SWAYAM NPTEL COURSE ON

MINE AUTOMATION AND DATA ANALYTICS

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Module 04

Virtual boundaries and camera systems

Lecture 10 A

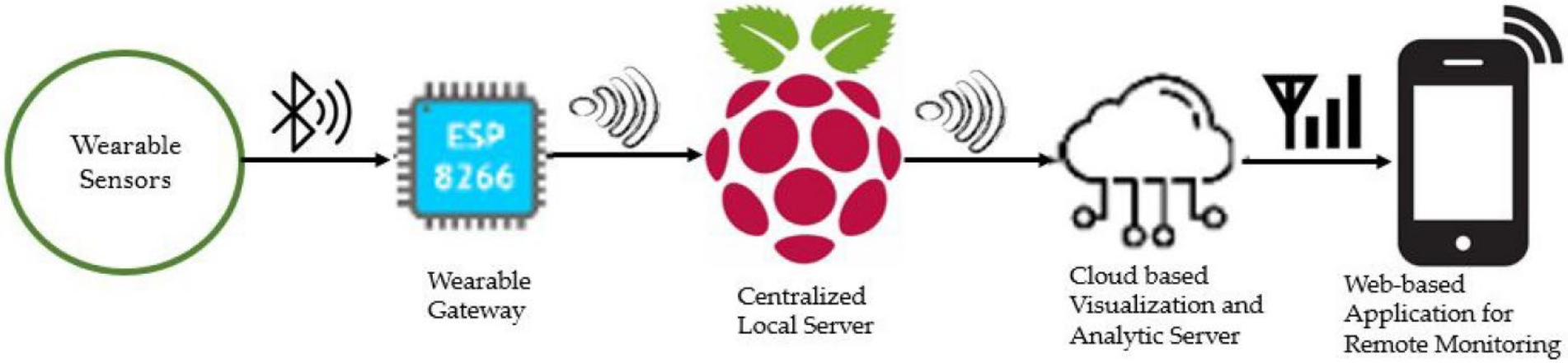
Introduction to Geo-fencing

CONCEPTS COVERED

- Introduction to geofencing
- Geofencing Implementation
- Geofencing Algorithms
- Geofencing keeps miners safe
- Track miners
- Geofencing Application
- Geofencing application use in the mining industry
- Key features of geofencing in mining industry

Introduction to geofencing

Geofencing is a location-based service that enables to detect and monitor when a mobile IoT/M2M device enters, leaves, crosses, or bypasses a precise geographical area delimited by a virtual perimeter, called geofence providing alerts or notifications, usually referred to as geo-notifications.



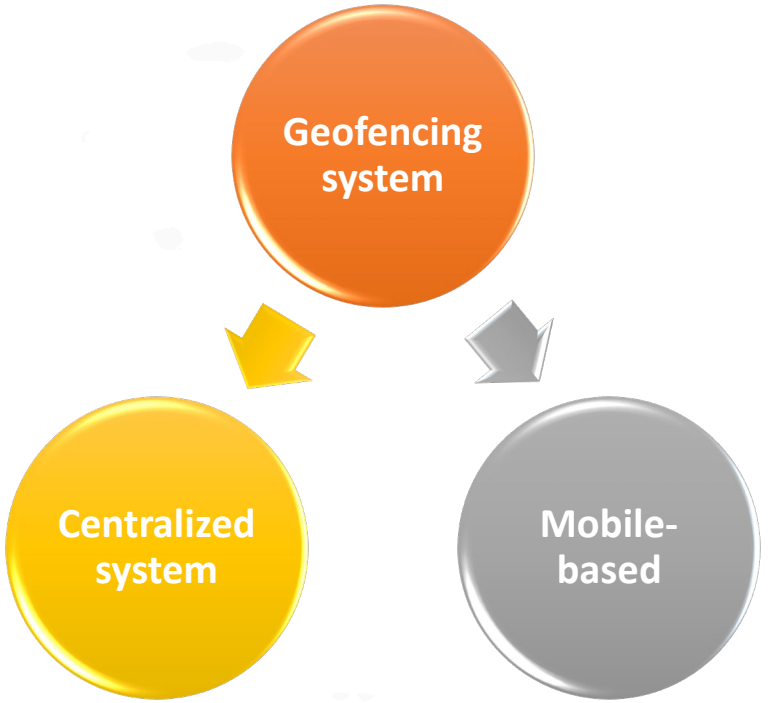
IoT-based framework for Geo-fencing and remote monitoring.

