

INTERNET OF THINGS AND BUSINESS PROCESS MANAGEMET

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Summary: *In recent years intelligent devices that include dedicated software, smart devices, sensors and advanced communication capabilities for sending and receiving data, began to be used in more diverse economic areas. The added value of using and connecting them via the Internet-of-Things (IoT) [1] is given by the capability of monitoring and permanent control state systems (energy, traffic, transport, agriculture, health, community public services, etc) without human factor intervention. Another feature of these devices is provided by the ability to make decisions based on analysis of data obtained. Although advanced technologies are evolving and investing in IoT devices industry increase more and more, the challenges of integrating these devices and communications security are still valid. This paper aims to present some significant issues related to the integration of IoT devices using concepts of Business Process Management (BPM).*

Key words: Internet of Things, smart devices, sensors, business process management, business, software

1. INTRODUCTION

As technology and communications evolve at an accelerated pace, the access to various sources of information and content using the Internet, it is becoming increasingly easy, putting increasingly more the problem of creating a universal virtual space in which people, machines, devices and systems to be connected permanently. This can help the speed in making critical decision and actions to be implemented and executed properly being correctly monitored and controlled.

The connection is achieved by the most diverse means, one of the concepts that allow the automation is possible using Internet-of-Things [1] that allows the realization and implementation of smart devices that will be placed in various environments. These devices collect and transmit real-time data on elements of the environment in which they are placed. To facilitate data processing it is necessary to integrate these devices in process flows, analyzing data and act according to predetermined rules and conditions.

On the other side, the execution of process flow and measuring performance indicators using Business Process Management Information Systems become a prerequisite for ensuring efficiency in resource usage, cost reduction through standardization, optimization, automation and preventing the occurrence of defects and errors.

The capabilities offered nowadays by Internet and the availability of exceptional bandwidth capabilities raised the issue of integration of intelligent devices connected by IoT in complex processes that allow the increasing the speed in decision making and that help increase quality of products and / or services resulting from their execution. Moreover, connecting intelligent devices and sensors using IoT space and BPM concepts allow collection, processing and interpretation of data in real time is putting the foundations of a new technological revolution.

2. INTERNET-OF-THINGS DEVICES

In an article published in 2013[2], we presented the concepts of IoT, the pros and cons of using it. To understand in detail the applicability of intelligent devices in IoT, it is necessary to identify how they work and are connected.

The functioning of a device or sensor connected to the Internet through an online communication environment, referred here as IoT devices, is relatively simple and easy to understand.

Regardless of their type and in order to accomplish their role, all IoT devices technical architecture is based on the following components [3]:

- Interfacing component for transforming sensor data taken by the microcontroller.
- Hardware component consisting of microcontroller that performs dedicated functions and secure data communications.
- Software component incorporated in microcontroller (embedded software) that implements algorithms for collecting and transmitting monitored data.

An example of traditional technological architecture in which IoT devices are used has the general structure consists of four levels [4]:

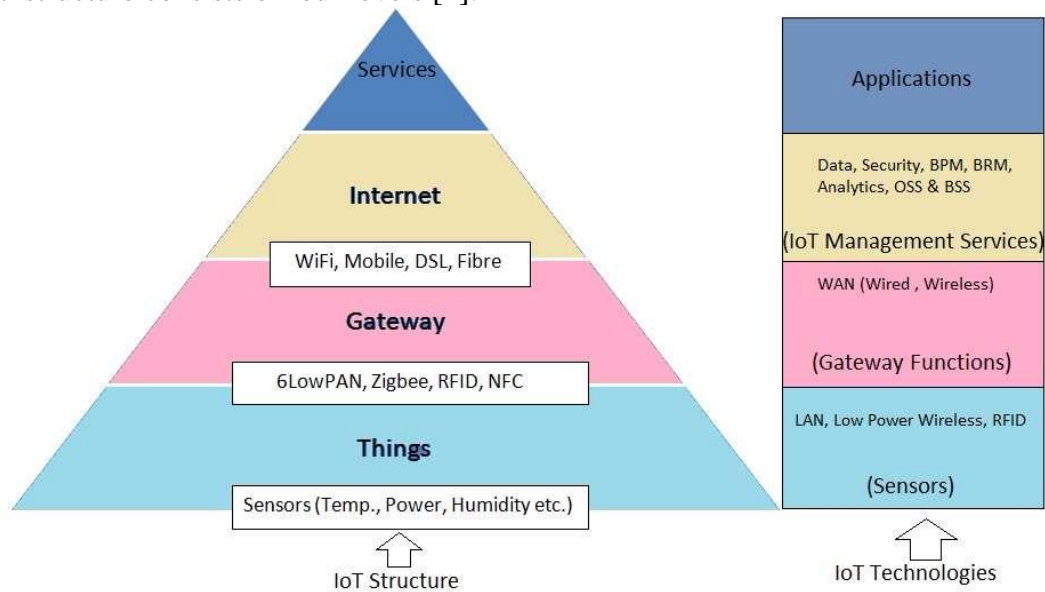


Fig. 1. The four levels are interconnected to perform the functions for which the device was designed.

