**Import and edit ontology with Neo4j**

**Xiaochen Zheng**

ICT4SM, EPFL, 1015 Lausanne, Switzerland

[xiaochen.zheng@epfl.ch](mailto:xiaochen.zheng@epfl.ch)

(10-02-2022)

**Abstract:** This document introduces how to import an existing ontology to Neo4j graph database and edit it by adding new classes and relationships. It is executed with Cypher language and enabled by the neosemantics package.

**Keyword:** Neo4j, Neosemantics, Ontology, Python

## Neo4j graph database installation and configuration

A previous document[[1]](#footnote-1) has introduced how to install and configure a Neo4j graph database on an Azure cloud Ubuntu Virtual Machine (VM). Follow that introduction to install and configure the Neo4j database, and install the *neosemantics* package if it’s not done yet.

Before importing ontology, it is necessary to initialize the database with the following code[[2]](#footnote-2):

CALL n10s.graphconfig.init();

CREATE CONSTRAINT n10s\_unique\_uri ON (r:Resource) ASSERT r.uri IS UNIQUE;

The ontology to be imported in this case is developed following BFO and IOF-Core upper-level ontology. The detailed development method is introduced in a previous paper[[3]](#footnote-3). A draft version of the ontology has been uploaded to GitHub for testing. It can be retrieved with this link:

<https://raw.githubusercontent.com/zhengxiaochen/ontology_aircraft_system/main/Aircraft_assembly_process_ontology.ttl>

## Import ontology

1. Change the handleVocabUris property to ‘MAP’ to avoid errors when exporting graph[[4]](#footnote-4).

CALL n10s.graphconfig.init({ handleVocabUris: 'handleVocabUris' });

1. Import ontology:

CALL n10s.onto.import.fetch( "https://raw.githubusercontent.com/zhengxiaochen/ontology\_aircraft\_system/main/Aircraft\_assembly\_process\_ontology.ttl", "Turtle",{ handleVocabUris: "MAP" })

1. Add new prefixes to map the relationships with proper names:

CALL n10s.nsprefixes.add("prefix", "neo4j://orbitaljoint#");

call n10s.mapping.add("neo4j://orbitaljoint#/process", "Process");

call n10s.mapping.add("neo4j://orbitaljoint#/operation", "Operation");

call n10s.mapping.add("neo4j://orbitaljoint#/haspredecessor", "hasPredecessor");

call n10s.mapping.add("neo4j://orbitaljoint#/requiresresource", "requiresResource");

call n10s.mapping.add("neo4j://orbitaljoint#/isindividualof", "isIndividualOf");

call n10s.mapping.add("neo4j://orbitaljoint#/issubclassof", "isSubclassOf");

call n10s.mapping.add("neo4j://orbitaljoint#/hasEssentialOperation", "hasEssentialOperation");

call n10s.mapping.add("neo4j://orbitaljoint#/hasSubprocess", "hasSubprocess");

call n10s.mapping.add("neo4j://orbitaljoint#/hasOptionalOperation", "hasOptionalOperation");

call n10s.mapping.add("neo4j://orbitaljoint#/hasOperation", "hasOperation");

call n10s.mapping.add("neo4j://orbitaljoint#/hasOptionalAutoOperation", "hasOptionalAutoOperation");

call n10s.mapping.add("neo4j://orbitaljoint#/hasOptionalManualOperation", "hasOptionalManualOperation");

1. Set label for visualizing classes and rename Resource name to n4sch\_\_Class:

MATCH (n:Resource) SET n.n4sch\_\_label=n.label RETURN n;

MATCH (n:Resource) WITH collect(n) AS n1

CALL apoc.refactor.rename.label("Resource", "n4sch\_\_Class", n1)

YIELD committedOperations

RETURN \*;

The ontology should be imported correctly with all the names properly visualized. Step 3 and 4 will need to be updated with corresponding relationship names or class names if a different ontology is imported.

## Edit ontology to add new classes corresponding to a dummy dataset

A dummy dataset is provided representing some typical operations of an aircraft Orbital Junction Process as shown below. These operations are more specific than the classes predefined in the imported ontology. Neo4j allows to add classes and relationships using Cypher querying. All the information indicated in the dataset can be added to the ontology with the following codes:

