IoT in MINING: A Review

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Abstract: The Internet of Things is the next big and potential technology which is revolutionising the industrial world. This paper highlights the role of IoT for optimisation of production, profit and safety in the mining industries. The internet of things (IoT) will readily provide big data exploration for the mining fields. These results will boost proficiency; provide solutions to several issues (health, production, assets) and services by connecting the tangible objects to trade data with the producers and other machines using electronics and software systems. The main aim of the present review paper is to investigate the current scenario of mining industry primarily through IoT.

Keywords: IoT, mining, automation, safety.

I. INTRODUCTION

The current updates in fields of science, technology and trade are of dynamic and promising features. The new updates are well beyond the domain of the customary techniques. The technology of IoT will begin a paradigm shift in the units of communication, industry, medicine, data trade & analysis and result in a smarter world.

In the Internet of Things (IoT) paradigm, many of the objects around us will be on the internet in one form or another. The IoT is at the heart of this transformation. It connects people, machines, items, and services to streamline the flow of information, enable real-time decisions, and open new opportunities in every sphere of life [1].

The internet of things (hereafter referred as IoT) was first documented by British visionary Kevin Ashton in 1999. This term pronounced a system where the Internet connects to the actuality via a global network of data sensors. The term today has several visions based on its user and use.

In more standard lyrics:
A dynamic global network arrangement with self-organizing capabilities based on standard and interoperable communication protocols where physical and virtual “Things” have identities, physical attributes and virtual personalities and use intelligent surfaces, and are effortlessly integrated into the internet network.

Fig 1: Applications of IoT [2]

On a restricted note, the IoT is about linking objects to the internet. The following image describes the various applications of IoT. There is a growing interest in using IoT technologies in various real world industries. The IoT used in industries is called Industrial Internet of Things (IIoT). IIoT is the use of IoT technologies in manufacturing. With increased connectivity and more collected data, mine operators are quickly turning to what other industries have been using for years. The Internet of Things (IoT) supports tremendous change for the mining and metals industry segments [1].

Mining is a physical activity which deals with the extraction of metal and mineral ores which forms the
mineralized package of economic interest to the miner [3]. The IoT is opening opportunities for mining and metals companies to pursue visibility, safety and efficiency. Apart from field work, mining involves data collection, analysis and computation for improving work efficiency, profit, optimize production process and strengthen the management. IoT includes machine learning and big data technology harnessing the sensor data, machine-to-machine communication and automation technologies that have existed in industrial world. IIoT refers to those smart machines which are better than humans in consistently capturing and communicating data with accuracy. IIoT holds great potential for quality control, sustainable and green practices, supply chain traceability and overall supply chain proficiency.

In mining industry, various companies like Rio Tinto, GE, and BHP etc. employ the technology by using driverless trucks in the mining process. These companies are also experimenting with independent drilling system that can function without human interference in the coming years the savvy users in the mining industry are making best use of the technology.

The core advantages that miners have recognised are[4]:

1. IoT provides advancement in automation techniques by developing a virtual network of devices used in an operation such that they can work simultaneously. This brings in more data and less guesswork.
2. IoT has made mining a safer workplace by eliminating the risk of collapse of unstable shafts or injuries resulting from the operation of mining trucks by providing real-time data which predicts where issues might occur.
3. IIoT in mining has made it easier to detect wear on key pieces of equipment and projecting when repair or maintenance needs to take place.
4. IoT excludes guesswork out of developing and maintaining the mine site allowing more products to be extracted and processed in a shorter frame of time.
5. IoT in mining leads to lower expenditure of energy to develop and maintain a site and make it easier to cover all the costs and generate a significant net profit.
6. IoT leads to large physical environments, changing market and environmental conditions, and the massive size and amount of equipment.

