IoT platforms for the Mining Industry: An Overview

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Abstract

Industry 4.0 and the Internet of Things are now very common concepts as solutions that can revolutionize the industry. Constant technological progress increases the possibilities of using computer tools and solutions to support processes in industry and production optimization. The use of the Internet of Things is particularly important in complex processes in mining, enabling the extraction of valuable information from data. The integration of physical facilities in the enterprise enables the digitization of production processes and the increase of efficiency and security.

This article presents an overview of the selected internet of things platforms and analytical tools that can be used in industry, with particular emphasis on the mining sector. It is pointed out, that the number of suppliers of IoT technologies and analytical tools offering advanced data analytics services for industry is significant and constantly evolving. The aim of the article is to evaluate selected IoT solutions based on the following criteria: offering predictive analytics, implemented artificial intelligence (AI) or machine learning (ML) algorithms, a mining-oriented process approach, advanced data visualization, interoperability, real-time data capture, remote device management and cloud-based technology. The review was prepared to provide knowledge about IoT vendors operating on the market, as well as to indicate the functionalities that are the most popular among solutions.

Keywords: Industrial Internet of Things, analytics platforms, mining, data analysis

Introduction

In the world of fast-growing technologies, enterprises are forced to constantly improve their processes to keep their market position or confirm competitive advantage. A response to a growing demand can be developing technology, especially the Internet and information technologies, which provide new solutions for the industry. The various components of the process are a valuable source of information, that properly interpreted and used, enable the overall management of a company. Hence, the integration of physical objects and infrastructure equipped with sensors enables them to communicate with computers (Krupanek, Bogacz, 2018; Boyes et al., 2018). This combination makes it possible to computerize and digitalize manufacturing processes. Transformation of the industry allows traditional machines to become self-learning and self-aware devices, which interact with the manufacturing environment. In this context, we often hear about the term Industry 4.0, what means the fourth industrial revolution (Vaidya et al., 2018).

Industry 4.0 is closely connected with a conception of the Internet of Things (IoT). The term Internet of Things was first used in 1999 by Kevin Aszton in the presentation for the company Procter&Gamble (Ogórek, Zaskórski, 2018). IoT is a broad concept with numerous definitions. One of them, introduced in (Gubbi et al., 2013) defines the Internet of Things as "an interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless ubiquitous sensing, data analytics and information representation with cloud computing as the unifying framework". Connecting IoT technologies with the manufacturing process to create smart enterprise led to the formulation the concept of The Industrial Internet of Things (IIoT). A definition presented in (Boyes et al., 2018) states that: "The IIoT vision of the world is one where smart connected assets (the things) operate as part of a larger system or systems of systems that make up the smart manufacturing enterprise".

The operation of an IoT platform enables data processing and storage, remote monitoring and support of the decision-making process. Various devices connected to a network provide data exchange between machines without human participation.

The increasing capability of collecting and processing information allows individual companies to independently store and process data to better understand their own processes and improve them. Production companies can reach for new solutions, which are much better adjusted to their requirements and the scale of operation. An enormous number of connected devices and the necessity of measuring different process parameters, puts a very high demand on providers regarding functionality, security and application's functionality. In addition, a key role in choosing the IoT platform has the selection of tools for data visualization and analytics as an essential component of the solution.

Mining is considered to be a very complex and difficult process to predict, where not only human error or the unreliability of equipment, but also nature plays a significant risk factor. Mining companies decide to use IoT solutions to enhance process effectiveness, and as a result achieve better economic and technical outcomes. Industrial IoT platforms connect industrial machinery and specially designed devic-

Tab. 1. Functionalities of IoT platforms and analytical tools, [Source: own elaboration]
Tab. 1. Funkcjonalności platform IoT i narzędzi analitycznych, [Źródło: opracowanie własne]