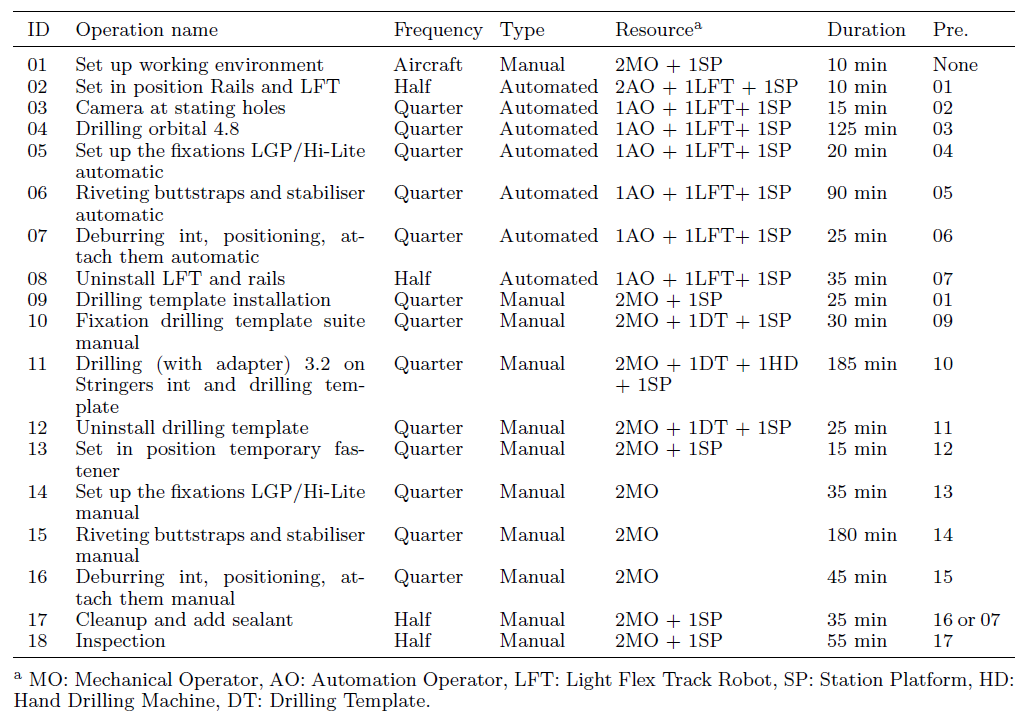


Figure 1 Some typical operations of an aircraft Orbital Junction Process

1. Add Operations

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Setup Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_01001\_Set up working environment", duration: 10 }), (op)-[:isSubclassOf]->(p);

//##automated process

//#1/2

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Installation Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_02001\_Set in position Rails and LFT", duration: 10, op\_type: "Auto"}), (op)-[:isSubclassOf]->(p);

//# 1/4

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Positioning Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04001\_Camera at stating holes", duration: 15, op\_type: "Auto" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Drilling Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04002\_Drilling orbital 4,8", duration: 125, op\_type: "Auto" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Positioning Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04008\_Set up the fixations LGP/Hi-Lite automatic", duration: 20, op\_type: "Auto" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Riveting Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04010\_Riveting buttstraps and stabiliser automatic", duration: 90, op\_type: "Auto" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Deburring Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04012\_Deburring int, positioning, attach them automatic", duration: 25, op\_type: "Auto" }), (op)-[:isSubclassOf]->(p);

//#1/2

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Uninstallation Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04014\_Deinstall LFT and rails", duration: 35, op\_type: "Auto" }), (op)-[:isSubclassOf]->(p);

// ## Manual process

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Installation Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04003\_Drilling template install", duration: 25, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Installation Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04004\_Fixation drilling template suite manual", duration: 30, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Drilling Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04005\_Drilling (with adapter) 3,2 on Stringers int and drilling template", duration: 185, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Uninstallation Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04006\_Deinstall drilling template", duration: 25, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Positioning Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04007\_Set in position temporary fastener", duration: 15, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Positioning Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04009\_Set up the fixations LGP/Hi-Lite manual", duration: 35, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Riveting Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04011\_Riveting buttstraps and stabiliser manual", duration: 180, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Deburring Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_04013\_Deburring int, positioning, attach them manual", duration: 45, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

//## 1/2 EssentialOperation

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Sealing Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_02002\_Cleanup and add sealant", duration: 35, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Inspection Operation'}) CREATE (op:n4sch\_\_Class { name: "S40\_02003\_Inspection", duration: 55, op\_type: "Manual" }), (op)-[:isSubclassOf]->(p);

//#SET all operations labels = name

MATCH (op:n4sch\_\_Class) WHERE op.name STARTS WITH 'S40\_0' SET op.n4sch\_\_label=substring(op.name,10);

1. Assign Operation sequence

MATCH (o1:n4sch\_\_Class ), (o2:n4sch\_\_Class ), (o3:n4sch\_\_Class ), (o4:n4sch\_\_Class ), (o5:n4sch\_\_Class ), (o6:n4sch\_\_Class ), (o7:n4sch\_\_Class ), (o8:n4sch\_\_Class ), (o9:n4sch\_\_Class ), (o10:n4sch\_\_Class ), (o11:n4sch\_\_Class ), (o12:n4sch\_\_Class ), (o13:n4sch\_\_Class ), (o14:n4sch\_\_Class ), (o15:n4sch\_\_Class ), (o16:n4sch\_\_Class ), (o17:n4sch\_\_Class ), (o18:n4sch\_\_Class )

