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UAV-Assisted Broadband Network for Emergency and Public Safety Communications

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Outline

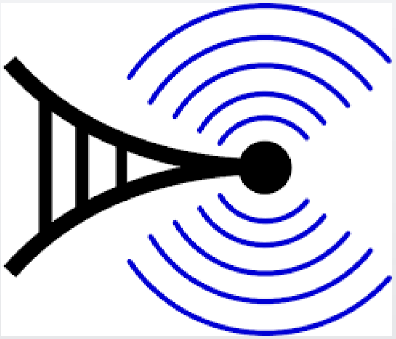
- Introduction
- System Model
- Analysis
- Results
- Conclusion

Introduction

- Earthquakes, Fire, Tornados, etc.

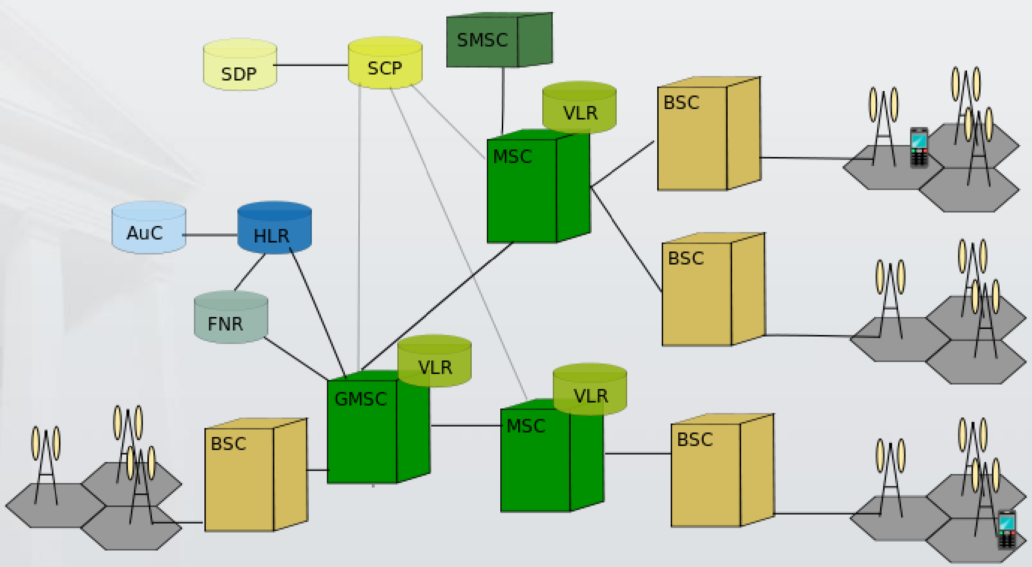
- Damage to Communication Infrastructure

- 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

http://www.hurtzz.com/hurtzzcom/tech/images/16.jpg

Public Safety Communuication

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

http://imgmax.com/photos/20130219136129433167814.JPG

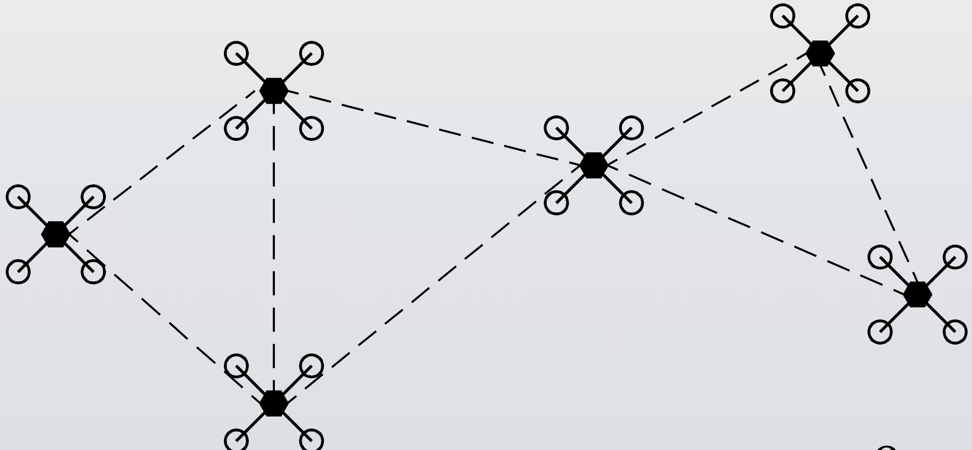
Public Safety Communication

- Spectrum Act
  - 700 MHz band

  - First Responder Network Authority (FirstNet)
    - Unified Nationwide Public Safety **Broadband** Network
    - Pictures, Video, Building Layouts, etc.

