# Methodological Approach of Integrating the Internet of Things with Enterprise Resource Planning Systems

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Keywords: Enterprise Resource Planning Systems, Digital Transformation, Internet of Things, Integration, ERP Implementation Methodologies.

Abstract: The ubiquitous term "digital transformation" brings in the focus the need for analyzing this concept in the industry today. Specifically, the paper describes how organizations look at one of the digital transformation's technologies – Internet of Things (IoT) and if they would like to integrate it with the existing information system or it should be mandatory with implementation of Enterprise Resource Planning (ERP) system. The digital transformation surely put the ladder higher and the organizations are researching new options and innovative ways of doing a business in order to survive in the global market. On the other side, the ERP vendors offer methodologies for implementing their product packages. The digital transformation brought the idea of integrating the IoT with ERP system. Studying these methodologies became obvious that no segments are dedicated to integrating the IoT with ERP system. Therefore, we suggest a generic set of steps applicable in existing methodologies of ERP's implementation.

## 1 INTRODUCTION

Digital transformation now stands on the technological scene. Enterprise resource planning (ERP) systems are also affected by it and therefore there are few ERP trends known nowadays – Cloud ERP and IoT ERP. Two technologies important for the ERP trends are the Internet of Things (IoT) and Cloud computing technologies. ERP systems are recognized as valuable software which are able to improve and because of this maintain their higher position on global market's leaderboard. In their article, Abdullah and Ambedkar list all issues that may affect a company without an ERP system (Abdullah and Ambedkar, 2018).

IoT is one of the digital transformation's technologies which requires Internet connection therefore, Cloud services are mandatory to use the full potential of IoT devices (e.g. Business intelligence, Business analysis). The birth of Cloud ERP unearthed new possibilities to operate IoT devices. The Cloud ERP is an ERP run in the Cloud which lowers the costs of the ERP vendors' clients (Raihana and College, 2012). With the emergence of Cloud ERP, a dilemma arise within the business world - whether to use the Cloud ERP or Cloud services. Answers to this question could not be found during the time of writing. It is preferable to choose the option with integrated IoT support, but this depends on current needs and odds of the company.

Digital transformation offers innovative ways of doing business. Various new technologies open new possibilities and can give the company advantage in the global market. IoT can automatize most of the processes and it offers more data for monitoring, making decisions and planning. ERP vendors recognized the potential of the IoT technology and began developing their product with integrated IoT support. We are aware that IoT has a lot of potential in ERP systems, therefore we began to look for a methodology which could guide a company through the process of IoT implementation.

The main motivations for the integration of IoT with the ERP system are possibilities to collect useful data for the company, to visualize gathered data, to control the IoT device through the ERP system and to

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Sokač, D. and Picek, R.
Methodological Approach of Integrating the Internet of Things with Enterprise Resource Planning Systems.
DOI: 10.5220/0007749303120319
In *Proceedings of the 21st International Conference on Enterprise Information Systems (ICEIS 2019)*, pages 312-319
ISBN: 978-989-758-372-8

use IoT's potentials easily when the ERP system supports it.

After conducting the analysis of the articles, it is concluded lack of articles dealing with a subject related to the methodological approach of integrating IoT with the ERP system. Considering the need for a standard in integrating IoT into the ERP system, these are the *research questions* dealt with in this article: Is there a methodology with defined steps for integrating IoT with an information system? Do best practices for integrating the IoT with an information system exist? Do the existing implementation methodologies (like Microsoft Sure Step, SAP Activate, etc.) include steps for integrating IoT with their products?

Exploring the state of the art of the subject will clarify whether methodologies for integrating smart devices with information system exist. Depending on the outcome of the previous research, we will analyze existing and/or propose a new framework. Afterwards, existing implementation methodologies will be analyzed and integrated with the proposed framework.

First, the state of the art is introduced in the "related work" section. The "framework proposal" section presents proposed steps and activities of our framework. The framework is put into a context with existing methodologies of the most popular ERP system vendors in the following section called "integration with methodologies". Potentials for future researches in this domain and the conclusion of this article are mentioned in the section "conclusions".

