CPS: Synergy: Enabling Smart Underground Mining with an Integrated Context-aware Wireless Cyber-Physical Framework

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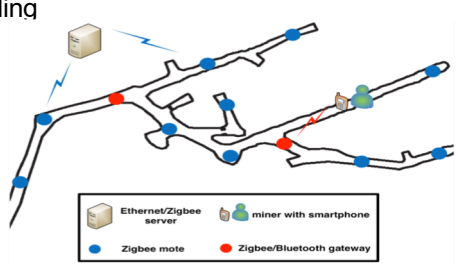
Mission: The aim of this project is to design, prototype, and test a wireless cyber-physical framework of low-cost, energy-efficient, and reliable sensor nodes and commodity smartphones for monitoring, tracking, and communication, to improve miner safety in underground mines.

Challenges:

- High cost of deploying safety infrastructure in underground mines encourages companies today to meet only the bare minimum required safeguards
- How to overcome monitoring, communication, and tracking challenges in the underground mines to realize a cost-effective safety infrastructure

Research Thrusts

- Develop energy-efficient and error-tolerant indoor (underground) localization to locate individual miners and groups of miners
- Enable high quality voice streaming over low-power wireless networks
- Characterize wireless signal behavior with EM modeling

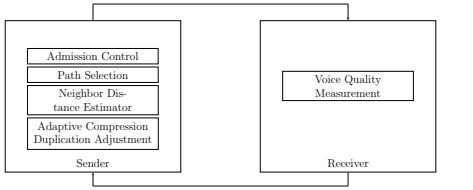


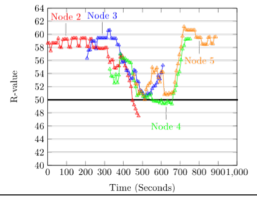
Societal Impact

The developed framework will minimize the risks facing hundreds of thousands of miners in the USA

Voice Convergecast in Mobile Low Power Wireless Networks

- Integrated routing and admission control
  - Maximize number of admitted streams
  - Key concept: quality of path (minimum number of contention domains affected on a path between a node and a sink)
  - Multi-layer approach
  - Deployed on Arduino Due and Xbee S1
  - 3 concurrent mobile streams can be supported





Education and Outreach

- Graduate Student Participants: Saideep Tiku, Xuejin Wen, Lixiao Zhu
- Undergraduate Student Participants: Colter Snyder, Robert Warner

A Lightweight Smartphone Heterogeneity Resilient Portable Indoor Localization Framework

- Conducted an in-depth analysis of WiFi fingerprinting across smartphones to emphasize the importance of device heterogeneity resilient indoor localization
- Designed a framework SHERPA for portable WiFi fingerprinting based indoor localization, which employs a lightweight software-based approach to combine noisy fingerprints over distinct smartphones and pattern matching/filtering to improve location accuracy
- Evaluated the framework against state-of-the-art localization techniques, across a variety of Android-based smartphones

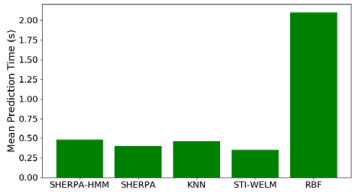


Figure 9: Mean indoor location prediction time for *SHERPA* and frameworks from prior work for the *Lib_Study* path using the OnePlus3 device.

Scientific Impact

Foundational research outcomes are applicable to a wide range of applications in the realms of S&CC and IoT

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