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Wireless communication in a collapsed mine tunnel

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2020
https://hdl.handle.net/10539/31113

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Abstract

The mining industry in South Africa is one of the biggest contributors to the country's Gross Domestic Product (GDP) and employs almost half a million people. Most of the mines, where mostly gold, platinum and diamonds are mined, are underground mines. During the mining process, miners' health and safety is of paramount importance. However, there have been numerous accidents in underground mines due to structural failures and rock fall which sometimes lead to tunnel collapses and inevitably the tragic problem of the missing or trapped miner. Rescue efforts are impeded by the lack of a communications infrastructure because the available infrastructure either gets destroyed or loses connectivity after the accident has happened. A reliable communication infrastructure is therefore seen as the first step towards addressing the saddening issue of the missing/trapped miner. The realisation of such a good communications infrastructure comes with the major task of designing new robust systems which are able to survive and still be able to establish connectivity after an accident has occurred in the underground mine. The current research aims to model the communication channel of a collapsed underground mine tunnel and to perform an evaluation on the performance of a Wireless Sensor Network (WSN) in a collapsed mine tunnel. The channel modeling part in the research focuses mainly on the modeling of the path loss profile which is dependent on transmission power, centre frequency and antenna gain. The research also focuses on the performance of a WSN communication system in a collapsed mine because it is seen as the best communication system to be used in such a scenario due to the redundancy provided by it such as in a mesh network. In the end, an analysis is made on the suitable frequencies, transmission power and topologies for a communication system that will be effective to be used in a collapsed mine tunnel. The results from the path loss modeling show that the channel presented in a collapsed mine tunnel is a combination of the models obtained for a normal mine tunnel without any collapses and that of wave propagation through a rock medium. In the models obtained, a large attenuation is seen in the collapsed section of the whole tunnel as compared to the open air sections. Results from the performance evaluation show a decline in performance as the transmission frequency increases and as the transmission power is reduced. Overall results suggest that a suitable communication system in a collapsed mine tunnel is that which makes use of a centre frequency below 6MHz when considering a maximum transmission power of 1000mW, for scenarios with a maximum collapse width of 5m and a receiver sensitivity of -80dBm.