
# The Internet of Things - Aware Business Processes for Logistics in Enterprise: IOT Enabled Processes and Current Approach Limitations

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ABSTRACT

The Internet of Things is intended to bridge the divide between physical business processes and information technologies. Supply chain management is a significant application area that can benefit from the Internet of Things. When connected to physical objects, IoT technologies such as sensor networks transform supply chain objects into smart objects. These products are capable of capturing context data and providing representations of things to information systems. This enables process-aware information systems to monitor supply chain processes. Additionally, intelligent things can conduct portions of business processes. They may exchange data and make judgments based on business logic in dispersed contexts. However, this logic acts solely in accordance with predetermined behavior. Unexpected exceptions resulting from real-world occurrences necessitate dynamic process adaptation in process definitions and associated instances. We cover the major IoT technologies connected with automated assistance of logistics business processes in this study. Additionally, we highlight the primary constraints of the Business Process Execution Language in terms of supporting design and runtime updates to these processes via smart items, and we focus on one of these obstacles: Integration of IoT services into corporate processes via process modelling and orchestration.

**Keywords:** The Internet of Things, Business Processes, Logistics of Enterprise, Supply chain management.

## Introduction

The term "Internet of Things" has gained traction in the enterprise sector during the last decade, owing largely to the growth of the web-based service economy [1]. By bridging the gap between the physical world and its representation in information systems, the IoT plays a critical role in the future Internet. Manufacturing, supply chain integrity, energy, health, and automotive are just a few of the IoT's primary application areas from a corporate perspective. Despite these benefits, significant technological difficulties such as internet scalability, identification and addressing, heterogeneity, and service paradigms have become notable study fields in recent years [2]. The supply chain is a web of organizations and commercial activities that involves the acquisition of raw materials, their transformation into goods, and their distribution to customers. The supply chain is composed of five primary processes: plan, source, manufacture, deliver, and return [3]. Logistics plays a critical part in these operations, as it is responsible for the control and planning of all aspects affecting transportation [3]. RFID and sensor technologies provide context data to assist senior management in making decisions. The inclusion of sensors capable of executing business logic at the item level, referred to as smart things [4], enables local decision-making and hence lowers centralized processing and data interchange. Business process breakdown via distributed environments introduces a paradigm change and new problems for business process modelling. The Business Process Execution Language for Web Services has established itself as the de facto standard for modelling the behavior of executable and abstract business processes using Web Services [5]. It specifies an interoperable integration model that extends the Web Services interaction model and enables business transactions to be supported. Thus far, information provided by the IoT has been used to support static business processes, i.e., processes defined at the time of design that do not anticipate aberrations. However, the usage of smart objects frequently necessitates dynamic business processes that are adaptable to changes in the execution context or behavior of smart items. We discuss the constraints of BPEL's ability to define business processes that support this dynamic behavior in this paper. Additionally, we discuss how this capability might determine the distribution of business process logic across smart products and regular process support. We are particularly interested in logistics and supply chain-related business operations that use smart goods.

The Internet of Things (IoT) is a prominent topic of discussion worldwide, both in academia and the media. As one aspect of a Future Internet, numerous application areas have been proposed – not just in industrial domains such as manufacturing, logistics, retail, service management, energy, public security, and insurance, but also in everyday life – where IoT can make significant improvements, even resulting in new business models [6,7]. Numerous hurdles must be overcome to accomplish this objective. Systems must be opened, secured, and made extremely dependable to permit worldwide collaboration across many businesses in a manner similar to how the Internet works now. Globally acknowledged standards, procedures, and tools must be created to enable the effective configuration, integration, and monitoring of large-scale infrastructures. To manage the huge and rapidly rising number of devices, intelligent systems with significant self-configuration, self-monitoring, and self-healing capabilities are necessary. While progress is being made in many of these areas, this position paper will focus on one that has received insufficient attention to date but is critical for developing and implementing IoT applications on a larger scale in industrial or enterprise settings: The modelling of business processes that are aware of the Internet of Things.

## The Internet of Things' Service-Enablement

Nowadays, enterprise systems are developed on service-oriented architectures, and business activities are described as an orchestration of underlying services in such systems. It is consequently important to service-enable IoT resources, such as sensors and actuators used to interact with physical environments, to incorporate the IoT into business process systems. This can be accomplished via either full-fledged Web Services or, more likely, REST-based techniques [8]. Additionally, a service-based strategy hides the heterogeneity of IoT devices and data protocols from the business application.

