**Table 1**. Instances with the respective asserted data and object properties for the application case (metal separation process).

|  |  |  |  |
| --- | --- | --- | --- |
| **Instance** | **Class** | **Object properties with the respective instances** | **Data properties and values** |
| Device I | Actor | * Executes Read Metal Detector Function * Executes Send Piece Data Function * Understands Request-Response Protocol * Understands JSON Formatted Text Language * Understands Plain Text Language * Generates Piece Process Data * Generates Piece Material Data * Receives Serial Data * Offers Send Piece Data Service | * Has Characteristic “Thing”, “SoftwareResource” * Has Description “I am a thing and I manage the data in the metal separation process” * Belongs to architecture level 1, 3 * Has Identifier 1 |
| Device II | Actor | * Executes Perform Separation Function * Executes Request Piece Data Function * Understands Request-Response Protocol * Understands JSON Formatted Text Language * Receives Piece Material Data * Offers Perform Separation Service | * Has Characteristic “Device” * Has Description “I am a controller device and I perform the operation of the metal separation process” * Belongs to architecture level 2 * Has Identifier 2 |
| Server I | Actor | * Executes Save Data Function * Understands Request-Response Protocol * Understands JSON Formatted Text Language * Understands Plain Text Language * Generates Serial Data * Receives Piece Process Data * Offers Save Data Service | * Has Characteristic “SoftwareResource” * Has Description “I am a server and I manage the data in the network” * Belongs to architecture level 4 * Has Identifier 3 |
| Conveyor Belt | Entity |  | * Has Description “Conveyor belt of the metal separation process” |
| Industrial Automation Semantics | Semantics | * Ensures Semantic Automation Interoperability * Formalizes Metallic/Non-metallic Process Representation |  |
| Industrial Automation Domain | Domain | * Establishes Industrial Automation Semantics * Is Normalized By Standards IEC 61131, IEC 61499, IEC 62264, IEC 61512, IEC 62890, OPC UA, W3C. |  |
| IoT Domain | Domain | * Establishes Industrial Automation Semantics * Is Normalized By the Standard OPC UA. |  |
| Semantic Automation Interoperability | Semantic Interoperability |  |  |
| Syntactic Automation Interoperability | Syntactic Interoperability |  |  |
| Metallic/Non-metallic Process Representation | Representation | * Defines Distributed Architecture for Metal Separation Process * Defines JSON Formatted Text Language * Defines Plain Text Language * Defines Request-Response Protocol * Defines Broadcast Protocol |  |
| Standard IEC 61131 | Standard | * Standardizes M/Non-M Process Representation. | * Has DBPedia Resource <http://dbpedia.org/page/IEC_61131> * Has Official Resource <https://webstore.iec.ch/publication/62427> * Has Software Content "SFC,LD,FBD,IL,ST" * Concerns To “Device” |
| Standard IEC 61499 | Standard | * Standardizes M/Non-M Process Representation. | * Has DBPedia Resource <http://dbpedia.org/page/IEC_61499> * Has Official Resource <https://webstore.iec.ch/publication/5506> * Has Software Content " FB,ECC" * Concerns To “Device” |
| Standard OPC UA | Standard | * Standardizes M/Non-M Process Representation. | * Has DBPedia Resource <http://live.dbpedia.org/page/OPC_Unified_Architecture> * Has Official Resource <https://opcfoundation.org/about/opc-technologies/opc-ua/> * Has Software Content " OPC-UA,M2M" * Concerns To “Thing,Device,SoftwareResource" |
| Standard IEC 62264 | Standard | * Standardizes M/Non-M Process Representation. | * Has DBPedia Resource <http://dbpedia.org/page/IEC_62264> * Has Official Resource <https://webstore.iec.ch/publication/6675> * Has Software Content "ECSIntegration" * Concerns To “Thing,Device,SoftwareResource" |
| Standard IEC 61512 | Standard | * Standardizes M/Non-M Process Representation. | * Has DBPedia Resource <http://dbpedia.org/page/ISA-88> * Has Official Resource <https://webstore.iec.ch/publication/5531> * Has Software Content "" * Concerns To “SoftwareResource" |