WHERE o1.name STARTS WITH 'S40\_01001' AND o2.name STARTS WITH 'S40\_02001' AND o3.name STARTS WITH 'S40\_04001' AND o4.name STARTS WITH 'S40\_04002' AND o5.name STARTS WITH 'S40\_04003' AND o6.name STARTS WITH 'S40\_04004' AND o7.name STARTS WITH 'S40\_04005' AND o8.name STARTS WITH 'S40\_04006' AND o9.name STARTS WITH 'S40\_04007' AND o10.name STARTS WITH 'S40\_04008' AND o11.name STARTS WITH 'S40\_04009' AND o12.name STARTS WITH 'S40\_04010' AND o13.name STARTS WITH 'S40\_04011' AND o14.name STARTS WITH 'S40\_04012' AND o15.name STARTS WITH 'S40\_04013' AND o16.name STARTS WITH 'S40\_04014' AND o17.name STARTS WITH 'S40\_02002' AND o18.name STARTS WITH 'S40\_02003'

CREATE (o18)-[:hasPredecessor]->(o17), (o14)-[:hasPredecessor]->(o12)-[:hasPredecessor]->(o10)-[:hasPredecessor]->(o4)-[:hasPredecessor]->(o3), (o15)-[:hasPredecessor]->(o13)-[:hasPredecessor]->(o11)-[:hasPredecessor]->(o9)-[:hasPredecessor]->(o8)-[:hasPredecessor]->(o7)-[:hasPredecessor]->(o6)-[:hasPredecessor]->(o5);

1. Add Resource

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'FlexTrack Body'}) SET p.n4sch\_\_label= "Light Flex Track Robot", p.name="Light Flex Track Robot", p.cost\_hour= 75, p.calendar= "24x7", p.number = 2;

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'FlexTrack Rail'}) SET p.n4sch\_\_label= "Light Flex Track Rail",p.name="Light Flex Track Rail", p.cost\_hour= 5, p.calendar= "24x7", p.number = 2;

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Facilities'}) CREATE (op:n4sch\_\_Class { name: "Station",n4sch\_\_label:"Station",cost\_hour: 80, calendar: "24x7", number: 2 }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Facilities'}) CREATE (op:n4sch\_\_Class { name: "Station platform",n4sch\_\_label:"Station platform",cost\_hour: 75, calendar: "24x7", number: 2}), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Operator'}) CREATE (op:n4sch\_\_Class { name: "Mechanical Operator",n4sch\_\_label:"Mechanical Operator",cost\_hour: 100, calendar: "shift\_40h\_week", number: 8 }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Operator'}) CREATE (op:n4sch\_\_Class { name: "Automation Operator",n4sch\_\_label:"Automation Operator",cost\_hour: 100, calendar: "shift\_40h\_week", number: 8 }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Equipment'}) CREATE (op:n4sch\_\_Class { name: "Hand drilling machine",n4sch\_\_label:"Hand drilling machine",cost\_hour: 10, calendar: "24x7", number: 6 }), (op)-[:isSubclassOf]->(p);

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Equipment'}) CREATE (op:n4sch\_\_Class { name: "Drilling template",n4sch\_\_label:"Drilling template",cost\_hour: 10, calendar: "24x7", number: 5 }), (op)-[:isSubclassOf]->(p);

1. Assign Resource to operations

MATCH (o1:n4sch\_\_Class), (o2:n4sch\_\_Class), (o3:n4sch\_\_Class), (o4:n4sch\_\_Class), (o5:n4sch\_\_Class), (o6:n4sch\_\_Class), (o7:n4sch\_\_Class), (o8:n4sch\_\_Class), (o9:n4sch\_\_Class), (o10:n4sch\_\_Class), (o11:n4sch\_\_Class), (o12:n4sch\_\_Class), (o13:n4sch\_\_Class), (o14:n4sch\_\_Class), (o15:n4sch\_\_Class), (o16:n4sch\_\_Class), (o17:n4sch\_\_Class), (o18:n4sch\_\_Class), (r11:n4sch\_\_Class { name: "Mechanical Operator" }),(r12:n4sch\_\_Class { name: "Automation Operator" }),(r2:n4sch\_\_Class { name: "Light Flex Track Robot" }),(r3:n4sch\_\_Class { name: "Light Flex Track Rail" }),(r4:n4sch\_\_Class { name: "Hand drilling machine" }),(r5:n4sch\_\_Class { name: "Drilling template" }),(r6:n4sch\_\_Class { name: "Station platform" }),(r7:n4sch\_\_Class { name: "Station" })

