Node-Based Tracking Using Received Signal Strength Indication

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Overview

- **Node-Based Tracking**
  - Handset = Tracking Device
  - Node = Reader
- **Received Signal Strength Indication (RSSI)**
- **Central Server Considerations Before and During Emergencies**
- **NIOSH Wireless Mesh Communication & Tracking Contract**

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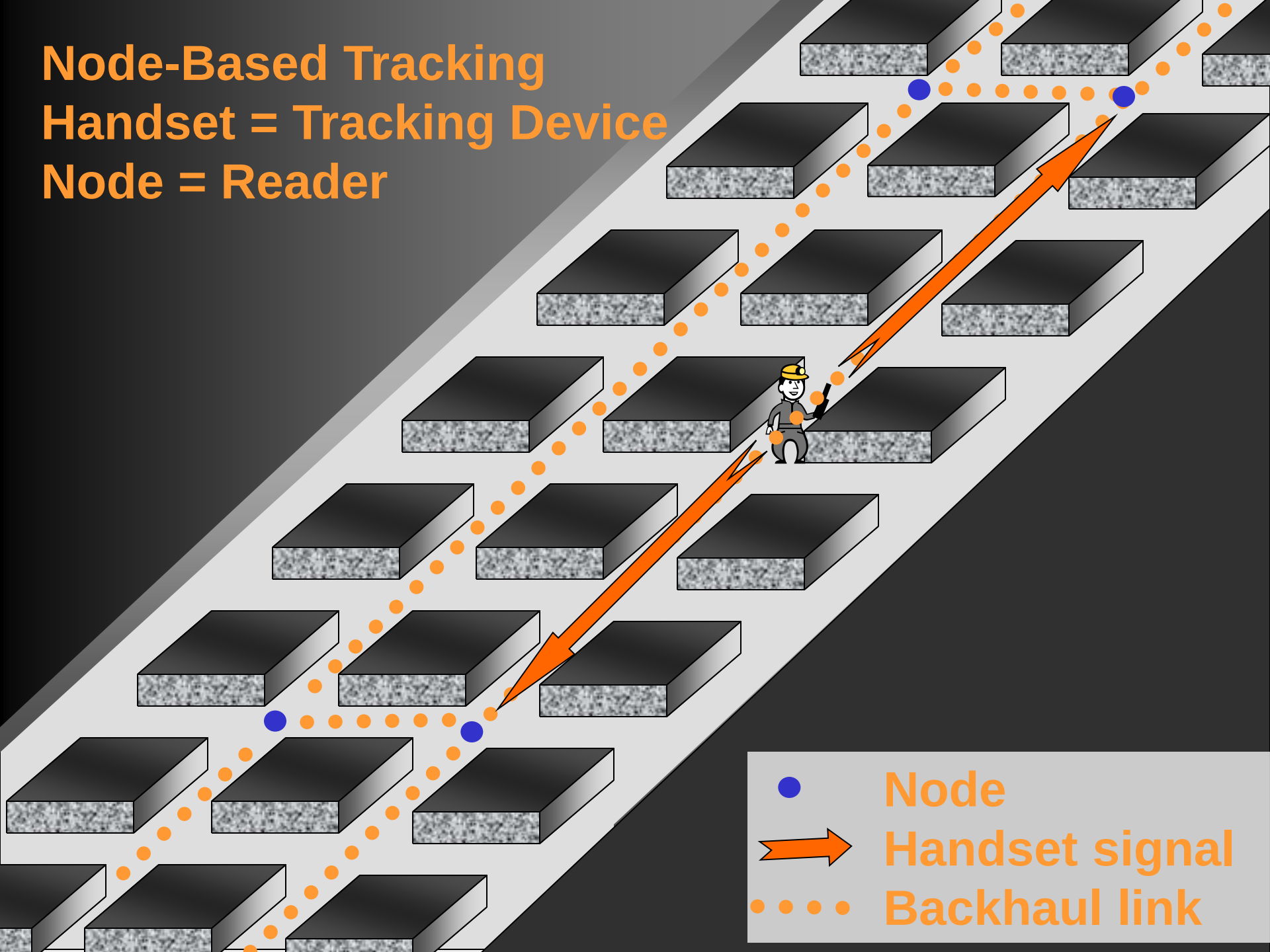


Handset Network Connectivity

- **Unless powered off, communication handsets used with node-based networks will transmit periodically to maintain network connectivity**
- **The miner does not need to key the handset for tracking purposes**

Received Signal Strength Indication (RSSI)

- **RSSI measurements are arbitrary indications of the signal power**
- **Relationship to actual signal power and range of reported RSSI values are vendor specific**
- **Supported by Zigbee (IEEE 802.15.4) and WiFi (IEEE 802.11) standards**
- **A similar metric also supported by WiFi is Received Channel Power Indicator (RCPI), with defined levels of power accuracy and resolution**

