combined sink product with specific-gravity cut-point of 3.00) with a recovery of 38.1 percent (Fig. 2) was achieved. This indicates that the ore contains a fairly large amount of spodumene grains (at least about 38 percent), which can be recovered by dense media separation.

Discussion and conclusion

Automated mineralogy, coupled with geochemical analyses and mineral chemistry, provide valuable quantitative data that can be used to guide the testwork and explain recoveries and potential losses. The results show that spodumene is the primary lithium mineral in the Zoro pegmatite, accounts for 96 percent of the total lithium and is well liberated (88 percent), favoring recovery by flotation. In preliminary testwork, HLS combined with magnetic separation tests yielded a high-grade (close to 6 percent Li_2O) lithium concentrate. The mineralogical characteristics of the pegmatite favor the economic potential of the project. ■

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Assessing the feasibility of a commercially available wireless Internet of Things system to improve conveyor safety

R. Jacksha* and K.V. Raj
CDC NIOSH, Spokane Mining Research Division, Spokane WA 99207, USA
*Corresponding author email: rjacksha@cdc.gov

Full-text paper:
Mining, Metallurgy & Exploration, https://doi.org/10.1007/s42461-020-00325-3

Keywords: Internet of Things, Conveyor safety, Data acquisition, Wireless communication

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Conveyor systems persist in being a source of injuries and fatalities in the mining industry. To reduce these incidents, better methods are needed to enhance the monitoring of probable hazards and improve situational awareness during the normal operation and maintenance of conveyor systems. To address these issues, researchers from the U.S. National Institute for Occupational Safety and Health (NIOSH) continue to investigate emerging technologies that show the potential to improve miner safety around conveyors. This paper presents a feasibility assessment by NIOSH researchers of a fully integrated, commercially available wireless Internet of Things (IoT) system to improve situational awareness around conveyor systems.

Summary

NIOSH researchers continue to investigate emerging technologies that may be beneficial in improving conveyor safety, specifically through enhanced situational awareness. With IoT making inroads into the mining sector and continually evolving to meet industry needs, low-cost commercially available IoT systems that are fully integrated (turnkey) solutions were explored.

Operating in the 915 MHz industrial, scientific and medical (ISM) band, the wireless IoT system selected for assessment had many features that made it suitable for a straightforward deployment. The option of a noncloud-based server with a fully developed Windows-based human-machine interface (HMI) preinstalled, coupled with the availability of a wide variety of sensor nodes and a control node, allowed the solution to be easily optimized to enhance conveyor safety for mining operations.

A purpose-built conveyor test bed was developed to assess the selected IoT system's potential to improve conveyor safety. The core of the test bed was a pair of small troughing conveyors (Fig. 1).

As implemented, should sensor data (status) indicate an

Fig. 1 Test bed conveyors.

abnormal (fault) condition that resulted in a hazardous situation, such as a guard not in place, personnel would be notified via the system HMI or status indicators on the conveyor controllers. The HMI could also be accessed remotely with handheld wireless devices, such as a smartphone or tablet PC, through Wi-Fi access points (WAPs). A block diagram of the system as implemented is shown in Fig. 2. One controller and conveyor sensor set is omitted for clarity.

As expected, an in-depth level of technical expertise was not essential to initially set up and configure the system. Once deployed, the system predominantly functioned as designed. Fault conditions were noted on the HMI and conveyor status indicators, sensor data were logged to the system server, and historical trends were easily viewed using the HMI. The HMI could also be successfully accessed using wireless devices via a WAP. However, during the system assessment two issues of concern did arise that required perseverance as well as wireless troubleshooting skills to resolve.

In most circumstances, latency between the occurrence of a fault condition and a resultant system notification was typically less than five seconds. However, at one point during the assessment, latencies degraded from seconds to minutes. It was discovered that a transceiver (radio) operating on a channel in the center of the 915 MHz ISM band had been placed in close proximity to the IoT system's gateway, resulting in wireless channel congestion. The increased latency due to channel congestion was not totally unexpected and is a potential issue with any wireless IoT system operating in an ISM band.

Another area of concern was race conditions between sensors. It was observed that occasionally the fault indicator on a motor controller would not be illuminated when a fault condition existed. Working closely with the system's manufacturer, it was determined that if two sensors indicated fault conditions simultaneously and one sensor then returned to a nonfault condition, the system would no longer indicate a fault condition existed. This would occur even though the other sensor remained in a fault condition. Although the system's manufacturer stated the race conditions could be resolved by reconfiguring monitoring and control algorithms in the HMI, as of this writing the correct algorithm has not been determined.