It's worth noting that these IoT services differ in several ways from traditional enterprise services. Not only could the technical implementation of the services differ, but also the communication model and orchestration of the services, as the dynamic nature of the real world necessitates flexible interservice communication that must account for unexpected events and, as a result, provide mechanisms for dealing with complex event patterns. Second, proximity is critical, both in terms of the data given (e.g., the temperature in a specific room) and the location of the service - not just somewhere in the cloud. Thirdly, we frequently encounter streaming data from which pertinent information and events must be extracted in (soft) real-time. Perhaps most significantly, IoT services are intrinsically unreliable: the data they send may be incorrect, for example due to a mis calibrated sensor, or they may become altogether inaccessible due to the device hosting the service running out of battery power or moving out of communication range. These disparate traits must be considered when modelling processes that use IoT services the adoption of the Internet of Things has evolved into the "Internet of Everything shows in figure 1

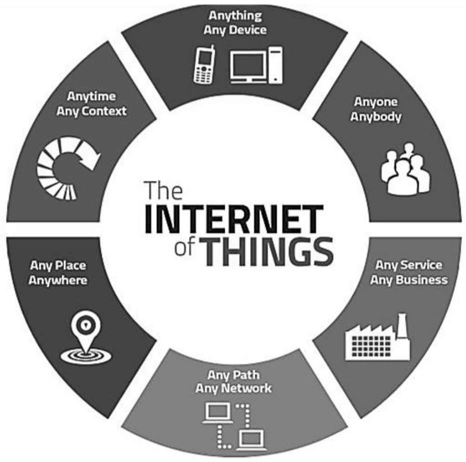


Figure 1 The adoption of the Internet of Things has evolved

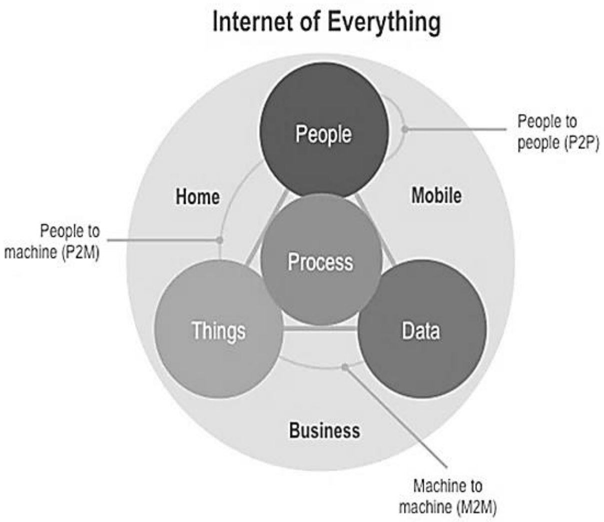


Figure 2 Internet of Things has evolved into the "Internet of Everything."

## Logistics intelligent objects

The IoT's primary objective is to close the gap between real-world business operations and their representation in information systems. As a result, technologies such as RFID and wireless sensor networks enable the collection of precise context data. These data are then utilized to create real-time representations of business processes and their associated objects within information systems. The technology and associated equipment are frequently referred to as smart things for these purposes.

## Types of intelligent objects

Three primary technologies are frequently used by smart products in logistics-related business activities. They are barcodes, radio frequency identification (RFID), and sensor networks. Barcodes are a widely used technology for electronic product identification. On the product, a barcode is applied and optically detected by a barcode reader. The reader recognizes the printed identity and transmits the data gathered to the information system, which updates the product's status. Due to the requirement for line-of-sight, this approach gives limited information. For example, it is impossible to detect a single item within a container of merchandise that has been closed. Data collection on products during transportation necessitates a more sophisticated infrastructure. As a result, barcodes are only relevant for loading and unloading activities inside the supply chain's logistics. Through radio-based frequency handling technology, radio frequency identification (RFID) devices [9] can be identified. In contrast to barcodes, they do not require line-of-sight to be read. Tracking of things in transit is possible, depending on the RFID readers deployed. Additionally, they can acquire sensor data from products (such as temperature) and transmitting it to the information system. Typically, these sensing capabilities are somewhat limited [10]. Barcodes and RFID are considered passive technologies due to their behavior [11]. The most promising approach for logistical processes is wireless sensor networks. Sensor nodes are electronic devices that incorporate sensing and processing capabilities and function together inside a network. Additionally, they are highly compact and may be customized to the specifications of the conveyed cargo. Unlike RFID, sensor networks can execute portions of procedures directly on the items from an information system. Embedded logistics information systems become embedded products [9]. Sensor networks can identify, tracing, tracking, monitoring, and real-time response. For example, Cobi's [10] proposes a sensor network that addresses all these concerns.