| Standard IEC 62890 | Standard | * Standardizes M/Non-M Process Representation. | * Has DBPedia Resource “” * Has Official Resource <https://www.iec.ch/dyn/www/f?p=103:38:15939379842517::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:1250,23,20929> * Has Software Content "" * Concerns To “SoftwareResource" |
| Standard W3C | Standard | * Standardizes M/Non-M Process Representation. | * Has DBPedia Resource <http://dbpedia.org/page/Semantic_Web> * Has Official Resource <https://www.w3.org/> * Has Software Content " OWL,RDF,SWRL,SPARQL" * Concerns To “SoftwareResource" |
| Distributed Architecture for Metal Separation Process | Architecture | * Is Implemented By Application Network * Is Composed By the Actors Device I, Device II, Server |  |
| Plain Text Language | Language |  |  |
| JSON Formatted Text Language | Language |  |  |
| Proprietary Language | Language |  |  |
| Request-Response Protocol | Protocol |  |  |
| Broadcast Protocol | Protocol |  |  |
| Proprietary Protocol | Protocol |  |  |
| Application Network | Network | * Spreads Send Piece Data Service, Save Data Service, Perform Separation Service * Transmits Piece Material Data, Piece Process Data, Serial Data |  |
| Piece Material Data | Information |  | * Has Transmitter 1 * Has Receiver 2 |
| Piece Process Data | Information |  | * Has Transmitter 1 * Has Receiver 3 |
| Serial Data | Information |  | * Has Transmitter 3 * Has Receiver 1 |
| Metal Separation  Product/Asset | Product/Asset | * Requires Metal Separation Process |  |
| Metal Separation Process | Process | * Has Associated Model Metal Separation Discrete Dynamics Model |  |
| Send Piece Data Service | Service |  |  |
| Save Data Service | Service |  |  |
| Perform Separation Service | Service |  |  |
| Metal Separation Discrete Dynamics Model | Discrete Dynamics Model | * Has Model Element all instances from Model Element (all in this application because just one model is addressed) |  |
| Metal Separation Data Stream | Data Stream | * Contains Conveyor Belt Output, Metallic Gate Output, Non-Metallic Gate Output, Metal Detector Input, Position 1 Detector, Position 2 Detector, Final Position Detector, Start Button Input, Weight, Serial Number, Piece Data * Provides Information to State States 0,1, 2, 3, 4, 5, 6, 7 |  |
| State 0 | Initial State | * Initializes Sequence Metal Separation Sequence * Has Next State State 1 * Has Previous State States 6, 7 * Has Resource Resource State 0 * Is Connected To Transition Transition 1 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "Initial state (state 0) of metal separation model" * Has Number of Assignment 1 * Has Number of Tasks 0 |
| State 1 | State | * Has Next State State 2 * Has Previous State State 0 * Has Resource Resource State 1 * Is Connected To Transition Transition 2 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "State 1 of metal separation model" * Has Number of Assignment 2 * Has Number of Tasks 0 |
| State 2 | State | * Has Next State State 3 * Has Previous State State 1 * Has Resource Resource State 2 * Is Connected To Transition Transition 3 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "State 2 of metal separation model" * Has Number of Assignment 3 * Has Number of Tasks 1 |
| State 3 | State | * Has Next State State 4 * Has Previous State State 2 * Has Resource Resource State 3 * Is Connected To Transition Transition 4 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "State 3 of metal separation model" * Has Number of Assignment 4 * Has Number of Tasks 0 |
| State 4 | State | * Has Next State State 5 * Has Previous State State 3 * Has Resource Resource State 4 * Is Connected To Transition Transition 5 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "State 4 of metal separation model" * Has Number of Assignment 5 * Has Number of Tasks 3 |