Tracking via RSSI

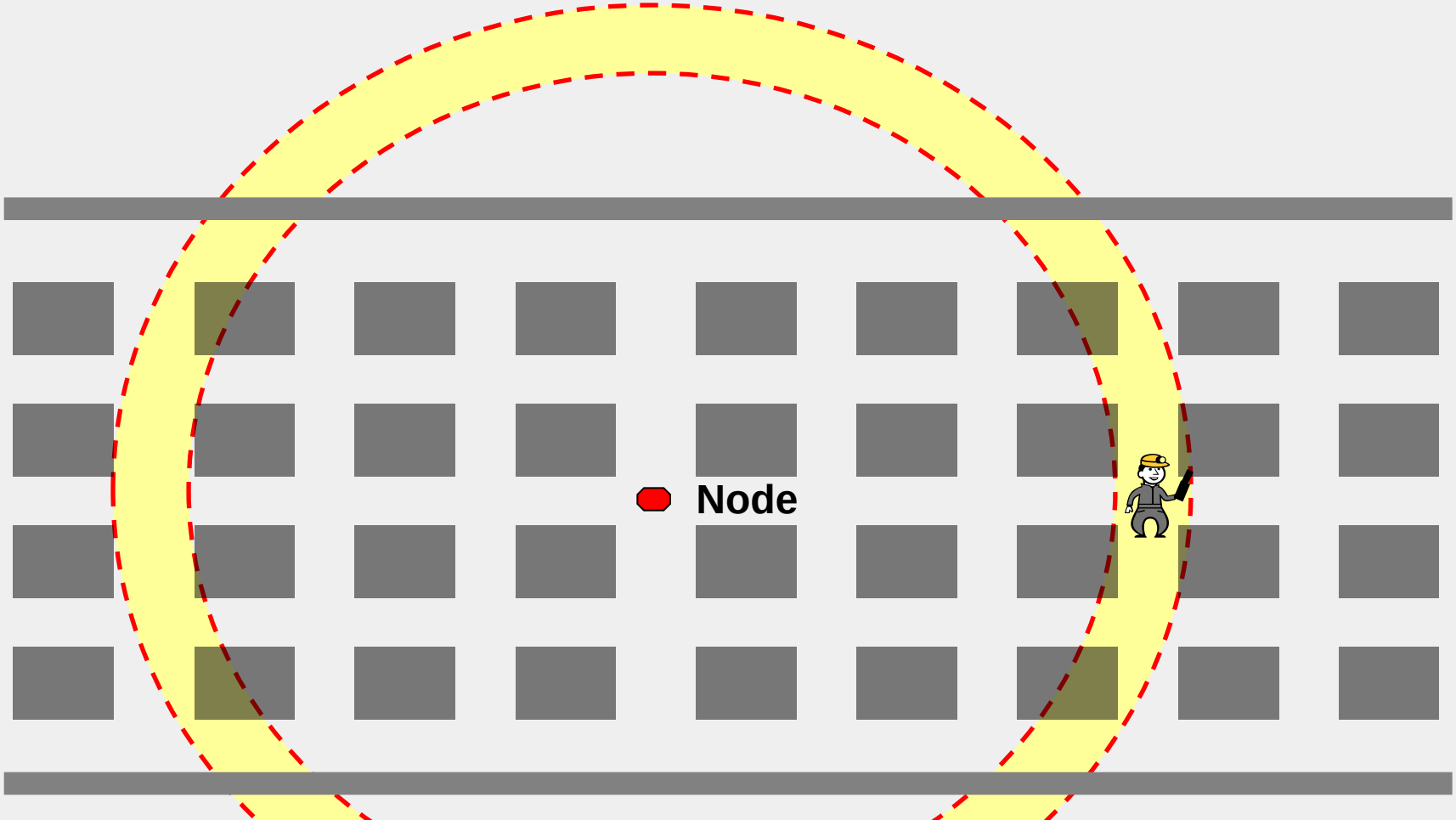
- **Takes advantage of line-of-sight signal power fade over distance**
- **Anything that affects the received signal strength influences the accuracy:**
  - Around coal pillars
  - Through stoppings
  - Body absorption
  - Equipment in the entries
  - Antenna orientation
  - Multipath constructive or destructive interference

RSSI Error Correction Techniques

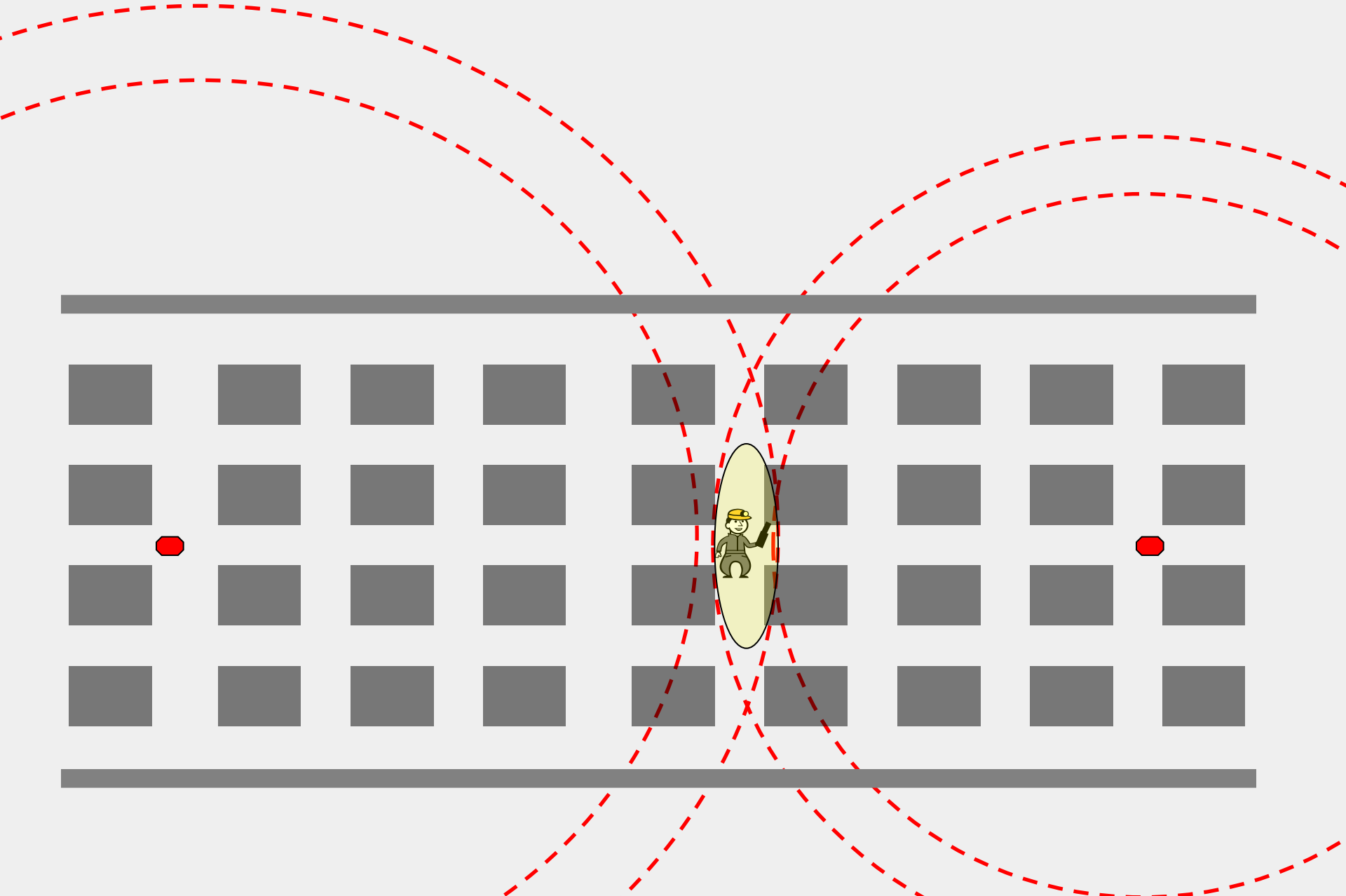
- **There are ways to improve the accuracy, including:**
  - Time averaging of the received signal
  - Considering the rate of travel
  - Mapping movement to the mine map
  - Time-of-arrival

