SUSTAINABLE MINING AND GEOINFORMATION

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Week – 02

Lecture 10: Internet of Things (IoT)

Thank you. Welcome. Having introduced to the cloud computation in the last class, the ninth lecture, let us now move forward in terms of understanding and knowing IoT. I am sure many of you must have heard this term, Internet of Things. This is an advanced concept where we are connected to a lot of information coming from different data sources using it mostly in terms of real-time analysis and the beautiful part of this is that we are connected through the data sources from different sources.

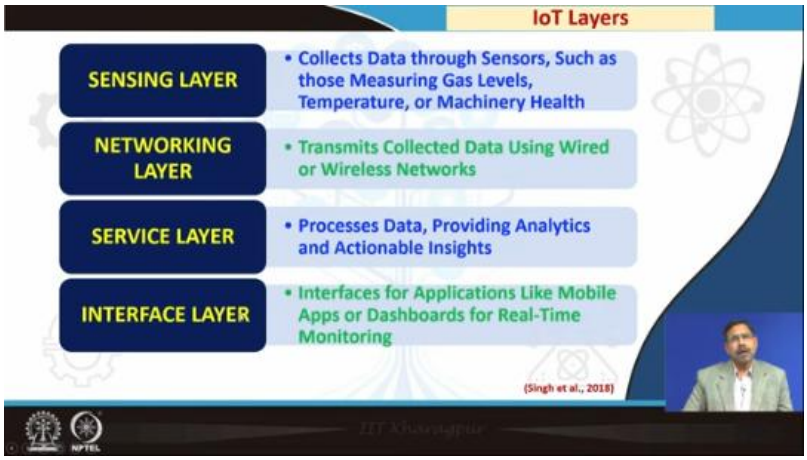
So, let us see the different concepts what are covered or we are going to cover in this particular discussion on IoT Internet of Things. We will be introduced to IoT in mining particularly the sensor networks and the real-time data collections. The integration of IoT with GIS for monitoring mining operations for example equipment performance environmental data friends we all have already discussed about gis the geographic information system where we discuss that this is a system where both the spatial and the non-special or the attribute data are integrated or combined and that's how we come out with new data in the new analytics and new data sets Right.

So we can integrate the IoT with GIS. So for monitoring different mining operations. And also we'll also talk about two studies in terms of case studies that are useful or that are used for smart mining operations using IoT for predictive maintenance and safety monitoring. Friends, many of the mining or the advanced mines, that means the group of mining management who are using advanced technology, one of them is use of IoT, Internet of Things technology. so let us understand what iot is iot is a network of interconnected devices equipped with sensors so you have a connection which is which is interconnected with the sensors the sensor network installed at different places it could be cameras it could be thermal sensor it could be rainbow sensor or what not you are coming or in terms of your measurement

It also is connected to softwares. It also has a network connectivity that has the capability to collect or generate the data, share the data and analyze the data on real-time basis. So if we have information coming in terms of real time basis from different sources, from different sensors, that means we are having lot of data and on real time basis we are able to analyze and take a decision about that. Take a precautionary measure on the basis of that. So that is how the IoT is the latest concept which connects the equipments in terms of sensors with software and in terms of collecting, sharing and analyzing the real-time data.

In mining, the IoT technology enhances the operational efficiency, safety and thereby helps in efficient environment management. Look at the figure of the depiction here. You have the satellites which are taking the measurements, the observation from over the Earth's surface. So, the data is transmitted from this means the satellite images, remotely sensed images are transmitted to the cloud. And you also have the mobile network, the data is transmitted from there.

You are also having sensors that are doing forest monitoring, the infrastructure safety monitoring, the security and surveillance monitoring, the infrastructure monitoring. So, these could be the applications also based on the different sets of data that can be linked and connected. Precisely IoT means or what IoT capability is, it is a network of interconnected devices equipped with sensors, it is interconnected devices equipped with sensors, softwares and having the capability to analyze the data on real time basis. Now let us have a look at the different IoT layers. The different IoT layers could be sensing layer, networking layer, service layer and interface layer.



