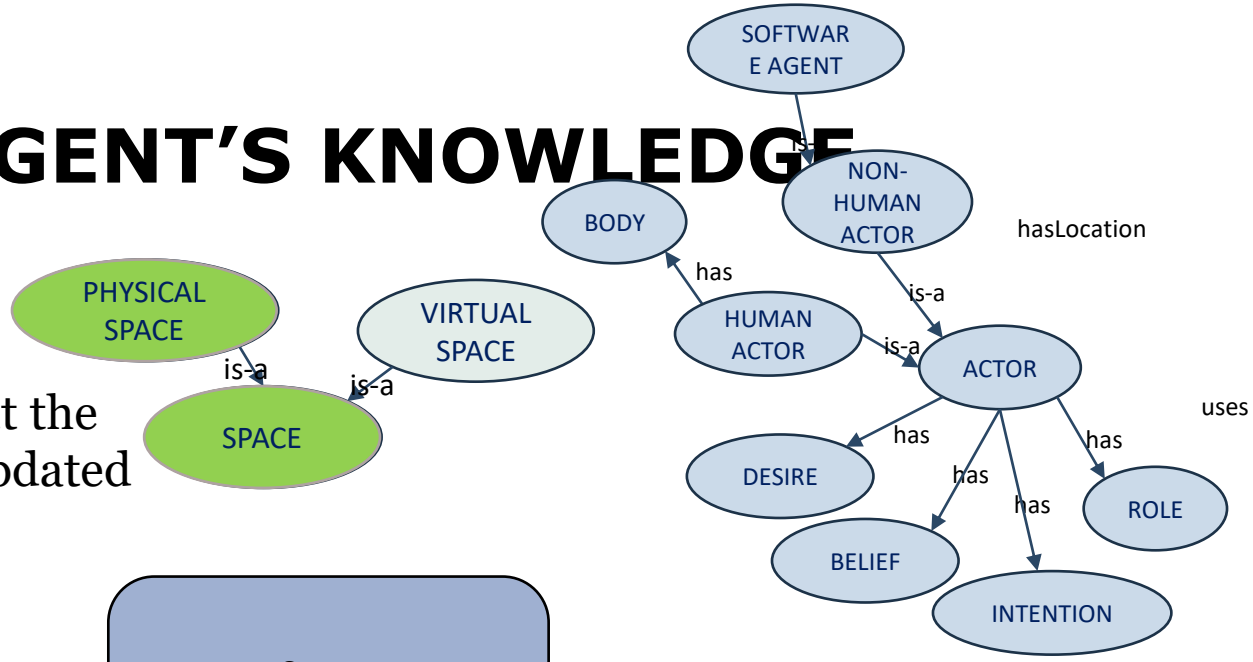


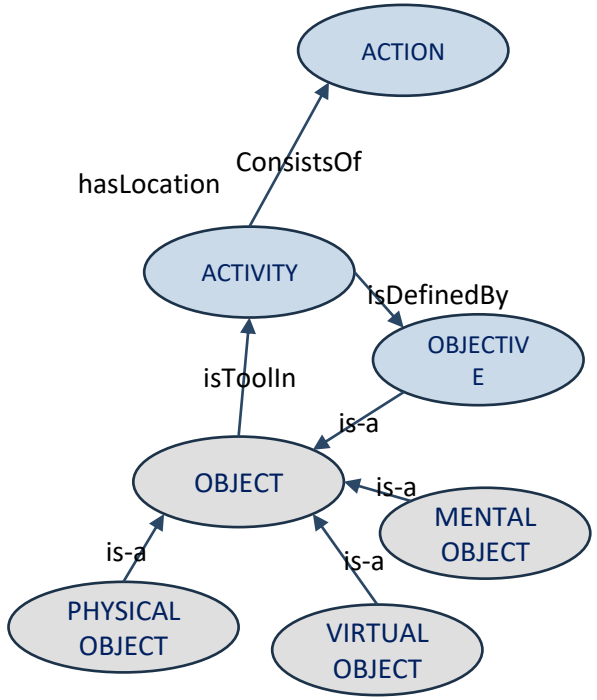
It depends on the environment!

THE AGENT'S KNOWLEDGE

Information about the environment is updated







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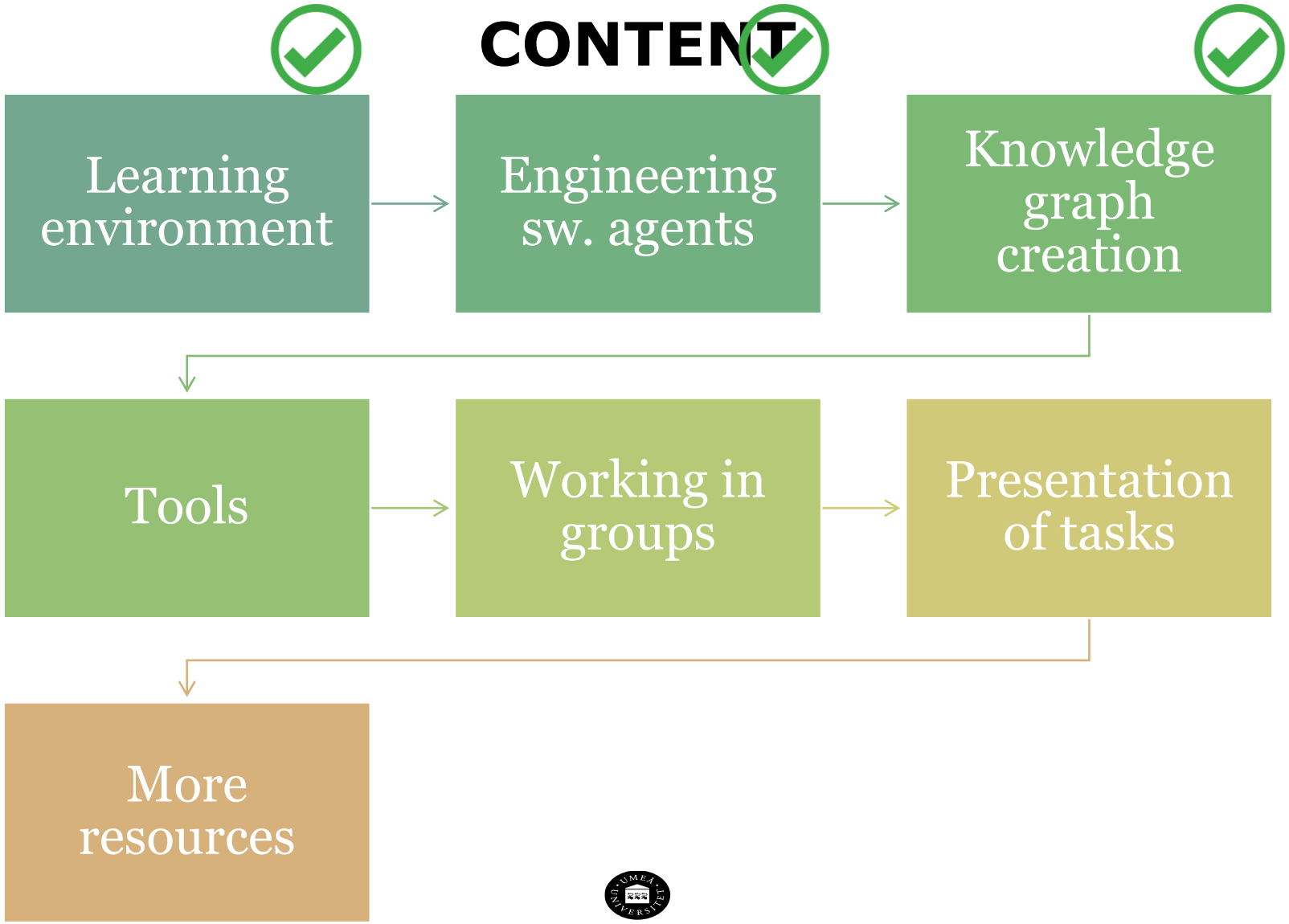
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TOOLS FOR KNOWLEDGE BUILDING