Tracking – Radio Contact With One Node

- **Location accuracy based on radius around node (omni directional antenna)**
- **Worst case accuracy is maximum radio range from the handset to the node (radius from node)**



Tracking Between Two Nodes



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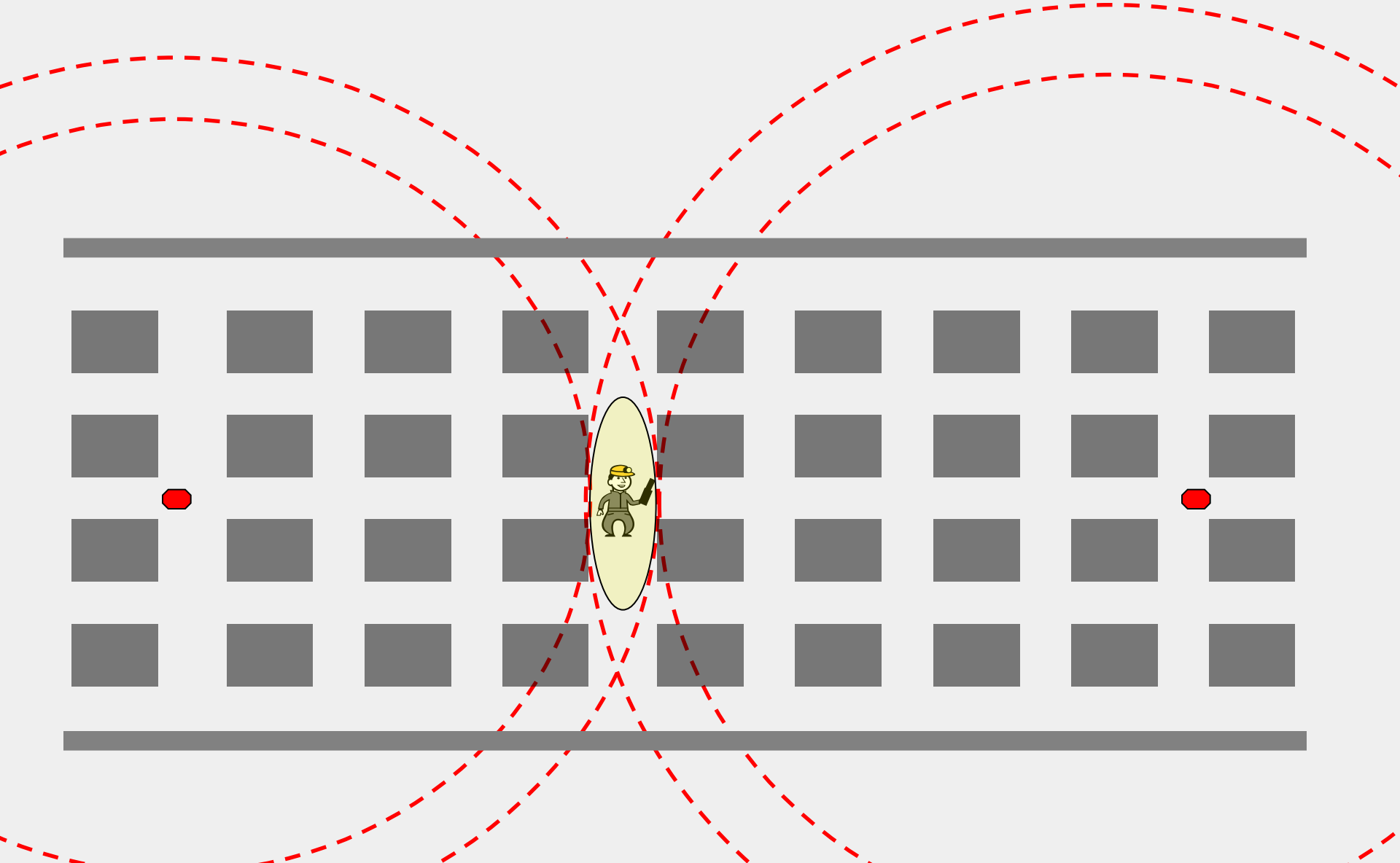