## 2 RELATED WORK

Companies have certainly thought about the IoT since the Industrial Internet of Things (IIoT) exists as a term, which is the same as IoT but dedicated to communication between machinery in the company (Gierej, 2017). There are two perspectives in literature: perspective of enterprise and perspective of IoT. Bi et al have illustrated what the differences are. Based on their explanation, the enterprise perspective includes machines, devices and other company's technology capable of connecting to the internet (Bi et al., 2014). The companies realize that IoT offers following improvements: smarter analytics, enhanced security (e.g. cameras, smart doorbells), increased productivity, smart inventory, safer travel and real time demand visibility (Singh and Singh, 2015). Large Chinese organizations were very interested in IoT and so they started exploring the provided possibilities by smart devices (Bi et al., 2014).

With the integration of IoT and the ERP system, some questions arise which are mentioned by Kowalke P. in his article (Kowalke, 2017). Generally, it is important for a company to adapt a new technology gradually and simultaneously focus on its priorities. Articles dealing with the question whether an ERP or non-ERP solution is better for integration with the IoT could not be found during the time of writing. Regardless, it is easy to conclude that such a decision is dependent on the company itself. The company decides which options suit it well in the current timeframe.

If we assume the company is ready for integrating IoT with ERP, it is important to know how to document the change of business processes. Meyer S., Ruppen A. and Magerkurth C. emphasize that IoT devices can work independently and they should be in a separate line in the business process modelling (BPM) tool (Meyer et al., 2013). Kowalke P. says that companies should choose a less dangerous path of the IoT integration even if that means using Cloud technologies to realize it (Kowalke, 2017). Carlton R. mentions few ways of integrating IoT with ERP which consist of using radio-frequency identification (RFID) or near-field communication (NFC) devices, supporting finances and monitoring processes in real time (Carlton, 2016).

The interest in adapting IoT was so high that research and discussions were conducted on the appropriate main goal of the IoT adaptation (Bi et al., 2014). One of first ERP vendors offering the ERP systems capable of working with IoT are: SAP and Microsoft. SAP offers its new methodology SAP Activate and the possibility to use IoT with their product called SAP S/4HANA ("Implementing SAP S4HANA, on-premise with SAP Activate - Additional Topics - SCN Wiki," n.d.). On the other hand, Microsoft offers its product called "Business Central" which supports working with Cloud Computing and the IoT technology (Microsoft, n.d.).

However, they did not define the framework specifically for integrating IoT. Increasing number of discussions and researches is a clear sign that interest in digital transformation is present. Even the demands for modularized and semantic integration of the IoT in the enterprise systems as well as its standardization and development scream for new findings in this area (Bi et al., 2014).

Conducting a research about methodologies for integrating IoT with the ERP system was somewhat successful. Cicibas H. and Demir K. A. explain socio-technical issues and give advice on how to overcome

each of them (Cicibaş and Demir, 2016). Being unable to find articles which provide a methodology of the integration, it was concluded that such articles could not be found during the time of writing. Therefore, the next section introduces a proposed methodology framework of integrating IoT in the information system and its fusion with existing ERP vendors' methodologies.

# 3 FRAMEWORK PROPOSAL

We propose the framework for integration IoT in the ERP systems beginning with three segments: discovery, implementation and usage. Each segment is decomposed into smaller parts, and each part consist of activities. A schema of the proposed framework is shown in Table 1. Each part has a label next to its name simplifying the explanation of integration with existing methodologies in section 4. We assumed the company use "Pay as you go" models to secure IoT platform from one of the providers at the market. This is optional – i.e. smart devices can be built and developed in-house.

Table 1: Schema of proposed framework.

| Framework | |
|---|---|
| **Discovery** | ▪ Acceptance (A1)<br>▪ Integration (A2)<br>▪ Adjusting (A3) |
| **Implementation** | ▪ Design (A4)<br>▪ Development (A5)<br>▪ Integration (A6)<br>▪ Testing (A7)<br>▪ Deployment (A8) |
| **Usage** | ▪ Maintenance (A9)<br>▪ Decline (A10) |

## 3.1 Discovery

Discovery represents a period when a company realizes that IoT would be beneficial for its business. Discovery focuses solely on the business domain of IoT integration. The terrain for IoT usage is prepared, new business models are used, and new diagrams are made. A business domain is being transformed to accept IoT technology. The idea of IoT integration was presented to the company and this marks the beginning of the process of accepting the idea.