So these four have been mentioned by Singh et al. in their publication in the year 2018. The sensing layer collects data through sensors. Such as those measuring gas levels, temperature, or machinery health. So if we have different sensors, you can have a sensor that measures the gas level. You can have another sensor that measures the temperature.

You can have another sensor that measures machinery health. So, the sensing layer, as far as the similar kind of term, is also used in GIS. So, GIS layers are sensing layers. So, you have different sensors, and the information comes from different sensors for different parameters, forming a layer that can be put under the framework of the sensing layer. Now let us look at the networking layer.

The networking layer transmits the data collected using either wired or wireless networks. So, whatever the networking means, the networking layer transmits the data collected from different sources to different network destinations. The third one is the service layer. As the term implies, the word 'service' means it processes the data, thereby providing analytics and actionable insights. So once the service processes the data, it will be analyzed.

By the service layer and based on the analysis, it can also give some suggestions which have actionable insights. Now, the fourth one is the interface layer. As the term suggests, the interfaces are for applications like mobile apps and dashboards for real-time monitoring. So, we have these four layers, each having slightly distinct functions. Now, let us discuss the sensors.

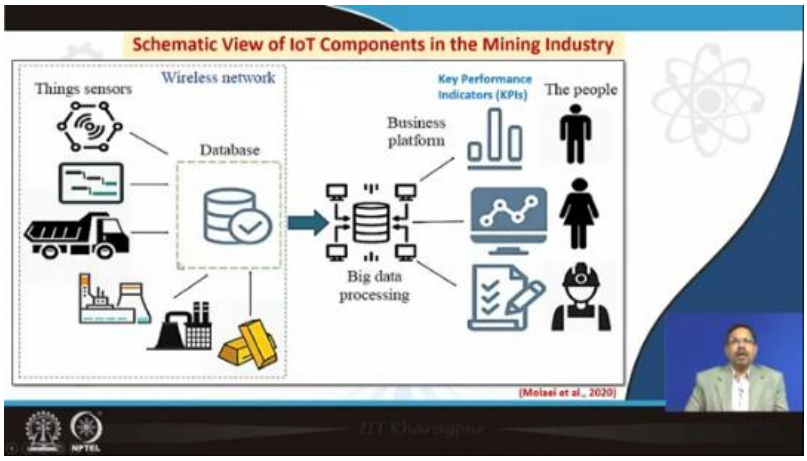
The sensors can detect temperature, pressure, gas levels, vibration, equipment status, and other parameters that are useful or emerging in the mining industry sector. And the phones, which have—what you say—which are mounted with the location, you connect, you switch on your GNSS. So, the geophones can be used for blast monitoring, the piezometers for water pressure, gas detectors for toxic gases, and temperature and vibration sensors. If we have installed these kinds of sensors at different places and are monitoring them in real-time, now look at how important and beneficial it is to collect real-time data, analyze it, and provide actionable advice if needed. The data collection platform. The data from sensors are transmitted to a central database where real-time analytics occur, allowing mining operations to track key performance indicators, abbreviated as KPIs.

