IASelect

Finding Best-fit Agent Practices in Industrial CPS Using Graph Databases

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OVERVIEW

- **Problem: *rank*** and ***select*** best-fit Industrial Agent (IA) practices[1].
- **Approach**:
  - Construct a *graph database* for storing practices.
  - Identify template query patterns for ranking, data extraction and selection.
  - Use MVC to construct a front-end for users.
- **Contribution**:
  - **IA*Select***, a tool for selecting best-fit Industrial Agent (IA) practices in P2660.1.

1. P. Leitão et al 2017 "Common practices for integrating industrial agents and low level automation functions,"

BACKGROUND

IEEE P2660.1: Recommended Practices on Industrial Agents

- Multi-agent systems in Industrial control systems
- Identify best-fit practices for a given context

Graph databases:

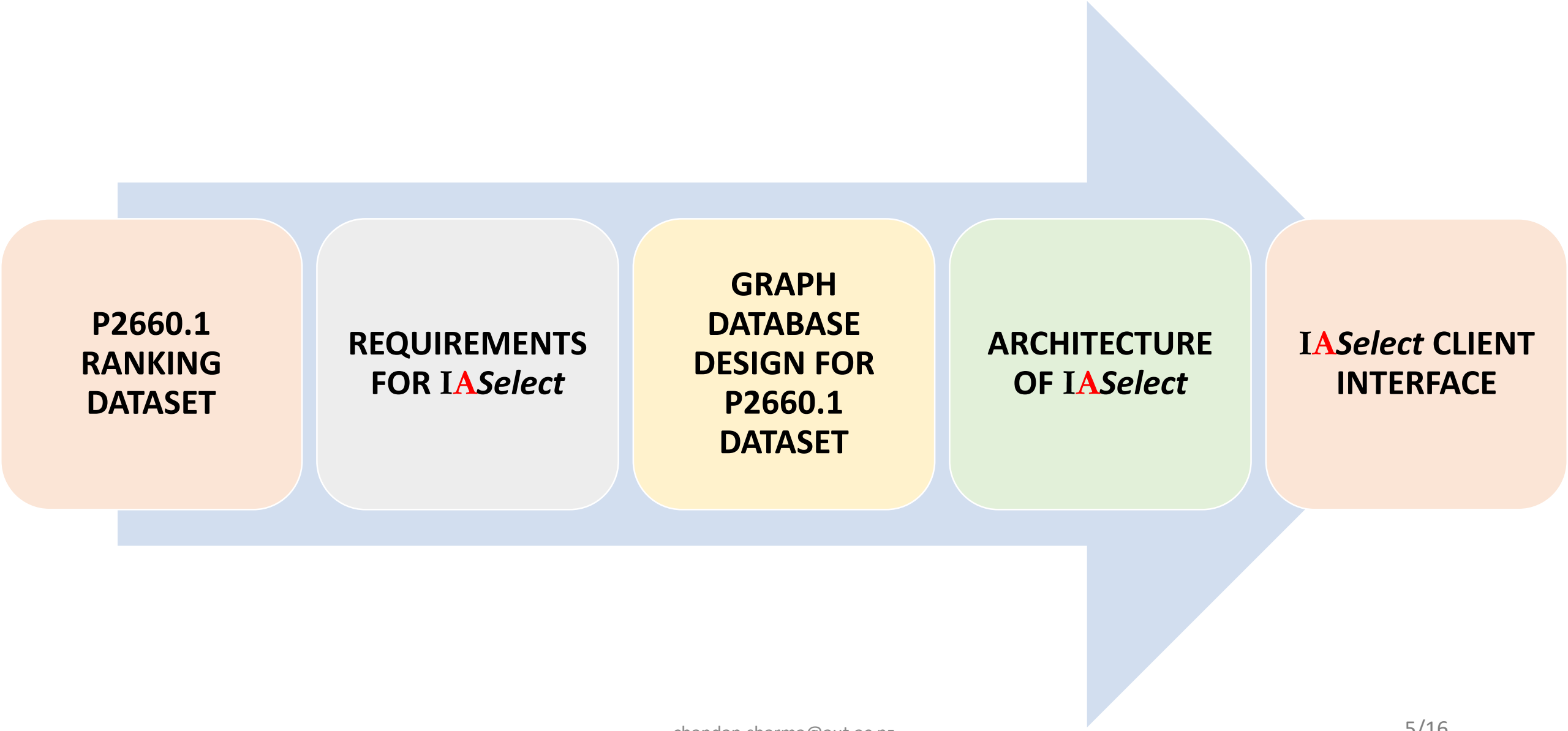
- Highly interconnected data
- Easier to visualise than relational databases
- Just as easy to query