Introduction to geofencing

- A geofence can be dynamically generated, like a circular area surrounding the current position of a mobile device, or can be made of a predefined set of boundaries, which may be arbitrarily drawn by the user or specific for a place or a building.
- Geofencing services can be classified, depending on the geographical references used to check the device's position, in static checks the geographical position of a mobile device with respect to a fixed area, and dynamic operates according to the position of a mobile device with respect to a changing area and peer-to-peer that uses the geographical position of a mobile device with respect to other mobile devices.

Geofencing Implementation

- One of the most important component in a geofencing system is the Location Monitoring Unit (LMU), which is the component inside the geofencing system infrastructure which is responsible for location processing of the positions of a mobile device and for keeping the geofence scenarios.



Geofencing Implementation

Mobile-based geofencing system

How it works: The device uses satellite-GPS technology to find its position and checks it against a set of geofences right on the device.

Key Feature: This approach is like having a smart device that does most of the work itself.

Consideration: It's good for ensuring trustworthy node positions but can use a lot of battery due to the device doing the geospatial processing.

Geofencing Implementation

Centralized geofencing system

How it works: The mobile device is tracked by the network infrastructure, and the position matching with geofences is done by servers in the geofencing system.

Key Feature: The heavy lifting is done by centralized servers, making it potentially more efficient for the mobile device.

Consideration: This could be a good choice when you want to minimize the impact on the mobile device's battery.

A geofencing can be characterized according to the following features.

- ✓ **Location accuracy**: geofencing accuracy is strictly related to the accuracy of the geographical position provided by the service used to track the location of the mobile device, either satellite/GPS or GSM-based.

- ✓ **Tracking Rate**: expresses the frequency by which the device provides a location update to the server of the proactive LBS.

✓ **Device Speed**: the speed of a device determines the period within which the device must provide a location update to be evaluated against eligible events.

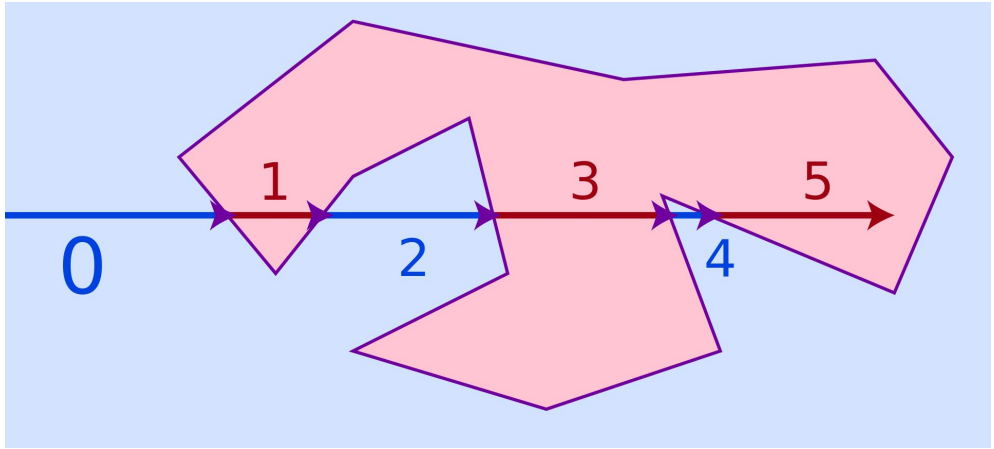
✓ **Device Route**: the path a device takes across a geofenced area, affecting the period within which location update must occur.

✓ **Geo-notification delivery**: geo-notifications can be delivered to the user only once or every time the mobile device successfully enters, leaves, crosses or bypasses a geofenced area.

Geofencing Algorithms

The "point-in-polygon test" is a geometric algorithm used to determine whether a given point lies inside or outside a polygon. This test is commonly employed in various applications, including geofencing algorithms and geographic information systems (GIS). The fundamental idea is to check whether a specific point's coordinates fall within the boundaries of a polygon.