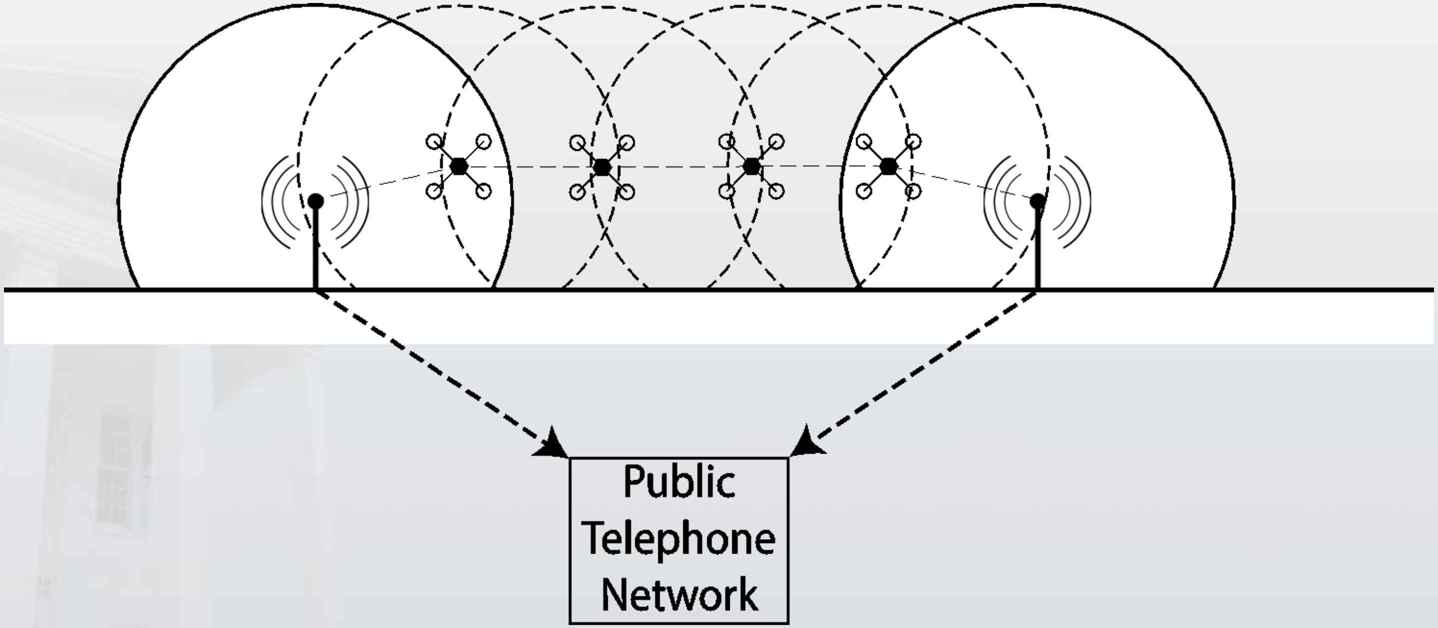
Unmanned Aerial Vehicles

- 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
  - γ_k = Signal to Interference plus Noise Ratio

Analysis

- SINR

$$\gamma_k = \frac{P_t . R^{-\alpha}}{B . N_0} K^{\alpha+1} = \sigma_s^2 / \sigma_n^2$$

- P_t = Transmitted Power
- α = Path loss exponent
- σ_s^2 = Variance of received signal
- $N_0 = \sigma_n^2$ = Variance of the noise