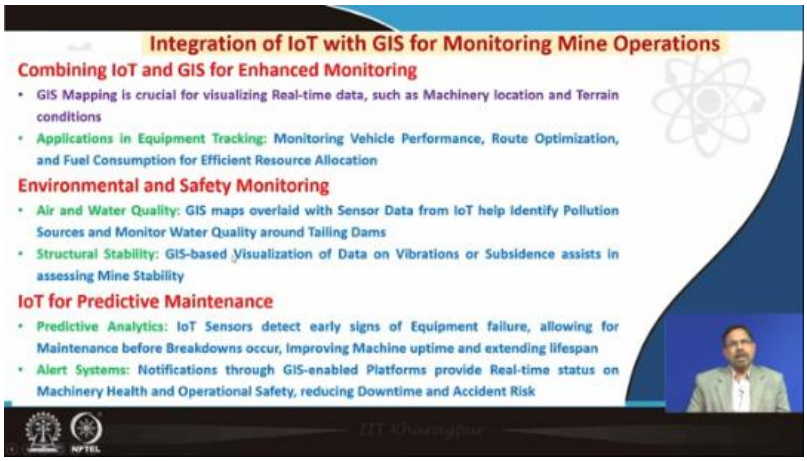
So, once the data from different sensors are transmitted to the central database where real-time analysis can be processed, it helps managers and mining operations track KPIs (key performance indicators) and take necessary actions in case of disturbances or irregularities. So, this is the potential as far as the data collection platform is concerned. Now, let us move to real-time data collection. In terms of real-time data collection, the two key points are data transfer and storage. It helps in real-time monitoring.

So real-time monitoring uses cloud platforms to aggregate the data, enabling responsive actions like adjusting ventilation in underground mining or moving machinery from one place to another based on temperature variations and similar factors. And safety and

efficiency. The Internet of Things allows for quick responses to hazardous conditions by tracking environmental metrics like air quality and structural integrity. So this is the power of IoT. Once we have the sensor devices installed in different places and they are capable of sensing various variables, they provide real-time data. We collect this data, analyze it, and then generate information to come up with actionable suggestions or advice.

Now, let's look at the schematic view of Internet of Things components in the mining industry. So the view on the left-hand side shows things like sensors and awareness networks coming from different sources—mining sensors, devices mounted on trucks or mobile devices—and the data is stored in a database on a server. Once it is stored, we enter the data processing domain, which involves big data processing. Based on this processing, we can generate various types of information that could be useful for analyzing KPIs (key performance indicators), involving people at different stages. This includes analyzing the data, generating insights, installing the sensors, and finally coming up with actionable suggestions. Let us have a look at the integration of IoT (Internet of Things) with GIS for monitoring mining operations.





Friends, in terms of combining IoT and GIS for enhanced monitoring, we have already discussed GIS mapping. GIS mapping is crucial for visualizing real-time data such as machine locations and terrain conditions. Once you have a map with geocoordinates, you know where everything is located. And once you know the locations, you can represent them on a map. Then you can gather measurements through sensor devices that are attached to or integrated with this GIS platform.

Then applications in equipment tracking, monitoring vehicle performance—you know which vehicle is where, in which direction it is moving—are monitored. Monitoring what the performance is, what its performance level is, and within the mining areas, you can also determine route optimization: the shortest route or the route which is suitable in a given situation. So you can have optimization of the routes. Fuel consumption for efficient resource allocation. So if you have this, then we can also plan things like fuel consumption to improve vehicle performance or resource allocation.

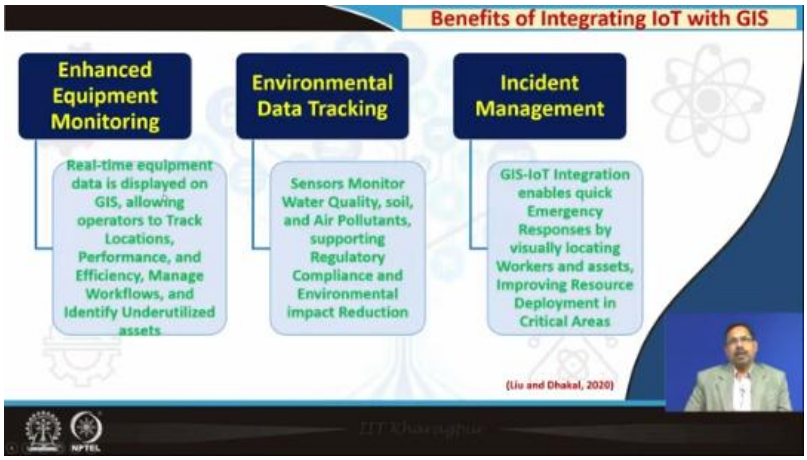
And the second component in terms of integration could be environmental and safety monitoring. Let us discuss water and air quality. Once the GIS maps are there, if they are overlaid with the sensor data from IoT, it helps in identifying different sources of pollution. It can help in monitoring the water quality around tailing dams or in various other activities in a mining environment. So the basic input is if you have the map on a GIS platform, which can be overlaid with the sensor data from IoT, it helps in channeling various other applications, including environmental and safety monitoring.