The number of intersections for a ray passing from the exterior of the polygon to any point: If odd, it shows that the point lies inside the polygon; if even, the point lies outside the polygon. This test also works in three dimensions.



Geofencing Algorithms

PISTON (Parallel In-memory Spatio-temporal Topological Join)Algorithm:

Origin: Developed by the University of Toronto's Computer Science Department.

Design: Parallel, in-memory infrastructure for efficient query execution.

Key Features:

- **Novel parallel, in-memory trajectory index (IR) for high location data update rates.**
- **In-memory spatial index (IS) with a two-level grid approach, optimized for point-in-polygon tests.**
- **Low query response times are suitable for real-time use, even with large geofence datasets.**

Geofencing Algorithms

SLGC-1(Scan-Line Algorithm and Grid Compression) Algorithm

Origin: Created by the Software School of Xiamen University, China.

Purpose: Addresses regional limitations in Internet of Vehicles (IoV) systems with time and storage constraints.

Operation:

- **Spherical grid imposed on the geofence area in preprocessing.**
- **Scan conversion algorithm determines location attributes for each grid cell.**
- **QuadTree compression provides a memory-efficient index structure for geofence area.**
- **Uses Morton Code (MD code) to identify nodes inside the QuadTree structure.**

Geofencing Algorithms

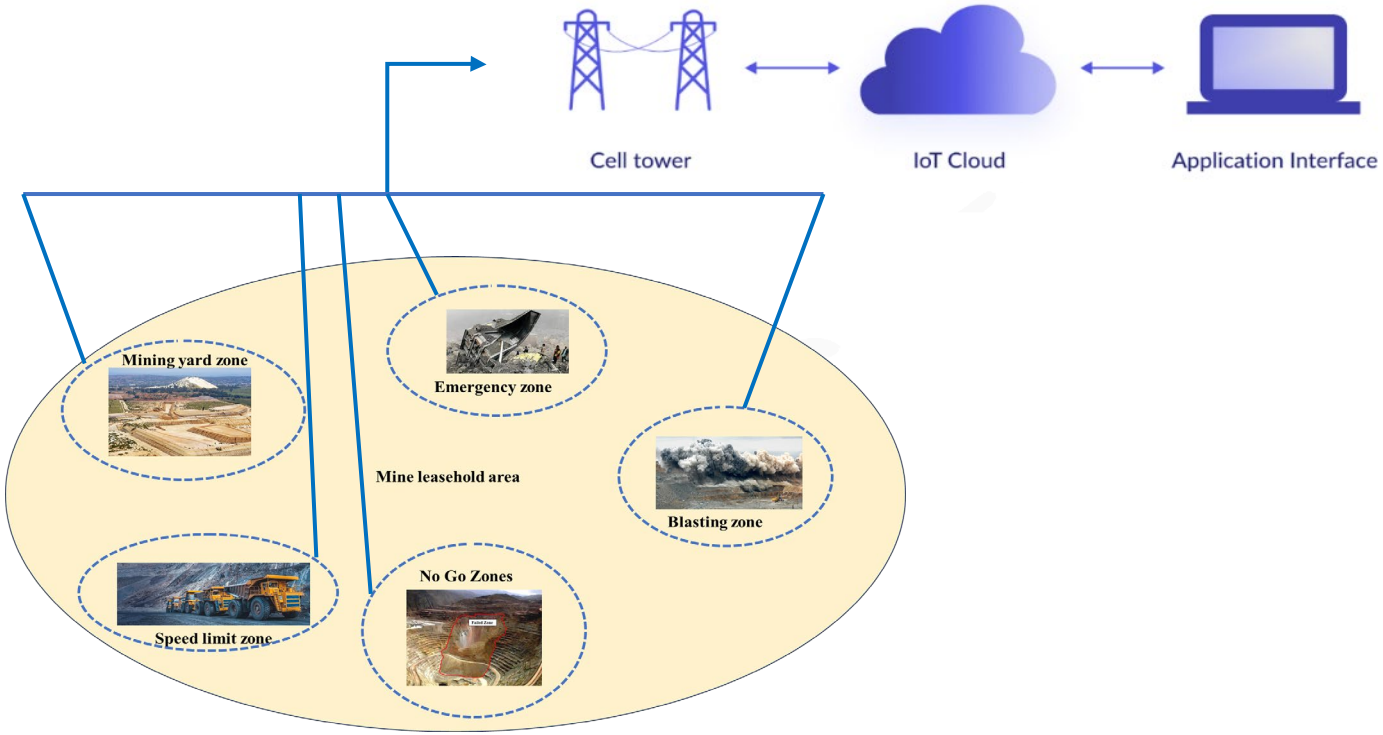
PFLGA (Proactive Fast and Low Resource Geofencing Algorithm)