| State 5 | State | * Has Next State State 6 * Has Previous State State 4 * Has Resource Resource State 5 * Is Connected To Transition Transition 6 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "State 5 of metal separation model" * Has Number of Assignment 6 * Has Number of Tasks 0 |
| State 6 | Final State | * Finalizes Sequence Metal Separation Sequence * Has Next State State 0 * Has Previous State State 5 * Has Resource Resource State 6 * Is Connected To Transition Transition 7 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "Final state (state 6) of metal separation model" * Has Number of Assignment 7 * Has Number of Tasks 1 |
| State 7 | Final State | * Finalizes Sequence Metal Separation Sequence * Has Next State State 0 * Has Previous State State 5 * Has Resource Resource State 7 * Is Connected To Transition Transition 7 * Receives Data Stream Metal Separation Data Stream * Belongs To Sequence Metal Separation Sequence | * Has Description "Final state (state 7) concurrent state of metal separation model - only for testing purposes" * Has Number of Assignment 7 * Has Number of Tasks 0 |
| Transition 1 | Transition | * Is Connected to State State 1 * Belongs To Sequence Metal Separation Sequence | * Has Description "Transition 1 between state 0 and state 1 of the metal separation model" * Is Enabled false |
| Transition 2 | Transition | * Is Connected to State State 2 * Belongs To Sequence Metal Separation Sequence | * Has Description "Transition 2 between state 1 and state 2 of the metal separation model" * Is Enabled false |
| Transition 3 | Transition | * Is Connected to State State 3 * Belongs To Sequence Metal Separation Sequence | * Has Description "Transition 3 between state 2 and state 3 of the metal separation model" * Is Enabled false |
| Transition 4 | Transition | * Is Connected to State State 4 * Belongs To Sequence Metal Separation Sequence | * Has Description "Transition 4 between state 3 and state 4 of the metal separation model" * Is Enabled false |
| Transition 5 | Transition | * Is Connected to State State 5 * Belongs To Sequence Metal Separation Sequence | * Has Description "Transition 5 between state 4 and state 5 of the metal separation model" * Is Enabled false |
| Transition 6 | Transition | * Is Connected to State State 6, 7 * Belongs To Sequence Metal Separation Sequence | * Has Description "Transition 6 between state 5 and states 6-7 of the metal separation model" * Is Enabled false |
| Transition 7 | Transition | * Is Connected to State State 0 * Belongs To Sequence Metal Separation Sequence | * Has Description " Transition 7 between states 6-7 and state 0 of the metal separation model" * Is Enabled false |
| Arc 1 | Arc | * Has Source Point State 0 * Has Sink Point Transition 1 |  |
| Arc 2 | Arc | * Has Source Point Transition 1 * Has Sink Point State 1 |  |
| Arc 3 | Arc | * Has Source Point State 1 * Has Sink Point Transition 2 |  |
| Arc 4 | Arc | * Has Source Point Transition 2 * Has Sink Point State 2 |  |
| Arc 5 | Arc | * Has Source Point State 2 * Has Sink Point Transition 3 |  |
| Arc 6 | Arc | * Has Source Point Transition 3 * Has Sink Point State 3 |  |
| Arc 7 | Arc | * Has Source Point State 3 * Has Sink Point Transition 4 |  |
| Arc 8 | Arc | * Has Source Point Transition 4 * Has Sink Point State 4 |  |
| Arc 9 | Arc | * Has Source Point State 4 * Has Sink Point Transition 5 |  |
| Arc 10 | Arc | * Has Source Point Transition 5 * Has Sink Point State 5 |  |
| Arc 11 | Arc | * Has Source Point State 5 * Has Sink Point Transition 6 |  |
| Arc 12 | Arc | * Has Source Point Transition 6 * Has Sink Point State 6 |  |
| Arc 13 | Arc | * Has Source Point Transition 6 * Has Sink Point State 7 |  |
| Arc 14 | Arc | * Has Source Point State 6 * Has Sink Point Transition 7 |  |
| Arc 15 | Arc | * Has Source Point State 7 * Has Sink Point Transition 7 |  |
| Arc 16 | Arc | * Has Source Point Transition 7 * Has Sink Point State 0 |  |
| Metal Separation Sequence | Sequence |  | * Has Number of States 8 * Has Number of Transitions 7 * Is Parent Set Element true |