## Logistics, information systems, and intelligent items

As demonstrated in Table 1, logistic functions can be associated with a collection of features that are frequently supported by information systems and smart item technologies. The fundamental logistical functions are to carry the appropriate commodities in the appropriate amount and quality at the appropriate time and place for the appropriate price [9]. To perform each of these jobs effectively, information systems must have several distinct capabilities, including identification, tracing, position tracking, monitoring, real-time responsiveness, and optimization. Product identification provides the system with information about the correct goods. Tracing enables the system to determine when an item has been misplaced. As a result, it ensures the correct quantity. The information system monitors the correct location via location tracking. It maintains a record of the transport itself. Monitoring the state of the product assures that it is of the highest quality. The complete logistics process may be studied in detail using all of these data included within the information system. As a result, timely response to unforeseen occurrences and other activities can be achieved. Additionally, these data serve as the foundation for optimizing the product's correct price. Smart goods are critical in enabling all of these functions. Additionally, the level of support given for these characteristics is directly proportional to the sorts of smart products discussed in the preceding section.

**Table 1. Logistic functions and the information systems capabilities required to carry them out. Additionally, it demonstrates the smart item's logistical possibilities.**

| Task | advantages | Barcode | interact | Sensor Networks |
|---|---|---|---|---|
| goods | Identification | Full | Full | Full |
| amount | Tracing | Partial | Full | Full |
| place | Location Tracking | | Full | Full |
| quality | Monitoring | | Partial | Full |
| time | Real-time responsiveness | | | Full |
| price | Optimization | | | Full |

## The importance of intelligent objects in ensuring supply chain integrity

The data provided by smart goods enables tracking and control of products throughout the shipping chain. For example, tracking their location can be used to determine whether the related products have deviated from their pre-planned journey. Tracking their state enables you to determine whether the products' condition has deteriorated and whether they are still useful. This refers to three distinct types of integrity that can be jeopardized: product integrity, component integrity, and route integrity. For example, the physical integrity of a product can be checked using sensors that track its condition throughout the logistical process. Consider the following scenario: a product initiates a process with the status closed. If this state changes during the process (from closed to opened or manipulated), the integrity of the product may be jeopardized. Sensors capable of measuring temperature can be used to monitor the status of perishable products. For instance, a truck loaded with fruit initiates the process, which is marked as excellent. If the temperature exceeds a predetermined threshold value, the quality of the fruit may be compromised [10]. Regarding the integrity of transportation routes, these can be monitored using technologies that offer product location information. Transporting these goods involves route planning. However, diversions from the original route may occur owing to changes in the surroundings. For instance, when dealing with hazardous materials, certain restrictions on possible routes may apply, and they may even be unauthorized. Unexpected events such as traffic, adverse weather conditions, or road closures may jeopardize the integrity of the product's path during delivery. Component integrity demands the most sophisticated monitoring. It entails monitoring and controlling each component of the product during its manufacturing and shipping. It ensures that the product is used for its intended purpose and that set regulations for legal and environmental compliance are followed throughout the logistical process. Additionally, compromising one of these integrity kinds may have ramifications for the remaining ones. For example, the fruit truck may be forced to detour due to a breakdown in product integrity. On the other hand, a forced detour can compromise the integrity of the product.