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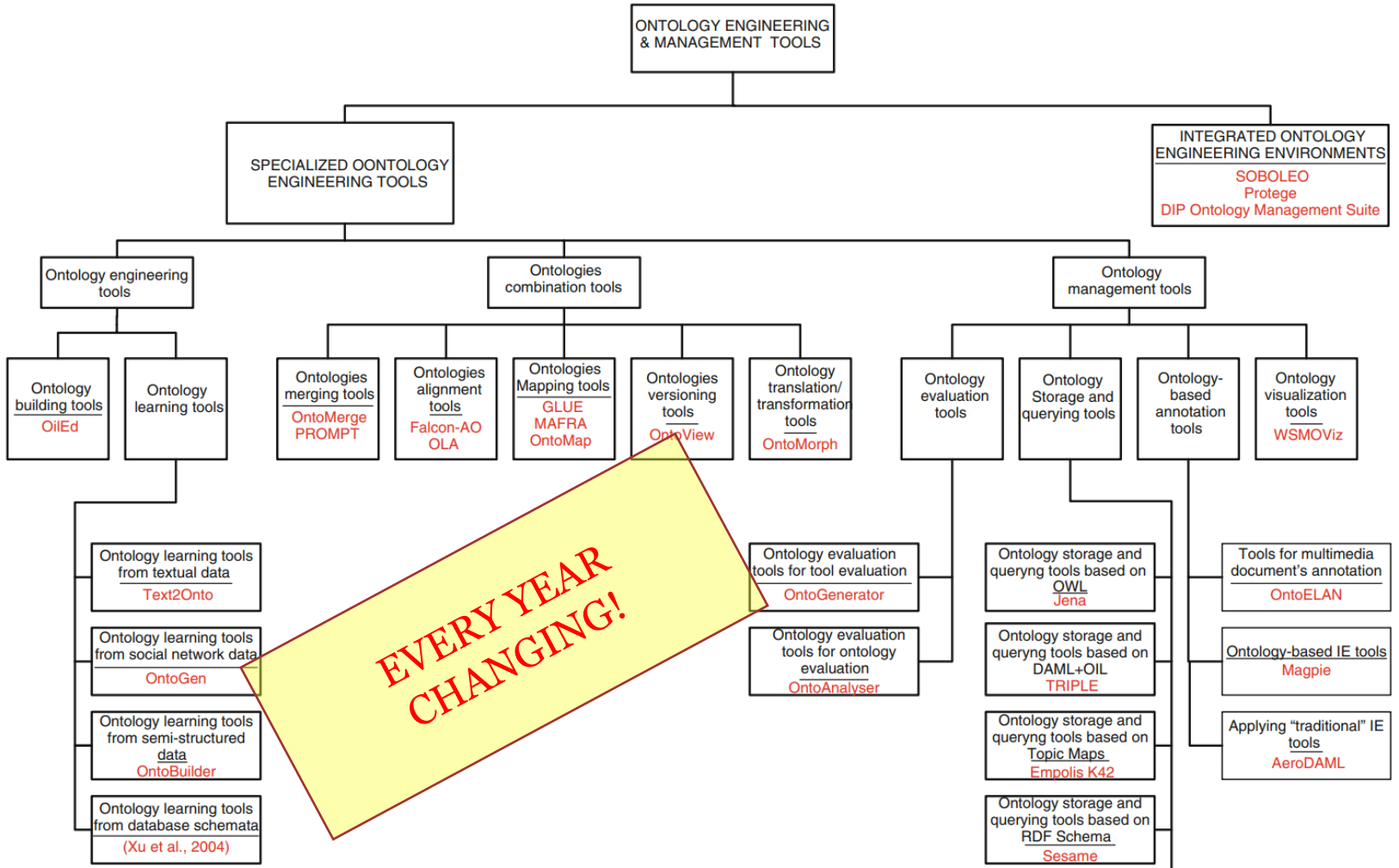
TOOLS FOR KNOWLEDGE BUILDING



Seremeti, L., & Kameas, A. (2010). Tools for ontology engineering and management. In *Theory and Applications of Ontology: Computer Applications* (pp. 131-154). Springer, Dordrecht.

Other alternatives:

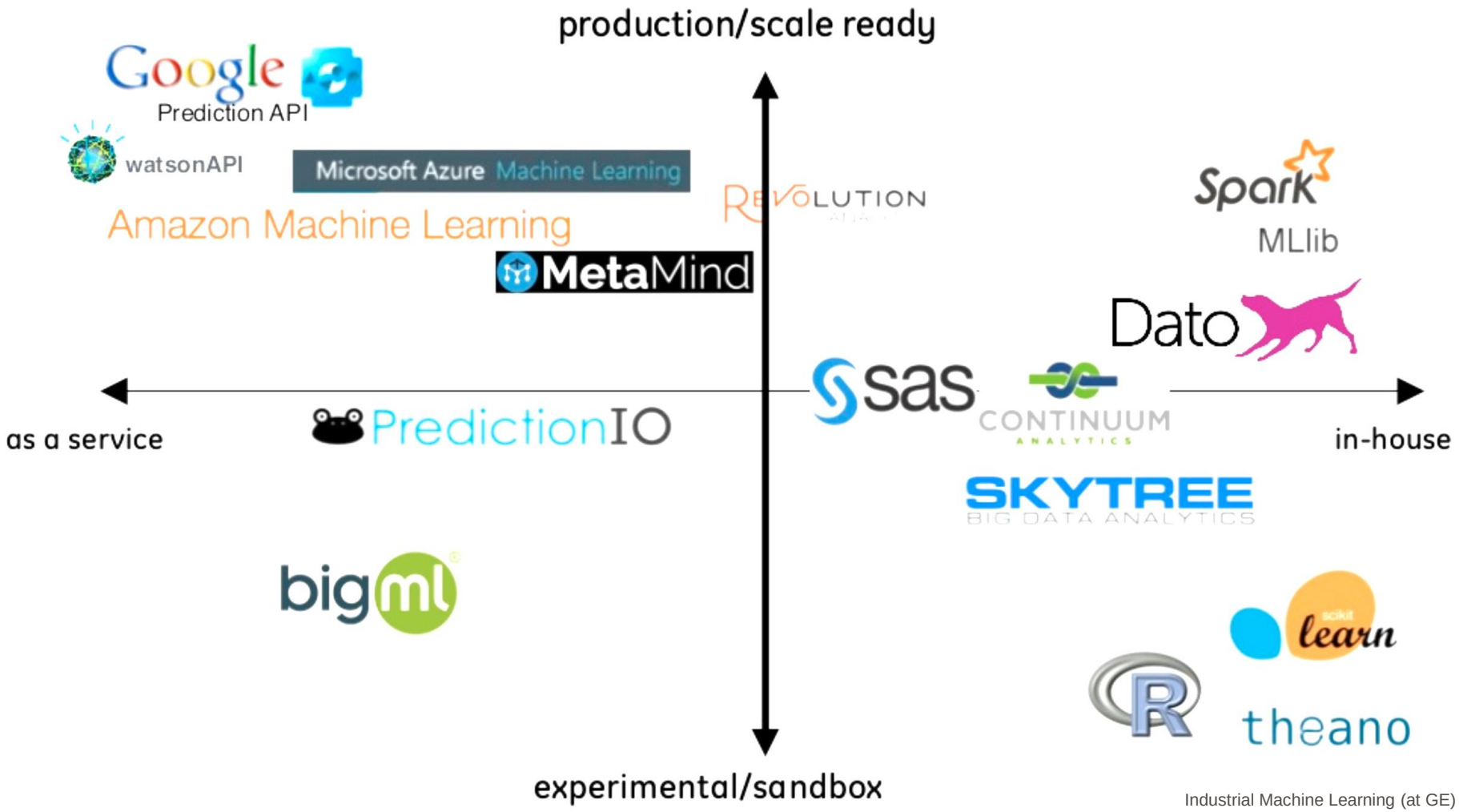
ALTOVA SchemaAgent (pro: connected with UML and other tools; con: non free). URL: https://www.altova.com/

~~AminePlatform~~ (pro: open source; con: current version - 2017- not working). URL: http://amine-platform.sourceforge.net/

Sigma (pro: open source; con: installation bugs mostly Linux support). URL: https://github.com/ontologyportal/sigmakee

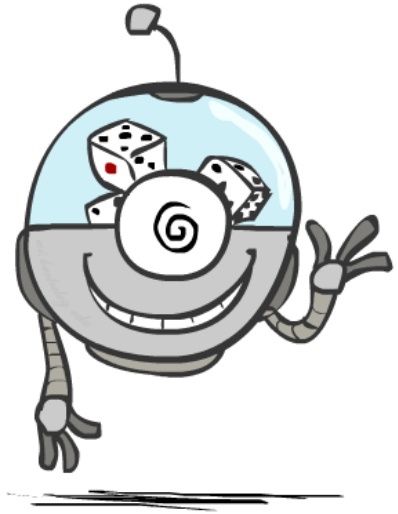
TopQuadrant (pro: Eclipse-like; cons: bugs, non free)

PROGRAMMING LANGUAGES USED IN ARTIFICIAL INTELLIGENCE TOOLS



Industrial Machine Learning (at GE)

Joshua Bloom, Professor at UC Berkeley, CTO Wise/GE



Question: What programming language(s) do you use/prefer?