- **PFLGA employs a tree-based indexing method for geofences, implements a smart trajectory filtering strategy, and provides flexibility with both trajectory-based and point-in-polygon queries. However, its response time for trajectory-based queries may not be the fastest among available algorithms.**

Geofencing keeps miners safe

- Geofencing is a virtual boundary drawn around a dangerous area.
- This can be achieved with GPS and other data signals including cellular, Wi-Fi, and RFID.
- The idea being that a geofencing application responds instantly when a mobile device enters or leaves the fenced area.
- It can limit personnel access to recently blasted areas, for example, or minimize the time for evacuation due to an explosion by determining the best escape routes.
- A geofencing application can be programmed to set off an alarm on a mobile device if a worker or vehicle operates too close to the edge of a dangerous boundary.

Geofencing keeps miners safe



schematic diagram of mining with geo-fencing application.

Geofencing keeps miners safe

- As an extra failsafe, the technology can automatically shut down dangerous equipment or alert site managers so that they can take decisive action quickly.
- Coupled with telematics, geofencing can track the whereabouts of assets and prevent them from leaving a defined area.
- Telematics is the technology used to track individual machines or a fleet. Telematics collects data from vehicles, including location, driver behavior, and vehicle activity
- It can help management keep track of heavy machinery assets and keep them out of hazardous environments, for example. If a machine handler is behaving erratically and endangering the safety of others, an alert can be sent to the site manager.

Track miners

Detecting Dangerous Driving Behavior

- Mining companies nowadays can detect and collect data that indicates truck driver behavior. Data on harsh driving activity can be seen via GPS devices.
- Moreover, mine site managers can easily monitor and detect dangerous driving behavior thanks to the advanced GPS features.
- Yet, once a mine manager detects dangerous driving and operational behavior, straight ahead he can alert drivers on their risky behaviors.