From the point of view of the means of data communication, IoT devices can be classification in:

- **Unidirectional** - transmit data and information in a single direction from source to destination;
- **Bidirectional** - send and receive data and information in both directions (from source to destination and vice versa).

2.1 How IoT Device works?

Sensors are fetching external data from the environment on which they are connected and communicate via gateways the primary processed information toward the cyberspace. The internet connection is made via a service management system to ensure data security and confidentiality. The last level is the application layer through which information is presented either directly or sent to other systems for the processing.

The areas in which these devices can be used are various considering functions that can be covered: from agriculture, logistics and transport of goods, platforms for coordinating traffic in large urban areas (platform eMobility developed by Bosch Software Innovation in Singapore) to the management activities of commercial aviation and airports (eg Aerportul Heathrow London) and last but not least more and more in public health services.

3. THE APPLICABILITY OF IoT DEVICES IN HEALTHCARE

The data on health of a human belongs to the most sensitive category of data. Digitization and data sharing related to people's health have brought major benefits in adopting measures to increase the efficiency of medical resources usage. Using smart devices connected by IoT bring a huge potential in this direction.

Two of the most relevant examples for application of IoT concepts in health care services are:

- **Patient monitoring.** Hospitalization and associated costs of this approach are extremely expensive. According to a study [5] the average costs for one patient were \$ 1,700 in 2013. The introduction of a dedicated remote monitoring system (BodyGuardian Remote Monitoring System) [6], has given the opportunity to collect data and information about the health condition of the patient in real time, taking into account the permanent privacy settings by data ensuring encryption mechanisms during transmission and storage.
- **Drug supply chain management.** The costs related to the design, production and delivery of medicines is a major challenge for the pharmaceutical industries. Given that the average costs for development and approval of a new drug use are nearly \$ 55 million (according to a report Forbes- [7]) real challenges arise from those companies that manufacture generic fraudulently drugs, apparently inoffensive but that can bring more health problems for those who use them instead of the original. For this reason, it has developed a model for supply chain based on RFID technologies where all drugs that came across supply chain process are strictly monitored and controlled. Due to the evolution of smart devices connected over the IoT, the model will go into a new phase by implementing a sophisticated process monitoring drug route from manufacturer to the patient.

4. THE INTEGRATION OF IoT DEVICES WITH BPM

The challenges of IoT devices usage are mainly related to the integration within services infrastructure enabling data processing using applications and complex information systems. An innovative approach is the one that helps integration through a BPM layer which will permit data processing and decision making in a controlled manner based on pre-defined business rules.

Technologies that implement BPM are in continuous evolution and offer a viable alternative to the development and maintenance of software applications developed using modularity principles.

Advantages of BPM suites lies in the fact that activities from processes can be automated (if it is possible to eliminate human intervention) and the future changes on the process are relatively easy to implement and maintain.

Moreover, BPM software suites use graphic modelers based on BPMN 2.0 modeling standard, which will help the creation of process diagrams. The result of modelling is the process diagrams that can be processed, interpreted and executed by the process engine specific.

Complete systems for business process management are provided by the world's leading suppliers of technology and software among them being able to find IBM through the IBM Process Manager [8] Oracle with Oracle Business Process Management [9], and companies that are dedicated for covering the market's needs with dedicated BPM tools: Bosch Software Innovation, Progress, AuraPortal, BizAgi, ProcessMaker, etc.

5. CONNECTING IoT DEVICES IN THE PROCESS

From the perspective of execution, the processes can be automated and can run in two situations:

- If a user initiates the process on demand.
- If there is an external factor (trigger) – i.e.: achieving a threshold of time, temperature, humidity, pressure, etc.

Connecting an IoT in a process can be performed through specific software services that evaluate and analyze the behavior of the subject of monitoring at predetermined intervals. Collection and interpretation of received data from the device is compared to predetermined references. Exceeding these thresholds will allow the triggering of processes and/or subsequent sub-processes that includes these devices. Depending on process logic and in conformance with defined business rules and logic, one or more actions will be executed.

Some of the advantages of using IoT devices integrated with BPM suites are presented below:

- Processes can be changed without the need of replacing existing smart devices.
- Standardization allows the reuse of the same process for triggering different actions using multiple devices with different roles and functions.
- Standardization brings low operating costs.

- Adding new devices is relatively easy; using software connectors the scalability and stable performance is ensured regardless of the number of newly added physical components.
- Ensure increased autonomy of the systems using the machines and devices in areas with high risk (medium toxic, radioactive, risks of biological hazard, etc.)