RELATED LITERATURE

- Available tools (storage and recommendation):
  - [1] and [2] use relational and XML databases respectively.
  - [3] uses a graph database for data visualization.
  - [4] and [5] use graph databases in domains such as Chemistry and Biology.
- **Novelty:**
  - **IA*Select*** provides query ***boiler-plates*** [6].
  - Practitioners ***do not*** require expertise in ***querying graph databases*** (unlike [1-3]).
  - **IA*Select*** enforces ***schema-based topological restrictions*** which reduce the risk of ***data corruption*** (unlike [2]).

1. S. Morimoto, D. Horie, and J. Cheng, "A security requirement management database based on iso/iec 15408," in International Conference on Computational Science and Its Applications. Springer, 2006, pp. 1–10.
2. S. Morimoto and J. Cheng, "A security specification library with a schemaless database," in International Conference on Computational Science. Springer, 2007, pp. 890–893.
3. R. Loof and K. Pussinen, "Visualisation of requirements and their relations in embedded systems," 2014.
4. R. J. Hall, C. W. Murray, and M. L. Verdonk, "The fragment network: A chemistry recommendation engine built using a graph database," Journal of medicinal chemistry, vol. 60, no. 14, pp. 6440–6450, 2017.
5. M. Graves, E. R. Bergeman, and C. B. Lawrence, "Querying a genome database using graphs," in Proceedings of the 3th International Conference on Bioinformatics and Genome Research, 1994.
6. R. Sinha, S. Patil, C. Pang, V. Vyatkin, and B. Dowdeswell, "Requirements engineering of industrial automation systems: Adapting the CESAR requirements meta model for safety-critical smart grid software," in Industrial Electronics Society, IECON 2015-41st Annual Conference of the IEEE. IEEE, 2015, pp. 002 172–002 177.

APPROACH FOR DESIGING IA*Select*



P2660.1 IA RANKING DATASET

			Domain			Function					
		Need host agents	Energy	Factory automation	Building automation	Monitor	Control	Simulation	Scalability	Time behaviour	Reusability
Hybrid, Tightly											
#HT,1	API client: Java Channel: Modbus	0	3	5	3	4	1	2	2	3	3
On-device, Tightly											
#OT,1	API client: Java Channel: Modbus	1	3	4	3	4	4	1	2	5	2
Hybrid, Loosed											
#HL, 1	API client: Apache Milo Channel: OPC-UA	0	4	5	4	5	1	5	4	3	5
#HL, 2	API client: Apache Paho Channel: MQTT Broker: Eclipse Mosquit	0	3	4	5	5	1	5	4	2	5
On-Device, Loosed											
#OL, 1	API client: Apache Milo Channel: OPC-UA	1	3	4	4	5	3	3	3	4	5
#OL, 2	API client: Apache Paho Channel: MQTT Broker: Eclipse Mosquit	1	2	4	4	5	3	3	3	4	5

IA CHARACTERISTICS IDENTIFIED IN P2660.1

Domain	Function	Maintenance	Performance Efficiency
Factory Automation Building Automation Energy	Monitoring Control Simulation	Re-usability Capacity To Host agents	Time behaviour Scalability

REQUIREMENTS FOR IA*Select*

Scenario defined by the user:	
Context	
Function?	Control
Application domain?	Factory automation
Technology capable to host agents is available?	Yes
Weights for criteria	
Scalability	10%
Time behaviour	10%
Reusability	80%
	100%