Conclusion

This study suggests that low-cost wireless IoT technologies may not always be suitable for safety-critical applications. However, with some improvements, and if used in conjunction with existing policies, procedures and safety controls, a wireless IoT system shows potential to improve mine worker safety around conveyors through enhanced situational awareness. This study also suggests the current state of IoT technologies is not "plug and play." Some technical knowledge of computer networking and radio-frequency environments is needed to deploy and maintain even the simplest "turnkey" wireless IoT systems. ■

Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC). Mention of any company name or product does not constitute endorsement by NIOSH.

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A list of all references is available in the full-text paper.

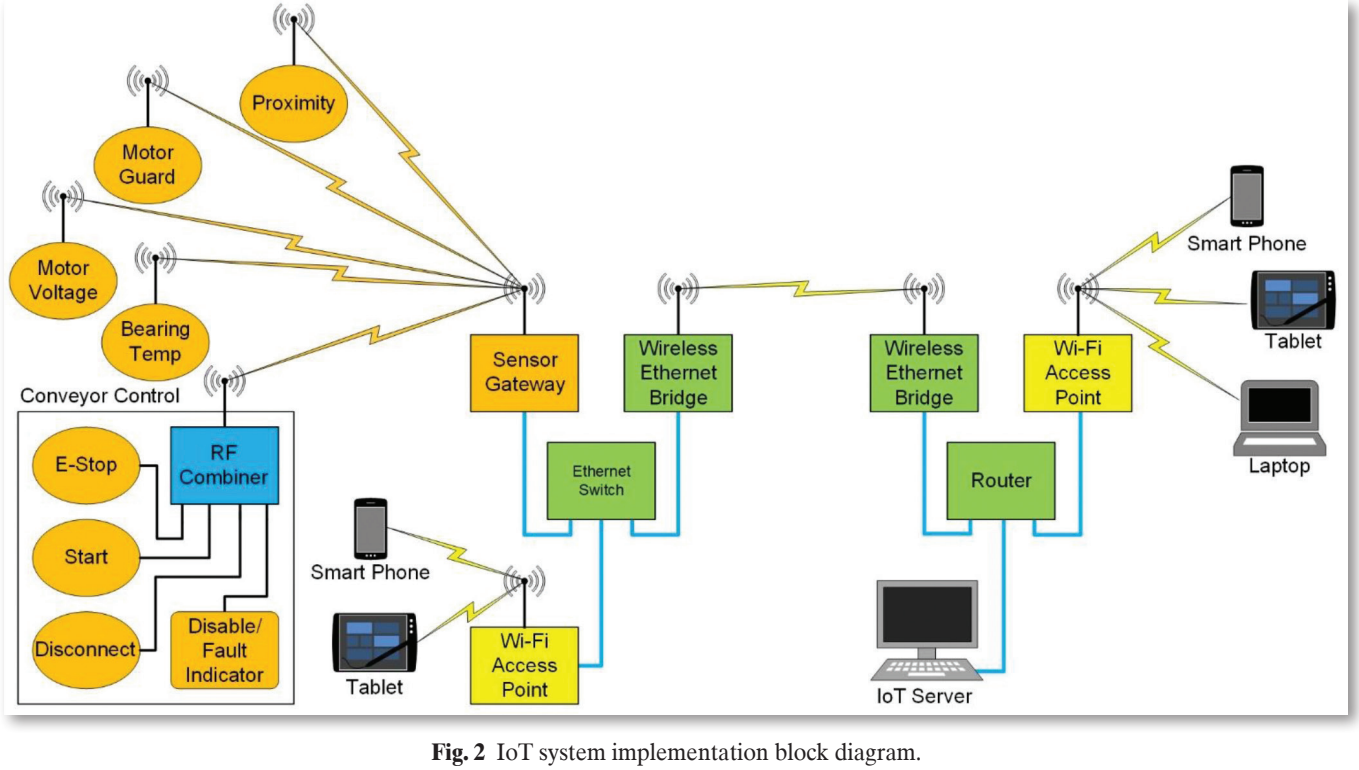

Fig. 2 IoT system implementation block diagram.