WHERE o1.name STARTS WITH 'S40\_01001' AND o2.name STARTS WITH 'S40\_02001' AND o3.name STARTS WITH 'S40\_04001' AND o4.name STARTS WITH 'S40\_04002' AND o5.name STARTS WITH 'S40\_04003' AND o6.name STARTS WITH 'S40\_04004' AND o7.name STARTS WITH 'S40\_04005' AND o8.name STARTS WITH 'S40\_04006' AND o9.name STARTS WITH 'S40\_04007' AND o10.name STARTS WITH 'S40\_04008' AND o11.name STARTS WITH 'S40\_04009' AND o12.name STARTS WITH 'S40\_04010' AND o13.name STARTS WITH 'S40\_04011' AND o14.name STARTS WITH 'S40\_04012' AND o15.name STARTS WITH 'S40\_04013' AND o16.name STARTS WITH 'S40\_04014' AND o17.name STARTS WITH 'S40\_02002' AND o18.name STARTS WITH 'S40\_02003'

CREATE (o1)-[:requiresResource {number: 1}]->(r11), (r6)<-[:requiresResource {number: 1}]-(o1)-[:requiresResource {number:1}]->(r7),

(o2)-[:requiresResource {number:2}]->(r12), (r2)<-[:requiresResource {number: 1}]-(o2)-[:requiresResource {number:1}]->(r3), (r6)<-[:requiresResource {number: 1}]-(o2)-[:requiresResource {number:1}]->(r7),

(o3)-[:requiresResource {number:1}]->(r12), (r2)<-[:requiresResource {number: 1}]-(o3)-[:requiresResource {number:1}]->(r3), (r6)<-[:requiresResource {number: 1}]-(o3)-[:requiresResource {number:1}]->(r7),

(o4)-[:requiresResource {number:1}]->(r12), (r2)<-[:requiresResource {number: 1}]-(o4)-[:requiresResource {number:1}]->(r3), (r6)<-[:requiresResource {number: 1}]-(o4)-[:requiresResource {number:1}]->(r7),

(o5)-[:requiresResource {number:2}]->(r11), (r6)<-[:requiresResource {number: 1}]-(o5)-[:requiresResource {number:1}]->(r7),

(o6)-[:requiresResource {number:2}]->(r11), (o6)-[:requiresResource {number:1}]->(r5),(r6)<-[:requiresResource {number: 1}]-(o6)-[:requiresResource {number:1}]->(r7),

(o7)-[:requiresResource {number:2}]->(r11), (r4)<-[:requiresResource {number:2}]-(o7)-[:requiresResource {number:1}]->(r5),(r6)<-[:requiresResource {number: 1}]-(o7)-[:requiresResource {number:1}]->(r7),

(o8)-[:requiresResource {number:2}]->(r11), (o8)-[:requiresResource {number:1}]->(r5),(r6)<-[:requiresResource {number: 1}]-(o8)-[:requiresResource {number:1}]->(r7),

(o9)-[:requiresResource {number:2}]->(r11), (r6)<-[:requiresResource {number: 1}]-(o9)-[:requiresResource {number:1}]->(r7),

(o10)-[:requiresResource {number:1}]->(r12), (r2)<-[:requiresResource {number: 1}]-(o10)-[:requiresResource {number:1}]->(r3), (r6)<-[:requiresResource {number: 1}]-(o10)-[:requiresResource {number:1}]->(r7),

(o12)-[:requiresResource {number:1}]->(r12), (r2)<-[:requiresResource {number: 1}]-(o12)-[:requiresResource {number:1}]->(r3), (r6)<-[:requiresResource {number: 1}]-(o12)-[:requiresResource {number:1}]->(r7),

(o14)-[:requiresResource {number:1}]->(r12), (r2)<-[:requiresResource {number: 1}]-(o14)-[:requiresResource {number:1}]->(r3), (r6)<-[:requiresResource {number: 1}]-(o14)-[:requiresResource {number:1}]->(r7),

(o16)-[:requiresResource {number:1}]->(r12), (r2)<-[:requiresResource {number: 1}]-(o16)-[:requiresResource {number:1}]->(r3), (r6)<-[:requiresResource {number: 1}]-(o16)-[:requiresResource {number:1}]->(r7),

(o11)-[:requiresResource {number:2}]->(r11),

(o13)-[:requiresResource {number:2}]->(r11),

(o15)-[:requiresResource {number:2}]->(r11),

(o17)-[:requiresResource {number:2}]->(r11), (r6)<-[:requiresResource {number: 1}]-(o17)-[:requiresResource {number:1}]->(r7),