Analysis

- Throughput

$$\theta = \frac{B_{PJ}.P_J}{P_d} \frac{B}{\sum_{\forall i}\left(P_J + K - 1 + i\right)p_i}$$

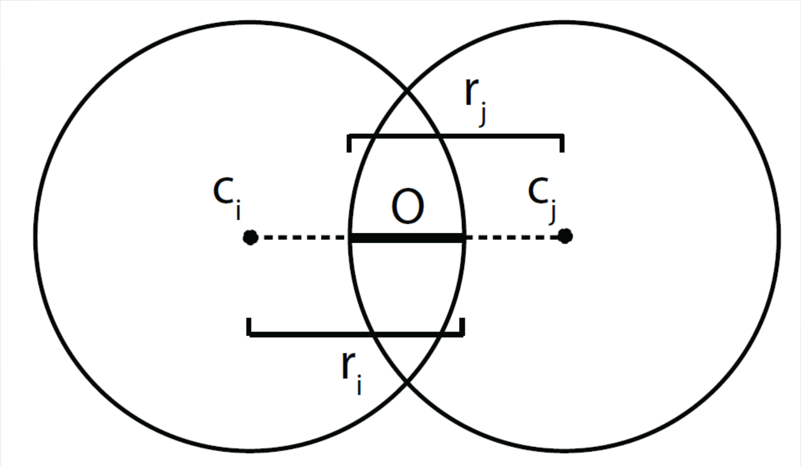
- B_{PJ} = Rate (bits/packet)
- P_J = Number of packets
- P_d= Propagation delay
- p_i = Probability of packet transmission
- i = Given duration

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



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Analysis

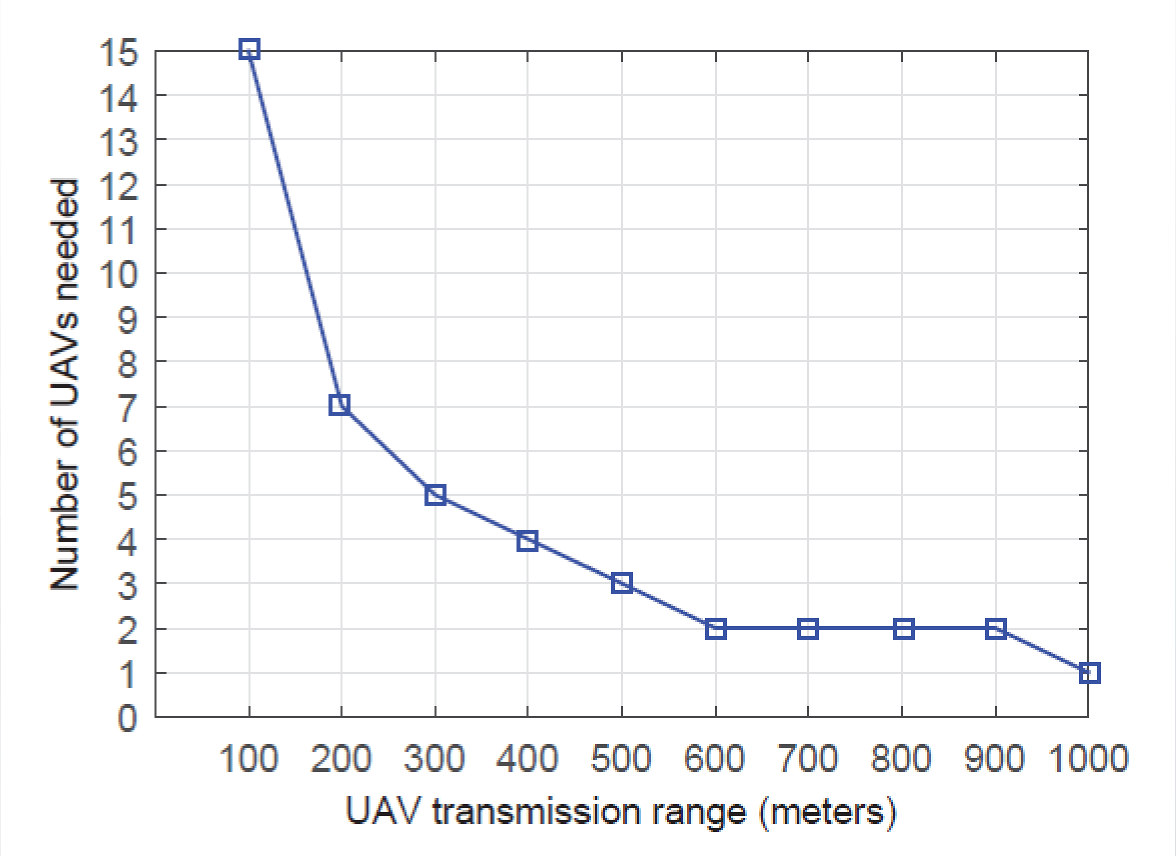
- Minimum number of UAVs for a given area