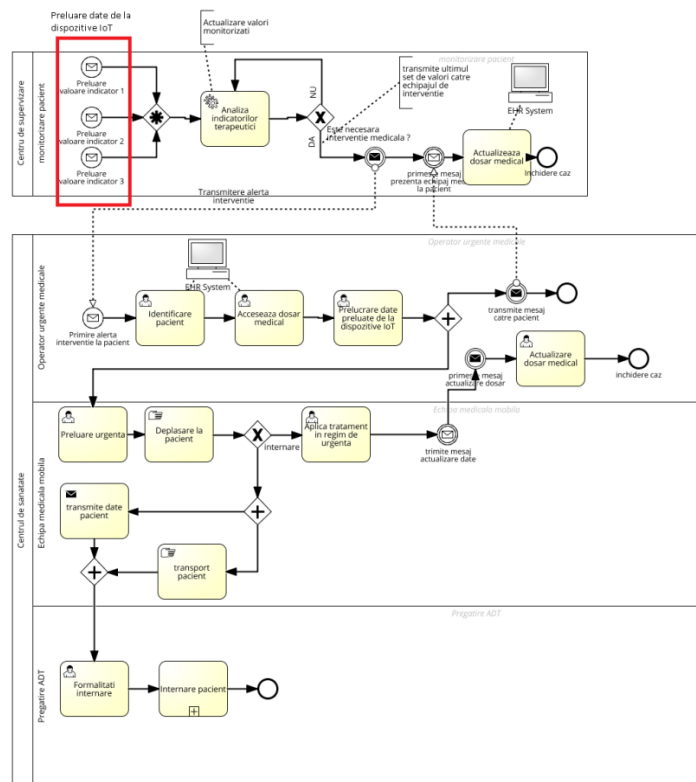
6. IoT INTEGRATED WITH BPM IN HEALTHCARE SERVICES

A key area in which the concept of IoT devices integrated with BPM is increasingly rapidly is related to the healthcare services. The world is permanently facing financial turbulences with major economic impact. It is very difficult to predict the uncertainties and a major goal is to increase the efficiency of spending resources. As a consequence of this status, one of the areas that need permanent adjustments and assessments is related to health services. Regardless of their nature (public or private) health services absorb annual amounts exceeding in developed countries an average of 4,500 USD per capita. Budgets allocated for healthcare services recorded significant increases from year to year. [10]

However, a World Health Organization report from 2015 shows an alarming increase in the number of people enrolled in the non-communicable diseases, diabetes and cardiovascular disease generating a rise in the number of hospitalization days and in the worst case, death. The report reveals that 46% of the total of deaths due to cardio-vascular diseases, most of which in turn can be caused by diabetes and other nutritional diseases. From the report [11] it is shown that 50% of death cases are statistically shown due to chronic conditions that require a preventive approach.

A mechanism for prevention of these diseases which may affect people's lives is realized with dramatic cost becoming greater given that government budgets allocated to health services are continuously monitored. For maintaining an optimum cost between health services and expenses, research institutes and technological innovation in medicine seek permanent solutions to prevent and combat the effects of chronic diseases.

Remote monitoring of patients and people at high risk of accidents is a preventive method that can assess permanently the health of the patient. Using this method, the patient may carry on their activities normally without being hospitalized in a specialized institution, being in constant contact with health systems and physician. To achieve this goal it is used advanced technologies for collecting data through sensors and transmitting them using permanent connection to the Internet, respectively of their interpretation by healthcare information systems.



The evolution of the Internet and smart devices such connected to IoT allowed the implementation of data transmission and processing in real time by medical information systems. Smart bracelets, belts equipped with sensors, patches or implants which measures physiological predetermined health parameters of the monitored person send data synchronous or asynchronous mode in real time.

Depending on the values of these parameters, information system built on process flow will analyze received data and make decisions on different types of actions to be taken. These are triggered by predetermined thresholds and are communicated to the treating physician and the patient or depending on the situation can generate alerts and intervention medical crews.

A process diagram that describes how the execution process in case of reaching critical thresholds of intelligent devices connected to the IoT is presented below and shows the action that takes place if a crew medical intervention is required.

The advantage of using smart devices connected to IoT and integrated with BPM is given by the fact that the medical team comes into action only when it is absolutely necessary and no longer requires inpatient in a healthcare unit, monitoring being performed remotely.

7. CONCLUSIONS

The widespread use of connected devices is increasing and the need for their integration in complex information systems is a challenge. Information systems built on BPM concepts help any business to increase efficiency by adopting standards which once met lead to reducing losses and errors. These systems can be used for the integration, collection, data processing from IoT devices. Based on these data it is possible to make decisions and it is possible to

prevent situations that can have huge social and economic impact.

Integration of IoT devices with BPM solutions and using specific mechanisms bring an innovation component in business as it helps in making proactive instead of reactive measures whose costs cannot be measured at the time of occurrence of unpleasant events. Areas of application of this concept of integrated BPM IoT are diverse: agriculture, aerospace, energy, manufacturing, commercial services, health, etc.

The key to success in this dual integrated approach is detailed understanding of the business and how smart devices can be integrated to automate certain activities, BPMN modeling and implementing complex IT solutions using BPM concepts.

8. REFERENCES

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