TOWARDS A META-MODELING APPROACH FOR AN IORT-AWARE BUSINESS PROCESS

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ABSTRACT

In the context of Industry 4.0, the Internet of Robotic Things (IoRT) represents an attractive paradigm that aims to supply real-time data and automate tasks via human imitation. An IoRT is defined as the incorporation of IoT technology within robotic systems. In this setting, the business managers may improve performance and increase the productivity of their process by integrating the IoRT within their Business Processes (BPs). Nonetheless, this integration is not a trivial task due to the diversity of the IoT, robot, and BP concepts. In this paper, we address the incorporation of the IoRT within the BP through a lightweight extension of the Business Process Modeling Language 2.0 (BPMN 2.0) meta-model called *IoRT-aware Business Process meta-model (IoRT-aware BP2M)*. Our proposed IoRT-aware BP2M allows, on the one hand, to represent the main concepts of IoT, robot and BP in a unique meta-model, and on the other hand to specify some practical constraints to select the suitable device. As a proof of concept, we generated an IoRT-aware BP model in the agriculture field with some implementation details. Besides, we used the Bunge-Wand-Weber (BWW) ontology to prove the proposed meta-model's completeness and clarity. The obtained results show that the proposed meta-model has an acceptable completeness value and ontological expressiveness.

INTRODUCTION

With the proliferation of Internet of Things (IoT) technologies and smart devices, Industry 4.0 (I4.0) is gaining more attention. This new paradigm is revolutionizing not only the way manufacturing is working but also several areas like agriculture, health, education, etc. It aims to increase the efficiency of production that is strongly based on IoT and the Cyber-Physical Systems-enabled manufacturing in several areas. This industrial revolution gives birth to the IoRT (Internet of Robotic Things) where IoT technologies and robotics systems should cooperate together to reach a higher level of automation. Thus, the essential pillars of an IoRT are IoT and robotics systems. The IoT allows the connection of anything with the internet via the use of some stipulated protocols to achieve different objectives, such as monitoring, smart recognition, automation, etc. However, robotics have been used for production since they can communicate and cooperate and even have learning ability. Moreover, the need of Industry 4.0 to an autonomous production can be performed only by incorporating robotic systems that can achieve repetitive tasks in the places of a human. A robot may refer either to a bot (Egger et al., 2020) or to an actuated device (machine) that can execute some tasks usually performed by users in manual ways (ISO, 2020).

In this setting, business managers can avail themselves of the IoRT advantages in their Business Process (BPs) by incorporating the latter within the traditional processes. Embedding IoRT within the traditional processes allows business managers, on the one hand, to speed up production and to avoid human errors and, on the other hand, to reduce their business costs by using IoT and robotic devices to accomplish traditional human tasks.

Nevertheless, this incorporation is not a trivial task regarding the diversity of the IoT, robot and traditional BP concepts. Most of the current works focus on integrating the IoT technology within the traditional process called an IoT-aware Business Process (IoT-aware BP) or integrating the robot within classic process called Robotic Process Automation (RPA). However, the IoT-aware BP fails to imitate human intervention, especially in the tasks that need the movements (e.g., pick the weeds, check the plant leaves). Moreover, the RPA refers to the automation of a BP based on a bot without considering the machine robots. Therefore, integrating IoRT within BP comes to bring the gap of the IoT-aware BP and the RPA. Recently, (Rebmann et al., 2020b) presented an approach for the real-time recognition of robot activities used for process assistance during a rescue mission based on IoT data. However, this model is applied to a specific field as it does not comply with any

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meta-model. In (Rebmann et al., 2020a), the authors define the incorporation of IoRT within BP as a supplementary dimension to an already stressful and complicated situation. whereas (Masuda et al., 2021) defines it as a firms digitization through the automation of its process tasks. Nonetheless, they do not present any proposal to model this incorporation. We get inspired from these definitions to propose the IoRT-aware BP that designates the integration of the IoT and robots concepts within the traditional BPs. To the best of our knowledge, no existing work proposed a meta-model integrating the IoRT concepts within the traditional BP in a common process.