### 3.1.1 Acceptance

Acceptance is the first step towards the whole process of integration of IoT with ERP. The company is informed about the benefits and effects of IoT in business. The analysis of IoT integration is performed and it is used as the basis for further steps. The focus lies on two questions: Why is the IoT good? Is it good for the company? This step consists of following activities.

**Presentation of the IoT's Effect in the Business Context.** The company gives some employee the task to research the possibilities and benefits of IoT in the business context. This presentation helps the company understand whether it should consider integrating the IoT.

**Analysis of the Need to Implement the IoT.** Analysis of the whole business model and its processes to see if IoT is applicable or not. Is there a possibility to add IoT devices to enhance current business? This is the question that should be answered.

**Analysis of IoT's Effects on the Business.** After implementation possibilities for IoT are found, the attention switches to the following question: Is the integration worth it? The company wants to know how IoT will affect the business and what will immediate and later improvements be. The focus is on the costs and the returns of the investment.

### 3.1.2 Integration

What follows is listing any potentials of IoT. The company creates a list of necessary IoT devices and all use cases involving these IoT devices. The focus is on deciding which IoT devices are needed, why they fit into a business and where they will be used.

**Locating the IoT Potentials.** Inspecting the current business process model reveals options where IoT could be used. These options play an important role in this activity. The company checks where IoT can be used and what they want to achieve with IoT implementation in that specific area. All processes are analyzed and after finding all IoT potentials, the company proceeds to the next step.

**Creating the IoT Devices List.** In the previous step, all IoT potentials were found. Now, it is decided upon which IoT device is appropriate for which area in their business. A list of wanted IoT devices is then created and will be used to order all devices.

**Defining Correlations between the Devices.** The correlation between IoT devices is important for knowing which devices will be interacting with one another. This step shows the future connection between new and existing business processes. In this step it is assured that there is no redundancy between the functional requirements of the new devices. (For instance, one device may do the same as a combination of two already present devices.)

**Defining all Possible use Cases Involving the Devices.** One use case is one task a device must complete in the business context. Use cases make it easier to understand the behavior of the thing (short term for the IoT device). They also help to understand the interaction between IoT devices and application(s).
**Ordering the IoT Devices.** The organization chooses the best IoT platform provider for IoT devices and places an order containing needed "things". As previously stated, smart devices can be developed in-house. In this case, the company needs to order all parts necessary for the development.

### 3.1.3 Adjusting

The company decides whether it should stay on the old track or choose a disruptive business model. In any case, business process reengineering takes place and business process diagrams are being changed to accept the new IoT technology. The old processes may be changed, removed or simply moved in these procedures. The focus is on business processes and changing them to form gaps into which IoT can be incorporated.
**The Business Process Analysis.** This step requires the documentation in the form of a business process diagram. If the company does not have such diagram, it is created in this step. With a complete picture of business processes, the company can easily proceed with their adjustment.
**The Business Process Reengineering.** The business process reengineering (BPR) is a mandatory step in this undertaking. The company considers including disruptive business process models simplify the BPR procedure. IoT technology results in independent business processes; therefore, the rest of the company's business processes should be revised. The main goal is to adjust appropriate business processes to be compatible with IoT devices, i.e. the process can use and/or serve the smart device with data. These steps result in a completely changed picture of business processes.
**The Business Process Optimization.** The business process model is inspected to avoid redundant use cases. The focus of the revision is on the existing IoT business processes and the processes which IoT devices interact with.

## 3.2 Implementation

Implementation comprises of project preparation and developing the behavior for IoT devices and integrating them with the information system. The implementation takes place after accepting IoT technology.