Now, let us have a look at the next one: structural stability. The GIS-based visualization of the data on vibrations or subsidence assists in assessing mining stability. For example, if it is attached to the GIS database, then anytime you see there is some subsidence or submergence or whatever it is, it can be useful in terms of mine stability analysis using the integration of IoT with GIS. So IoT is useful for predictive maintenance.

Predictive analysis IoT sensors detect early signs of early signal of equipment failure because you have the sensors you can sense that how the equipment is performing which is located remotely on ground. Thereby, it allows for maintenance before any breakdown or disaster occurs. So, that is how the machine efficiency is improved uptime or extended, the lifespan is also extended. So, it helps in doing predictive analysis and thereby taking care of the machine and their machine performance and their health. And coming to alert systems, we can also have notifications through GIS enabled platform that can provide a

real-time status on machine health, operational safety and thereby reducing the downtime and accidental risk related things.

So if we have some kind of signal, some kind of notification based on this kind of analysis, we can take early action preventive measures. That's how we can also minimize the risk from different accidents. Let us talk about the benefits of integrating IoT with GIS. We have put it under three headings.



One is enhancement equipment monitoring. Second is environmental data tracking. Third is incident management. As far as the enhanced equipment monitoring is concerned, real-time equipment data is displayed on GIS, allowing operators to track locations, performance and efficiency, management workflow and identify underutilized assets. As an example, in a mining area, if we have already the map which is displayed on a GIS platform, then we track the real-time observation, the real-time changes from various sensors and we track the changes or the measurements which is coming for different variables.

And that helps us in terms of performance management, increasing efficiency, and managing workflow. The second one is environmental data tracking. If the sensor network is there, it monitors various data in terms of water quality, soil, and air pollutants. Thereby, it supports regulatory compliance and environmental impact reduction. What do we mean by regulatory compliance?

We know that we have to maintain the water quality level up to this. So, we have different parameters as far as water quality, soil quality, air quality, or air pollutants are concerned. So, if we know this in real time, we can take measures and also comply with the rules—

the legal regulations prescribed for the mining industry. So, that is how we comply in terms of environmental prescriptions. The third one is incident management.

GIS and IoT (Internet of Things) integration enables quick emergency response. Once you have a database that is mostly static or already existing, and on top of that, you are loading real-time data through IoT integration. So, it will enhance capability in terms of quick response, such as emergency response, by visualizing or visually locating workers and assets, thereby improving resource deployment in critical areas. So, suppose we receive a sensor-based signal indicating that some subsidence is happening somewhere. So, we can immediately alert our workers and remove the assets that are on the spot.