Therefore, this paper aims to present a generic metamodel called IoRT-aware BP2M that integrates the most common concepts related to IoT, robot and traditional BP. This meta-model represents a lightweight extension of the BPMN 2.0 meta-model. Moreover, it is built upon standards which makes it more realistic and useful for industry. The IoRT-aware BP2M specifies also some constraints useful to select the suitable executor device for a process task. As proof of concept, we used the BWW ontology based analysis to measure the completeness and clarity values of our meta-model (Wand and Weber, 1993). In addition, we generated an IoRT-aware BP model in the agriculture field, we give also some implementation details.

The remainder of this paper is structured as follows, the second section gives an overview of the related works that deal with BP's automation. In the third section, we present the IoRT-aware BP2M. The fourth section presents the implementation details of the generation of an IoRT-aware BP model based on the suggested meta-model. The fifth section presents the assessment of the proposed metamodel. Finally, the last section concludes the article with an overview of our future works.

RELATED WORK

Many research works deal with the integration issue of the traditional BP either with IoT or robot capabilities. Few of them have proposed solutions to integrate both paradigms with BP. This section gives an overview of the existing works.

Among the recent works that deal with the automation of a traditional process based on IoT technology and robots, we cite (Rebmann et al., 2020b) that designed and developed a global architecture for a real-time recognition of robot activities integrated into traditional process assistance during a rescue mission. Towards this objective, the authors use, on the one hand, an ad-hoc process model that is modeled via the BPMN language, and on the other hand, they use a rescue robot that is equipped with some IoT sensors. However, the proposed model does not refer to any meta-model through which it is possible to generate other models. Moreover, their proposal is limited to an ad-hoc process which is an unstructured process and it needs human intervention to decide which process activity to do and when to do it.

In the BP automation based on robot concepts, there are several proposed initiatives. We cite (Van Looy, 2020) that target the incorporation of the bot within the BP. Nevertheless, these works are limited to a theoretical study of integration without any modeling suggestion. In (Hindel et al., 2020), the authors introduce an exemplary process that is automated via the incorporation of a robot as a bot. During the traditional process transformation, the authors chose to keep the sophisticated and non-standardized tasks without automation. Moreover, these works do not give any detail about neither the integrated concepts nor the supported meta-model. In addition, they are limited to robots as bots and they do not consider the robots as machines which are also useful for tasks that require movement.

In the BP automation based on IoT technology setting, several approaches, are based on the BPMN standard to integrate the IoT concepts (Fattouch et al., 2020). Recently, (Seiger et al., 2021) propose a meta-model for mixed reality uses case where they use the BPMN as a defacto standard for the BPs. This meta-model can be improved by using a standard for the IoT concepts such as the ISO/ IEC 20924.

In summary, most of the existing approaches deal either with the IoT technology or the robotic one in order to automate the classic BP. Moreover, the existing solutions are limited to specific areas. To the best of our knowledge, no existing work proposed a meta-model integrating the IoRT concepts within the traditional BP in a common process.

IORT-AWARE BP2M: METAMODEL AND CONSTRAINTS

This section is devoted to detail our generic IoRT-aware BP2M (meta-model). First, we detail the integrated concepts related to IoT and robotics. Then, we present a set of suggested constraints that are useful to select the type of an executor which can be an IoT actuator, a robot as machine or a bot.

IoRT-aware BP2M

This paradigm managed to achieve a boost in the business field thanks to its advantages. Nevertheless, this incorporation must be conformed to a meta-model that defines its main used concepts.

A meta-model is a set of concepts that are used to describe an interest area; it allows the generation of an infinite number of models as an instance in different domain. In this setting, we propose in this paper an IoR-Taware BP2M (IoRT-aware BP meta-model) which is a lightweight extension of the BPMN 2.0 meta-model as shown in Figure 1. This generic meta-model incorporates in addition to BP concepts, IoT concepts (colored in purple), robotic ones (colored in grey and orange) and some meta-classes (colored in green).