Answer keywords
in https://www.menti.com/
code: 3093764

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PROTÉGÉ

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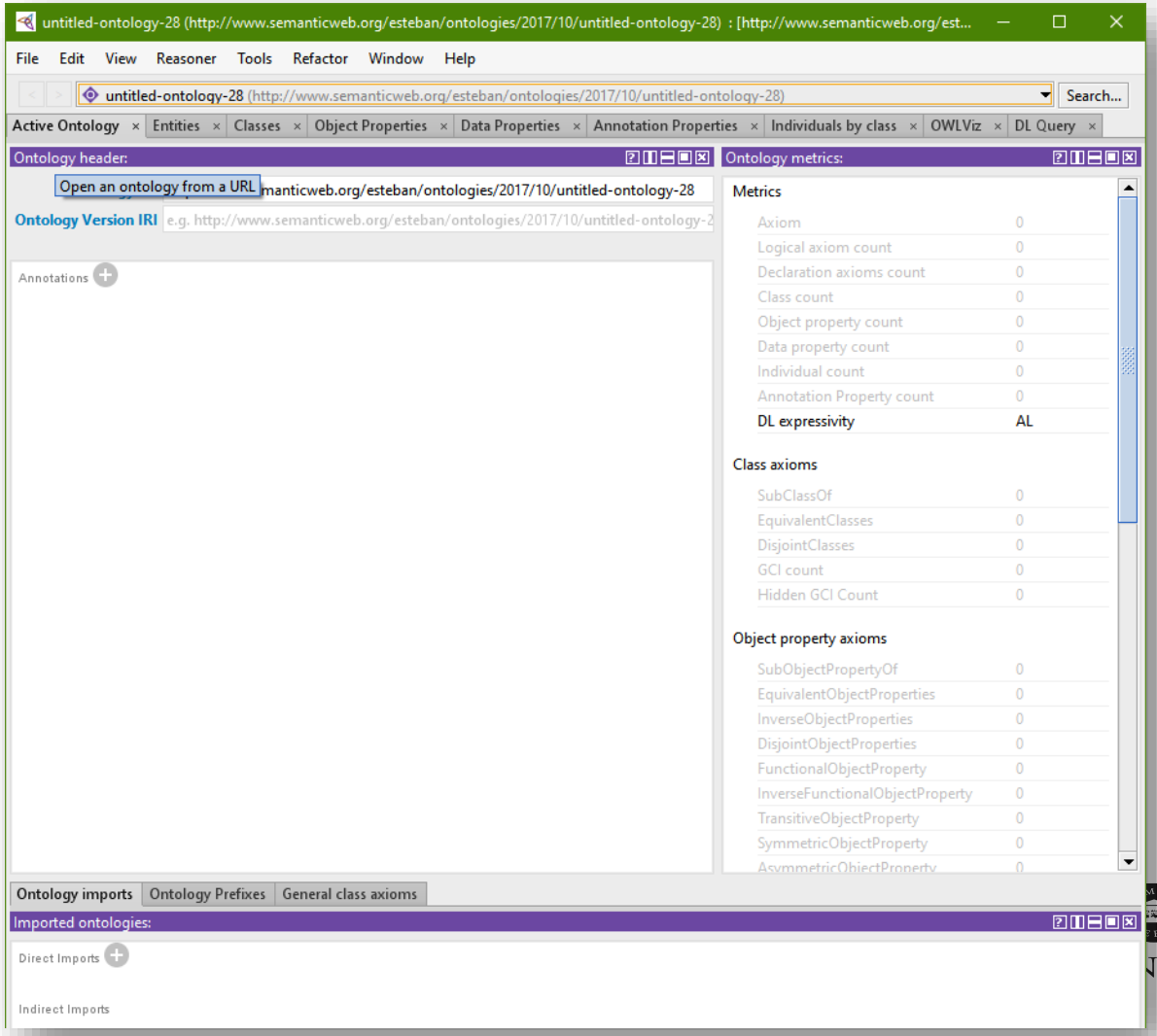
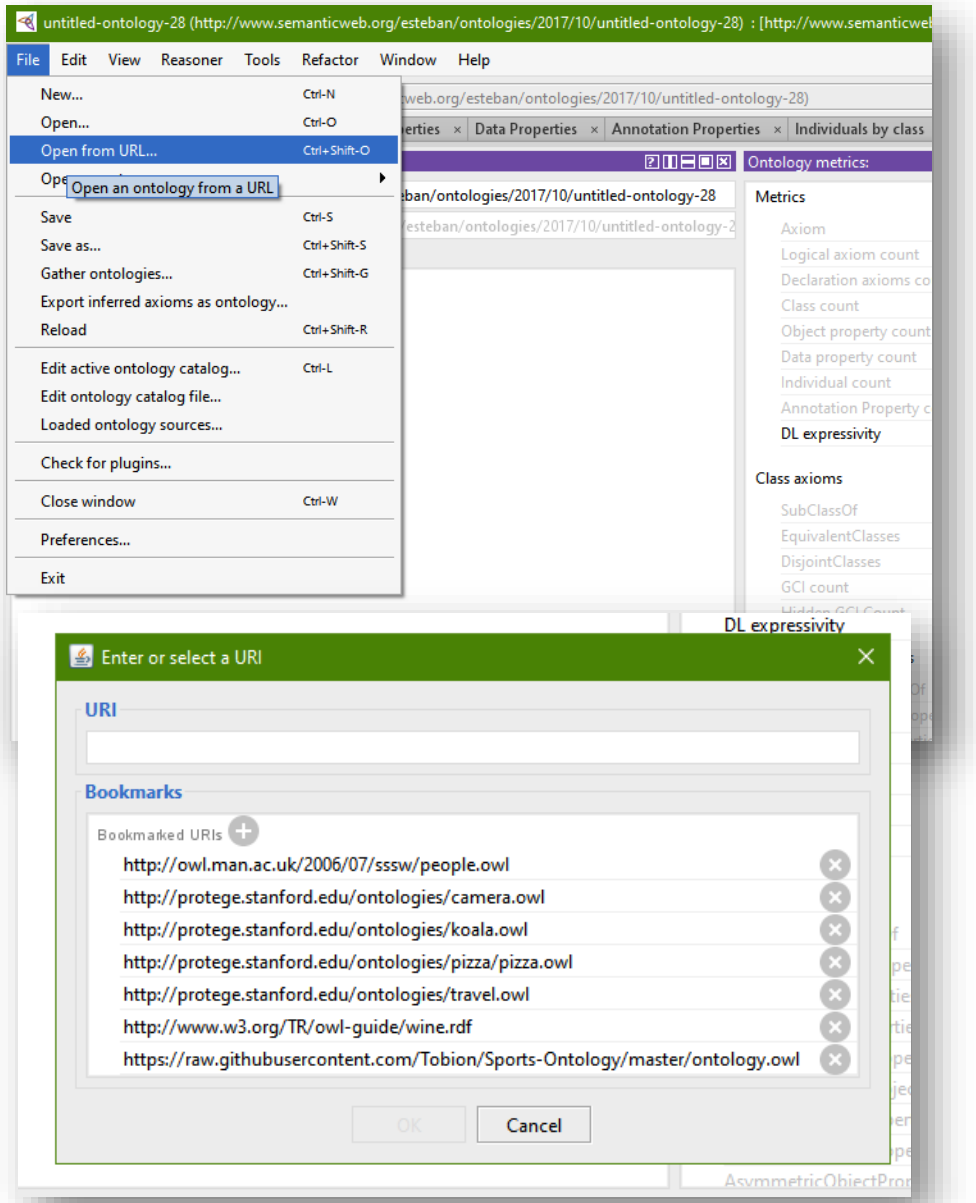
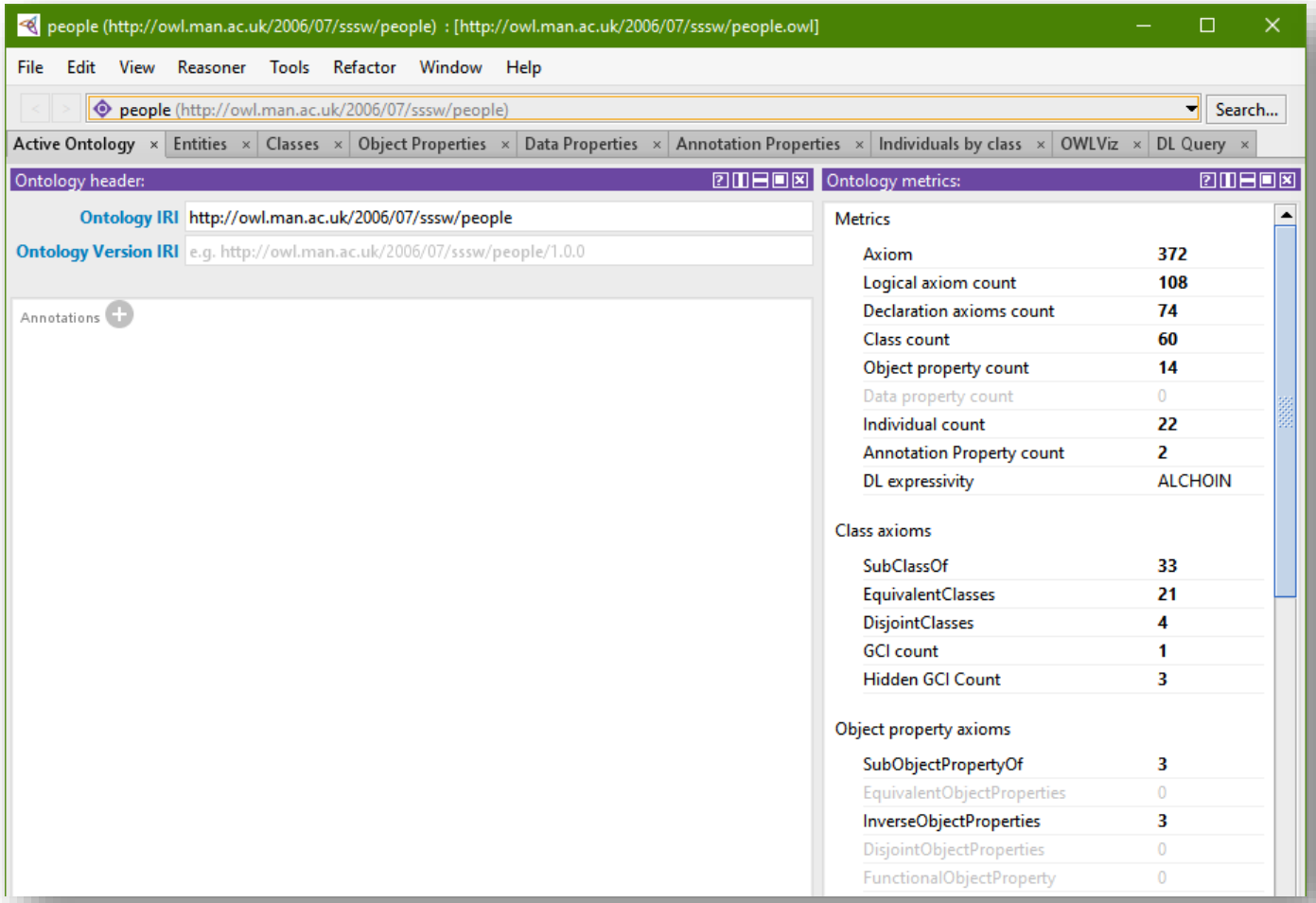
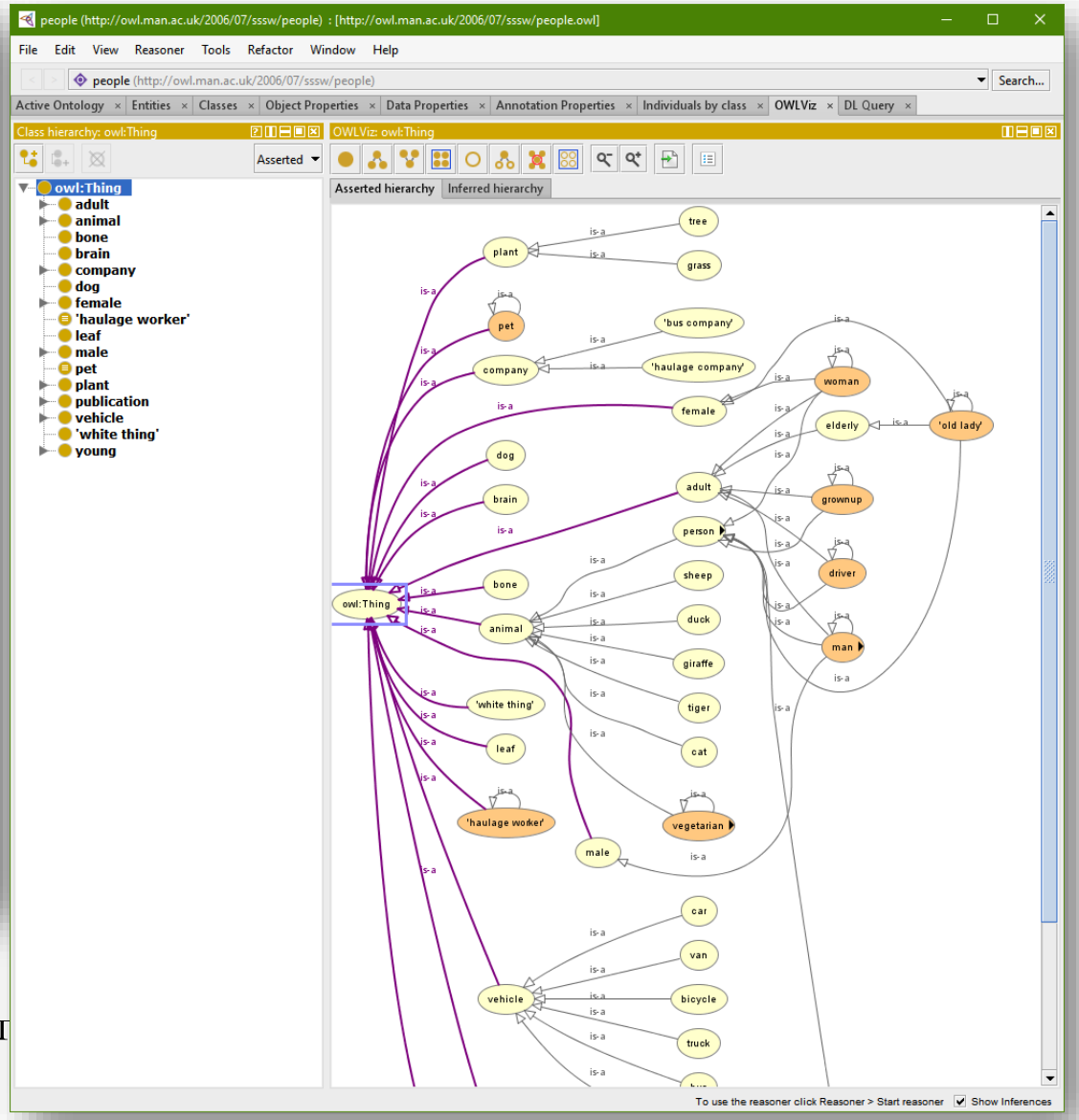
PROTÉGÉ