## Business Process Modeling For The Internet Of Things

Integrating IoT devices – RFID, sensors, and actuators, for example – into business systems now needs extensive engineering, deployment, and configuration of middleware, as well as some custom software. Each new installation necessitates considerable work. By contrast, Business Process Modelling (BPM) is a well-established technique for modelling and performing complicated business processes. If similar methodologies could now be applied to IoT-aware processes as well, a big step toward broader use of IoT technology would be taken. Indeed, one could argue that this is a must, given how many organizations rely on BPM to manage their operations. Current business process modelling, on the other hand, is aimed toward planned and deterministic processes. The associated tools are not yet capable of meeting the problems posed by IoT-aware processes. Among the obstacles are the following: Processes that are adaptive and event driven One of the primary advantages of IoT integration is that processes become more flexible to what happens in the real world. This is intrinsically based on events that are noticed either directly or by real-time processing of sensor data. These types of occurrences can occur at any point during the procedure. For some of the occurrences, the probability of occurrence is extremely low. However, one can only guess when or if they will occur. Modeling such occurrences into a process is time consuming, since they would have to be incorporated in all potential activities, adding complexity, and making the modelled process more difficult to grasp, particularly the primary flow of the process (the 80 percent case). Second, how to react to a single event can be context-dependent, i.e. the set of previously identified events. A simple illustration: If humans enter an area and a sudden rise in temperature, as well as smoke, is detected later, a rescue squad must be dispatched. Alternatively, if the truck is delayed to the point where the delivery cannot reach the planned B customer on time and the company has recently received an urgent order from its preferred A client, the truck is diverted to the A customer. Processes that include the use of faulty data: When dealing with events originating in the physical world (e.g., via sensors), processes introduce an element of unreliability and uncertainty. If decisions in a business process are to be made based on uncertain occurrences, it makes sense to assign a value to each of these events based on the information's quality (QoI). This therefore enables the process modeler to specify thresholds in basic cases: For instance, if the degree of confidence is more than 90%, it is presumed that the event occurred. If it is between 50% and 90%, more activities will be triggered to ascertain whether the event occurred or not. If the value is less than 50%, the event is ignored. When numerous events occur at the same time, the situation becomes more complicated: For example, one event is likely to occur 95% of the time, another is certain to occur 73% of the time, and another is certain to occur 52% of the time. The underlying services that generate the original events must be designed to associate these QoI values with them. However, from a BPM perspective, such information must be recorded, processed, and communicated using the modelling notation language in use, such as BPMN. Second, such QoI values' syntax and semantics must be standardized it a simple certainty percentage, as in the instances above, or should it be something more expressive (e.g., a range encompassing the true value)? Processes involving insecure resources: Not only is data from resources intrinsically unreliable, but so are the resources that provide the data, for example, due to the hosting device failing. Processes that rely on such resources must be capable of adapting to such circumstances. The first challenge is detecting such a failure in the first place: When a process directly calls a resource, this detection is straightforward. When we're discussing resources that may generate an event at some point in time (for example, the resource that monitors the temperature inside the truck and sends an alarm if it becomes too hot), the situation becomes more complicated: It is possible that you did not receive any events due to resource failure, but it is also possible that there was nothing to report. To detect such issues, monitoring software is required; however, it is uncertain whether this software should be included into the BPM execution environment or should be a separate component. Processes that are widely distributed: When interaction with real-world objects and devices is required, decentralised execution of a process may make sense. As stated in [6] decomposition and decentralization of existing business processes improves scalability and performance, enables more informed decision making, and may even result in new revenue streams via entitlement management for software products placed on smart things. For instance, in environmental monitoring or supply chain tracking applications, no signals to the central system are required if all parameters remain within predefined ranges. Only when a deviation occurs does an alarm (event) need to be generated, which can result in the overall process being adapted. From a business process's perspective. The process can be defined centrally from a modelling standpoint, but some operations (such as monitoring) will be performed remotely. Once the entire process has been modelled, the related services may be deployed to the location where they must be conducted, and the entire process can be run and monitored.

## Logic for Business Processes Contained Within Smart Products

Intelligent things present new opportunities and problems for system design and integration. They are capable of more than providing real-time data, owing to their potential and collaboration with external services. Additionally, they interpret data and make decisions based on it, including data exchange between smart items that are not centralized. This section discusses the software designs that are frequently employed to overcome these difficulties. Additionally, we discuss significant aspects affecting the quantity of business logic divided between a central system and cooperative smart devices [21,22,23].