Driver behaviour detecting

Track miners

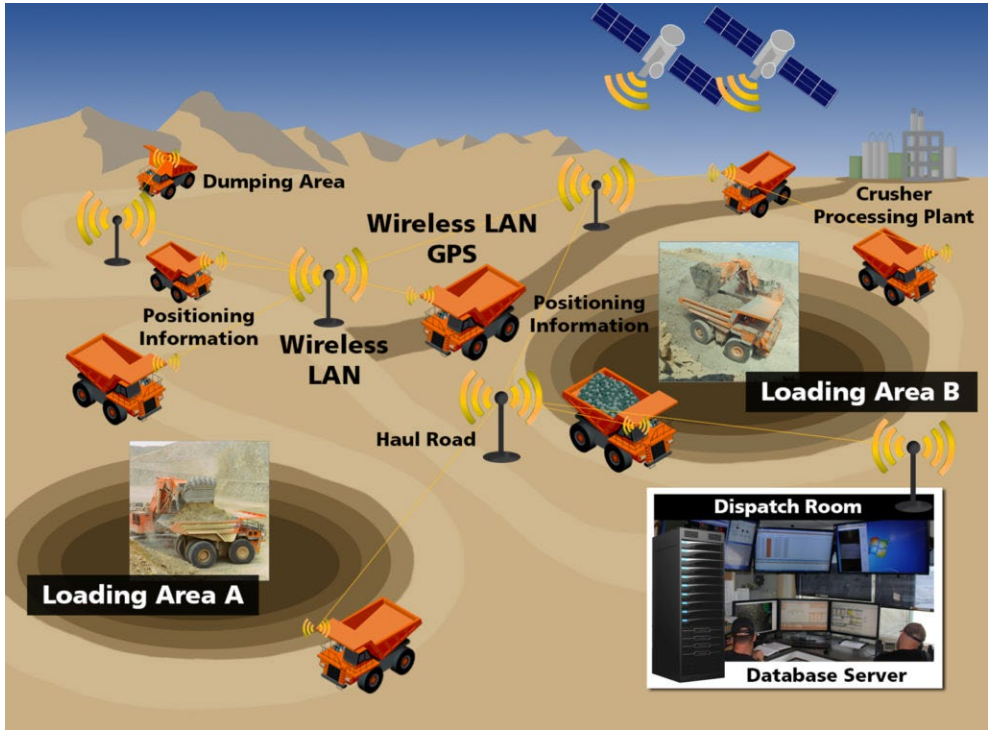
Detecting Dangerous Driving Behavior

- In addition, this application characterization of the GPS features can decrease the chances of accidents or any injury happening on mine sites.
- By that, not only that mining company can decrease the chances of accidents and injuries, but they can as well reduce the wear and tear on the vehicles.
- So, by detecting dangerous driving behaviors via the global positioning system mining companies can improve their overall efficiency.

Track miners

Hazard Avoidance

- The application characterization of GPS features for mining companies can be seen in the process of hazard avoidance as well. In general, the mining industry is a risky one. Geofencing will add an extra layer of safety for mine workers.



Geofencing Application

1. Static Virtual-notification

This application works on the geographical position of a mobile user concerning a fixed area.

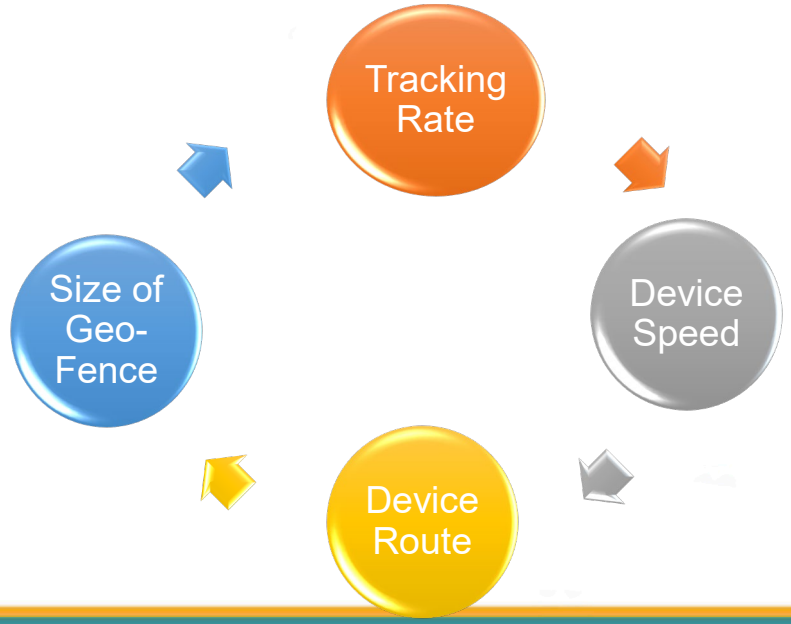
2. Dynamic Virtual-notification

This application is rooted in the geographical location of a mobile user concerning a changing data stream.

Geofencing Application

3. Peer-to-Peer virtual-notification:

- **This application works on the geographical location of a mobile user concerning other users.**
- **Location Accuracy – The device location must be correctly identified to a geo-fence for the action to occur appropriately (i.e., the right user receives a notification)**



How fleet management is used in Geofencing using IoT?

Fleet management can be used in different ways in IoT:

1. Planning trips & Scheduling trips:

Fleet management uses planning trips and Scheduling trips in such a way that owners can plan their trips in a specific manner using Geo tracking and communication with the help of IoT.

2. Fleet management:

When a truck driver diverts from his route, the dispatcher gets an alert. This is used as fleet management using Geo-Fencing.