International Telecommunications Union of UN first published its report on IoT in 2005 and advocated that it was a new dimension in the world of information and communication technologies (ICTs). The first European conference took place in between 2006 and 2008 and finally IoT was „ born”.[5] Ground-breaking developments were made in this field and for manufacturers, an increasing number of products are made with unique identification technologies, such as barcodes, RFID tags, intelligent sensors on personal electronic
devices, and home appliances. These identification technologies make products be monitored and tracked in their life cycles. It could increase the effectiveness of traditional industries by introducing new data exchange and processing techniques.

In 2011, Jian et al showed that the use of IoT in coal mines met the monitoring and tracking health diagnosis of mining equipment and materials production, transportation, storage, use, maintenance and other links. The coal mine safety in production, disaster early warning, emergency rescue were realized. Mine comprehensive automation level was raised, and coal mine safety production was improved.[6] Dhengong in his paper divided the elements of the mine into "man, machine, rings, tubes," and devised the system through the mine property so that they become a unified whole, to achieve the interaction between things communication, in order to achieve intelligent mine identification, location, tracking, monitoring and management.[7]. Zhao and Dong explained the practical significance of IoT in mines. They explained that IoT provided reliable equipment monitoring functions to make all equipments concentrated in a controllable network and analyze and compare the data information effectively to have a good failure prediction. [8]. The paper by Sun et al(2011) pointed out that the combination with the information perception, information transmission, intelligent processing, modern control technology and modern mining technology could be applied to establish the mine internet of things coordinative network system of the mine safety production with the dynamic perceptions of the mine disaster status, the equipment health status and the personnel safety environment in order to have the coordinative management and control of the personnel, machinery, equipment and infrastructures within the production network under the complicated environment and to effectively solve the problems of the mine safety mining and the major disaster prevention. Meanwhile based on the safety information identification processing, on time transmission of sensor network in the limited heterogeneous space.[9].

In 2011-12, Wang, Zhou and Zhao used the IOT technology to research and implement a coal mine real-time location system. The system overcame defects of old location system based on RFID. On one hand it could realize coal mine staff attendance and on the other hand it realized real-time location in coal mine. The results showed that system was low cost, stable, economic and reliable. The location accuracy was within 3meters. It provided basis for not only preventing and reducing rate of coal mine accidents, but also improving efficiency of emergency rescue and emergency evacuation.[10].

Yanjun et al in 2012 worked on design of monitoring system in coal mine based on IoT and put forth the use of IoT technology for an anti-interference, sensitive and efficient mine. The complex geological conditions could be monitored by combining IoT with down whole equipment and suitable decisions for working could be made with the use of smart machines which will add to safety of working in a mine[11].

In 2013, Vermesan and Friess demonstrated the use of IoT in industries for M2M Applications, Indoor Air Quality, Temperature Monitoring, Indoor Location and Vehicle Auto-diagnosis, and also mentioned that this convergence of microelectronics and micromechanical parts within a sensing device, the ubiquity of communications, the rise of micro-robotics, the customization made possible by software will significantly change the world of manufacturing. [12] In 2014, Wu He et al stated that Internet of Things (IoT) had provided a promising opportunity to build powerful industrial systems and applications by leveraging the growing ubiquity of radio-frequency identification (RFID), and wireless, mobile, and sensor devices[13].

Fluid Intel released a paper in 2014 on key technologies for the mining industry explaining that embedding sensors and actuators in machines and bringing them into the connected world was spreading rapidly. Software named AdaptFMS was made that could exploit this sort of technology. Remote tank sensors, for instance, calculated fuel tank levels and that data was pushed live to the software thereby allowing clients to monitor their fuel supplies in real-time via the web-based system. Using this technology, fuel consumption...
could be monitored from anywhere at any time[14]. Boulter and Hall (2014) noted that automation technologies like IoT were being implemented into the mining industry to improve production efficiency, reduce maintenance costs and improve reliability [15].