Name of IoT platform	Predictive analytics	AI/ML	Mining oriented	Visualization	Interoper-ability	Real time data capture	Device managemen t	Cloud-based	Support and service
ABB Ability	+	+	++	+	+	+	+	+	+
Buddy's IoT Data Graph	N/A	N/A	+	+	N/A	+	N/A	+	N/A
C3 IoT	+	+	N/A	+	+	+	N/A	+	+
Connected Mine	+	+	++	+	N/A	+	N/A	+	N/A
Cumulocity	+	+	N/A	+	+	+	+	+	○
DeviceHive IoT	+	+	N/A	+	+	+	N/A	+	N/A
Dingo Trakka	+	N/A	+	N/A	N/A	+	N/A	+	+
Hexagon Mining	N/A	N/A	+	N/A	N/A	+	N/A	+	+
IBM Watson	+	+	+	+	+	+	+	+	+
IntelliSense	+	+	+	N/A	N/A	+	N/A	+	N/A
IoT.nxt	+	N/A	+	N/A	+	+	N/A	N/A	N/A
Kaa IoT	+	+	N/A	+	N/A	N/A	+	+	N/A
Loop IoT Cloud	N/A	N/A	N/A	+	N/A	+	+	N/A	N/A
Losant	+	+	+	+	N/A	+	+	N/A	N/A
Hitachi's Lumad	+	+	○	+	+	+	N/A	+	+
Microsoft Azure+Power BI	+	+	N/A	+	+	+	+	+	+
Modular Mining	N/A	N/A	+	+	N/A	+	N/A	+	+
Predix GE	+	+	○	+	N/A	+	+	+	+
PTC Thingworx	+	+	N/A	+	N/A	+	N/A	+	+
SAP Leonardo	+	+	○	N/A	+	+	+	+	+
Siemens Mindsphere	+	+	○	+	N/A	+	N/A	+	+
Thinger.io	N/A	N/A	N/A	+	+	+	N/A	+	N/A
Uptake	+	+	+	N/A	+	+	N/A	+	+
Explanations of markings: ++advanced, + well-developed, ○ satisfactory, N/A - not available									

es to ensure comprehensive insight into operational data. At present, especially in industry, IoT platforms are heading towards predictive maintenance to provide exactly planned processes without undesirable events and defined future states of the manufacturing environment.

The main purpose of this paper is to provide an overview of selected industrial IoT platforms. A significant number of IoT platforms and their constant development among new technology providers indicate the scale of this phenomenon and the growing popularity of analytical solutions used in production processes to provide reliability. Taking into consideration contemporary trends, an analysis of the industrial internet of things (IIoT) platforms and analytical tools will be performed. To identify solutions available on the market, main vendors websites and white papers will be searched.

Overview of IoT platforms

The number of platforms and analytical solutions that offer comprehensive services for advanced data analysis is significant. The range of services is also extensive and wide. Platforms include artificial intelligence algorithms and machine learning applications. Moreover, remote monitoring and management are used to provide alerts in real time. Visualization ensures a better understanding of enormous and diversified data sets, visual exploration and visual analytics. Storing data in the cloud offers their security without expensive infrastructure. By means of predictive analytics, companies use data to predict equipment failures and future trends.

The following section presents an overview of 23 IoT platforms and analytical tools which could be applicable in the mining industry. Some solutions are developed by companies from the mining domain or are prepared as platforms dedicated typically for mining enterprises. Examples of such solutions that were chosen for analysis are as follows: the ABB Ability IMS (Intelligent Mining Solution), Uptake, Hexagon Mining, IntelliSense, Modular Mining and Connected Mine.

The overview includes also platforms with significant market presence, often offered by well recognized producers such as: the IBM Watson IoT Platform, Siemens Mindsphere IoT, Hitachi's Lumada, Cumulocity IoT, SAP Leonardo IoT, The C3 IoT Platform, PTC ThingWorx IoT and Microsoft Azure IoT with analytical tool Power BI.

In the analyzed solutions only a small percentage are open-source platforms. Examples of platforms offered in such a business model are: the Kaa IoT Platform, the GE Digital Predix Platform, DeviceHive IoT, Thinger.io IoT according to the information on the vendor's websites.

In the prepared survey also were considered IoT platforms and analytics solutions such as: Dingo Trakka, Loop IoT Could, Losant Enterprise, Buddy's IoT Data Graph and IoT.nxt to point out some lesser known solutions and evaluate the possibility to adapt them in the mining industry.