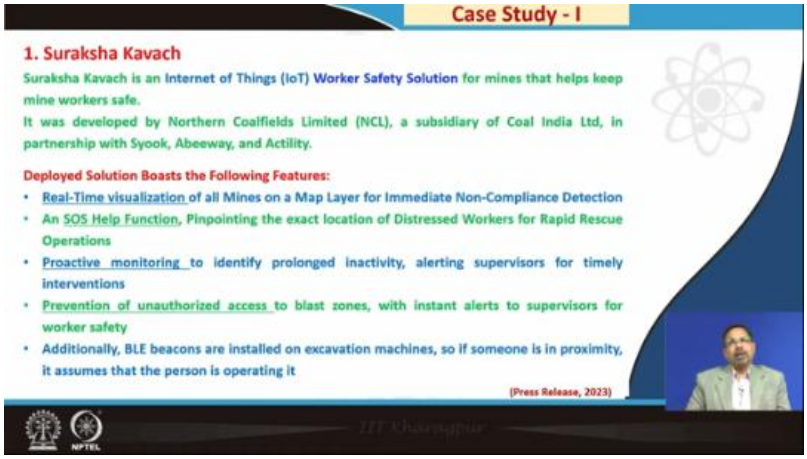
So, that means we can improve resource management and resource deployment in critical areas. Now, coming to smart mining operations. So, if we can manage mining operations this way using the integration of GIS and IoT, that means we are doing smart management and smart operation of the mining environment. So, this helps in terms of predictive management, maintenance, and safety monitoring. Predictable mining operations, tailing dam monitoring, and a pre-alarm system.

So, this is a monitoring and alarm system, TDMPAS. This system monitors pressure, water level, rainfall, and deformation. Embedded GPS identifies the exact location of dam deficiencies to prevent failures. So, Sun et al. came out with this study in 2012. They proposed a predictive mining operation system with tailing dam monitoring and a pre-alarm system.

The second one is a surveillance system in underground mining, Molaei et al. in 2020. They came out with an RFID-based safety and traceability platform that is useful for environmental monitoring using IoT nanotechnology detectors. Look at the term

nanotechnology, which can detect—it's the sensor capability in terms of using advanced technology, that's nanotechnology. So, it depends on the user: what kind of detectors you are using, what kind of sensors you are using, what is their efficiency, and what is their sensitivity. So, these all give you very sensitive information, very precise information for real-time monitoring or real-time surveillance. Then, coming to mining safety enhancements, another system called SAGES, Self-Advancing Goaf Edge Support System, which is also an IoT-based roof support model used by Singh et al.

in 2018, has been developed by them. which has the potential to improve safety in underground coal mines particularly during the deep layering operations. So, friends the this is what falls under the smart mining using IOT. So, you can do the predictive analysis you can do also surveillance improve efficiency improvement you can also enhance the safety protocols of the safety measures in mining sector. Now let us take one or two case studies.



One important one we have chosen is Suraksha Kavach. So as we know these are a kind of Sanskrit word Suraksha protection Kavach means a kind of guarantee. It gives us a guarantee as far as protection or as far as our safety is concerned. So, Suraksha Kavaj is an IoT, Internet of Things, has the potential to, is used for worker or gives us the worker safety solution for mining sector or in mining sector. In a sense, it helps to keep the mining worker safe.

Look, we have in past have come out with a lot of mining related disasters and casualties and so that is why the Suraksha coverage has come into play in using IoT, particularly for the protection of our workers, for the safety of our workers. It was developed by Northern Coal Fields Limited, NCL, which is a subsidiary body of Coal India Limited in partnership with few other groups like Syook, Abeeway and Actility. So, it is deployed solution, it

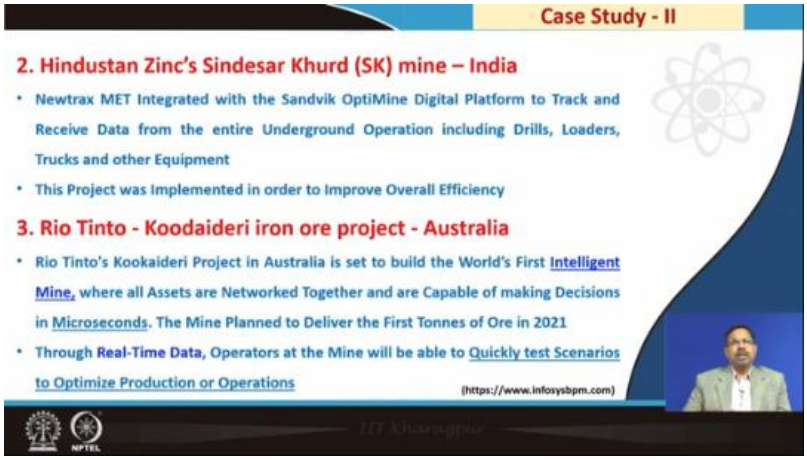
gives deployed solutions both the following features. Now, these are the solutions, these are the things which has been deployed in this Surakshakavaj. One is the solution it offers is real-time visualization of all mines on a map layer for immediate non-compliance detection.