Mine production is along with water, fire, gas and coal dust, roof and other complex natural disasters and with the characteristics of poor, dangerous working conditions. Internet of Things (IOT) as an emerging technology provides a new technique for safety and security to underground production. According to the needs of mine safety production, key technologies of Internet of Things are introduced. That the technologies are RFID technology used to label things, sensor technology used to perceive things, intelligent technology used to think about things, and intrinsic safety technology. Mine IOT key technologies and the research content are analyzed in-depth which have provided a direction for the research and application of mine IOT[16]. Rubo LAN (2014) proposed that in internet of things each terminal equipment had the ability to perceive the whole through the information sharing , thus making it a more reasonable control decision and proper scientific management could be implemented. The mining thing connection system could be established using modern internet of things which helps each equipment terminal to obtain the information to make calculation and ensure a corresponding rational decision. The information was accurate and greatly improved the working at the management level[17].

In 2015, Sun Jiping proposed the characteristics of coal mine internet of things as follows :electric explosion protection ,large wireless transmission attenuation ,no GPS signal in underground mine ,low wireless transmission power, strong anti-interference and anti-fault capability ,suitable for using tree-structure ,long transmission distance ,repeater is inappropriate to be used ,small bulk of equipment, powerful adaptive capacity of network voltage fluctuation ,be good at protection performance, etc. key issues put forward were that need to be handled in coal mine internet of things : the standards of information coding, transmission, processing,etc; secondly, the mine-used safety admittance products in whole control process . thirdly, whole process manage and safe explosive control in production, transportation ,storage, draw and return ,usage ,etc ;fourthly, management and control of main equipments in whole course ,production, transportation ,storage ,application and maintenance are included ;fifthly ,staff precise location ,automatic identification and training ,supervision ;sixthly, coal gas examiner ,safe inspector ,fitter, blasting technician ,winch man, shearer driver ,water pump operator and their operation devices ,man-environment lock control ;seventhly, ground remote control of unmanned working face ;eighthly ,management and control of coal at production, transportation, sales ,usage ;ninthly, management of emergency rescue equipment, ambulance corps ,etc; tenthly,coal geological exploration ,design ,coal mine construction ,safety production ,management and administration.[18]

Feng et al in 2015-2016 conducted a survey which mentioned the future development in IoT include network scalability, a continuously produced data stream, and methods for handling heterogeneous data for use in industries[19].The recent developments in IoT for mining (2016) will help in predicting downtime, improve efficiency, revolutionize safety, catalyse decision making, automated mines which help in creating real-time multi-dimensional models and used to optimize the mine”s layout,operation,vehicle paths and so forth , coordinating all the moving pieces for the most efficient operation.[20].

III. WORK DESCRIPTION

Present manufacturing Ethernet and the technologies based on sensors, actuators for Internet of Things, wireless broadband, optical fiber transmission are being built to reduce hidden dangers of mines and accelerate the process of informatisation of mining projects. In the upcoming sections, the system construction and features of a coal mine based on IoT is analysed to understand the use of IoT in mining industries. The
major functions of the platform of coal mine automation technology based on IoT are demonstrated [21].

Why IoT?
The technology of Internet of Things is being widely used in the mining industry because it overcomes the shortcomings of the traditional monitoring and controlling system of mines. The shortcomings are: poor real-time performance, compatibility, low rate, small coverage and lack of flexibility. The IoT approach provides a network of new sensor, wireless sensor and RFID technology for safety production of modern mines. The IoT builds an overlay network where the exchange of information takes place without interference. The system built using IoT has the features of automation, self feedback and intelligent control.

To explain the use of IoT in mining industry, an example of coal mine is used.

System Construction and Features of a Coal Mine Based on Internet of Things: Coal mine automation helps in establishing an inclusive way for the customers with numerous functions like monitoring, equipment control and system detection. IoT in mining has various characteristics making it a perfect approach for development in industry. It constructs monitoring platform, implementation of effective way of working. Overall, providing a unified network monitoring system.