Results:			
Recomended interface practice			
#OL, 1			
Suggested technologies			
Details			
		Score	Score final
Hybrid, Tightly			
#HT,1	API client: Java	2.9	0.6
	Channel: Modbus		
On-device, Tightly			
#OT,1	API client: Java	2.3	1.8
	Channel: Modbus		
Hybrid, Loosed			
#HL, 1	API client: Apache Milo	4.7	0.9
	Channel: OPC-UA		
#HL, 2	API client: Apache Paho	4.6	0.9
	Channel: MQTT		
	Broker: Eclipse Mosquito		
On-Device, Loosed			
#OL, 1	API client: Apache Milo	4.7	2.8
	Channel: OPC-UA		
#OL, 2	API client: Apache Paho	4.7	2.8
	Channel: MQTT		
	Broker: Eclipse Mosquito		

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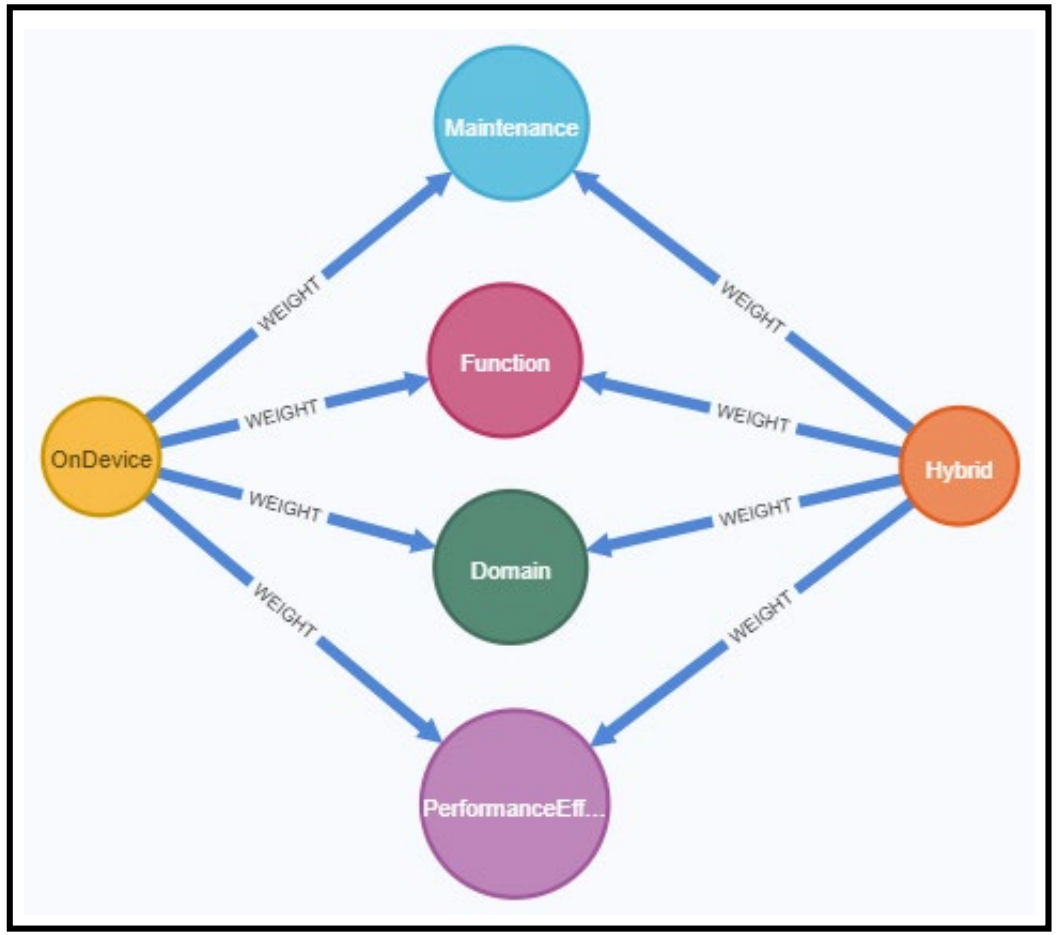
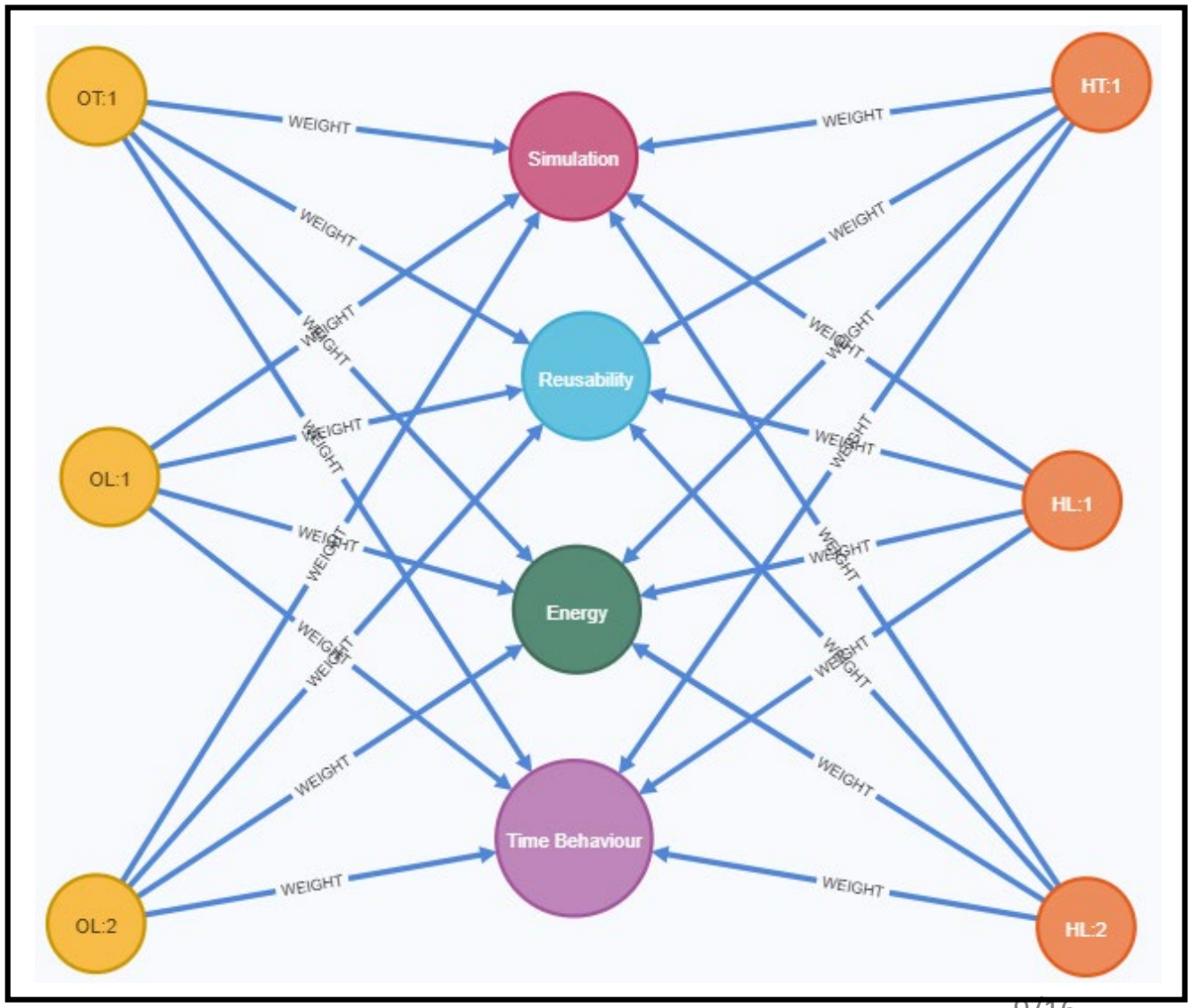
GRAPH DB DESIGN FOR P2660.1 DATASET

