UAV-Assisted Broadband Network for Emergency and Public Safety Communications

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Outline

- Introduction
- System Model
- Analysis
- Results
- Conclusion
Introduction

• Earthquakes, Fire, Tornados, etc.

• Damage to Communication Infrastructure

• Wireless communication becomes unusable
Cellular Communication

- Cell Tower
- Mobile Switching Center
- Public Telephone Network

https://en.wikipedia.org/wiki/Cellular_network
Mobile Base Stations

- Truck Based
  - Take time to set up
  - Must follow roads
  - Generally considered slow

Public Safety Communication

• Emergency Responders
  • Emergency Medical Services (EMS)
  • Fire and rescue
  • Police

http://imgmax.com/photos/20130219136129433167814.JPG
Public Safety Communication

• Spectrum Act
  • 700 MHz band

• First Responder Network Authority (FirstNet)
  • Unified Nationwide Public Safety Broadband Network
  • Pictures, Video, Building Layouts, etc.
Unmanned Aerial Vehicles

• Equipped with various sensors and equipment
  • Magnetometer, Accelerometer, Gyroscope, GPS, etc.

• Capable of autonomous navigation and flight
  • Microcontroller
System Model

• UAV Base Stations
  • Form ad hoc network with closest cell tower
System Model

• Deployment Centers
  • House UAVs
  • Receive information about disasters and damaged cell towers
  • Deploys appropriate amount of UAVs
Analysis

- \( T_{Response} = T_{Activation} + T_{Flight} + T_{Sensing} + T_{Setup} \)

- \( T_{Activation} = \) Activation Time of UAV
- \( T_{Flight} = \) Flight time to desired area
- \( T_{Sensing} = \) Time to sense RF spectrum
- \( T_{Setup} = \) Time to setup and begin routing
Analysis

• Channel Capacity

\[ C = \frac{B}{K} \left( \frac{R_D}{R} \right)^{-1} \log_2(1 + \gamma_k) \]

• B = Bandwidth
• K = Number of sub-channels
• \( R_D \) = Reuse Distance
• R = Distance between two nodes
• \( \gamma_k \) = Signal to Interference plus Noise Ratio
Analysis

• **SINR**

\[
\gamma_k = \frac{P_t R^{-\alpha}}{B \cdot N_0} K^{\alpha+1} = \frac{\sigma_s^2}{\sigma_n^2}
\]

- \( P_t = \) Transmitted Power
- \( \alpha = \) Path loss exponent
- \( \sigma_s^2 = \) Variance of received signal
- \( N_0 = \sigma_n^2 = \) Variance of the noise
Analysis

• Throughput

\[ \theta = \frac{B_{PJ} \cdot P_J}{P_d \sum_{i}(P_J + K - 1 + i)p_i} \]

• \( B_{PJ} \) = Rate (bits/packet)
• \( P_J \) = Number of packets
• \( P_d \) = Propagation delay
• \( p_i \) = Probability of packet transmission
• \( i \) = Given duration
Analysis

• Overlap of any two UAV nodes

\[ O = r_i + r_j - \|c_i - c_j\|_2 \geq 0 \]

• \( r_{i,j} = \) Radius of UAV transmission range

• \( \|c_i - c_j\|_2 = \) 2-norm Distance from one UAV to another
Analysis

• Minimum number of UAVs for a given area

\[ N = \frac{A_t}{A_u} \rho_p \]

• \( A_t \) = Coverage area of downed tower
• \( A_u \) = Coverage area of each UAV
• \( \rho_p \) = Packing Density
Results

UAV Transmission Range vs. Needed number of UAVs
Results

Channel Capacity vs. SINR
Results

Channel Capacity vs Reuse Distance Factor
Conclusion

• UAV-Assisted Broadband Network for Emergency and Public Safety Communications
  • Problem Statement
  • Proposed Solution
  • Analysis
  • Results

• Future Works
  • How quick as compared to ground based systems
  • How many users can each UAV handle
  • How to provide security or priority for responders
Questions?