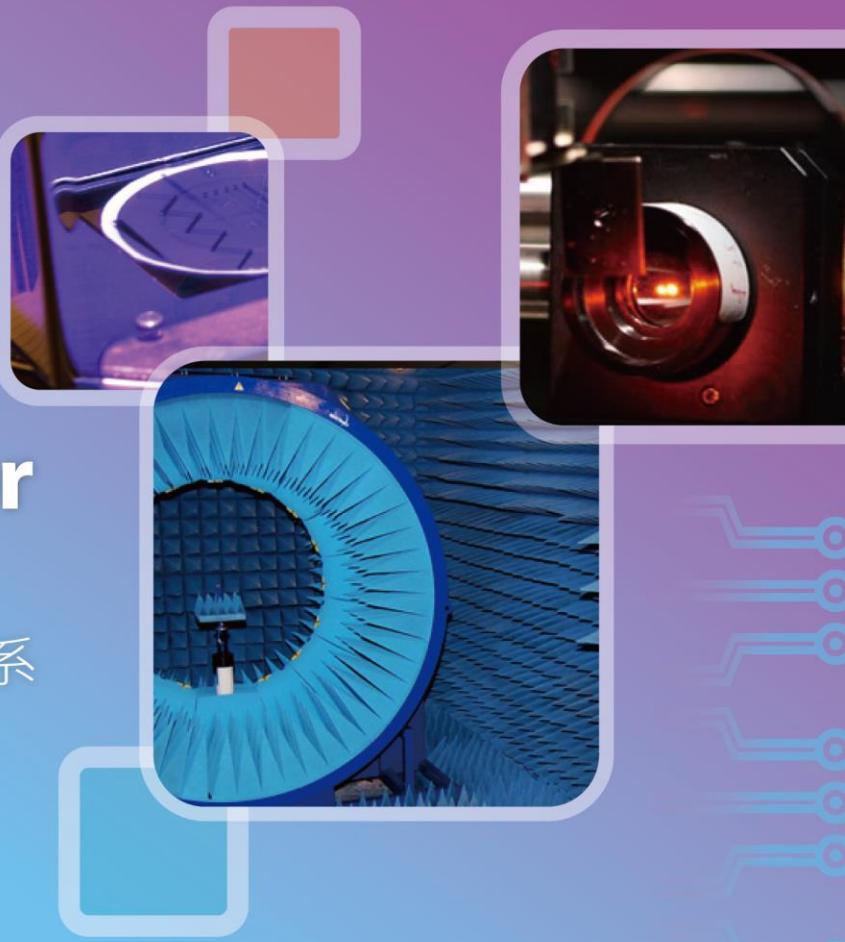
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of Electronic & Computer Engineering

電 子 及 計 算 機 工 程 學 系



Communication:
Mobile Wideband Waveguide Channels

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Acoustic Communication Systems

Background

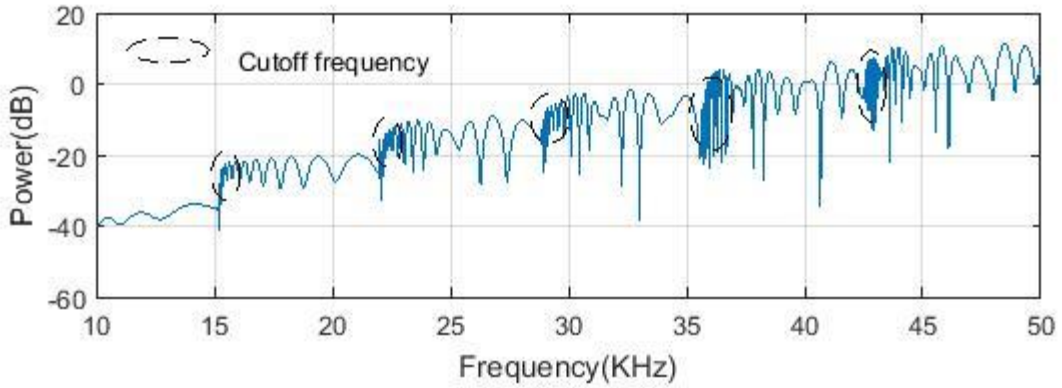
- Communication in Urban Water Supply System for monitoring
  - Moving robots and Sensor network
  - Acoustic waveguide