GRAPH SCHEMA



GRAPH DATABASE



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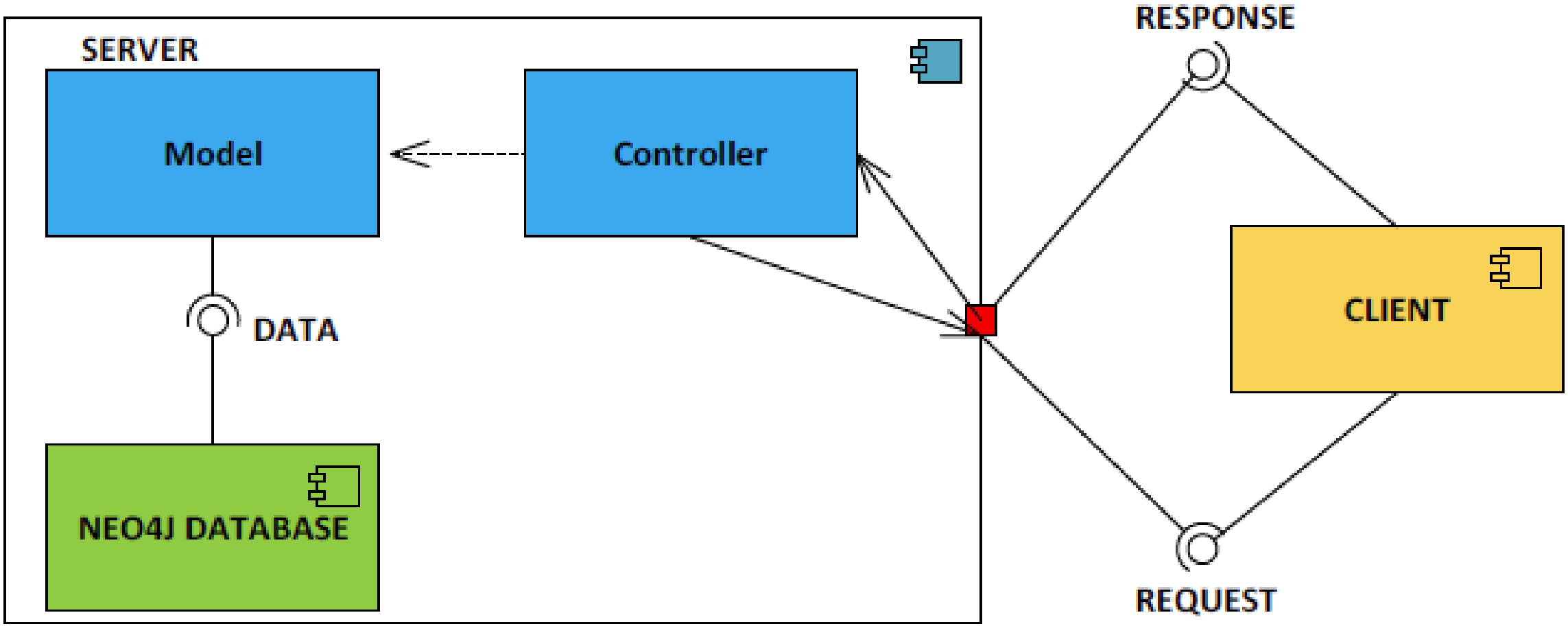
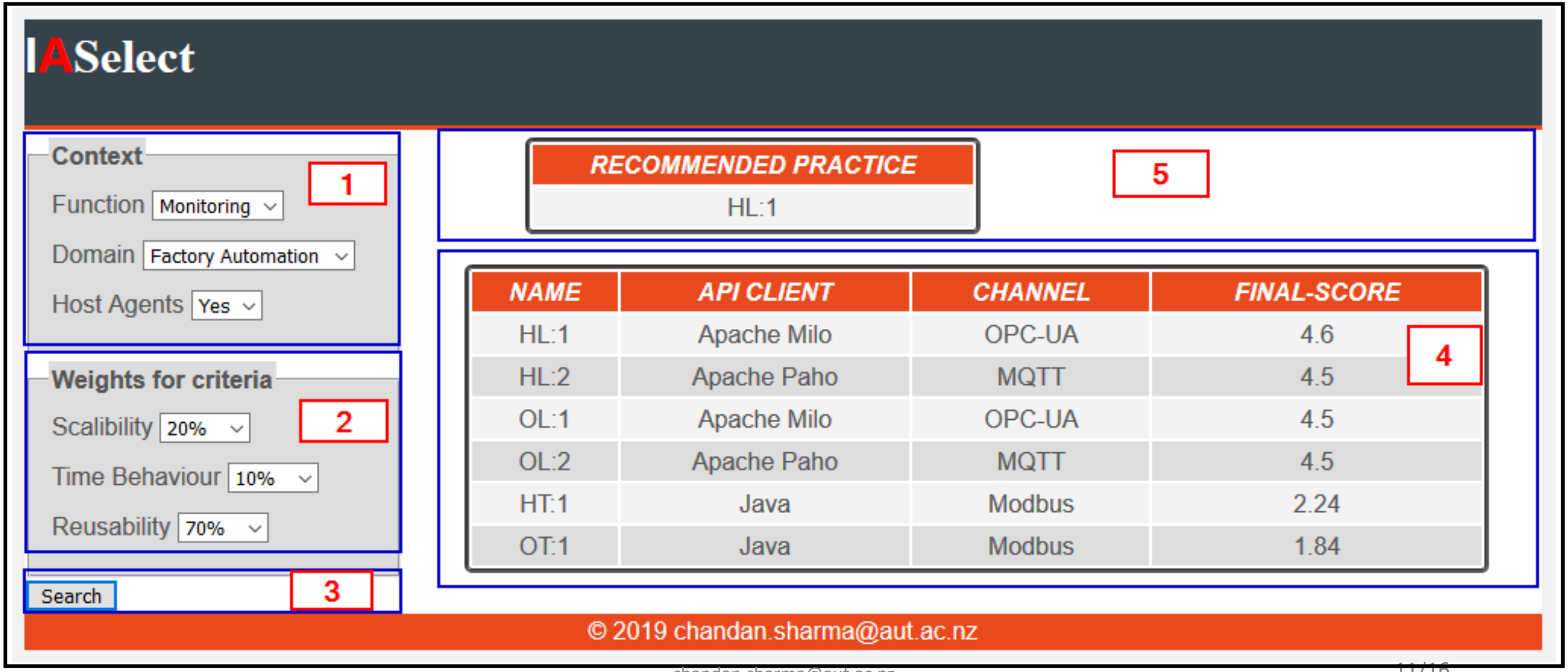
ARCHITECTURE OF IA*Select*