The BPMN is an Object Management Group (OMG) standard used to model BPs by adding new meta-classes (OMG, 2001). The BPMN has several advantages that make it among the most used BP modeling languages. First, it provides a process flow modeling technique that offers a straightforward model of the process flows. Besides, it provides a concise and intuitive modeling approach for non-expert users in BP Modeling (BPM).

To specify the integrated concepts, we used the ISO/ IEC 20924: 2018 (ISO, 2018) and the ISO/ DIS 8373: 2020 (ISO, 2020) as defacto standards. We opt for these standards to avoid any conflict with concepts notations. Moreover, they provide globally agreed notations with detailed description for each suggested concept.

The ISO/ IEC 20924: 2018 specification (ISO, 2018) presents various concepts related to the IoT concepts. In this paper, we are interested in integrating the most used ones in the literature. This concepts are colored in purple as depicted in figure 1 and they represent the following:

- IoT device: is an entity that is used to interact with the physical world through sensing and/or actuating. An IoT device can be a sensor, an actuator, or an IoT gateway.
- Sensor: is an IoT device that can capture some physical entity properties. The sensor offers digital data as an output transmitted via several technologies such as Bluetooth, WiFi.
- Actuator: is an IoT device that can act on a physical entity to modify some physical entity properties.
- IoT gateway: is a device that stores the gathered data and facilitates the D2D (device to device) or the device to cloud connections.
- Physical entity: represents the physical world, its properties are captured through one or more sensors and are actuated via one or more actuators.

IoRT-aware BP2M is built also upon robotics concepts. However, a robot may represent a bot or an actuated device (machine). For the specification of the robot machine concepts, we used the ISO standard 8373: 2020 (ISO/DIS 8373: 2020) (ISO, 2020). This standard defines various robot concepts. We have limited ourselves to the concepts that are required to understand the inner robot workings and that are considered as the most used ones.