(o18)-[:requiresResource {number:2}]->(r11), (r6)<-[:requiresResource {number: 1}]-(o18)-[:requiresResource {number:1}]->(r7);

1. Split Orbital Junction Processes to upper/lower subprocesses, and left/right quarter processes

//##delete original relation with Operations

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Orbital Joining Process'})-[re:n4sch\_\_SCO\_RESTRICTION]->(op) DELETE re RETURN p,op;

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Orbital Joining Process'})<-[re:n4sch\_\_SCO\_RESTRICTION{onPropertyName:'RC3SMTo1pqRXZWD5dLjQzIu'}]->(op) DELETE re RETURN p,op;

//##add new relationships

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Orbital Joining Process'}), (o1:n4sch\_\_Class {n4sch\_\_label: 'Front Fuselage'}), (o2:n4sch\_\_Class {n4sch\_\_label: 'Rear Fuselage'}) CREATE (o1)<-[:joinsMaterial]-(p)-[:joinsMaterial]->(o2) RETURN p;

//##Add subProcess

MATCH (p:n4sch\_\_Class {n4sch\_\_label: 'Orbital Joining Process'}) CREATE

(sc1:n4sch\_\_Class { name: "Upper Orbital Joining Process", n4sch\_\_label: "Upper Orbital Joining Process"}),

(sc2:n4sch\_\_Class { name: "Lower Orbital Joining Process", n4sch\_\_label: "Lower Orbital Joining Process"}),

(sc11:n4sch\_\_Class { name: "Upper Left Orbital Joining Process", n4sch\_\_label: "Upper Left Orbital Joining Process"}),

(sc12:n4sch\_\_Class { name: "Upper Right Orbital Joining Process", n4sch\_\_label: "Upper Right Orbital Joining Process"}),

(sc21:n4sch\_\_Class { name: 'Lower Left Orbital Joining Process', n4sch\_\_label: 'Lower Left Orbital Joining Process'}),

(sc22:n4sch\_\_Class { name: 'Lower Right Orbital Joining Process', n4sch\_\_label: 'Lower Right Orbital Joining Process'}),

(sc1)<-[:hasSubprocess]-(p)-[:hasSubprocess]->(sc2), (sc11)<-[:hasSubprocess]-(sc1)-[:hasSubprocess]->(sc12),(sc21)<-[:hasSubprocess]-(sc2)-[:hasSubprocess]->(sc22);

1. Assign EssentialOperations and OptionalOperations

MATCH (o1:n4sch\_\_Class), (o2:n4sch\_\_Class), (o3:n4sch\_\_Class), (o4:n4sch\_\_Class), (o5:n4sch\_\_Class), (o6:n4sch\_\_Class), (o7:n4sch\_\_Class), (o8:n4sch\_\_Class), (o9:n4sch\_\_Class), (o10:n4sch\_\_Class), (o11:n4sch\_\_Class), (o12:n4sch\_\_Class), (o13:n4sch\_\_Class), (o14:n4sch\_\_Class), (o15:n4sch\_\_Class), (o16:n4sch\_\_Class), (o17:n4sch\_\_Class), (o18:n4sch\_\_Class), (p1:n4sch\_\_Class {n4sch\_\_label: 'Orbital Joining Process'}), (sc1:n4sch\_\_Class {n4sch\_\_label: 'Upper Orbital Joining Process'}), (sc2:n4sch\_\_Class {n4sch\_\_label: 'Lower Orbital Joining Process'}), (sc11:n4sch\_\_Class {n4sch\_\_label: 'Upper Right Orbital Joining Process'}),(sc12:n4sch\_\_Class {n4sch\_\_label: 'Upper Left Orbital Joining Process'}), (sc21:n4sch\_\_Class {n4sch\_\_label: 'Lower Right Orbital Joining Process'}),(sc22:n4sch\_\_Class {n4sch\_\_label: 'Lower Left Orbital Joining Process'})

WHERE o1.name STARTS WITH 'S40\_01001' AND o2.name STARTS WITH 'S40\_02001' AND o3.name STARTS WITH 'S40\_04001' AND o4.name STARTS WITH 'S40\_04002' AND o5.name STARTS WITH 'S40\_04003' AND o6.name STARTS WITH 'S40\_04004' AND o7.name STARTS WITH 'S40\_04005' AND o8.name STARTS WITH 'S40\_04006' AND o9.name STARTS WITH 'S40\_04007' AND o10.name STARTS WITH 'S40\_04008' AND o11.name STARTS WITH 'S40\_04009' AND o12.name STARTS WITH 'S40\_04010' AND o13.name STARTS WITH 'S40\_04011' AND o14.name STARTS WITH 'S40\_04012' AND o15.name STARTS WITH 'S40\_04013' AND o16.name STARTS WITH 'S40\_04014' AND o17.name STARTS WITH 'S40\_02002' AND o18.name STARTS WITH 'S40\_02003'