untitled-ontology-28 (http://www.semanticweb.org/esteban/ontologies/2017/10/untitled-ontology-28) : [http://www.semanticweb.org/est...
File Edit View Reasoner Tools Refactor Window Help
untitled-ontology-28 (http://www.semanticweb.org/esteban/ontologies/2017/10/untitled-ontology-28)
Search...
Active Ontology
Entities
Classes
Object Properties
Data Properties
Annotation Properties
Individuals by class
OWLViz
DL Query
Ontology header:
Open an ontology from a URL
Ontology Version IRI
e.g. http://www.semanticweb.org/esteban/ontologies/2017/10/untitled-ontology-2
Annotations
Ontology metrics:
Metrics
Axiom 0
Logical axiom count 0
Declaration axioms count 0
Class count 0
Object property count 0
Data property count 0
Individual count 0
Annotation Property count 0
DL expressivity AL
Class axioms
SubClassOf 0
EquivalentClasses 0
DisjointClasses 0
GCI count 0
Hidden GCI Count 0
Object property axioms
SubObjectPropertyOf 0
EquivalentObjectProperties 0
InverseObjectProperties 0
DisjointObjectProperties 0
FunctionalObjectProperty 0
InverseFunctionalObjectProperty 0
TransitiveObjectProperty 0
SymmetricObjectProperty 0
Ontology imports
Ontology Prefixes
General class axioms
Imported ontologies:
Direct Imports
Indirect Imports


untitled-ontology-28 (http://www.semanticweb.org/esteban/ontologies/2017/10/untitled-ontology-28) : [http://www.semanticweb
File Edit View Reasoner Tools Refactor Window Help
New... Ctrl-N
Open... Ctrl-O
Open from URL... Ctrl+Shift-O
Open an ontology from a URL
Save Ctrl-S
Save as... Ctrl+Shift-S
Gather ontologies... Ctrl+Shift-G
Export inferred axioms as ontology...
Reload Ctrl+Shift-R
Edit active ontology catalog... Ctrl-L
Edit ontology catalog file...
Loaded ontology sources...
Check for plugins...
Close window Ctrl-W
Preferences...
Exit
Data Properties
Annotation Properties
Individuals by class
Ontology metrics:
Metrics
Axiom
Logical axiom count
Class count
Object property count
Data property count
Individual count
DL expressivity
Class axioms
SubClassOf
EquivalentClasses
DisjointClasses
GCI count
DL expressivity
Enter or select a URI
URI
Bookmarks
Bookmarked URIs
http://owl.man.ac.uk/2006/07/sssw/people.owl
http://protege.stanford.edu/ontologies/camera.owl
http://protege.stanford.edu/ontologies/koala.owl
http://protege.stanford.edu/ontologies/pizza/pizza.owl
http://protege.stanford.edu/ontologies/travel.owl
http://www.w3.org/TR/owl-guide/wine.rdf
https://raw.githubusercontent.com/Tobion/Sports-Ontology/master/ontology.owl
OK
Cancel

PROTÉGÉ





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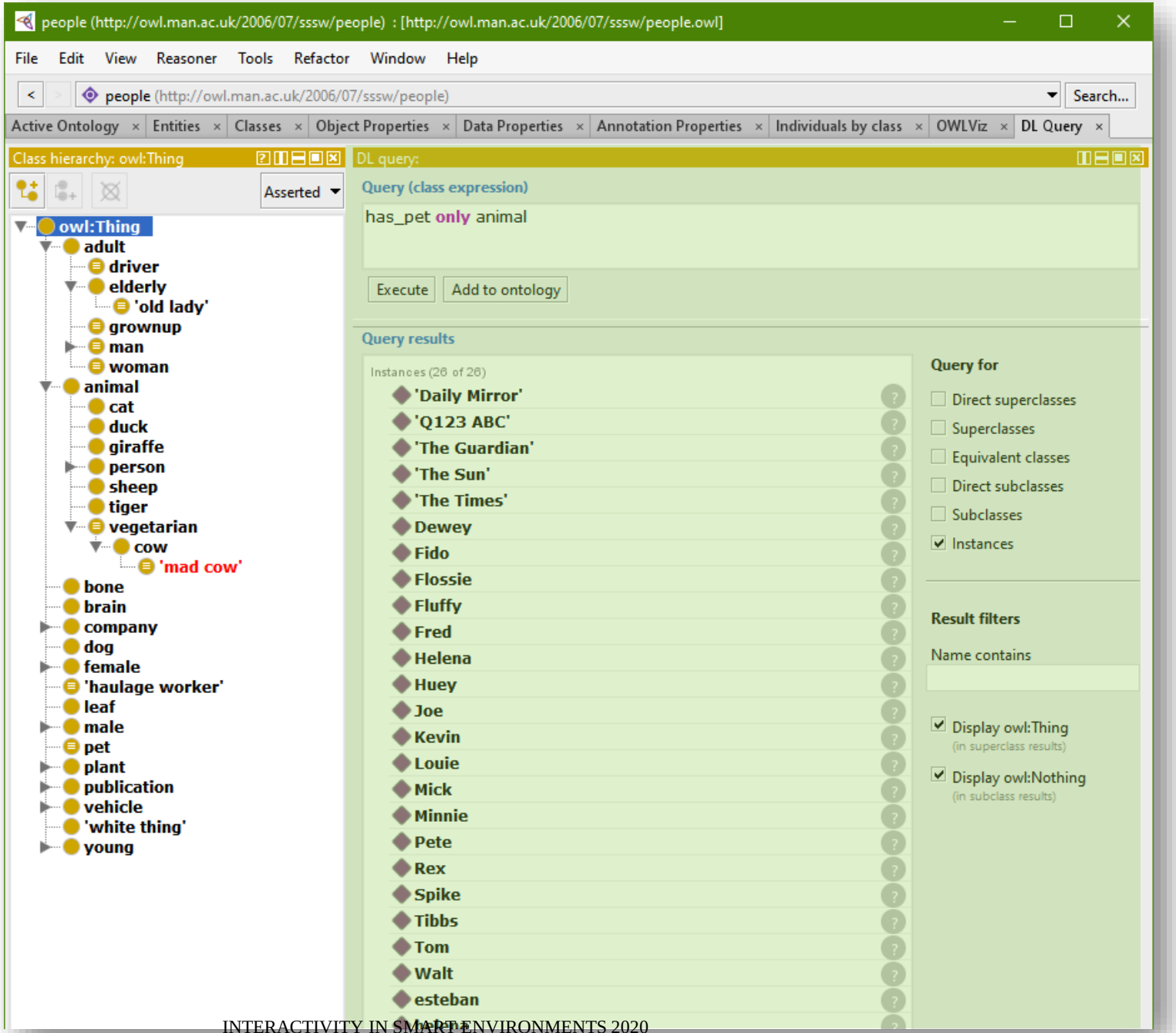

