Chapter 10
Reliable Communication Network for Emergency Response and Disaster Management in Underground Mines

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ABSTRACT

Emergency response and disaster management in underground mines are very challenging due to the hostile nature. Environment monitoring in mines has been an obligatory requirement to ensure safe working conditions for miners. Reliable communication network is essential to quickly detect the underground condition especially in emergency situation and to conduct proper rescue operations. This chapter presents an overview of reliable communication network needed for emergency response and disaster management in underground mines. The chapter begins by introducing the most common accidents occurring in the mining, underground mine environment and channel properties. Subsequently, communications in underground mines, existing underground communication and tracking systems, and disaster forecasting & mine safety management are discussed. The chapter also covers post-disaster mine communications & tracking systems and optimized backbone networks for underground mines. Finally, the chapter concludes by reporting relevant research at Ryerson Communications Lab and pointing out some open issues and possible research directions.

INTRODUCTION

Natural or man-made disasters are unpredictable and increasing in number nowadays throughout the world. Without warning, disaster can strike and affect people, living society and environment in many ways. An underground mine is an inherently hazardous workplace. Mine disasters have been a crucial issue among mine operators, safety and health personnel, and miners for decades (Brnich, 2010). Although catastrophic mine accidents, such as the Benxihu colliery mine disaster that killed 1,549 people and the Courrieres disaster in France that killed 1,099 people, understandably make the headlines, many smaller incidents remain unnoticed. For example, there were 69 fatalities and 11,800 injuries in US mines in 2006-2007 alone. Every year several miners die due to fatal incidents. Even during normal operations, mining workers are five times more likely to be exposed to occupational hazards than the industrial average. In case of disaster in an underground mine, it is very difficult for emergency response and disaster management team to identify actual person trapped, their number, and exact location (Bandyopadhyay, 2009). Therefore, identifying and locating of miners, explosives and critical exits are very important tasks for underground mine management in case of disaster as well as usual working conditions.

Most important factors of accidents in the mining industry are (i) Poisonous or explosives gases present in the ground and (ii) Use of explosives (blasting operations) for rock breaking purpose. Followings are the most common accidents occurring in the mining industry (Dozolme, 2016):

- **Methane and Consecutive Coal Dust Explosions:** Methane is a highly explosive gas trapped within coal layers. Mechanical errors from improperly used or malfunctioning mining equipment (such as safety lamps or electrical equipment) or the use of improper explosives underground can trigger methane and initiate consecutive coal dust explosions. Methane and coal dust explosions have caused the largest mining disasters in history and frequently kill or trap underground miners.
- **Blasting Related Accidents:** Blasting consists in using explosives for rock breaking purpose. Proper, and improper, use of explosives could lead to dangerous situations such as: a) Fly-rocks: For the past two decades, most explosives-related injuries and fatalities in surface mines occurred when workers were struck by rock, either because they were too close to the blast or rock was thrown much farther than expected; b) Premature blast: The detonation of an explosive charge earlier than warranted. Premature explosion may be due to carelessness, accidental percussion, a faulty fuse, or degenerated explosives; c) Misfires: Misfire means the complete or partial failure of a blasting charge to explode as planned; d) Mine-induced seismicity: It is especially dangerous in underground mining areas, mine-induced seismicity also cause slope instability in surface mining, and is a major threat for all miners.
- **Fire:** The followings are the potential sources of fire in underground mines: a) Friction from defective bearings, conveyor idlers, drums, wheels/axles; b) Seized brakes on vehicles; c) Internal combustion engines – exhaust systems, air inlets, hot surfaces; d) Spontaneous heating of coal in the waste or of broken coal in the roadside in high-risk seams; e) Sparks from cutting machinery picks; e) Electrical and mechanical machinery and equipment; f) Electrical sparking and hot surfaces from electrical equipment and distribution systems; g) Short circuits and earth faults on electrical equipment and distribution systems; h) Natural sources, for example, electrostatic discharges and lightning; i) Hot work – burning, welding, and grinding; j) Smokers' materials, e.g. cigarettes, lighters and matches.

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