CREATE

(p1)-[:hasEssentialOperation]->(o1), (sc1)-[:hasEssentialOperation]->(o17)<-[:hasEssentialOperation]-(sc2), (sc1)-[:hasEssentialOperation]->(o18)<-[:hasEssentialOperation]-(sc2),

(o2)<-[:hasOptionalAutoOperation]-(sc1)-[:hasOptionalAutoOperation]->(o16), (o2)<-[:hasOptionalAutoOperation]-(sc2)-[:hasOptionalAutoOperation]->(o16),

(o3)<-[:hasOptionalAutoOperation]-(sc11)-[:hasOptionalAutoOperation]->(o4), (o10)<-[:hasOptionalAutoOperation]-(sc11)-[:hasOptionalAutoOperation]->(o12),(sc11)-[:hasOptionalAutoOperation]->(o14), (o5)<-[:hasOptionalManualOperation]-(sc11)-[:hasOptionalManualOperation]->(o6), (o7)<-[:hasOptionalManualOperation]-(sc11)-[:hasOptionalManualOperation]->(o8), (o9)<-[:hasOptionalManualOperation]-(sc11)-[:hasOptionalManualOperation]->(o11), (o13)<-[:hasOptionalManualOperation]-(sc11)-[:hasOptionalManualOperation]->(o15),

(o3)<-[:hasOptionalAutoOperation]-(sc12)-[:hasOptionalAutoOperation]->(o4), (o10)<-[:hasOptionalAutoOperation]-(sc12)-[:hasOptionalAutoOperation]->(o12),(sc12)-[:hasOptionalAutoOperation]->(o14), (o5)<-[:hasOptionalManualOperation]-(sc12)-[:hasOptionalManualOperation]->(o6), (o7)<-[:hasOptionalManualOperation]-(sc12)-[:hasOptionalManualOperation]->(o8), (o9)<-[:hasOptionalManualOperation]-(sc12)-[:hasOptionalManualOperation]->(o11), (o13)<-[:hasOptionalManualOperation]-(sc12)-[:hasOptionalManualOperation]->(o15),

(o3)<-[:hasOptionalAutoOperation]-(sc21)-[:hasOptionalAutoOperation]->(o4), (o10)<-[:hasOptionalAutoOperation]-(sc21)-[:hasOptionalAutoOperation]->(o12),(sc21)-[:hasOptionalAutoOperation]->(o14), (o5)<-[:hasOptionalManualOperation]-(sc21)-[:hasOptionalManualOperation]->(o6), (o7)<-[:hasOptionalManualOperation]-(sc21)-[:hasOptionalManualOperation]->(o8), (o9)<-[:hasOptionalManualOperation]-(sc21)-[:hasOptionalManualOperation]->(o11), (o13)<-[:hasOptionalManualOperation]-(sc21)-[:hasOptionalManualOperation]->(o15),

(o3)<-[:hasOptionalAutoOperation]-(sc22)-[:hasOptionalAutoOperation]->(o4), (o10)<-[:hasOptionalAutoOperation]-(sc22)-[:hasOptionalAutoOperation]->(o12),(sc22)-[:hasOptionalAutoOperation]->(o14), (o5)<-[:hasOptionalManualOperation]-(sc22)-[:hasOptionalManualOperation]->(o6), (o7)<-[:hasOptionalManualOperation]-(sc22)-[:hasOptionalManualOperation]->(o8), (o9)<-[:hasOptionalManualOperation]-(sc22)-[:hasOptionalManualOperation]->(o11), (o13)<-[:hasOptionalManualOperation]-(sc22)-[:hasOptionalManualOperation]->(o15);

Now all the information of the dummy dataset is stored in the ontology. We can use this ontology to generate some Orbital Junction Process alternatives based on certain rules.

## Knowledge instantiating to create new Orbital Junction Process individuals

The example below shows how to generate an Orbital Junction Process: name starts with ‘N1’, 1/2 AUTO concurrent 1/2 AUTO.