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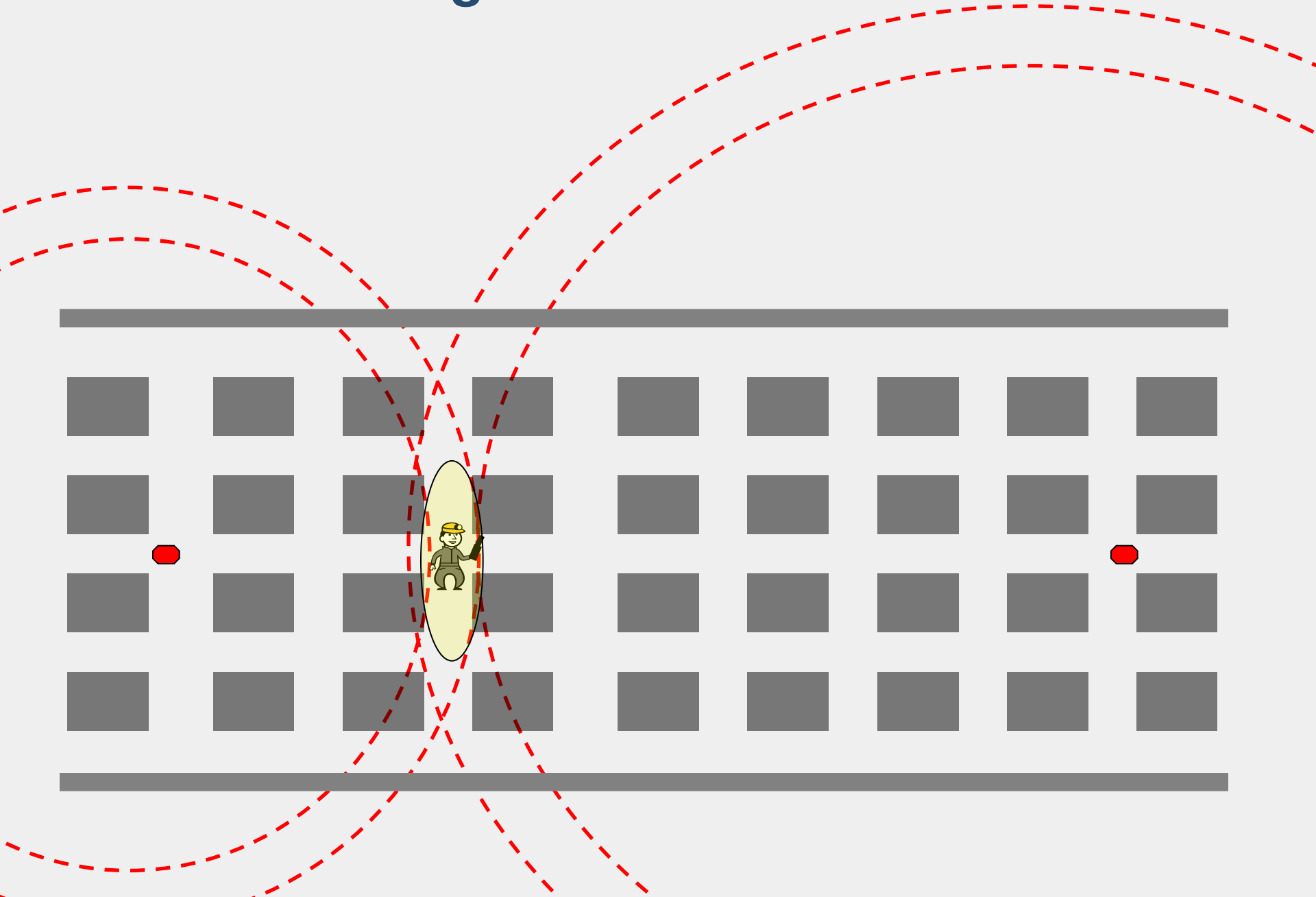
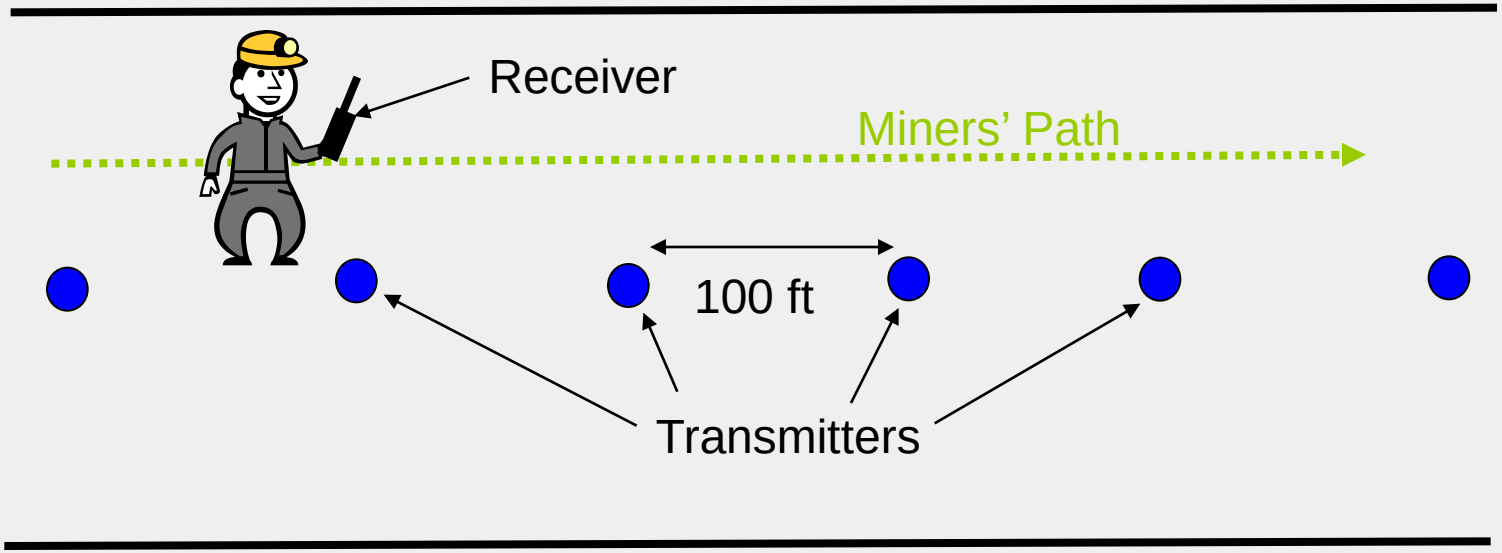