## Evolution of Structure

The Internet of Things is a notion that is continually evolving, owing to its infancy. It began with the use of RFID and has since evolved using related technologies such as sensor networks and intelligent embedded devices. The integration of intelligent goods into supply chain logistics processes necessitates continuous optimization and innovation to boost firms' competitiveness and service quality. Similarly, the architectures used to support interactions between smart objects and information systems have evolved at a similar rate. For example, client-server architectures continue to play a significant part in these interactions. Nonetheless, Service Oriented Architectures (SOA) are rapidly becoming the preferred way for interacting with more powerful smart objects. Additionally, this is predicted to be the dominant architectural approach for future devices of this type [13]. The SOA-enabled integration of smart objects into business processes enables information systems to communicate with real objects, hence establishing the Internet of Services (IoS). This integration is enabled by running web service instances on various devices. This architectural transformation creates a disproportionate number of opportunities and problems for ensuring successful collaboration between services and centralized information systems. Middleware techniques have shown to be a solid option for integrating back-end applications and services given by devices, service-mediators, and gateways [13]. SIRENA (Service Infrastructure for Real-time Embedded Networked Applications) [10] was created to exploit SOA architectures to connect embedded devices across domains smoothly. This project demonstrates the possibility and benefits of embedding web services on devices through proof-of-concepts. However, these pioneering initiatives neglected to address concerns such as device oversight, device life cycle management, and device status maintenance. Additionally, SIRENA served as the basis for the SODA [12] and SOCRADES [13] initiatives. SODA's objective was to build a comprehensive, scalable, easy-to-deploy service-oriented environment on top of the SIRENA foundations. This initiative resulted in a significant decrease in the time required to bring novel services to market. SOCRADES' objective was to establish a platform for design, execution, and management that used the SOA paradigm at the device and application level. SOCRADES middleware is an architecture that enables the integration of business processes with information systems such as enterprise resource planning (ERP) systems in the manufacturing sector [24,25].

**Assigning business logic to intelligent things**

As discussed in Section 2, smart products are classified into various categories based on their behavior and attributes. As a result, some authors divide intelligent items into two categories: passive and active. At transshipment points, passive technology such as RFID and barcodes can be used to identify products. Semi-passive RFID data recorders enable cost-effective temperature tracking. Active technologies, such as wireless sensor networks, enable communication between all actors in the logistic process of a supply chain (freight, containers, warehouses, and vehicles).

Bose and Wind proposed a set of thirteen criteria for assessing the autonomy of logistic systems [14]. The location of decision-making is regarded as the primary criterion for autonomous control. Despite their critical function in process monitoring, smart things have typically been deployed as information suppliers rather than participants in decision making or business process planning. By delegating certain business logic to intelligent things, decision-making is shifted away from centralized, server-based solutions and toward a network of distributed processing devices. This fosters self-sufficiency within logistical business processes. Each intelligent item is equipped with its own piece of software that can independently seek a partial solution when confronted with process-related challenges. In transportation scenarios, this software gathers data, makes judgments, and negotiates with other parties to accomplish their objective. For instance, a truck laden with multiple pallets of fruit can be equipped with a smart item on each pallet. These can monitor a physical parameter such as temperature, which can then guide the truck route to ensure that all products are delivered at the lowest possible cost [10]. Everything is predetermined in controlled transportation scenarios, i.e., those that are not subject to unforeseen circumstances. As a result, there is no need to delegate additional behavior to the level of smart items. However, changes in traffic patterns, new incoming orders, a breakdown in communication with the central system, or any other unforeseen occurrence may necessitate a detour to a previously scheduled path. To accommodate these unforeseen events, it is required to deploy intelligent things with sufficient embedded intelligence to enable dynamic planning. This method may need the relocation of business logic and associated control from the central system to the level of smart items. From this vantage point, smart devices on the ground make real-time judgments based on their interaction capabilities and intelligence, without human intervention. Thus, to keep the system functioning, the embedded software must provide robustness, flexibility, privacy, low communication costs, and cheap calculation time. Supply chain management systems equipped with these intelligent objects must be adaptable enough to react quickly to unexpected developments. For instance, in a transportation scenario, if a roadblock occurs, the best alternate route must be sought immediately. This route must adhere to logistical functions and maintain supply chain integrity (referred above in section 2). The requirement for rapid reaction necessitates a short computation time. However, depending on the smart item processing capabilities, a complete search for the ideal route in a complex circumstance may take an inordinate amount of time. If there is a communication breakdown in the network, the system should be strong enough to continue operating. Internal planning methods and other proprietary information must be kept private. For instance, if a route change is required, some customers' delivery times will almost certainly vary. Regardless of their awareness of the modification, each client must be denied access to the changes of other customers [2]. In a centrally managed logistics process, items are merely information providers. As a result, they execute only the atomic operations specified in a business process operating on a central system [13]. Smart objects with embedded intelligence process incoming data, observe and evaluate their environment, and make decisions based on the information gathered. These, however, are contingent upon the objects' decision-making freedom within the process and, thus, their capacity for dynamic process alterations [10].