- Varying communication properties
  - robot in the channel is mobile and will experience different pipe materials and geometries, generating a changing mode cutoff structure

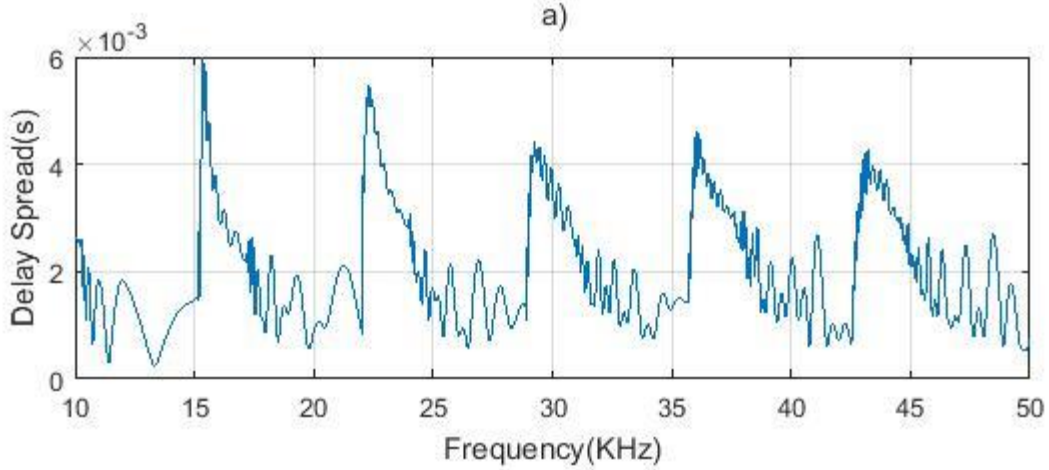
Background

- Propagation occurs in modes, each with a specific cutoff frequency
  - Delay spread characteristics of the channel change significantly across frequency domain
  - High data rate need wider bandwidth, exist more modes
- It is not a uncorrelated scattering wide sense stationary channel
  - Path delays due to modes' dispersion are not uncorrelated
  - Channel correlation function is not invariant over time

Delay spread



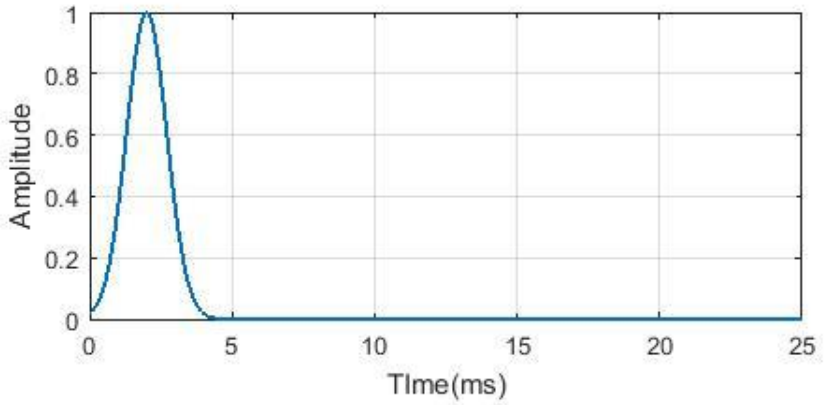
a)



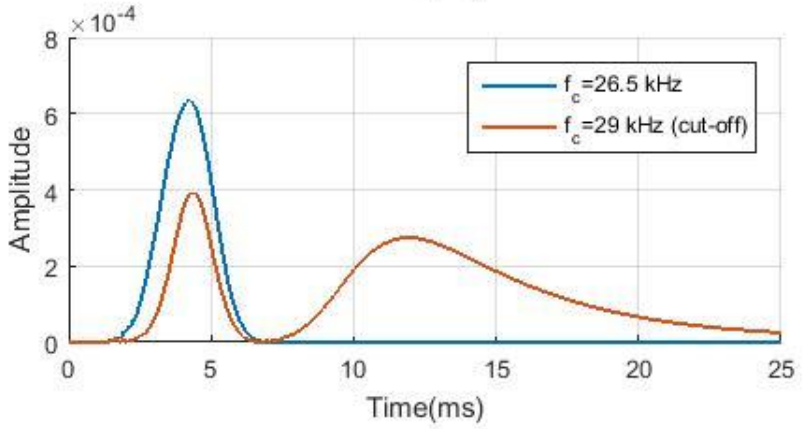
b)