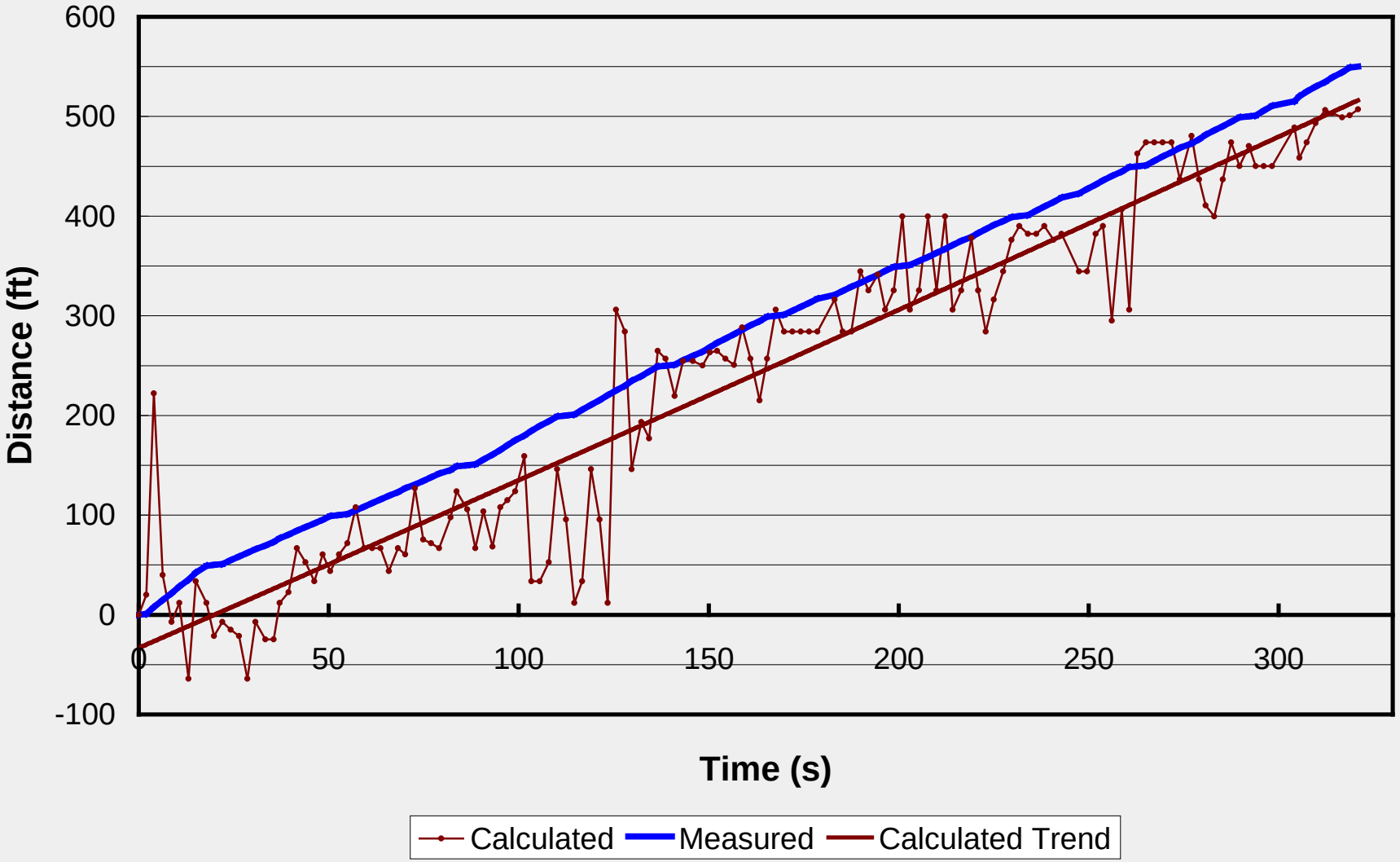
RSSI Error Test

- **Transmitters spaced every 100 ft**
- **Miner walks along entry for 500 ft**

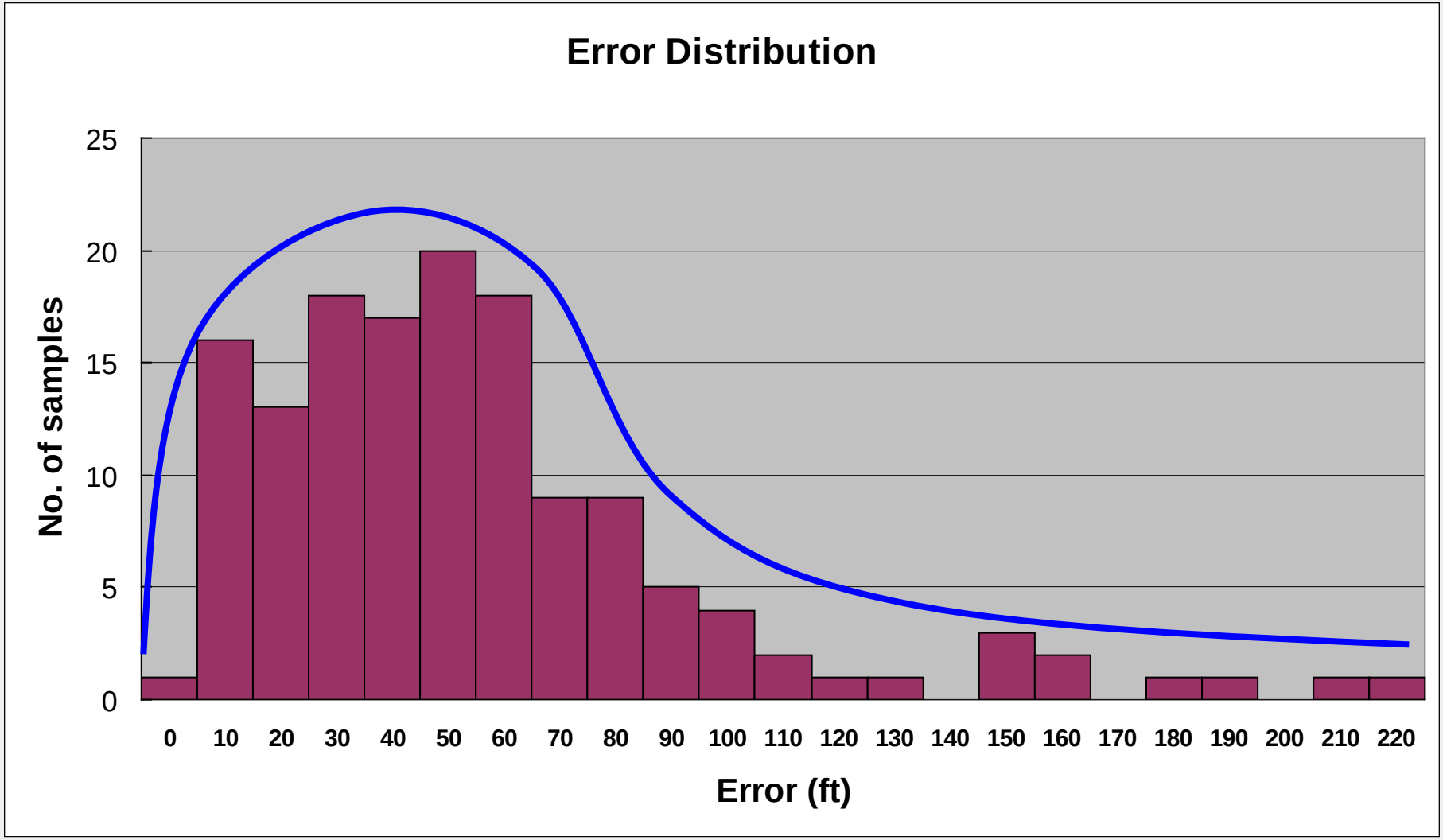


- **True position and RSSI estimated position recorded at regular intervals along path**