**Enables dynamic changes to business processes.**

Dynamically changing business processes entails adjusting the process's control flow, data or resource perspectives during execution. Adding, skipping, updating, or deleting an activity, modifying the data items connected with an activity, or even changing its role assignment are all examples. These modifications, however, must ensure the accuracy (syntax) of process definitions and instances, as well as the consistency of concurrently executed process instances [18]. As a result, flexibility has been a focus of research in the business process management and workflow management fields.

**Types of process flexibility**

Following multiple case studies and years of research, consensus was reached regarding the necessary flexibility to cope with exceptions. Eder and Liebherr [17] classified exceptions as expected or unpredicted. Predicted exceptions indicate a process's unique but predictable behavior. These exceptions might be portrayed as alternate paths to typical behavior in the process specification. Unexpected exceptions indicate the unanticipated behavior of a real-world business process in relation to its description. To deal with these unexpected exceptions, systems must alter the process specification and associated process instances. Schoenberg et al. propose a taxonomy of process flexibility in a series of also recent papers [18]. There are four basic forms of process flexibility, each with its specific application area. We list them below, each with a simple transportation process scenario: Design: for anticipating changes in the operational environment and defining supporting strategies at the time of design. Deviation: used to deal with rare instances of unexpected behavior where deviations from expected behavior are modest; Under specification: to account for anticipated changes in the operational environment in which tactics cannot be determined at the time of design, due to The ultimate strategy is unknown or is not universally applicable; Change: either to deal with sporadic unforeseen behavior, or Differences necessitate process modifications or the management of persistent unexpected behaviour.Each of the flexibility categories is unique in its operation. Figure 1 illustrates an illustration of the distinctions between the various forms of flexibility in isolation, in terms of the time required to configure specific flexibility choices - during design time, either as part of the process definition or at runtime via process facilities environment of execution. Additionally, it displays the process's predicted completion.