$$N = \frac{A_t}{A_u} \rho_p$$

  - A_t = Coverage area of downed tower
  - A_u = Coverage area of each UAV
  - ρ_p = Packing Density

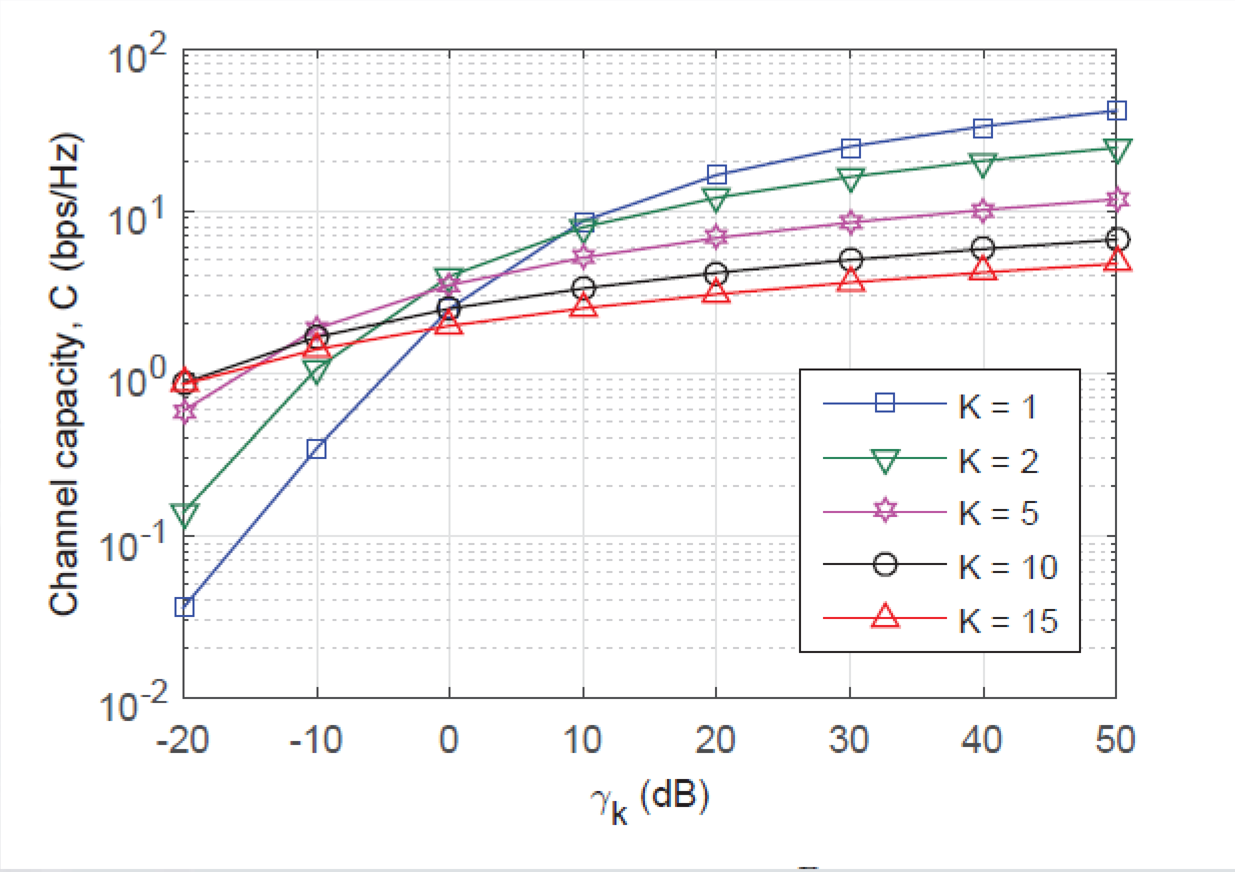
Results

UAV Transmission Range vs. Needed number of UAVs