Comparison of Actual and RSSI Calculated Displacement as a Miner Walks 500 Feet Down an Entry



RSSI Tracking Error Distribution (Example)



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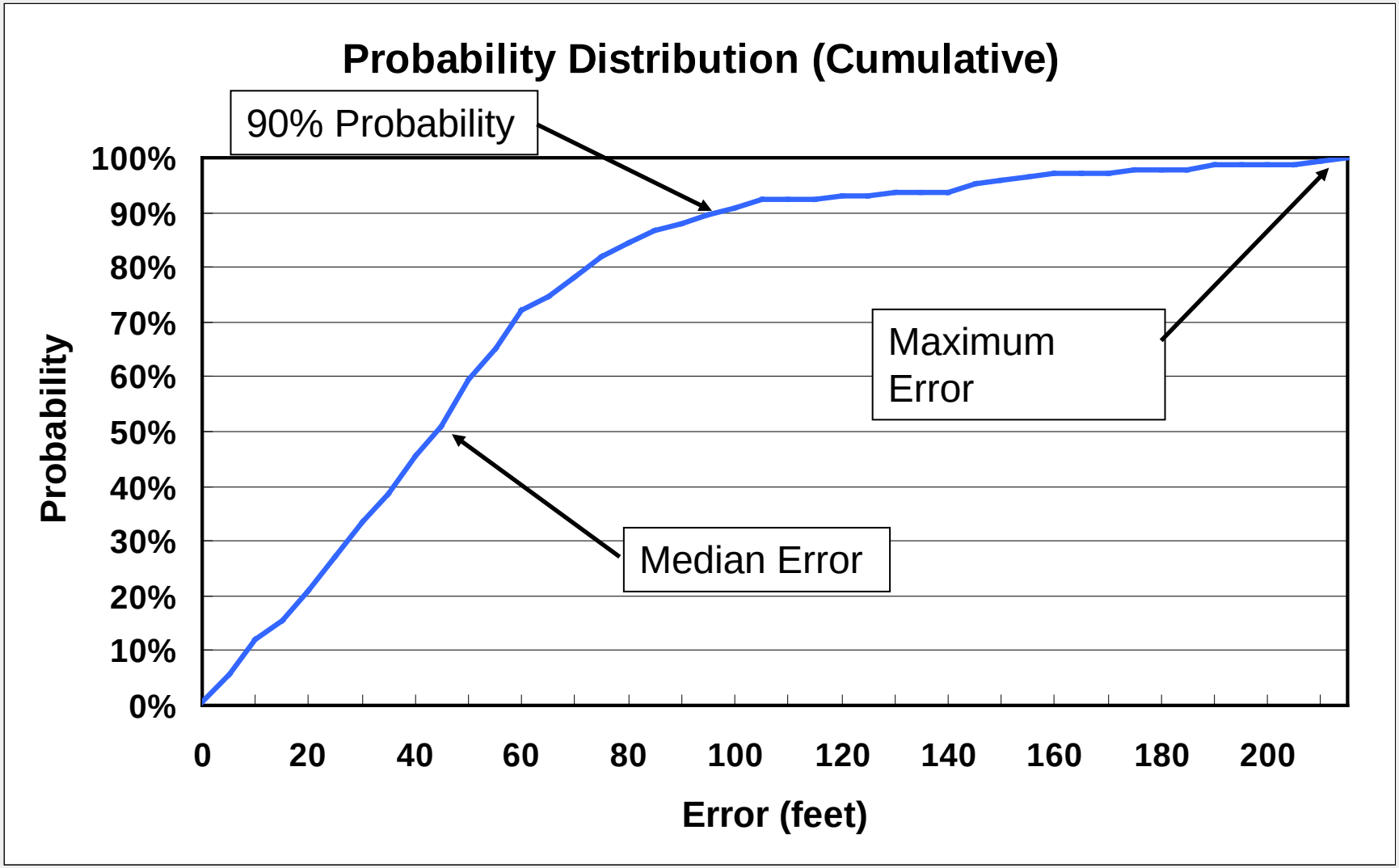