So it is very very important the moment we have a real time visualization of the minds and on a map layer in form of a visualization in form of a map so we can see that where something has gone without any or something has not been complied. So immediately we can see that this is a non-compliance has been detected here and we take the action. So, this helps in improving the safety or particularly the workers safety and also including the safety of the machineries. And SOS help function. So, SOS we use for if it is required.

So, an SOS help function pinpoint the exact location of distressed worker for rapid rescue operation. many of the time it may be it is needed or it could be needed that our workers are working in a very very risky environment so once this SOS function is developed it helps by pinpointing the exact location of the workers we will not say the distress worker the workers which who need some kind of help in terms of some indifferent situation, in terms of some disaster related situation, some distress related situation. And in this way, this helps in proactive monitoring to identify inactivity, thereby allotting the supervisors or the other managers for timely interventions. And it also helps in prevention of authorized access to blast zones.

So it helps unauthorized access to blast zones with instant alerts to supervisors for worker safety. In case of some eventuality, this IoT-based package, Suraksha Cupboards, helps in preventing unauthorized access to the blast zones. Additionally, these BLE beacons are installed on exclamation machines. So, if someone is in proximity, it assumes that the person is operating it. So, this Suraksha Kavach, it is an IoT-based machine.

solution developed or aimed at the safety of the worker working in the high risk mining areas so that the casualty or any loss of life can be minimized to nearly zero. Next is the Hindustan Zinc's Sindesar Court Mine located in India. The new trucks MET integrated with Sandvik OptiMine digital platforms to track and receive data from entire underground operations including drilling, loaders, trucks and equipment. So this particular IoT based system helps in giving the or helps in tracking and receiving the data that is coming from the entire underground operation including drilling, loader, stocks and other equipment. So once you have the real time data that means we are comfortable in terms of monitoring and taking any kind of measures if it is required in terms of any eventualities.



This project, the new tracks MET, it helps in terms of improving the overall accuracy. Now let us take another example from Rio Tinto iron ore project, Kookaideri, located in Australia. The Rio Tinto Kookaideri project in Australia is set to build the world's first intelligent mine. So this is regarded as the world's first intelligent mine where all assets are networked together and are capable of making decisions in different ways. So, it is one of the very, very efficient and intelligent mine that way as far as the first one is concerned.

So, first one in the world. The mine planned to deliver the first tons of ore in 2021. Through real-time data tracking, operators at mine will be able to quickly test scenarios to optimize productions and operations. So the time efficiency is up in microseconds. So that is the case study number 2.

So, friends, we have used these six references for the discussion on IoT, Internet of Things technology in the mining sector. So, Internet of Things in mining is a transformative technology. The term 'advanced and transformative technology' is used because it improves security, ensures safety, enhances operational efficiency, and effectively monitors the mining environment. The IoT, Internet of Things, enables real-time data collection for predictive maintenance, reduces equipment downtime, and ensures proactive safety responses. So, the challenges in terms of IoT include connectivity and data management.

Sometimes, when we conduct underground sensing, connectivity could be an issue. Additionally, sensor-based data collection from harsh environments may face connectivity problems, and data management can also present challenges. So, in short, the Internet of Things advancements support more automation and improve efficient mining practices. That's how it contributes to sustainable mining operations. Thank you very much.