1. Create new process and add essential operations

//## structure of the process

//MATCH (op) WHERE op.name STARTS WITH 'N1' DETACH DELETE op;

//MATCH (op),(ob), (res) WHERE op.name STARTS WITH 'N1' AND ob.name STARTS WITH "RD1" AND res.name STARTS WITH "N1R" DETACH DELETE op, ob, res;

MATCH (p:n4sch\_\_Class{n4sch\_\_label: 'Orbital Joining Process'})-[:hasEssentialOperation]->(Eop:n4sch\_\_Class)

CREATE (np:Process{name: "RD1" + p.n4sch\_\_label}), (np)-[:isIndividualOf]->(p), (nEop :Operation{name: "N1" + Eop.n4sch\_\_label}), (nEop)-[:isIndividualOf]->(Eop), (np)-[:hasOperation]->(nEop) //only 1 EssentialOperation

WITH \* MATCH (p)-[:hasSubprocess]->(sc:n4sch\_\_Class)-[:hasEssentialOperation]->(Eop1:n4sch\_\_Class)<-[:hasPredecessor\*1..10]-(pr:n4sch\_\_Class)//sc:upper and lower half

WITH DISTINCT Eop1, pr

CREATE (nEop1:Operation{name: "N1" + Eop1.n4sch\_\_label+"\_1"})-[:isIndividualOf]->(Eop1), (nEop1)<-[:hasPredecessor]-(fop1:Operation{name:'N1' + pr.n4sch\_\_label+"\_1"})-[:isIndividualOf]->(pr), (nEop2:Operation{name: "N1" + Eop1.n4sch\_\_label +"\_2"})-[:isIndividualOf]->(Eop1), (nEop2)<-[:hasPredecessor]-(fop2:Operation{name:'N1' + pr.n4sch\_\_label+"\_2"})-[:isIndividualOf]->(pr) //only 1 EssentialOperation and its following ops

RETURN nEop1, fop1, nEop2, fop2

1. Add OptionalOperation

MATCH (p:n4sch\_\_Class{n4sch\_\_label: 'Orbital Joining Process'})-[:hasSubprocess]->(sc:n4sch\_\_Class)-[:hasOptionalOperation]->(Oop:n4sch\_\_Class)

WITH DISTINCT Oop

CREATE (nOop:Operation{name: "N1" + Oop.n4sch\_\_label})-[:isIndividualOf]->(Oop)

RETURN nOop

1. Quarter-level ¼ processes

MATCH (p:n4sch\_\_Class{n4sch\_\_label: 'Orbital Joining Process'})-[:hasSubprocess]->(sc:n4sch\_\_Class)

WITH DISTINCT sc

MATCH (sc)-[:hasSubprocess]->(ssc:n4sch\_\_Class)-[:hasOptionalOperation]->(Oop:n4sch\_\_Class) //2 OptionalOperation

WITH DISTINCT Oop

CREATE (nOop:Operation{name: "N1" + Oop.n4sch\_\_label + "\_1"})-[:isIndividualOf]->(Oop)

WITH \* MATCH (Oop)<-[:hasPredecessor\*1..10]-(pr:n4sch\_\_Class)

WITH DISTINCT pr as pr0

UNWIND pr0 as pr1

CREATE (fop1:Operation{name:'N1' + pr1.n4sch\_\_label+ "\_1"}), (fop1)-[:isIndividualOf]->(pr1)

WITH \* MATCH (op1)-[:isIndividualOf]->(oc1:n4sch\_\_Class)<-[:hasPredecessor]-(pr1) WHERE op1.name STARTS WITH "N1"

CREATE (fop1)-[:hasPredecessor]->(op1)

RETURN op1, fop1

//create a copy of 1/4 operations

MATCH (p:n4sch\_\_Class{n4sch\_\_label: 'Orbital Joining Process'})-[:hasSubprocess]->(sc:n4sch\_\_Class)

WITH DISTINCT sc

MATCH (sc)-[:hasSubprocess]->(ssc:n4sch\_\_Class)-[:hasOptionalOperation]->(Oop:n4sch\_\_Class) //2 OptionalOperation

WITH DISTINCT Oop

CREATE (nOop:Operation{name: "N1" + Oop.n4sch\_\_label + "\_2"})-[:isIndividualOf]->(Oop)

WITH \* MATCH (Oop)<-[:hasPredecessor\*1..10]-(pr:n4sch\_\_Class)

WITH DISTINCT pr as pr0

UNWIND pr0 as pr1

CREATE (fop2:Operation{name:'N1' + pr1.n4sch\_\_label+ "\_2"}), (fop2)-[:isIndividualOf]->(pr1)

WITH \* MATCH (op2)-[:isIndividualOf]->(oc1:n4sch\_\_Class)<-[:hasPredecessor]-(pr1) WHERE op2.name ENDS WITH "\_2" AND op2.name STARTS WITH "N1"

CREATE (fop2)-[:hasPredecessor]->(op2)

RETURN op2, fop2

1. Concurrent 1/2

MATCH (lft1:Operation), (lft2:Operation), (cam1:Operation), (cam2:Operation), (deb1:Operation), (deb2:Operation), (cln1:Operation), (cln2:Operation), (drl1:Operation), (drl2:Operation), (deb3:Operation), (deb4:Operation), (pre:Operation)