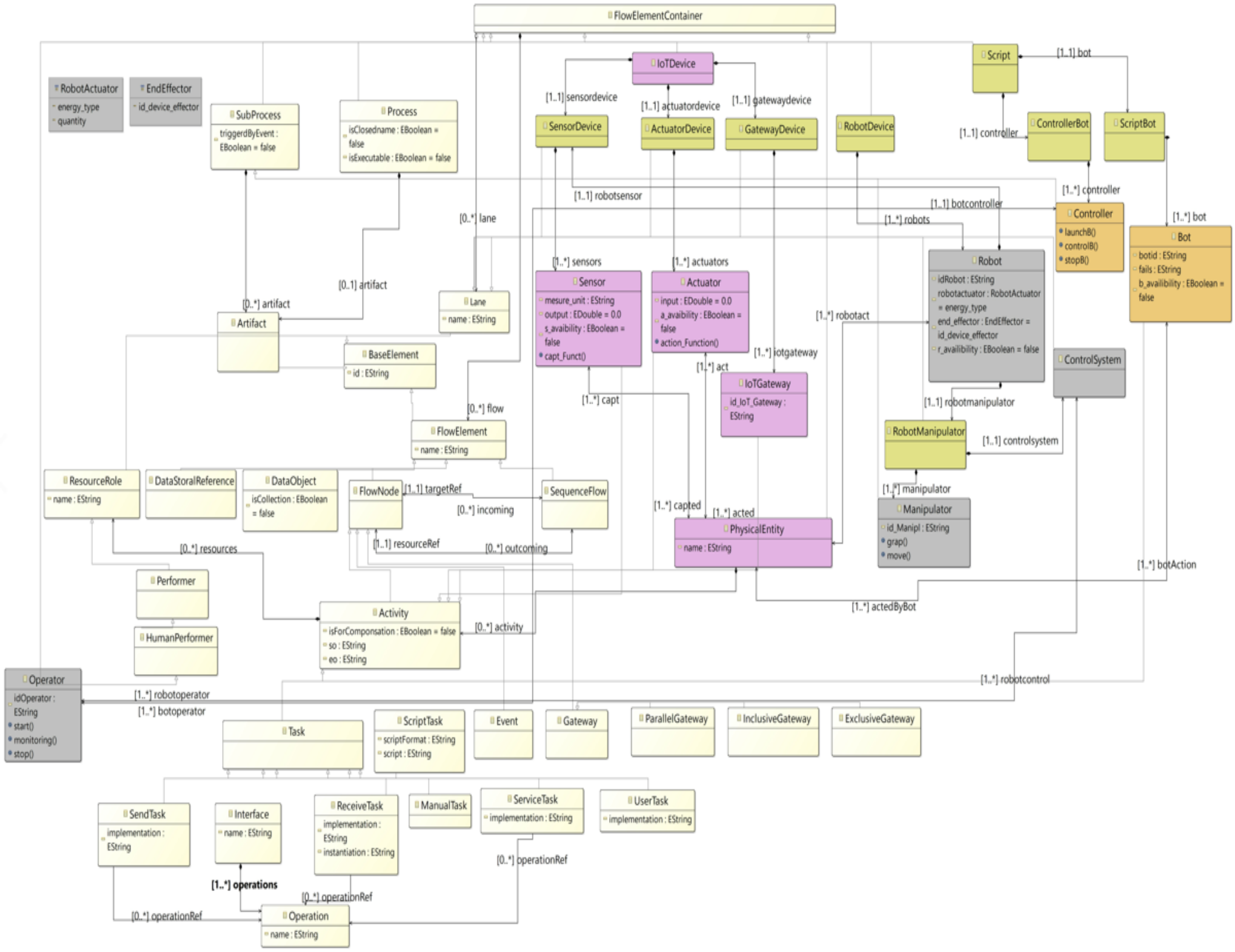

Figure 1: The IoRT-aware Business Process meta-model (*IoRT-aware BP2M*).

The integrated robot concepts (colored in grey) are the following:

- Robot: is an actuated mechanism that is characterized by its ability to move and it should be equipped by sensors.
- Control system: represents a set of hardware and software components having logical and control functions (e.g., launch, control, etc.).
- Manipulator: lays out a mechanism that allows the robot to perform its functions.
- EndEffector: represents a device (e.g., spray gun, welding dun, etc.) used by the robot to achieve some actions.
- RobotActuator: is a powerful mechanism within the robot device used to convert pneumatic, electronic, and hydraulic energy to the robot's motion.
- Operator: is a person that can launch, control and stop a robot.

Since a robot may also represent a software script (bot), we are interested to integrate the bot concepts in the IoRT-aware BP2M specification. Back to the literature, there are no predefined standards that specify the bot concepts. Consequently, we pinpoint the bot concepts based on some existing works such as (Romao et al., 2019). The following concepts (colored in orange) present the most used ones in the bot field according to the literature and they are presented in what follows.

- Bot: is a software program that runs on a physical or virtual machine.
- Controller: orchestrates the bot during its execution.
- Operator: represents a person who can launch, monitor and stop the bot execution.

The IoRT-aware BP2M contains some other metaclasses (colored on green) that we added to our metamodel to guarantee its simplicity and clarity. These metaclasses are here after:

- SensorDevice: is an added meta-class, modeled via a lane to display all used sensors for an IoRT-aware BP model.
- ActuatorDevice: is an added meta-class, modeled via a lane to present all used actuators within an IoRT-aware BP model.
- GatewayDevice: is an added meta-class, modeled via a lane, to show all used IoT gateway devices for an IoRT-aware BP model.
- RobotDevice: is an added meta-class, modeled via a pool, to present all used robots (machines) for an IoRT-aware BP model.
- Script: is a meta-class added to the meta-model to display all bots and their ControllerBot that are used by an IoRT-aware BP model. It is modeled via a Pool.
- ScriptBot: is a meta-class that modeled via a lane. It grouped a set of bots.
- ControllerBot: is a meta-class drawn as a lane to model all used controller bots on the IoRT-aware BP model.
- RobotManipulator: represents a meta-class modeled through a lane to indicate all used manipulators to execute a robot's tasks.