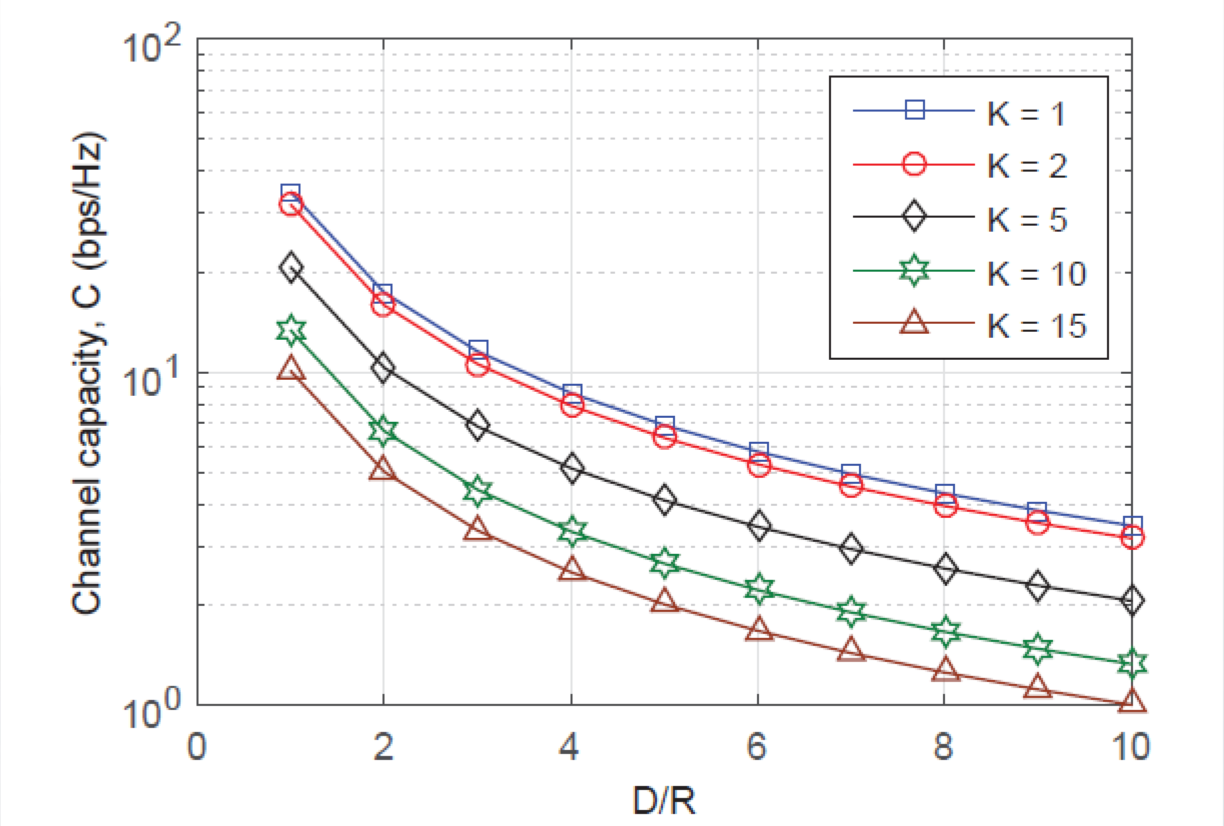
Results

Channel Capacity vs. SINR



Results

Channel Capacity vs Reuse Distance Factor



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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?