Based on available materials from producers, the IoT platforms and analytical tools were evaluated taking into account the main functions and criteria as: predictive analytics, implemented artificial intelligence or machine learning algorithms, the mining oriented approach to the process, data visualization, interoperability - as a possibility to integrate different tools, products or systems, real time data capturing, device management and cloud-based technology. Furthermore, support, consultations and services from providers were taken into account. The category of support and service includes a wide range of professional services such as: trainings, deployment, engineering support, guidance in the technological as well as in the analytical fields and support from provider's partners, not only remotely, but also on site.

The evaluation was based on the grounds of available information and descriptions, with paying attention to the mentioned, essential points. The characteristic of the selected platforms is presented in Table 1.

Crucial, in choosing the appropriate platform, is to have access to a complete and accurate offer. The majority of the vendors provided precise products' descriptions, which are the basis in the preselection during market research. The features, chosen for the analysis, were collected to compose general outlook for the issue. The summarisation could be advantageous for the potentially interested users in comparing IoT solutions for industry. In some cases, there is a lack of information about certain properties or functionalities of platform in the provider's offer. Such cases are marked in the mentioned table.

The key aspect for a customer is also the safety of data and technical functionalities of the presented platforms, such as: device management, interoperability and well-developed analytical and visualization tools. Important is also the provider's size as a company and reputability, which often entails market stability, service and guidelines in the future. From an industrial point of view, maintenance and reliability, early detection of defects and machinery failures are essential to effective processing. By knowing past and current states, enterprises are able to make predictions and support decision making processes through real time data capturing. Furthermore, this knowledge enables the enhancement of processes and the entire company.

Selected platforms differ to some extent, depending on the level of adaptation of their functionalities to the industry, in particular to the mining sector. Some technologies are widely adopted and implemented in most of the considered platforms or tools. Nevertheless, some functionalities are not equivalent to each other. Depending on the industry and the specifics of the process, certain features will be considered as more valuable to implement in the company. A compilation of selected features' frequency was developed to indicate the most popular properties of platforms. The frequency of reported features in the IoT solutions is shown in Figure 1.

The most frequent functionalities among the analyzed platforms and tools are: real time data capturing, cloud based servicing and predictive analytics. The results of the evaluation indicate that the vast majority of vendors offer not elementary analytics but diversified and highly advanced techniques and algorithms for analyzing data and making predictions based on it. The mining oriented approach is distinguished for 15 platforms, similarly the ML and AI implementation are found in 16 offers. Highly evolved visualization abilities are provided by 17 platform providers from the analyzed group. It can be seen, that the least commonly provided properties are: device management, interoperability with another tools and equipment, besides vendor's support and service.

The above resume constitutes about the distinguishing features of the evaluated platforms and point out some technological fields in which providers might develop their offers to compete on the rapidly growing market.

The majority of the analyzed IoT platforms are addressed to the industrial sector. These solutions can operate with various processes and are able to connect industrial devices. However, an industrial profile is not always equivalent to working effectively in mines. A mining-oriented solution means that a platform should be accustomed to complex processes, carried out in different areas of operation, with specialized equipment, numerous of hazards and the necessity of interoperability.

It is difficult to conclude on the usefulness of the majority of the listed and analyzed platforms for the mining industry solely based on the solution description. Taking into consideration the specificity of mining and data from this sector, it can be deduced that conventional platforms are not adapted to the analysis of specific and unstructured data sets without the process-oriented approach. Partly, analytical tools and IoT platforms specialized for the mining industry are usually characterized by lower analytical sophistication, whereas highly advanced platforms are not typically targeted at the mining industry. The process-oriented approach is particular-