IoRT-aware BP2M constraints

The generic IoRT-aware BP2M includes also a set of constraints called *Selection Executor Constraints* as shown in Figure 2. These constraints specify which kind of an executor is recommended for a specific task. The IoRT-aware BP2M considers three main types of executor which are a robot machine, an IoT actuator and a bot. Some tasks should be executed by a robot machine where they require a movement, whereas the tasks that do not require the movement, should be performed by an IoT device (actuator). Nonetheless, the tasks that execute a script code are performed by a bot. In what follows, we detail the suggested constraints.

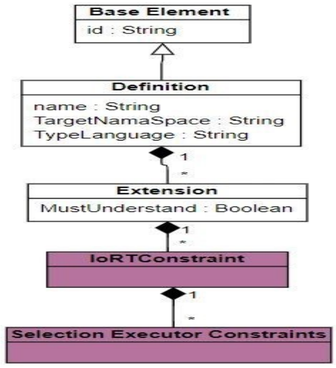

Figure 2: Selection executor constraints for the IoRT-aware BP2M.

- Constraint 1: only a robot as a machine can perform a task that requires movement. Otherwise, an IoT device (i.e., actuator) can execute task without movement.
- Constraint 2: a bot performs a task that has an executed code script. This constraint refers that a bot accomplishes only the script tasks.
- Constraint 3: a task performed by an actuator, can not be performed by a robot and vice versa.

IMPLEMENTATION

We have generated an IoRT-aware BP model in agriculture field from the suggested IoRT-aware BP2M as a proof of concept. Towards this goal, we have extended the BPMN Modeler 2.0 plug-in which is an open source Eclipse editor. This plug-in allows us to extend the traditional process concepts via the adding of new properties and/or icons. In addition, the BPMN Modeler 2.0 plug-in allows us to add new concepts. These extensions consist of adding three categories of element to the palette which are *IoT Components*, *Robot Components*, and *Bot Components* that refer respectively to the IoT concepts, robot concepts, and bot concepts as shown in Figure 3.

The generated IoRT-aware BP of a smart irrigation management system aims to enhance the water and nutrient use efficiency. The presented process starts with the sensing temperature, soil moisture and solar radiation data, which are recorded throughout the day as depicted by figure 3. These data are captured via dedicated sensors and stored in the cloud. After 12 hours, a message event launches a bot to access the data stored on the cloud and apply a machine-learning algorithm to make decision irrigation. Afterward, the bot sends a decision notification to *Receive irrigation decision* task. According to this notification, the process will end if there is no irrigation need. Otherwise, two actions are launched, which are *Start irrigation* and *Request picking weeds*. The irrigation and the picking weed tasks start at the same time. An IoT actuator performs the irrigation task while a robot device accomplishes the second task as it requires movement. Finally, both of them stop the execution as soon as they receives a notification from the *Finish irrigation* task or the *Finish picking weeds* one. The operator can interact at any time during the process execution to start, monitor and stop the robot and the bot. Without automation of some of these tasks, this process becomes more difficult due to the massive repetitiveness of tasks such as capturing data throughout the day, launching irrigation or picking weeds.

To validate the generated model, we have suggested a set of practical constraints defined in the meta-model and they are used to select the type of device to execute an IoRT-aware BP task. These constraints are described by using the Object Constraint Language (OCL). The OCL is a formal language, it intends to describe the expression on Unified Modeling Language (UML) and Meta-Object Facility (MOF) (ISO, 2020). To achieve this goal, we use both Eclipse modeling Framework (EMF) and OCLinEcore plug-ins. The EMF is a modeling framework that provides a set of modeling tools. However, the OCLinEcore plugin is used to embed the OCL constraints within an Ecore model (Meta-model) in order to enrich its provided models.