people (http://owl.man.ac.uk/2006/07/sssw/people) : [http://owl.man.ac.uk/2006/07/sssw/people.owl]
File Edit View Reasoner Tools Refactor Window Help
people (http://owl.man.ac.uk/2006/07/sssw/people)
Search...
Active Ontology Entities Classes Object Properties Data Properties Annotation Properties Individuals by class OWLViz DL Query
Class hierarchy: owl:Thing
Asserted
owl:Thing
adult
driver
elderly
'old lady'
grownup
man
woman
animal
cat
duck
giraffe
person
sheep
tiger
vegetarian
cow
'mad cow'
bone
brain
company
dog
female
'haulage worker'
leaf
male
pet
plant
publication
vehicle
'white thing'
young
DL query:
Query (class expression)
has_pet only animal
Execute
Add to ontology
Query results
Instances (26 of 26)
'Daily Mirror'
'Q123 ABC'
'The Guardian'
'The Sun'
'The Times'
Dewey
Fido
Flossie
Fluffy
Fred
Helena
Huey
Joe
Kevin
Louie
Mick
Minnie
Pete
Rex
Spike
Tibbs
Tom
Walt
esteban
Query for
Direct superclasses
Superclasses
Equivalent classes
Direct subclasses
Subclasses
Instances
Result filters
Name contains
Display owl:Thing
(in superclass results)
Display owl:Nothing
(in subclass results)

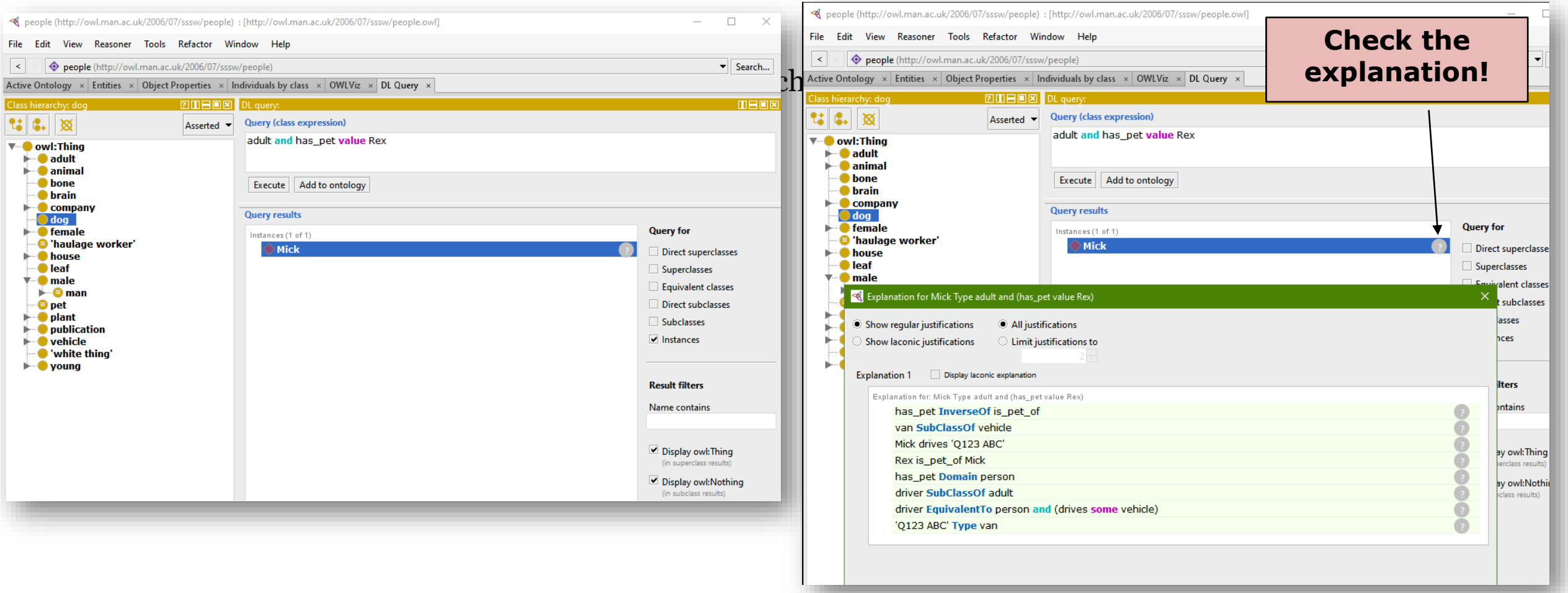
PROTÉGÉ

Try some DL (Description Logics) queries with the people ontology and check the explanations:

- adult and has_pet some cat or has_pet some dog
- adult and has_pet value Rex
- woman and has_pet min 1 cat
- animal and is_pet_of some adult

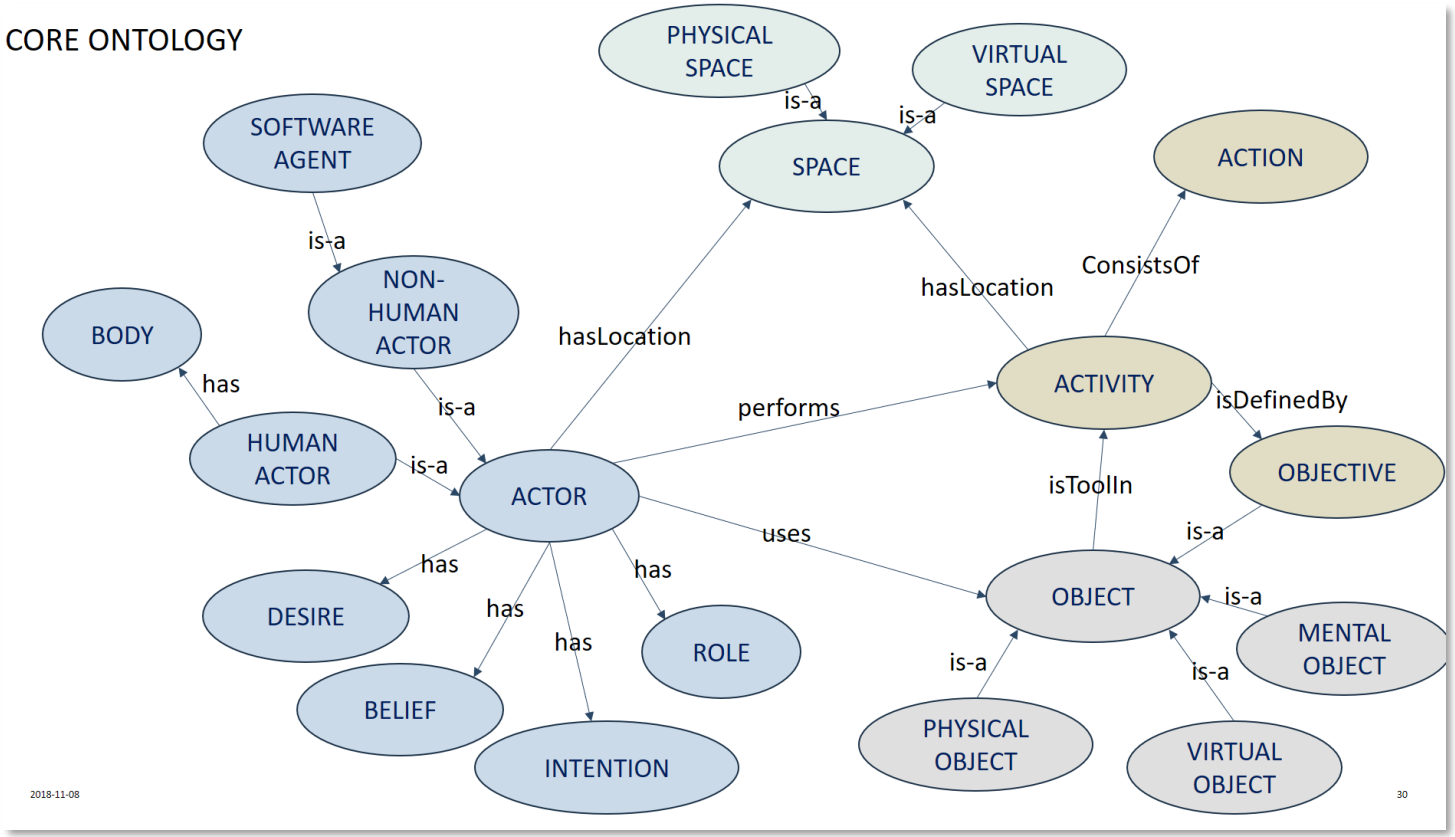
∃	**Existential, someValuesFrom**	**“some”, “at least one”**
∀	Universal, allValuesFrom	“only”
∋	hasValue	“equals x”
=	Cardinality	“exactly n”
≤	Max Cardinality	“at most n”
≥	Min Cardinality	“at least n”