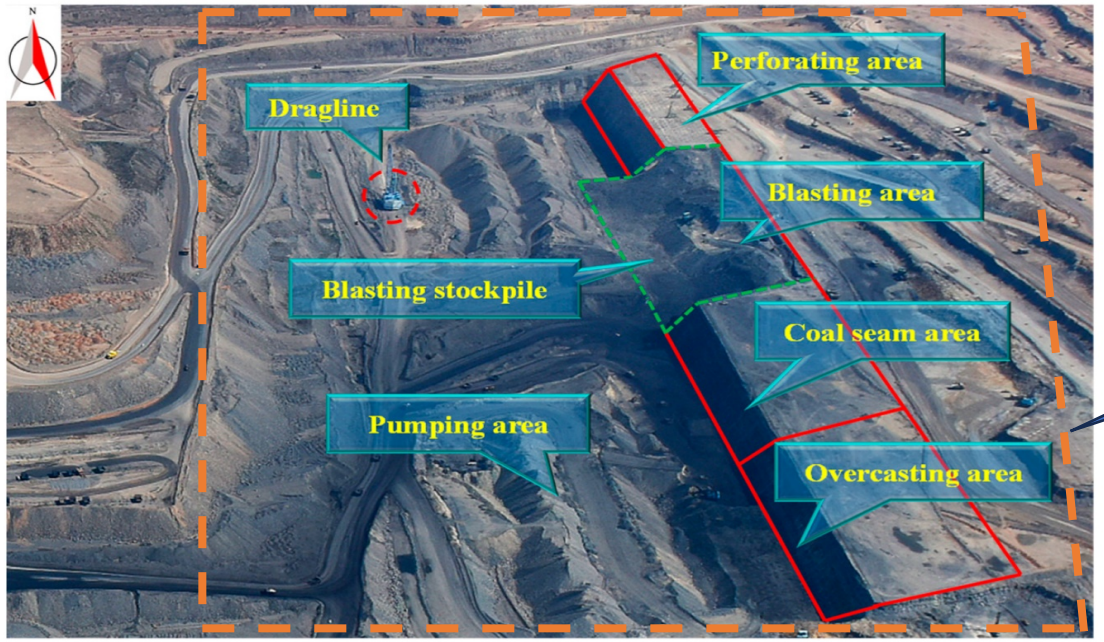
3. Maintenance:

There are hundreds of vehicles operating on fleet management, so it is crucial to have conservation of these vehicles and the consequences of inappropriate actions.

Geofencing application use in mining industry

Blast Zones

- When it's time to conduct blasting to loosen iron ore for extraction, for example, obviously you need to be sure no people are in the blast zone, so a geofence can alert the right people if and when this occurs.



Yard and Site

- Should your business involve workers transporting supplies or equipment from a home base (known as a yard) to a temporary work site, creating a geofence can allow you to easily log the times users come and go between each area.
- For example, a concrete truck returning to the yard to fill up, before heading back to the site to drop off its load.

Confinement

- While the applications above have all been about keeping track of who is entering an area, geofences can also be put in place to keep people in who are already there.
- Confinement is where you want someone to stay within an area, and can be set up to send you an alert should they leave the specified zone.

No Go Zones

- Functioning similarly to blast and emergency geofences, this is a solution for areas you don't want people to go to enter, although not necessarily for safety reasons.
- Security-sensitive areas or environmentally protected zones are good examples.

Emergency

- For use in critical situations, emergency zones can be quickly setup for evacuation and warning zones. An example of this is a fire zone, so when such an event occurs an emergency geofence can be created to cover an area to evacuate.
- As soon as the area is mapped out the system can identify which radio users are in the zone and send out an alert to ensure they leave.

Speed Limiting

- Heavy industrial areas such as mine sites often have certain areas where you are not to exceed a certain speed limit.
- A speed limit geofence can track any incidents of speeding and help you to send any warnings if necessary.

Geofencing application in Open-cast mine

- Geo-fencing, used for miners safety, if miners enter in mining area then the mining office can get a notification.
- In the heavy earth moving machinery tracker, user can get alerts about machinery for example production activity and transportation activity list notification.
- In the mine leasehold boundary area notification.
- Human resource management- An employee smart card or GPS tracking device will send an alert to security if an employee attempts to enter an unauthorized geofence/area.