Referring back to the generated agriculture IoRT-aware BP model, Figure 4 shows the validation of the *Selection Executor Constraints*. At this level, we have validated

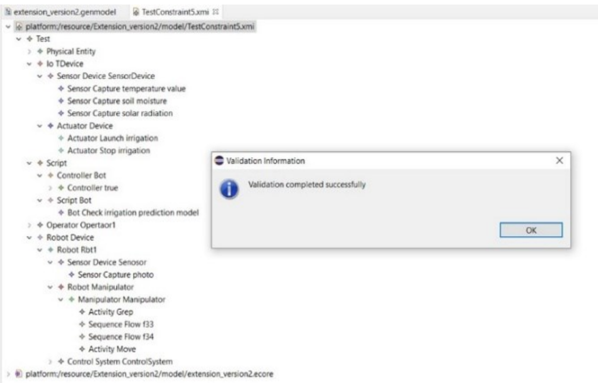

Figure 4: Validation of an agriculture IoRT-aware BP model using the *Selection Executor Constraints*

that a robot device performs only the tasks that require movement. Additionally, we have proved that each task that does not require movement is accomplished by an IoT device. Moreover, we have approved, that each used task that executes a script is achieved by a bot.

IORT-AWARE BP2M ASSESSMENT

The suitability of a meta-model can be measured through estimation of its completeness and clarity. The completeness measures a meta-model's capacity to cover all the IoT, robot and bot concepts. At the same time, the clarity defines the meta-model gaps by gauging some measures such as the redundancy.

To assess the completeness and clarity measures, we rely on an ontology-based analysis. Among the most important ontology-based analysis, we cite the BWW ontology proposed by Wand and Waber in 1990. BWW proposes two main mapping types: representation mapping and interpretation one. The representation mapping allows for each real-world construct, provided by the BWW ontology constructs, to be mapped to a grammatical construct provided within the design constructs (meta-model) (Wand and Weber, 1993). As a result, the first mapping will help assess the proposed IoRT-aware BP2M completeness. In contrast, the second mapping aims to evaluate the meta-model's clarity by evaluating its overload, excess, and redundancy degrees. Based on these two mappings, we estimate the value of the following ontology dependency measurements:

- Completeness: aims to estimate the degree to which the modeling technique can present a complete description for a real-world according to the BWW ontology's constructs. A modeling technique says complete when it covers all the BWW constructs. We measure the completeness value as one minus deficit degree (Recker et al., 2009). For our meta-model, the deficit degree is equal to the number of the BWW constructs which are not mapped to any IoRT-aware BP2M constructs, divided by the total number of the BWW constructs.
- Clarity: evaluates the gaps of a modeling technique. The clarity relies on the overload, redundancy and excess degrees described in what follows.
  - Overload: verifies whether the modeling technique provides a construct that can be mapped on one BWW construct. Following the formula proposed in (Recker et al., 2009), we measure the overload degree of the suggested IoRT-aware BP2M as the number of the constructs that are mapped to more than one BWW construct, divided by the total number of constructs. The overload occurs if each construct in the IoRT-aware BP2M is mapped to more than one BWW construct.
  - Redundancy: validates if each BWW ontology construct is presented through