PROTÉGÉ

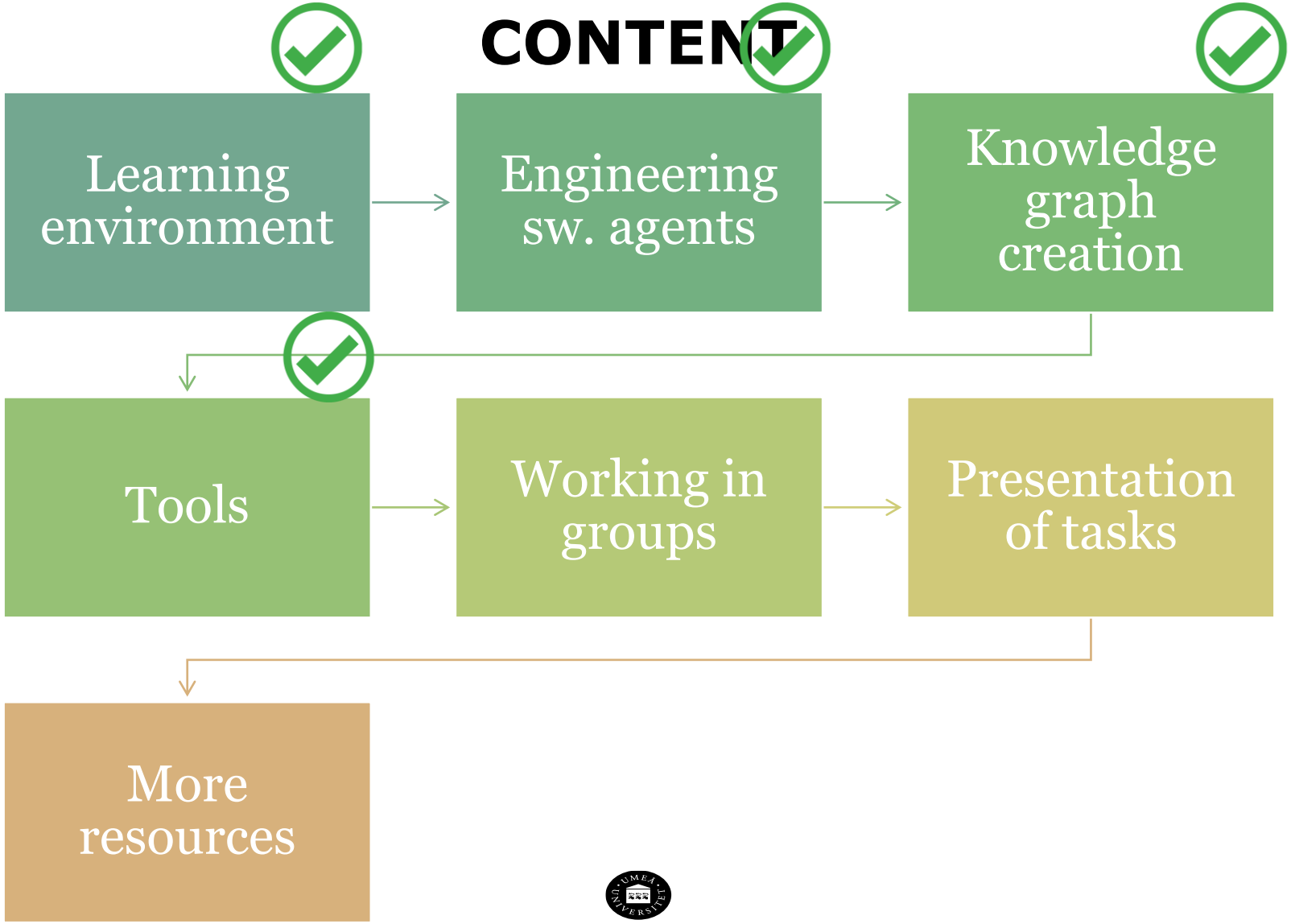

people (http://owl.man.ac.uk/2006/07/sssw/people) : [http://owl.man.ac.uk/2006/07/sssw/people.owl]
File Edit View Reasoner Tools Refactor Window Help
Active Ontology Entities Object Properties Individuals by class OWLViz DL Query
Class hierarchy: dog
DL query:
Asserted
Query (class expression)
adult and has_pet value Rex
Execute
Add to ontology
Query results
Instances (1 of 1)
Mick
Query for
Direct superclasses
Superclasses
Equivalent classes
Direct subclasses
Subclasses
Instances
Result filters
Name contains
Display owl:Thing
(in superclass results)
Display owl:Nothing
(in subclass results)
owl:Thing
adult
animal
bone
brain
company
dog
female
'haulage worker'
house
leaf
male
man
pet
plant
publication
vehicle
'white thing'
young
Check the explanation!
Explanation for Mick Type adult and (has_pet value Rex)
Show regular justifications
Show laconic justifications
All justifications
Limit justifications to
Explanation 1
Display laconic explanation
Explanation for: Mick Type adult and (has_pet value Rex)
has_pet InverseOf is_pet_of
van SubClassOf vehicle
Mick drives 'Q123 ABC'
Rex is_pet_of Mick
has_pet Domain person
driver SubClassOf adult
driver EquivalentTo person and (drives some vehicle)
'Q123 ABC' Type van

PROTÉGÉ

Try Protégé with the core ontology!



CONTENT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TASK
BUILDING A KNOWLEDGE BASE COLLABORATIVELY

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COLLABORATIVE TASK

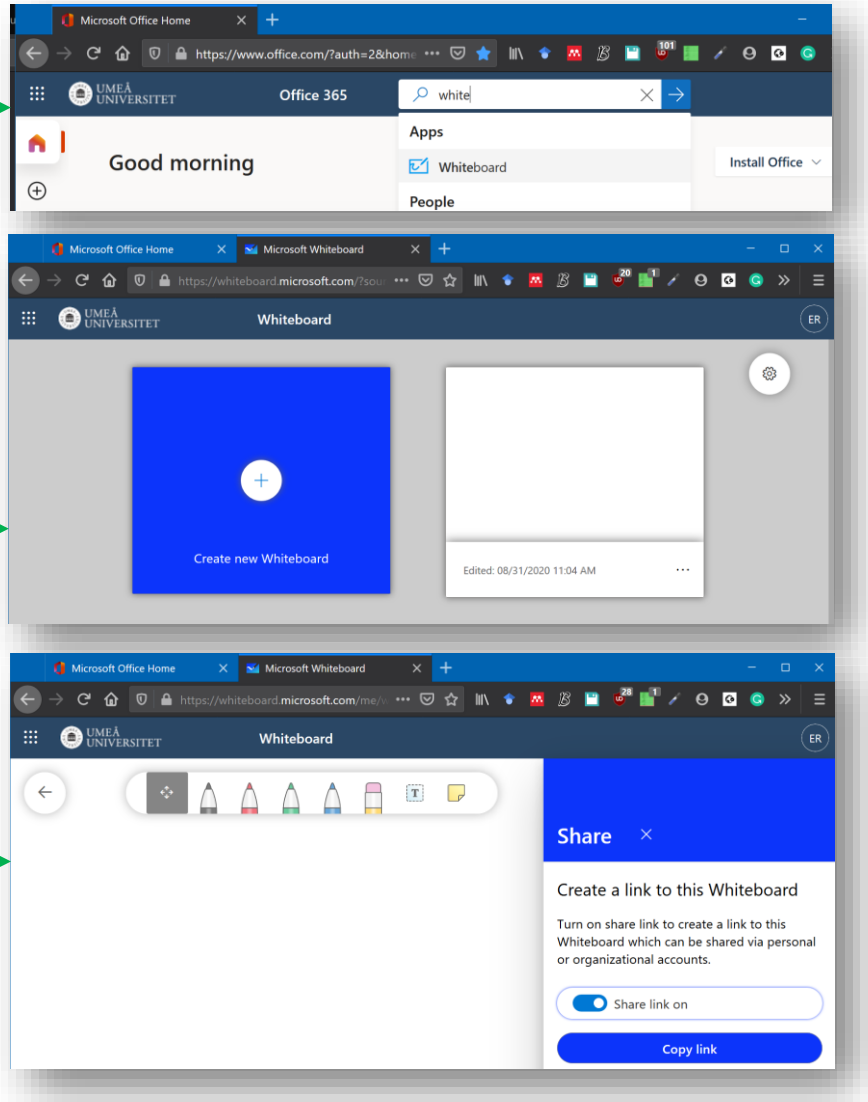
Procedure:

- Split the group in Zoom rooms to form teams **–randomly-**
- Select a specific running example of a smart environment
    1. Examples: an older adult living at home with some specific needs (smart home environment), a tourist looking for specific city places with particular needs (smart city), a mixed reality pet that work as a companion of a person with specific needs (smart virtual environment), etc. **–please imagine other scenarios**
    1. **Re-use the previous example - maybe**
- Knowledge graph collaboratively building based on the example
    2. In the Zoom room one person opens the Zoom Whiteboard (Share Screen->Whiteboard-> Share)
    3. Create the taxonomy of entities (nodes) with relationships ***(is-a)*** using a color
    4. Create semantic relationships (e.g. **has_pet, is_pet_of**) with other color
    5. Add some *individuals* in other words, examples or instances of those entities with other color
    6. Add names of the group member in the top-left of the drawing
    7. Add a title to the graph, example: older adult smart environment graph, tourist smart city graph, etc.
- Save the drawing graph locally
    8. In Zoom click in Save on top of the Whiteboard
- Answer questions (next slide), take notes about those answers. Then present those answers.
- **Time 10 minutes**

COLLABORATIVE TASK

Alternatively, for sharing if Annotations and Whiteboard in Zoom is limited:

1. All the team members go to 0365.umu.se/
2. Login with UmU credentials
3. One person creates and opens a new Whiteboard
4. Share the link of the new whiteboard with the other members via Zoom
5. Make the knowledge graph collaboratively
6. Save the graph



COLLABORATIVE TASK

Procedure:

- Open Web protégé: https://webprotege.stanford.edu/
- Create an account
- Create the taxonomy (the families of knowledge entities)

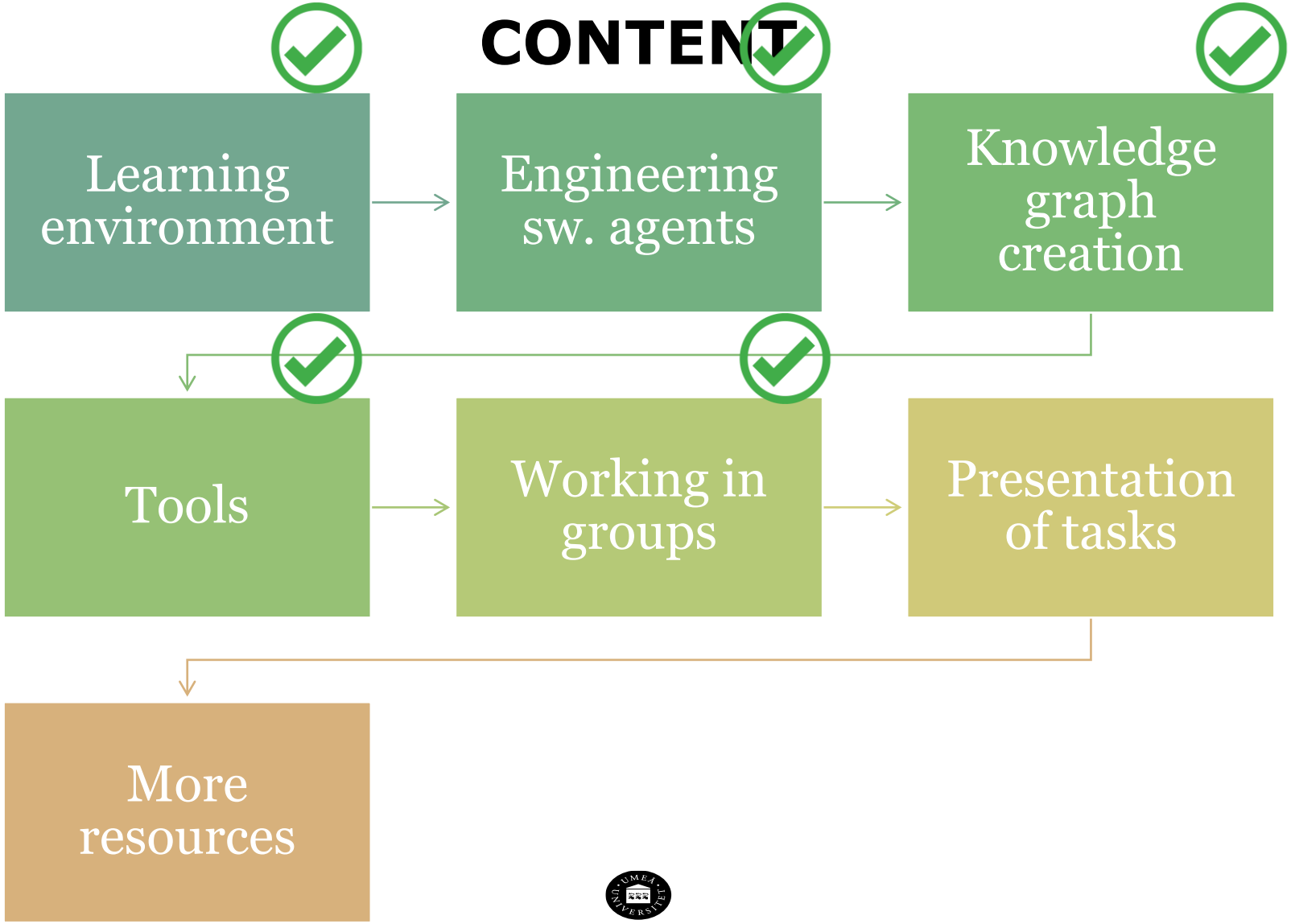
•Time 10 minutes

COLLABORATIVE TASK

Questions

- What information of the graph is *necessary*?
- What parts of the graph *change on time* (dynamic smart environment variables)?
- What information may be *uncertain* or *incomplete*?

CONTENT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More resources

PRESENTATION OF THE RUNNING EXAMPLE AND KNOWLEDGE GRAPH

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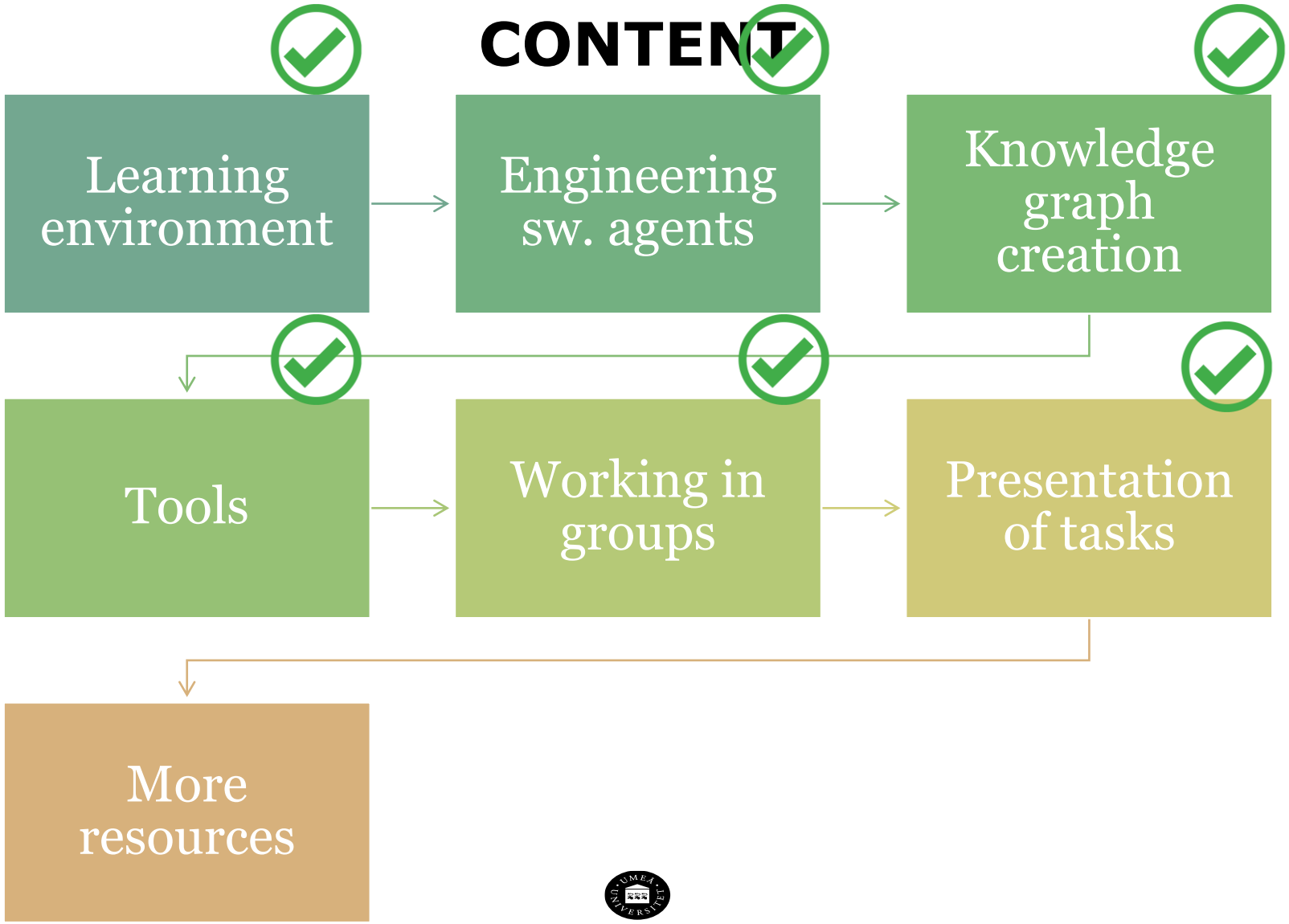
PRESENTATION OF EXAMPLE AND KNOWLEDGE GRAPH

Procedure:

- Join the main Zoom session
- Different members of the group present the running example.
- Others present the graph.
- Other the reflections

Time for every presentation 5-10 minutes

CONTENT


Learning environment
Engineering sw. agents
Knowledge graph creation
Tools
Working in groups
Presentation of tasks
More resources