IA*Select* CLIENT INTERFACE



TECHNOLOGY STACK OF IA*Select*

SERVER

Implemented in **JAVA** using **Gradle** and **Maven**.

Gradle → Spring Boot **Plugin** → Embedded **TomCat** Server

Maven → **Neo4j** Database

CLIENT

HTML 5

CSS 3

JAVASCRIPT

AJAX (XmlHttpRequest)

DEMO OF IA*Select*

IASelect

Context

Function: Monitoring

Domain: Factory Automation

Host Agents: Yes

Weights for criteria

Scalibility: 20%

Time Behaviour: 10%

Reusability: 70%

Search

RECOMMENDED PRACTICE
HL:1

NAME	API CLIENT	CHANNEL	FINAL-SCORE
HL:1	Apache Milo	OPC-UA	4.6
HL:2	Apache Paho	MQTT	4.5
OL:1	Apache Milo	OPC-UA	4.5
OL:2	Apache Paho	MQTT	4.5
HT:1	Java	Modbus	2.24
OT:1	Java	Modbus	1.84

ARCHITECTURAL ADVANTAGES OF I*ASelect*

Functional Suitability: Ability for ***Users* to query** the graph database to **rank available** practice.

Usability: Allow ***Users*** to enter information in an **interactive manner**, provide appropriate ***user error protection*** and **present results** clearly.

Availability: Accessible to multiple ***Users***, present in different locations at same time.

Portability: Independent of ***Users'*** computer configuration.

LIMITATIONS AND FUTURE WORK

- **Performance:** As database grows in size, loading the entire graph into RAM will result in slow query processing.
  - Databases are I/O bound so what would be the performance of GraphDBs?
  - This is an open question related to graph database research.
- **Future Work:** Add a Admin console for practitioners to perform CRUD operations.

Thank You!