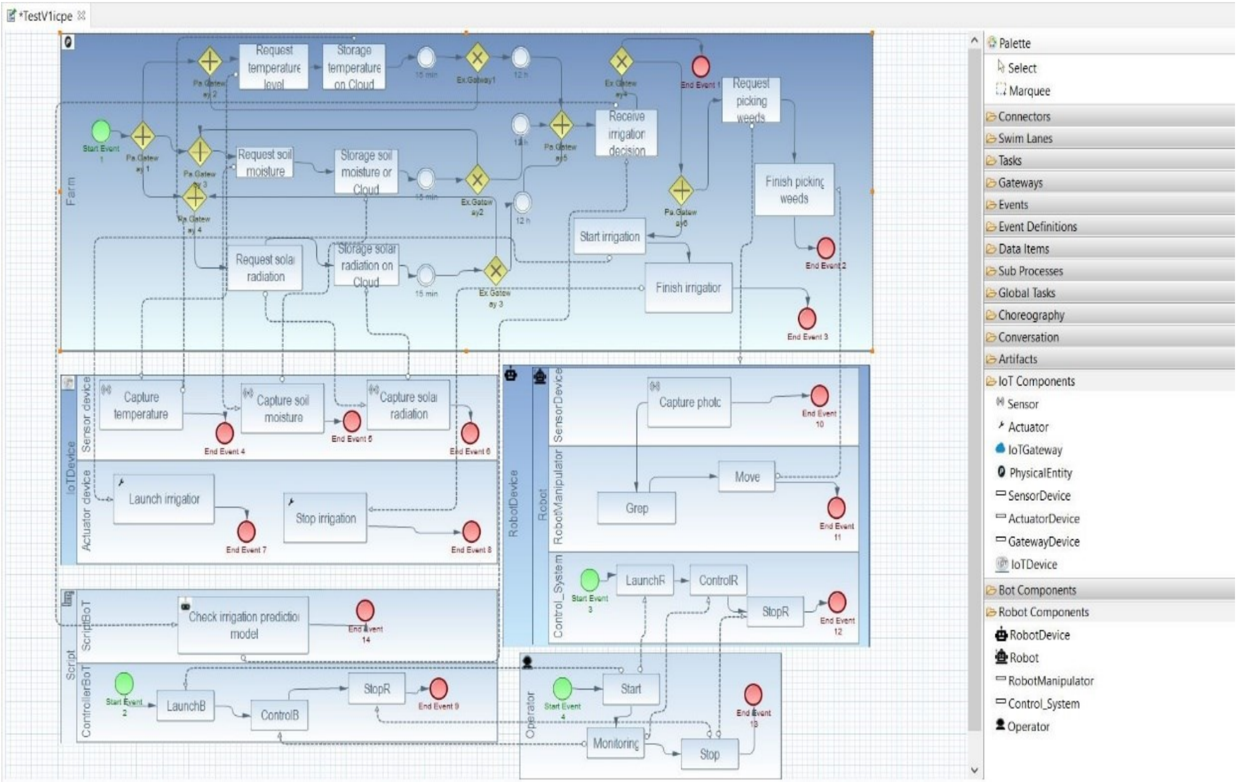

Figure 3: An extended BPMN 2.0 modeler plug-in in Eclipse tool.

exactly one modeling technique construct. The redundancy occurs when a BWW construct is mapped into several modeling technique constructs. In our case, we measure the redundancy degree as the number of the IoRT-aware BP2M constructs that have been mapped to the same BWW construct, divided by the total number of our meta-model constructs.

- Excess: measures whether a modeling technique construct can be mapped on at least one BWW ontology construct. The excess occurs when the modeling technique provides at least one construction that does not correspond to any BWW constructs. Following the formula presented in (Recker et al., 2009), the excess degree of the proposed meta-model can be measured by the number of the IoRT-aware BP2M constructs that have not mapped to any BWW construct divided by the total number of the meta-model constructs.

Table 1 summarizes the obtained results after the application of the ontological analysis. To evaluate the obtained results, we compare them with the threshold values found in the littérature. Referring to the existing works, we notice that a modeling technique says complete when its completeness value becomes equal to 100% (Kudo et al., 2020). Nevertheless, according to table 1, we note that the completeness of the suggested IoRT-awareBPMN is equal to 69%, which indicates that the deficit of this metamodel is equal to 31%, which is an acceptable result compared to the

Table 1: Meta-model assessment based on BWW.

	Comple-teness	Clarity		
		Overl-oad	Redunda-ncy	Excess
IoRT-aware BP2M	69 %	28.8 %	23 %	12.8 %

threshold value and the other modeling languages illustrated in (Recker et al., 2009). Besides, as highlighted in the literature, the overload can be a confusion source due to the provided constructs that may have many significations in the real world (Recker et al., 2009). Consequently, the overload value will be better when it is close to zero. Furthermore, the redundancy can be a confusion source due to several provided constructs for a real-world construct. Hence, the redundancy value also will be better when it is close to zero. Moreover, the excess can be a disarray source due to the provided constructs that do not have real meaning, according to BWW. As a result, the excess value will be better when it is close to zero. Table 1 shows that the IoRT-aware BP meta-model has a 12.8% as an overload construct value, 23% as a redundancy value, and its excess value is equal to 12.8%. These results demonstrate that the proposed IoRT-aware BP2M has an acceptable ontological expressiveness compared to the existing threshold values.