### 3.2.1 Design

The focus is on preparing for a development process. Functional requirements, technical specification, a project plan and project teams are being created. This is the step in which all the requirements for the development process are being met and consequently the development step can continue without any issue. If the company develops smart devices in-house, the documentation will include wiring diagrams and functional requirements specific for the devices, an additional project team will be in charge of developing smart devices and the hardware development team must begin to develop devices before the next step.
**The Functional Requirements Specification.** Functional requirements specify what the devices should do and all the operations related to them. If IoT devices are integrated in a web application or an ERP system, that means the functional requirements will contain the functionalities related to the system or the web application. The functional specification describes the behavior of smart devices and all systems in interaction with them.
**The Software Architecture Definition.** The definition makes it clear how the whole system and its components should look like. It shows the information flow between the components for the development phase.
**The Project Team Allocation.** The company should allocate the project team to realize the implementation. The project team's main task is developing new features and modules for integration of IoT with the business. A project manager must be assigned to the team in order to coordinate the team's actions.
**The Project Plan Definition.** As the final step, the project plan should be created. The project plan should contain information on the project's domain, budget, team, timeline, schedule, and owner. The files attached to the project will be all documentation created until now: use cases specifications, functional requirement specifications and the technical documentation (the software architecture definition). When the document is ready and authorized, next step will take a place.

### 3.2.2 Development

IoT devices have defined behavior from previous steps. The project team is creating all required layers of the architecture – from the technical specification

for a minimal setup to the start of behavior development. The Cloud services for the IoT may be used to ensure a smooth development process and to ensure everything is working properly in this early stage.

**The Project Backlog Specification.** The input document is the project plan. Based on the functional requirements and the use cases for IoT devices, the project backlog is created. The project backlog contains all functionalities for IoT devices and for the systems which are in interaction with them.

**The Initial Project Teams' Meeting.** The tasks are assigned to the teams. The project manager informs the teams about the deadlines. They come to an agreement regarding the procedure and the flow of the development in the form of weekly meetings and presentations of finished parts.

**The Software Development.** The software development team is dedicated to developing modules for existing systems or applications to support IoT devices. During this step, light testing is required to ensure the hardware and the software work correctly. Testing IoT devices is conducted in order to prove the devices are accurately functioning according to their documentation.

### 3.2.3 Integration

The IoT devices with behaviors need to be integrated into the system. The things are being set in the place, the Cloud services are being used (the accounts are created and added to the things). The integration with the system is incomplete unless the things are integrated into the ERP system or any other system the company uses. The integration with the system begins with a question: Does the system support IoT or not? If not, then additional modules are required to use IoT to its full potential.

**Exploring the Integration Possibilities.** There is no definitive integration that can occur. IoT devices can be integrated with an ERP system, a web application, a single web page or some commercial or free business software. It is important to detect the possibilities of integration depending on the place of their occurrence.

**Preparing the System to Accept IoT Devices.** Some systems do not support IoT devices initially and additional development is required to create IoT modules. It is essential to create such modules before proceeding.

**Integration of IoT Devices with the Information System(s).** IoT devices need Cloud services to offer a complete IoT experience. Some accounts for Cloud services from the development phase can be found here; however, these should not be used in the official deployment of IoT devices. It is mandatory to create accounts for the official versions and note down all the credentials for future use. IoT devices usually have an identification value and these values are used to connect IoT devices with the business information system. When data starts to gather, the integration is completed successfully.

### 3.2.4 Testing

With the IoT devices in place and running, all integrations should be tested for possible bugs or errors. The testing is a process and not a phase – the process comprises of multiple steps or phases and extends over a longer period of time. Smaller part of the implementation segment are tested in order to check if new integrations function correctly. During the development and integration, there must be some light testing and its documentation. Moreover, test requirements and test cases are created. In order to continue, the test execution must be successful.

**Creating the Test Requirements.** The test requirements are needed to define the domain of the test process.

**Creating the Test Cases.** The test cases are required to identify which activities or actions should be tested. Usually, there is a limited number of steps which lead to a specific outcome. It is important to define the test cases for easier test execution.

**Running the Test Cases.** Running the test cases confirms success or failure where the developer is meant to fix issues and confirm successful executions. Running test cases speeds up the code checking process.

**Confirming the Tests or Fixing the Failed Tests.** After running tests, there can be two outcomes: success or failure. A successful outcome is confirmed, and a failed outcome should be fixed. After the issue is fixed, the test is run again to confirm the changes and the problem's resolution.