Probabilistic nature of radio measurements is inherent to radio location systems

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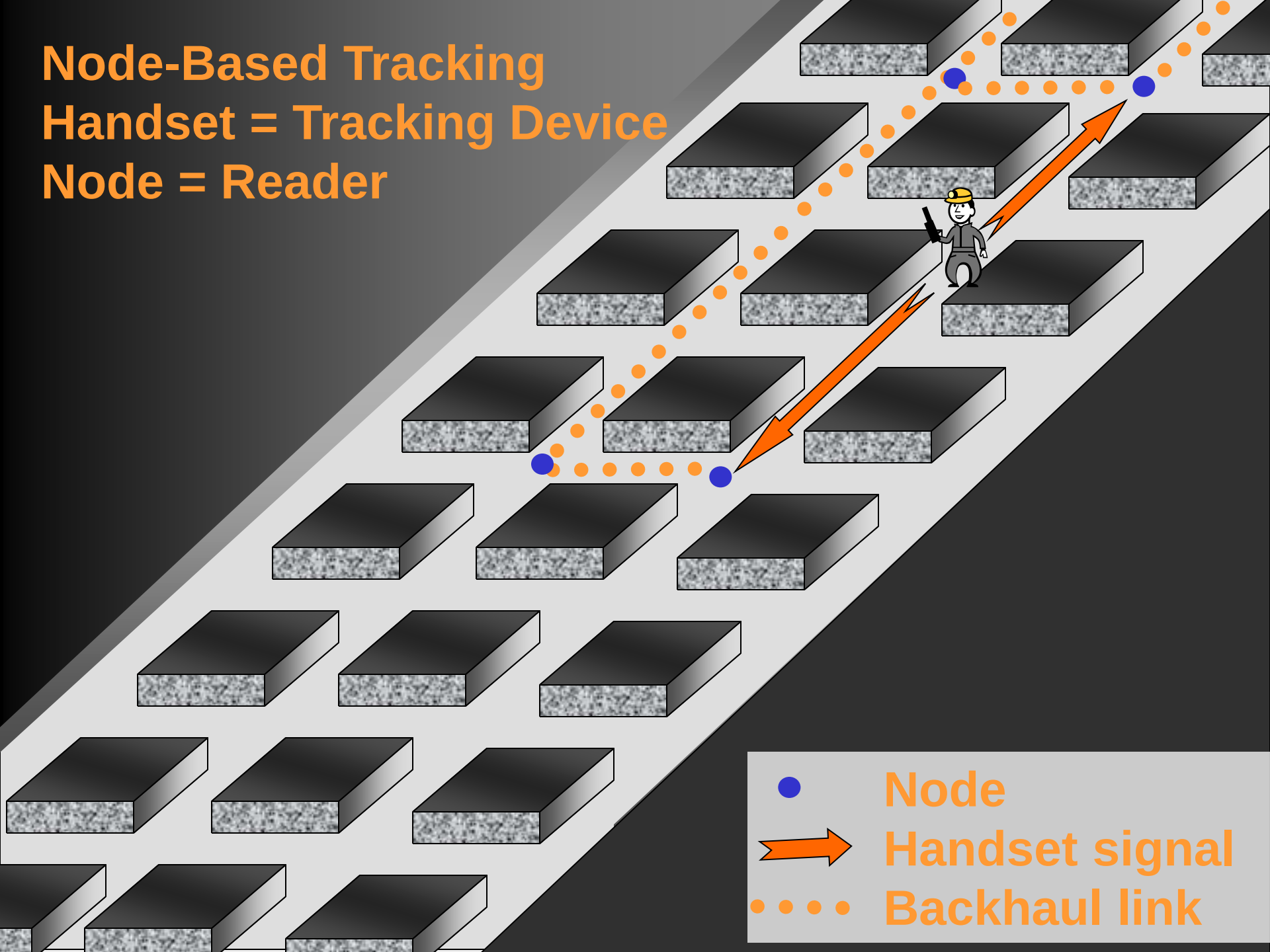
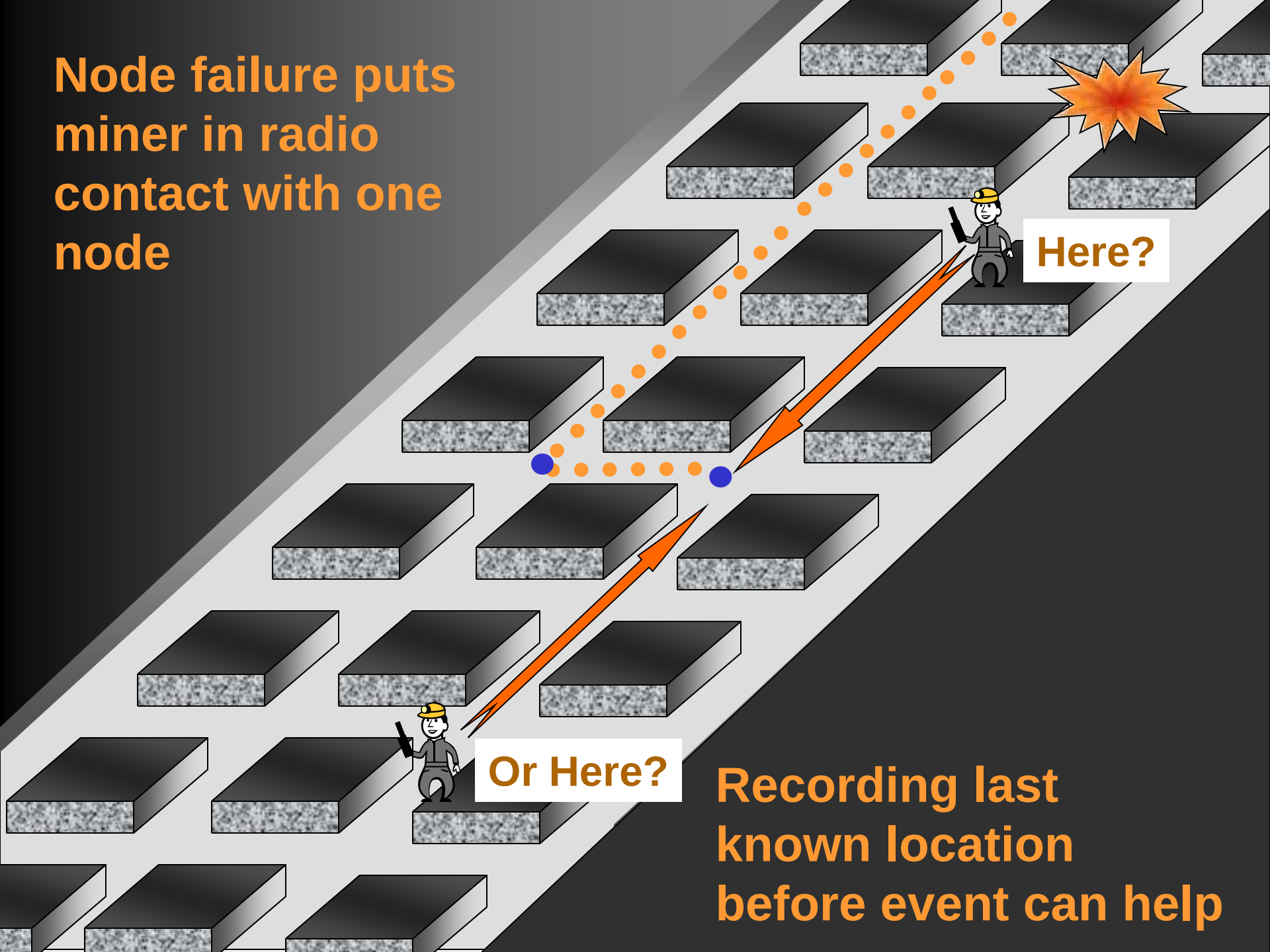
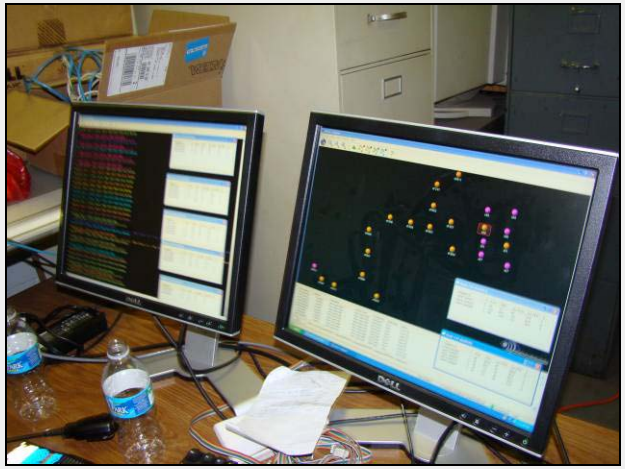



Node failure puts miner in radio contact with one node
Here?
Or Here?
Recording last known location before event can help

Central Server

- **Calculates and displays handset location**
- **Node placement on display must be updated frequently**
- **Last known location before emergency will be saved per MINER Act**
- **Detailed network status must be easily accessible post-event**

Dispatch Display



Network Display

NIOSH Contract: Wireless Mesh Mine Communication and Tracking System

- **L3 Communications Global Security & Engineering Solutions**
- **ICG-Wolf Run Mining Co. Sentinel mine**