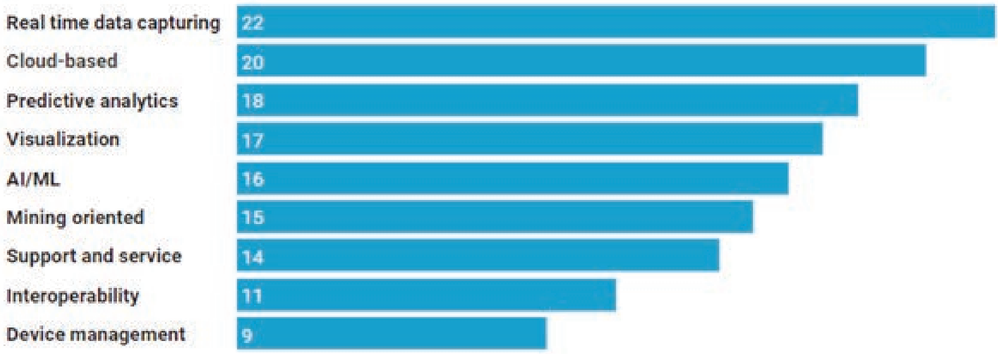

Fig. 1. The number of IoT platforms regarding to the offered functions, [Source: own elaboration]
Fig. 1. Liczba platform IoT oferujących poszczególne funkcjonalności, [Źródło: opracowanie własne]

ly important for underground mining, where the specifics and requirements are substantial.

Summary

Mining processes are complicated, unpredictable and require a special and tailored approach. The necessity of process improvement and the possibility of accurate data based prediction, require production automation and new technologies utilization. These technologies should include IoT as a comprehensive solution for overall process management.

Currently, the number of data is growing constantly, and hence the percentage of useless data increases as well. The point is to extract from produced data only valuable and important information. Due to this fact, data need to be captured, recorded and processed with the appropriate tools and algorithms to transform them into valuable knowledge. Having regard to the mentioned trends, in the article, survey of IoT platforms and analytical tools applicable in industry was drawn.

The collected information according to the IoT platforms for industry and analytical tools was analyzed in terms of selected aspects. Afterwards, a summary of the frequency of using selected functionalities and technologies was presented in the bar chart. An evaluation is based on platforms providers website and published white papers.

With technological progress, IoT platforms and solutions are gaining a very high level of sophistication. Development is visible in many fields to meet the requirements of customers. For the selected group of platforms, offered by various suppliers, from large technology companies, through open source solutions to the mining industry enterprises suppliers, the analyzed solutions offer a wide range of functionalities and services to ensure full control, support as well process optimization in the industry, productivity improvement, cost reduction and interaction with technology.

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Przegląd platform Internetu rzeczy dla przemysłu górniczego

Koncepcje Przemysłu 4.0 i Internetu rzeczy są obecnie bardzo powszechne, jako rozwiązania, które mogą zrewolucjonizować przemysł. Nieustanny postęp technologiczny zwiększa możliwości wykorzystania narzędzi i rozwiązań komputerowych do wspomagania procesów w przemyśle i optymalizacji produkcji. Zastosowanie Internetu rzeczy ma również istotne znaczenie w skomplikowanych i złożonych procesach w górnictwie, umożliwiając pozyskanie wartościowych informacji z danych. Ponadto, integracja obiektów fizycznych w przedsiębiorstwie umożliwia digitalizację procesów produkcyjnych oraz zwiększenie wydajności i bezpieczeństwa prowadzonych prac.

W artykule przedstawiono przegląd wybranych platform internetu rzeczy i narzędzi analitycznych, które mogą być wykorzystywane w przemyśle, w szczególności z uwzględnieniem branży górniczej. Zwrócono uwagę na fakt, że liczba dostawców technologii IoT i narzędzi analitycznych, oferujących usługi zaawansowanej analityki danych dla przemysłu jest znacząca i ciągle się rozwija. Celem artykułu była ocena wybranych rozwiązań IoT na podstawie następujących kryteriów: zastosowanie predykcyjnej analityki, wdrożone algorytmy sztucznej inteligencji lub uczenia maszynowego, podejście procesowe zorientowane na górnictwo, zaawansowana wizualizacja danych, interoperacyjność, przechwytywanie danych w czasie rzeczywistym, zdalne zarządzanie urządzeniami oraz technologia oparta na chmurze. Przegląd został przygotowany, aby zestawić wiedzę na temat dostawców rozwiązań IoT działających na rynku, a także wskazać funkcjonalności wyróżniające poszczególne rozwiązania.

Słowa kluczowe: przemysłowy Internet rzeczy, platformy analityczne, górnictwo, analiza danych