### 3.2.5 Deployment

When all tests are successful, it is time to begin the deployment step. The deployment is divided into two subcategories: the beta deployment and the production deployment (the official deployment). The beta deployment is used to observe how the integrated devices interact with the system. It is also used to detect issues and bugs which were somehow missed during the testing step. When the beta deployment finishes, the production deployment takes place. And during this phase, less attention is

directed towards active searching for bugs and more attention to the regular usage and monitoring.

**The System Acceptance.** The top management accepts the newly developed system and agrees to integrate it in the business information system.

**The User Training.** This implementation project consists of hardware and software parts. The hardware part is usually not maintained by the company, consequently IoT device maintenance training is not relevant if the project team is internal and devices are bought from a chosen supplier. If that is not the case, the hardware is handled by the team which built it. The software part should be introduced to employees who will use the new features. The training will clarify the new software modules or features and offer first steps of working with such modules or features.

**The Database Cleanup.** The existing databases may be filled with data from the development and the testing stage. Such data is not welcome in the official environment, so a cleanup is performed.

**Assigning the Official Cloud Service Accounts.** Cloud services, mentioned in the previous phases, may also store test and development data. Such data should be removed and new official Cloud service accounts should be assigned to the appropriate components.

**The System Installation.** The necessary downloads, upgrades and system customizations are performed.

**The System Goes Live.** Occasional training sessions are occurring in this step. The documentation and all used accounts are passed to the system administrator of the company and the system goes live.

## 3.3 Usage

The last segment is called "usage". This is a post implementation segment and it is focused on the maintenance and the usage of the new system. An analysis is run to identify whether the system is still beneficial for a company or it became a burden. This segment lasts until the new system is ready to be replaced with a new innovative technology.

### 3.3.1 Maintenance

The system maintenance is a mandatory process in post implementation. The maintenance includes monitoring, measurement, evaluation and improvements. The main goal is to keep the system updated and optimal, and to fix all occurring errors to ensure maximal availability.

**Monitoring and Measuring the System Performance.** It is mandatory to keep an eye on the new system's progress and performance. The new system is still untrustworthy and needs to be supervised. Monitored metrics are important for the business's improvement. It is important to be aware of possible bugs and/or errors which can cause the system's unavailability. The monitoring is mostly connected with dashboard and graph visualizations which can make the monitoring process easier. The metric that could be monitored is the system availability (the whole system or its module). These measurements help in understanding how well their system performs, while monitoring is just a way of showing how the system performs. The results of the measurement process are used in the next step – the evaluation. The data is collected to perform aggregations and calculations which will be used in the next step. The collected metrics for every component could be: a fault rate, peak periods, power usage, cost of the device/system, earnings (or participation in earnings) of the device/system.

**Evaluating the System's Performance.** This step is important for deciding whether to continue using the system or its component. The decision is made after considering the whole business picture and data collected from the previous step. It is discussed here if the system or its components still have a supportive role in improving the business or if it became a burden and needs to be removed from the business to ensure better results. In general, monitoring, measurement and evaluation form a repetitive process sequence. When the decision for removing the system or its component is made, that component or system moves to the "decline" step.

**Improving the System's Performance.** The evaluation and the measurements are inputs for this step. At this point, one decides to update, upgrade or fix issues that occurred during the working period. The goal of this step is to keep the system optimal and updated. The domain of applied upgrades or fixes varies from a single component to the whole system.

### 3.3.2 Decline

Decline takes place when the company decides to replace the existing system with new and innovative technologies because the system or its components do not contribute to the company's competence and earnings anymore. This is the last step in the "usage" segment and leads to the end of the existing system's life cycle or that of its components. There are no activities here and it is assumed that all activities regarding researching better options and replacing the existing system take place in this step.

Table 2: Integration of proposed framework with ERP vendors' methodologies.

| | | Oracle OUM | | | | | SAP Activate | | | | | | Microsoft Sure Step | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | O1 | O2 | O3 | O4 | O5 | S1 | S2 | S3 | S4 | S5 | S6 | M1 | M2 | M3 | M4 | M5 | M6 |
| Discovery | A1 | X | | | | | X | | | | | | X | | | | | |
| | A2 | X | | | | | X | | | | | | X | | | | | |
| | A3 | X | | | | | X | | | | | | X | X | | | | |
| Implementation | A4 | | X | | | | | X | X | | | | | | X | | | |
| | A5 | | | X | | | | | | X | | | | | | X | | |
| | A6 | | | X | | | | | | X | | | | | | X | | |
| | A7 | | | | X | | | | | | X | | | | | X | | |
| | A8 | | | | X | | | | | | X | | | | | | X | |
| Usage | A9 | | | | | X | | | | | | X | | | | | | X |
| | A10 | | | | | X | | | | | | X | | | | | | X |