CONCLUSION

In the context of Industry 4.0, integrating robotics systems and IoT concepts with traditional BP, will allow the business managers to improve performance and increase the productivity of their BPs. We denote by a an IoRT-aware BP a business process that embodies the traditional concepts of a process within IoT and robotics ones. Nonetheless, modelling an IoRT-aware BP is not a trivial task regarding the diversity of concepts. Towards this issue, we proposed, in this paper, a generic meta-model called IoRT-aware BP2M that integrate the intended concepts referring to standards specifications. Thus, it is possible to generate an IoRT-aware BPs applied for any domain areas. In addition to the concepts specification, the proposed meta-model defines a set of useful constraints to recommend the convenient type of a process task executor (i.e. a robot as machine, an IoT actuator or a bot) for a defined IoRT-aware BP task.

As a proof of concept, we generated an IoRT-aware BP model in the agriculture field and we give some implementation details. To assess the IoRT-aware BP2M, we used the Bunge-Wand-Weber (BWW) as an ontology based analysis. The objective was to measure the completeness and the ontological expressiveness of the IoRT-aware BP2M. As a future endeavor, we are working to outsource some IoRT-aware BP parts to the Cloud and/or Fog with the intention of enhancing performance and reduce cost of the process execution.

REFERENCES

Fattouch, N., Lahmar, I. B., and Boukadi, K. 2020. ‘‘ IoT-aware business process: comprehensive survey, discussion and challenges’’. In *International Conference on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE)*. IEEE, 100–105.

Hindel, J., Cabrera, L. M., and Stierle, M. 2020. ‘‘ Robotic process automation: Hype or hope? ’’. In *Wirtschaftsinformatik (Zentrale Tracks)*. 1750–1762.

ISO . 2018. In *Information technology — Internet of Things (IoT) — Vocabulary-ISO/IEC 20924*.

ISO . 2020. In *Draft International Standard ISO/ DIS 8373*.

Kudo, T. N., Bulcao-Neto, R. F., and Vincenzi, A. M. R. 2020. ‘‘Metamodel quality requirements and evaluation (mquare)’’. In *arXiv prepint arXiv : 2008.09459*.

Masuda, Y., Zimmermann, A., Shirasaka, S., and Nakamura, O. 2021. ‘‘Internet of robotic things with digital platforms : Digitalization of robotics enterprises’’. In *Human Centred Intelligent Systems*. Springer, 381-391.

OMG. 2001. Business process model and notation (bpmn), version 2.0.

Rebmann, A., Rehse, J., Pinter, M., Schnaubelt, M., Daun, K., and Fettke, P. 2020a. ‘‘IoT-based activity recognition for process assistance in human-robot disaster response’’. In *International Conference on Business Process Management.* Springer, 71–87.

Rebmann, A., Rehse, J.-R., Pinter, M., Schnaubelt, M., Daun, K., and Fettke, P. 2020b. ‘‘IoT-based activity recognition for process assistance in human-robot disaster response’’. In *International Conference on Business Process Management*. Springer, 71–87.

Recker, J., Rosemann, M., Indulska, M., and Green, P. 2009. ‘‘Business process modeling-a comparative analysis’’. In *Journal of the association for information systems*. 1.

Romao, M., Costa, J., and Costa, C. J. 2019. ‘‘Robotic process automation: A case study in the banking industry’’. In *Conference on information systems and technologies (CISTI)*. IEEE, 1–6.

Seiger, R., Kuhn, R., Korzetz, M., and Aßmann, U. 2021. ‘‘Holoflows: modelling of processes for the internet of things in mixed reality’’. In *Software and Systems Modeling*. Springer, 1– 25.

Van Looy, A. 2020. ‘‘Adding intelligent robots to business processes: A dilemma analysis of employees attitudes’’. In *International Conference on Business Process Management*. Springer, 435–452.

Wand, Y. and Weber, R. 1993. ‘‘On the ontological expressiveness of information systems analysis and design grammars’’. In *Information systems journal*. Wiley Online Library, 217–237.

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