WHERE lft1.name CONTAINS "N1Set in position Rails and LFT" AND lft2.name CONTAINS "N1Deinstall LFT and rails" AND cam1.name CONTAINS "N1Camera at stating holes\_1" AND cam2.name CONTAINS "N1Camera at stating holes\_2" AND deb1.name CONTAINS "N1Deburring int, positioning, attach them automatic\_1" AND deb2.name CONTAINS "N1Deburring int, positioning, attach them automatic\_2" AND cln1.name CONTAINS "N1Cleanup and add sealant\_1" AND cln2.name CONTAINS "N1Cleanup and add sealant\_2" AND drl1.name CONTAINS "N1Drilling template install\_1" AND drl2.name CONTAINS "N1Drilling template install\_2" AND deb3.name CONTAINS "N1Deburring int, positioning, attach them manual\_1" AND deb4.name CONTAINS "N1Deburring int, positioning, attach them manual\_2" AND pre.name CONTAINS "N1Set up working environment"

CREATE (cam1)-[:hasPredecessor]->(lft1), (cam2)-[:hasPredecessor]->(deb1), (lft2)-[:hasPredecessor]->(deb2), (deb4)<-[:hasPredecessor]-(cln2),(cln1)-[:hasPredecessor]->(lft2), (drl2)-[:hasPredecessor]->(deb3), (lft1)-[:hasPredecessor]->(pre)<-[:hasPredecessor]-(drl1)

RETURN lft1, lft2, cam1, cam2, deb1, deb2, deb3, deb4, cln1, cln2, drl1, drl2, pre

1. Add resources

MATCH (op:Operation)-[:isIndividualOf]->(cl:n4sch\_\_Class)-[:requiresResource]->(res:n4sch\_\_Class) WHERE op.name STARTS WITH 'N1'

WITH DISTINCT res

CREATE (rob:Resource{name: "N1R\_" + res.n4sch\_\_label, n4sch\_\_label:"N1R\_" + res.n4sch\_\_label})-[:isIndividualOf]->(res)

WITH \* MATCH (op:Operation)-[:isIndividualOf]->(cl:n4sch\_\_Class)-[r]->(res:n4sch\_\_Class)<-[:isIndividualOf]-(rob) WHERE op.name STARTS WITH 'N1'

CREATE (op)-[:requiresResource{number: r.number}]->(rob)

RETURN rob, op

1. add time

MATCH (op:Operation)-[:isIndividualOf]->(cl:n4sch\_\_Class) WHERE op.name STARTS WITH 'N1'

SET op.duration = cl.duration, op.op\_type=cl.op\_type

A new Orbital Junction Process has been created. We can query it to see how it looks like:

//Displaying 68 nodes, 328 relationships.

MATCH (operation)-[Relationship]-(entity) WHERE operation.name STARTS WITH 'N1'

RETURN \*;

It is also possible to export the query results in RDF format[[5]](#footnote-5):

:POST http://localhost:7474/rdf/orbitaljoint/cypher

{ "cypher" : "MATCH (operatoin)-[relationship]-(entity) WHERE operatoin.name STARTS WITH 'N1' RETURN \*", "format": "Turtle" }

It is also possible to make the above process generating automatic by embedding Cypher codes into a Python script, which is available in GitHub[[6]](#footnote-6).

All the Cypher code mentioned above is also available in a clean .cpy file without explanations[[7]](#footnote-7).

1. <https://www.researchgate.net/publication/355889982_Neo4j_graph_database_installation_on_Azure_cloud_Ubuntu_Virtual_Machine_and_configuration_of_Neosemantics_package_for_Ontology> [↑](#footnote-ref-1)
2. <https://neo4j.com/labs/neosemantics/4.2/config/> [↑](#footnote-ref-2)
3. Zheng, Xiaochen, et al. "Development of an Application Ontology for Knowledge Management to Support Aircraft Assembly System Design." Proceedings http://ceur-ws. org ISSN 1613 (2020): 0073. [↑](#footnote-ref-3)
4. <https://community.neo4j.com/t/problem-exporting-rdf-using-neosemantics-n10s/20880/9> [↑](#footnote-ref-4)
5. <https://neo4j.com/labs/neosemantics/4.0/export/> [↑](#footnote-ref-5)
6. <https://github.com/zhengxiaochen/ontology_aircraft_system/blob/main/auto_generate_process.py> [↑](#footnote-ref-6)
7. <https://github.com/zhengxiaochen/ontology_aircraft_system/blob/main/CYPHER_import_edit_ontology.cyp> [↑](#footnote-ref-7)