MORE EXAMPLES AND RESOURCES

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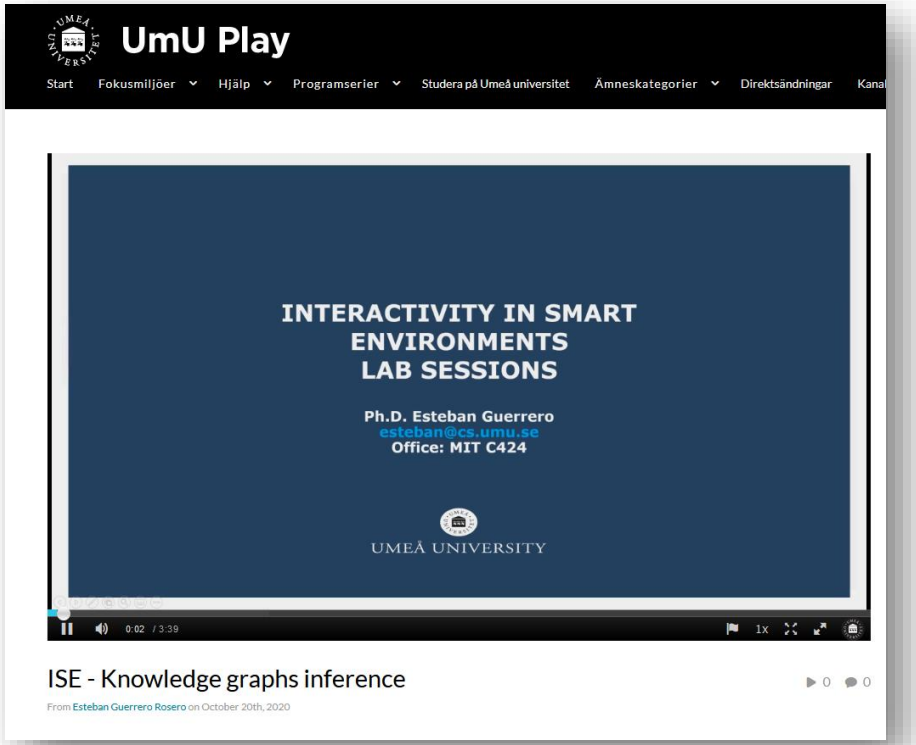
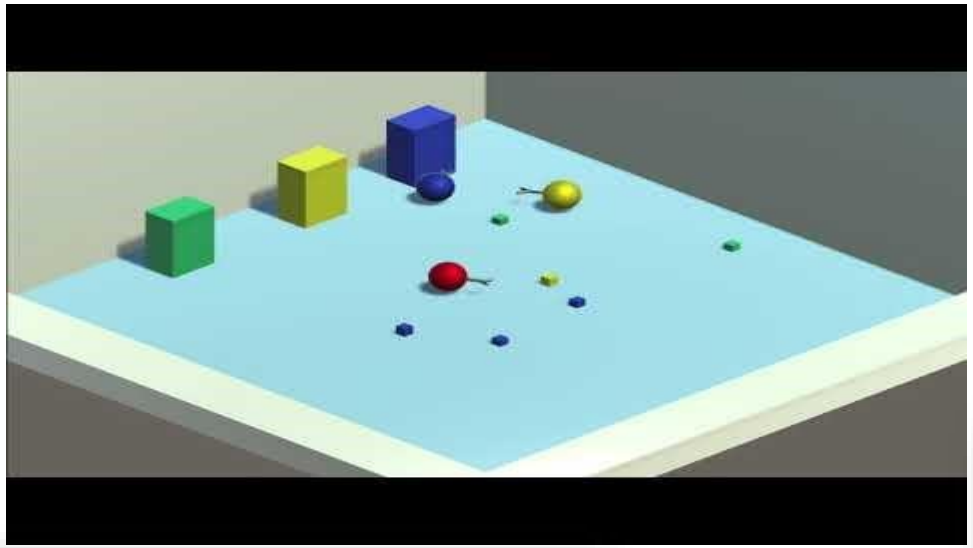
RESOURCES

Videos

1. Knowledge graph introduction using Protégé and Web Protégé
   - https://play.umu.se/media/t/0_3x6wbk3a
2. Knowledge graph inference using Web Protégé
   - https://play.umu.se/media/t/0_w26f2068
3. Knowledge graphs relationships
   - https://play.umu.se/media/t/0_kvb62yvt



EXAMPLES



BDI Agents and Artifacts in Unity

14 commits | 2 branches | 0 releases | 1 contributor

Branch: master | New pull request | Find file | Clone or download

conner985 Update README.md — Latest commit 4114c1e on Oct 24, 2018

Examples/RecyclingRobots	the example now have some balloons to visualize what the bot is doing	2 years ago
UnityLogic	the example now have some balloons to visualize what the bot is doing	2 years ago
README.md	Update README.md	last year

README.md

UnityLogic

BDI Agents and Artifacts in Unity

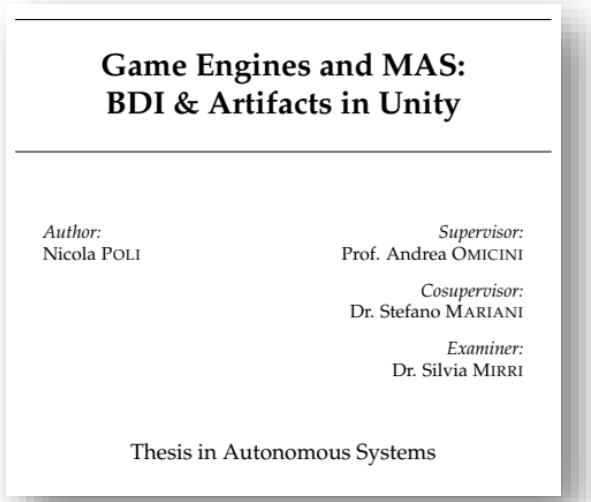
Development framework based on Prolog with interoperability with Unity to write complex behaviours in a declarative way - i.e. do_this, than_this, finally_this

You can read more about this project in my master thesis at: http://amslaurea.unibo.it/15657/1/poli_nicola_tesi.pdf

A video of the example developed using this architecture is available at: https://www.youtube.com/watch?v=BMHiZImVC3A

In the example, agents learn from one another and build their own behaviour at runtime sharing their knowledge of the world

For any question you can contact me at: conner985@gmail.com



Game Engines and MAS: BDI & Artifacts in Unity

Author: Nicola POLI

Supervisor: Prof. Andrea OMICINI

Cosupervisor: Dr. Stefano MARIANI

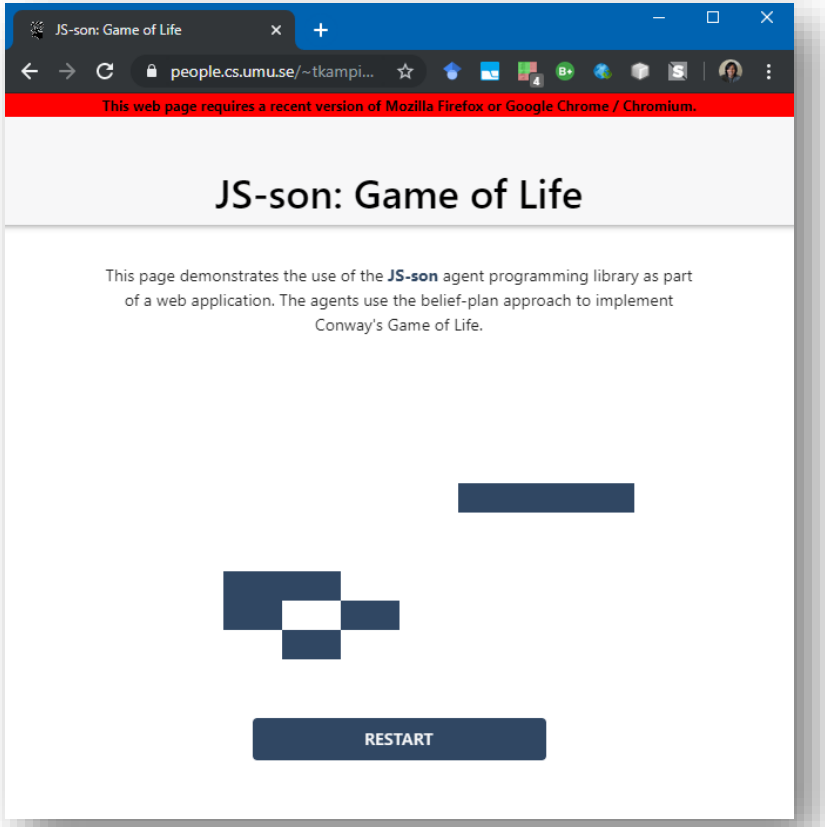
Examiner: Dr. Silvia MIRRI

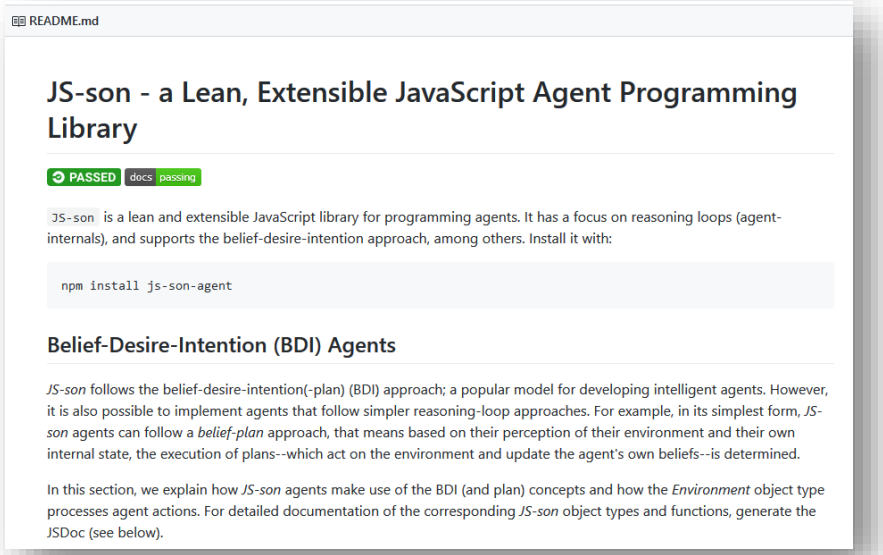
Thesis in Autonomous Systems

https://amslaurea.unibo.it/15657/1/poli_nicola_tesi.pdf

https://github.com/conner985/UnityLogic

EXAMPLES





Game of Life

- At each step in time, the following transitions occur:
- Any live cell with fewer than two live neighbours dies, as if by underpopulation.
- Any live cell with two or three live neighbours lives on to the next generation.
- Any live cell with more than three live neighbours dies, as if by overpopulation.
- Any dead cell with exactly three live neighbours becomes a live cell, as if by reproduction.

https://people.cs.umu.se/~tkampik/demos/js-son/


THANK YOU