Geofencing application in Open-cast mine

- **Compliance management- Network logs record all geo-fence crossings to document when the proper use of devices and their compliance with established rules.**
- **Asset management- An RFID tag on a pallet can send an alert or notification if the pallet is removed from the warehouse without authorization.**
- **Law enforcement**

Question 1

How does geofencing technology impact the mining industry?

A) It has no impact on the mining industry.

B) It creates physical perimeters around designated areas.

C) It relies solely on GPS for real-time monitoring.

D) It revolutionizes the industry by enabling virtual perimeters and automated responses.

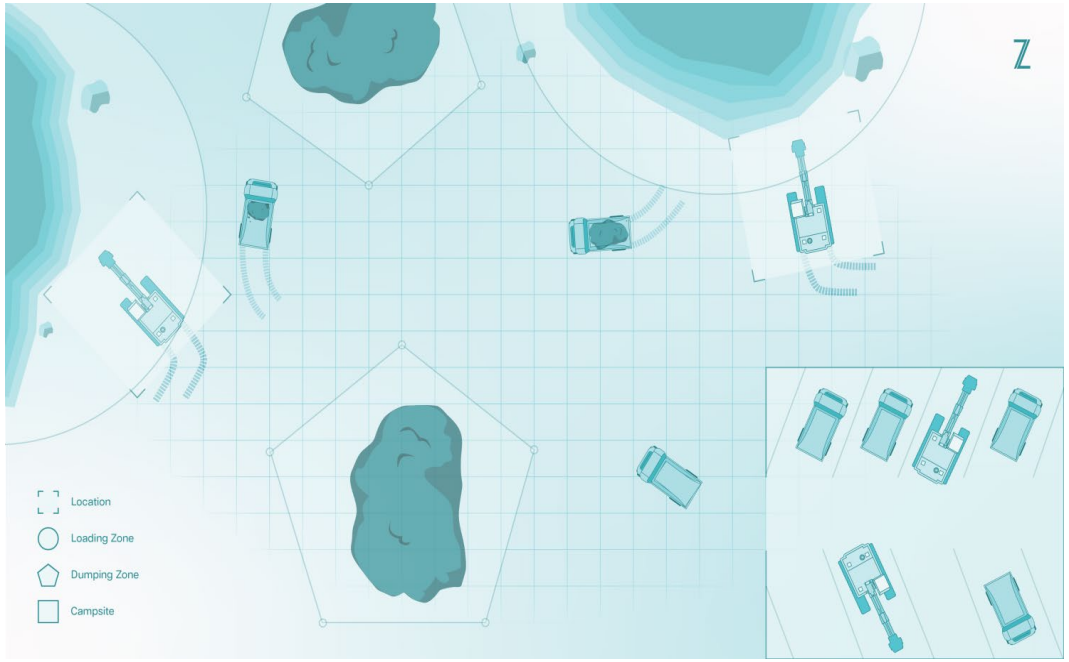
E) It only monitors assets, not people, within the virtual fences.

Answer: D) It revolutionizes the industry by enabling virtual perimeters and automated responses.

Key features Geofencing Application in the mining industry

Geofencing and Access Control:

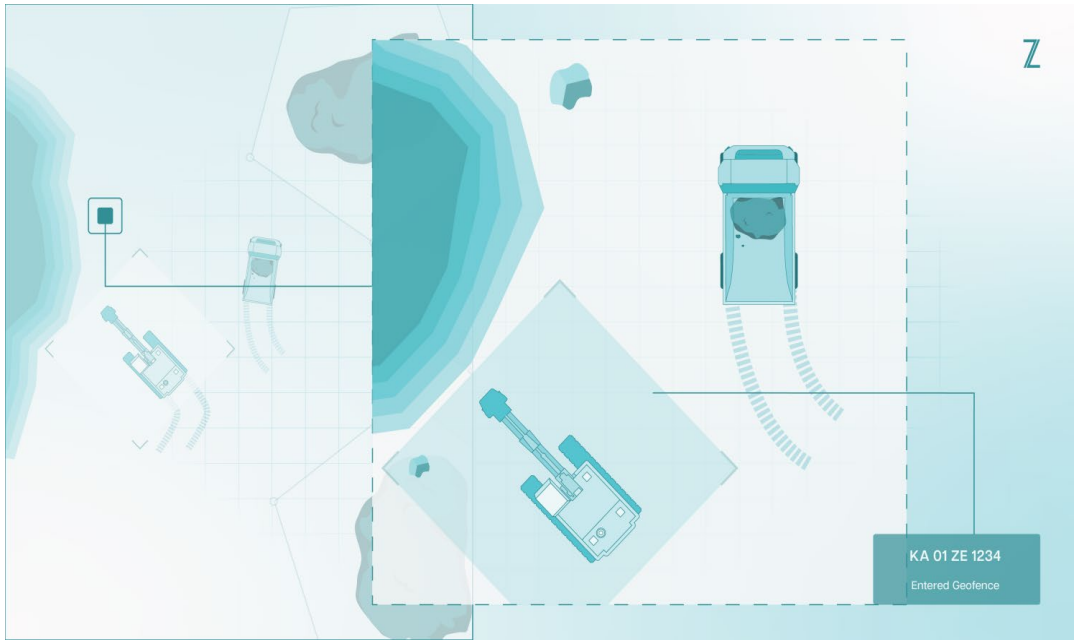
- **Implementation of geofencing technology to create virtual boundaries around excavation zones. Only authorized vehicles and equipment can enter specific areas, preventing accidental encroachments, ensuring a safer work environment.**



Geo-Fencing of Areas in the Mining Site

Real-Time Tracking and Visualization:

- The system integrates GPS and RFID technologies to track the location and movement of all excavators and vehicles in real time. A user-friendly interface displays the mining site layout with color-coded zones, enabling operators to monitor activities and detect any unauthorized entry.



Real-Time Tracking of fleet movements and notification of event on Geo-Fenced Area access

Intelligent Routing and Dispatch Management:

- The system employs predictive analytics and AI algorithms to recommend optimal routes for each vehicle and excavator.
- This minimizes traffic congestion, reduces turnaround times, and enhances overall operational efficiency.
- Dispatch managers receive real-time suggestions to make informed decisions.
- Additionally, manual route planning can be implemented with geofencing to assist drivers in adhering to the designated route.
- Any deviations from the planned route within the geofenced areas can be tracked in real time.
- So, whenever an event of geofence breach occurs, a real-time alert can be generated and reported.

Automated Alerts and Notifications:

- When a vehicle or excavator enters a restricted or active excavation zone, the system triggers automated alerts to relevant stakeholders, including operators, supervisors, and drivers.
- These alerts prompt immediate corrective actions and prevent safety hazards and resource wastage.

Driver and Fleet Mapping:

- Enabling an access control system that links drivers to specific vehicles facilitates the process of assigning vehicles and aligning drivers with their designated shifts.
- This system ensures that access is granted exclusively to vehicles that have been pre-approved and onboarded by the fleet manager.
- Moreover, this access control mechanism serves the vital purpose of restricting unauthorized personnel from entering vehicles located in hazardous areas.
- Only individuals who have undergone specialized training are permitted to access and operate these specific vehicles.
- It's important to note that vehicle operation is only allowed once a trip has been officially assigned; otherwise, alerts can be generated for such events to enable quick preventive action.

Performance Analytics and Reporting:

- The system collects data on vehicle movements, operational patterns, and efficiency metrics.
- Detailed reports are generated such as Fleet utilization reports, Delay/ Miss reports in trip plan, incident report, Total KMs Covered report, Driver-wise report and customized reports based on operational requirements, providing insights into performance trends, potential bottlenecks areas for improvement.

Emergency Response Integration:

- The system includes an emergency override feature that allows operators to remotely halt vehicles and equipment in case of a safety threat.
- This ensures swift action to prevent accidents or hazardous situations.

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CONCLUSION

- Provided an overview of the concept of geofencing.
- Explored the practical application and integration of geofencing technology
- Discussed the algorithms employed in geofencing systems to define and manage virtual boundaries.
- Explored the role of geofencing in enhancing safety measures for miners.
- Discussed how geofencing is utilized to track and monitor the movements of miners.
- Examined the practical application of geofencing technology.

CONCLUSION

- **Explored specific use cases of geofencing technology within the mining sector.**
- **Highlighted essential features that make geofencing valuable for enhancing safety and monitoring in mining operations.**


THANK YOU