| Conveyor Belt Output | Digital Output | * Acts Over Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Motor activation control for the conveyor belt in the metal separation process” * Has Value false |
| Metallic Gate Output | Digital Output | * Acts Over Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Gate activation for the metal elements in the metal separation process” * Has Value false |
| Non-Metallic Gate Output | Digital Output | * Acts Over Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Gate activation for the non-metallic elements in the metal separation process” * Has Value false |
| Metal Detector Input | Digital Input | * Reads About Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Metal detector for pieces in the metal separation model” * Has Value false |
| Position 1 Detector | Digital Input | * Reads About Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Position 1 reached detector in the metal separation process” * Has Value false |
| Position 2 Detector | Digital Input | * Reads About Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Position 2 reached detector in the metal separation process” * Has Value false |
| Final Position Detector | Digital Input | * Reads About Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Final position reached detector in the metal separation process” * Has Value false |
| Start Button Input | Digital Input | * Reads About Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “boolean” * Has Description “Start button in the metal separation model” * Has Value false |
| Weight | Analog Input | * Reads About Conveyor Belt * Is Context Variable of Metal Separation Data Stream | * Has Data Type “double” * Has Description “Weight of piece sensor in the metal separation process” * Has Value 0.0 |
| Serial Number | Data Input | * Is Context Variable of Metal Separation Data Stream | * Has Data Type “string” * Has Description “Serial data input in the metal separation process” * Has Value “” |
| Piece Data | Data Output | * Is Context Variable of Metal Separation Data Stream | * Has Data Type “string” * Has Description “Piece output data in the metal separation process” * Has Value “” |
| Read Metal Detector Function | Function | * Is Executed By Device I * Returns Result Metal Detector Input | * Has Return Data Type “boolean” * Has Description “reads the metal detector state” * Has Return Value false * Has Number of Parameters 0 |
| Request Piece Data Function | Request Function | * Is Executed By Device II * Returns Result Piece Data | * Has Return Data Type “string” * Has Description “requests the piece data from the device I” * Has Return Value “” * Has Number of Parameters 0 |
| Send Piece Data Function | As a Service Function | * Is Executed By Device I | * Has Return Data Type “void” * Has Description “sends the piece data to the device II” * Has Return Value “” * Has Number of Parameters 0 |
| Perform Separation Function | As a Service Function | * Is Executed By Device II * Receives Parameter Piece Data | * Has Return Data Type “boolean” * Has Description “performs the metal separation operation” * Has Return Value false * Has Number of Parameters 1 |
| Save Data Function | As a Service Function | * Is Executed By Server I | * Has Return Data Type “boolean” * Has Description “saves the process data” * Has Return Value false * Has Number of Parameters 0 |
| Resource State 0 | Resource |  | * Has Data Type “boolean” * Has Value true |
| Resource State 1 | Resource |  | * Has Data Type “boolean” * Has Value false |
| Resource State 2 | Resource |  | * Has Data Type “boolean” * Has Value false |
| Resource State 3 | Resource |  | * Has Data Type “boolean” * Has Value false |
| Resource State 4 | Resource |  | * Has Data Type “boolean” * Has Value false |
| Resource State 5 | Resource |  | * Has Data Type “boolean” * Has Value false |
| Resource State 6 | Resource |  | * Has Data Type “boolean” * Has Value false |
| Resource State 7 | Resource |  | * Has Data Type “boolean” * Has Value false |