# 4 INTEGRATION WITH METHODOLOGIES

One of the goal of this article is to see how to integrate proposed steps with the existing methodologies. The methodologies, which will be observed, are: Microsoft Sure Step, SAP Activate and Oracle Unified Method (OUM). These methodologies were chosen because they are standards of the most popular and influential ERP vendors ("Enterprise Resource Planning (ERP) Software Reviews," n.d.). Their steps were summarized in one table. The steps were extracted and the appropriate steps from previous section are added to this picture. For the sake of easier understanding, each step in Table 2 is replaced with a label mentioned next to the step's name (including steps from Table 1).

The proposed segments can fit in the existing methodologies nicely. Oracle Unified Method (OUM) offers the following steps: inception (O1), elaboration (O2), construction (O3), transition (O4) and production (O5) (Nagpal et al., 2015, p. 6). SAP Activate contains these steps: discover (S1), prepare (S2) and explore (S3). Microsoft Sure Step introduced the following steps: diagnostic (M1), analysis (M2), design (M3), development (M4), deployment (M5) and operation (M6) (Nagpal et al., 2015, p. 7).

Table 2 contains the letter "x" in some intersections of columns and rows. The letter "x" means that a step from the proposed framework fits in the existing methodology's step. Table 2 shows how proposed steps can be integrated nicely in existing methodologies while only some steps from the "implementation" segment are being distributed among the existing vendors' steps in order to match the goal of the steps. The proposed framework is independent and can be used with other methodologies. It is not strictly limited to the ERP system and it can be used in other information systems. The general nature of the proposed framework enables its application in other technology where the activities should be mapped to fit the needs.

# 5 CONCLUSIONS

The new industrial revolution brings out new ways of using already known technology. The IoT potentials were recognized. It can transform the existing business and offer a new innovative way to run a business. The transition between the old ways and the new ways alerted companies and they are willing to adopt the digital transformation for the sake of their businesses. The main problem is that options for a change towards new ways are not well documented yet. IoT technology was recognized as immensely helpful in measuring and monitoring which occur in the business. Even the ERP vendors began working on ways to integrate the option of using IoT in their products (e.g. Microsoft and SAP).

Since lack of articles with this subject were identify, a methodology framework is proposed to make the process of integrating IoT in the ERP system easier. The framework consists of segments and steps beginning with discovery, through

implementation and all the way to usage and declining at the very end. The discovery is focused on preparing the field for the development of the IoT devices and the mandatory applications. After the development is finished, monitoring the new system and ensuring its efficient and correct workings is the main task of the "usage" segment. Even though specifically the ERP system is taken as an example, the work flow can also be applied to a web application which supports the IoT devices. Since this article began by mentioning the ERP system, it was taken as the basis for showing how the new proposed steps can fit in the existing methodologies to unify the process of implementing the ERP system and integrating IoT devices into one single flow. This may start a new avalanche of ideas on how to offer ready-to-use IoT ERP systems.

The proposed framework provides steps which will make the integration process easier. The framework is still based on theory and its practical usage needs to be tested in collaboration with the company willing to dive in such an implementation process.

Right now, this is the first step towards developing the best practice for integrating IoT with an information system. Some interesting points for future researches would be: How to integrate other technologies of digital transformation in the business context? How to integrate customer-specific processes which support IoT? How does integration of IoT into business affect business results? The framework is still based on theory and its practical usage needs to be tested in collaboration with the company willing to dive in such an implementation process. Consequently, this would provide qualitative results to evaluate frameworks in the form of a research paper. It may be interesting to see ERP vendors updating methodologies which implement steps similar to those in our proposal. Additionally, it would be useful to provide information on opportunities offered by IoT integration – controlling smart devices, influence of smart devices on the ERP system's work flow. IoT represents the beginning of innovative ways of doing business.

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