## Constraints on process flexibility imposed

Thus far, we've discussed the many types of smart products and how they might help logistical business processes. Additionally, because of architectural evolution, we have noticed the delegation of business logic to smart things. Additionally, this evolution enables the deconstruction of business operations via dispersed networks rather than centralized solutions. None of these systems, however, offers process flexibility that includes smart things. This means that these business processes do not anticipate anticipated or unanticipated changes that could need updating the business logic running on both the central system and smart objects. As mentioned previously, WS-BPEL has established itself as a de facto industry standard for modelling and executing business processes. A WS-BPEL process definition has partner links that specify the relationships between business partners, process data declarations, handlers for various purposes, and actions. Basic behaviors, such as receiving a message from a partner or editing data, serve only their intended purpose. Structured activities can contain other activities and create the business logic that governs the control flow (see [6] for further details). We envision its application in business processes involving smart products, such as logistics. However, as previously stated, these types of systems are prone to several foreseen and unpredicted variations. In this regard, WS-BPEL has some restrictions, which we shall categories using the flexibility categories Regarding design time flexibility, we may identify the following constraints while working with WS-BPEL: – WS-BPEL enables for the management of predicted exceptions via exception handlers, as well as alternate flows via the usage of if/else control structures (flexibility by design). However, WS-BPEL falls short of enabling for a compact process specification for a greater number of unforeseeable or undefined exceptions and alternate pathways. In the context of the Internet of Things, business process designs that rely on the gathered data from smart things may imply a significant number of exception handlers or alternative paths; all process views (control flow, data kinds, and handlers) must be established statically and a priori — WS-BPEL does not support under specification, which means that process definitions cannot be partially defined or incomplete, or even dynamically specified (e.g., it is not possible to provide the name of a partner link after the process has already begun to execute); WS-BPEL does not support the definition of business logic to be executed in smart items. It would be beneficial to have access to and specification of all sub-process definitions that comprise a business process model. This may include the definitions of business process logic that will be implemented centrally or on smart things. WS-BPEL includes extension tools for defining additional language constructs for modelling business logic to be loaded into smart things; however, WS-BPEL does not support the distribution of business logic between a central system and smart items based on their attributes. It's important to remember that smart products are technological gadgets. As a result, they are limited in their autonomy by physical features such as power (batteries) and processing speed. Processing is necessary when business logic is delegated to smart items. As more business processes are delegated, additional processing will be required. As a result, power usage will increase marginally. On the other hand, the more business processes that are delegated to smart things, the more communication is necessary, resulting in a significant increase in power consumption. Additionally, intelligent products might have a variety of functions. capabilities. As a result, they can support a variety of different types and quantities of business process logic; WS-BPEL does not provide for the control of which, how, and by whom components of a process description can be modified. This controlled flexibility [20] may be advantageous in our scenario, particularly in terms of determining which components of a process are modifiable when the process is dispersed between the central system and the smart things. In terms of runtime flexibility, the key constraints that we can detect in WSBPEL are the following: a lack of support for changing business process instances in response to unanticipated, ad-hoc circumstances. Logistics with smart objects is constantly exposed to a variety of different scenarios, which result in occurrences that must be instantly reflected in modifications to the governing business processes. The absence of functionality for moving instances from old to new process definitions when a business process is redefined. Several works have already addressed similar concerns in WS-BPEL, including issues of correctness and compliance (e.g., see [14], [18]), but not in the context of the IoT. However, the behavior of smart objects can be redefined at runtime, for example, using the Callas language described in [19].

Additionally, integrating these two types of flexibility introduces unique issues that are not handle by WS-BPEL. These include the use of runtime ad-hoc adjustments in conjunction with design updates. Reichert et al. enable the propagation of changes to process instances that have already been exposed to ad-hoc alterations [17]. Additionally, the usage of design changes in conjunction with runtime flexibility for underspecified processes (late binding) creates additional issues for the validity and compliance of process definitions and underspecified process running instances.

## Conclusion

Integrating Internet of Things elements into Business Process Modeling and related tools is a critical challenge that must be overcome to accelerate the adoption of IoT technologies and thus reap the numerous potential benefits associated with the IoT. When this is done, the unique characteristics of IoT services and processes, as well as likely existing business process modelling, must be considered. BPMN [5] and WS-BPEL [6] are execution languages, while USDL [9] is a service description language. require extension. In terms of modelling distributed processes, a first step should be the ability to define the modelling language. which activities should be carried out where, and to select the services that will carry out these remote activities? It should be noted, however, that these services – because they are provided on a resource-constrained basis are frequently not based on SOAP, but rather on REST. A second, more sophisticated step is then to utilize the model is also applicable to the deployment of services: All necessary services are deployed to the target if necessary. once the model is instantiated, or even a complete subprocess is deployed to a remote device/environment. Execution engine for BPM. Additionally, it would be beneficial to assist the business process modeler in determining which activities should be carried out where, initially via guidelines, and possibly later via (semi-) decomposition that occurs automatically [20]

The Internet of Things is a concept that is generating interest in logistics business processes, primarily due to the use of technology dubbed smart items. These items provide precise information. information systems with context data, which they use to create real-time representations of enterprise processes. Items that are intelligent, such as wireless sensor networks with embedded Computing systems are capable of much more than simply providing data. They can carry out portions of business processes and provide support for fundamental logistics functions While centrally based solutions continue to play a significant role in logistics processes, Distributed solutions are gaining popularity. Sensors are being introduced with the ability to execute business logic at the item level, local decision-making is enabled, which reduces the amount of centralized processing and exchanged data. data. None of these approaches, however, is consistent with predicted or unpredicted changes which is a possibility in real-world business processes. These changes necessitate action. dynamically redefined processes or process instances, including changes to the process control flow, data, and resources that occur during the execution of the process, such a reprogramming the intelligent devices.

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