The characteristics includes high speed, storage, sharing and provides a real time production information of enterprises making it comfortable for the manager to make decisions accordingly. High speed ensures rapidity, stability and reliability of the processing of the production data. It also helps in realization of sharing of the resources. The storage of the data is done using optical fibre ring making it accessible for inspection and analysis. The other major characteristics are stability and safety which ensures smoothness of the data. For safety purpose antivirus and firewall-end hardware are used and to ensure stability automation adapts the structure of browser and client site.

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<th>Layers</th>
<th>Description</th>
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<tr>
<td>Sensing layer</td>
<td>This layer is integrated with existing hardware (RFID, sensors, actuators, etc.) to sense/control the physical world and acquire data</td>
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<tr>
<td>Networking layer</td>
<td>This layer provides basic networking support and data transfer over wireless or wired network</td>
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<tr>
<td>Service layer</td>
<td>This layer creates and manages services. It provides services to satisfy user needs</td>
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<tr>
<td>Interface layer</td>
<td>This layer provides interaction methods to users and other applications</td>
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Method of implementing IoT in coal mine:

There are various methods of implementing the platform for IoT in mines. One way is the use of access modes. There are three access modes:

- Open Platform Communications Server: This is a software program that converts the hardware communication protocol into the OPC protocol. The OPC client uses the OPC server to get data from or send commands to the hardware. The OPC helps with on-site process control by exchanging real-time data.
- Database access mode: various databases including the configuration software of IoT, ground control and manual control systems have connection interfaces which make exchange of information above the ground and underground easy.
Ethernet access model: Mines mainly use RS485, 422 and CAN highways whose data procuring capability is low and strength is less. An Ethernet model can cover all these shortcomings by transferring the real-time data into a compatible industrial Ethernet protocol and then this data is processed by acquisition server for big data analysis and safer working of mine.

Major Functions of the Platform of Coal Mine Automation Technology Based On IoT:
The automation of the coal mine includes three dimensional processing techniques, network techniques and information processing technique which helps of which management of information, digital monitoring of the underground fields and process automation. This information can be managed simultaneously.

Table 2: Major functions of mine automation using IoT [4]

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<td>1.</td>
<td>SAFE PRODUCTION</td>
<td>Sensors based on iot are used to collect data about physical conditions like temperature, humidity, etc on the working surface. This data is exchanged with the host computer in the form of reports, curves and three effect graphs.</td>
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<td>LINKAGE CONTROL REAL TIME</td>
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<td>MONITORING:</td>
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<td>2.</td>
<td>TRACKING OF PERSONNEL</td>
<td>Using iot for tracking there is a clear control of staff attendance, working situation of staff, avoiding sudden loss of relevant information</td>
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<td>3.</td>
<td>EARLY MINING DISASTER WARNING OF</td>
<td>Technical personnel continuously analyze all kinds of mining activities according to the data; investigate potential threats and timely send out warning signals.</td>
</tr>
<tr>
<td>4.</td>
<td>IMPLEMENTATION EMERGENCY RESCUE AND DISASTER RELIEF OF</td>
<td>Due to continuous monitoring and use of historical data emergency plans can be easily developed and in</td>
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This paper reviews the current technological advancement of IoT in mining industry using IoT from industry’s perspective. Change is constant and technology is the growing engine of change. With the marriage of smart devices, advanced connectivity and management platforms to the collaboration, IoT and M2M communication is already gaining traction in many areas of mining. IoT is one of the latest technological ventures of this generation. It helps in ensuring safe and proper working conditions and also helps in the growth of economy of a country. Mining is a primary contributor to the economy which is entirely field-based and requires heavy data transmission. So a technological approach to improve the efficiency of the industry is suitable. It provides a safe workplace with advancement in automation techniques eliminating the guesswork. IoT is considered as a global network infrastructure devices that rely on sensors, communication, networking and information processing technologies providing benefits like high productivity, safety, asset management, connected logistics, real-time alerts etc. Along with the above mentioned upcoming, the discussed technology has some shortcomings like loss of privacy and security, compatibility, complexity, lesser employment of menial staff and creates excessive dependency. Appropriate solutions for these shortcomings have to be devised to make IoT more reliable.

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