Inter-symbol interference

Transmitted Pulse



Received Pulse (carried by different central frequency)

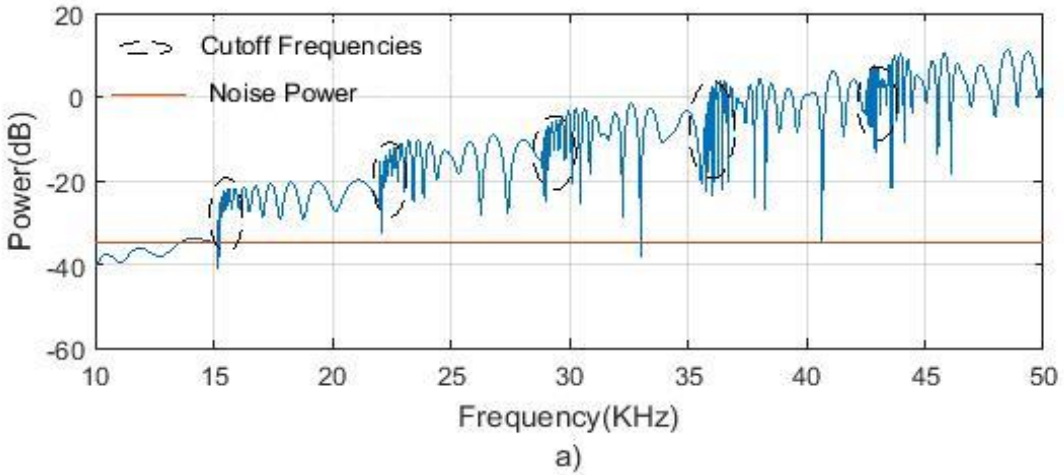


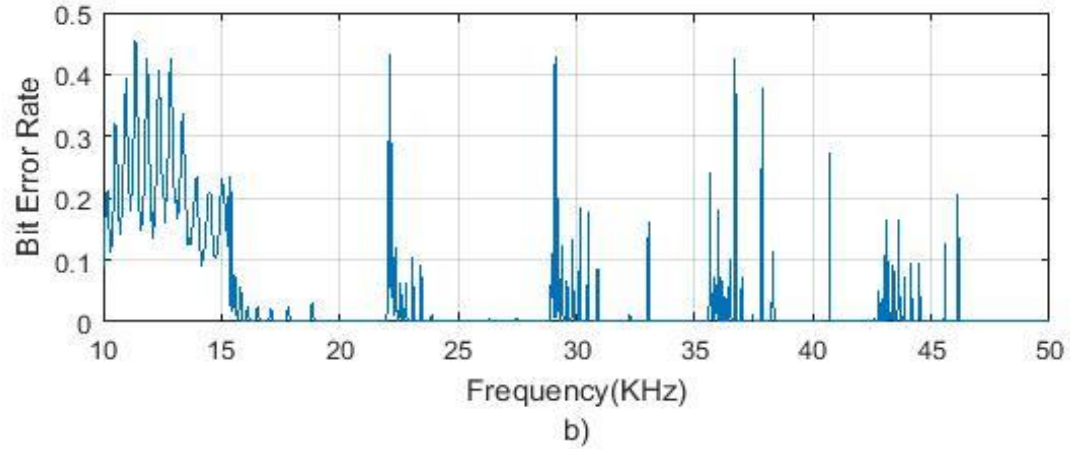
Overlapping to other successive pulse

Method

- OFDM
  - Multi-carrier method
  - Divide wideband signals into multiple narrowband subcarriers
  - Subcarriers are orthogonal to each other and frequency-flat across individual narrow bands
- Advantages of OFDM
  - Easy to implements (FFT/IFFT)
  - Low complexity equalization
- Problem
  - Long guard intervals

Method


Cutoff Frequencies
Noise Power
Power(dB)
Frequency(KHz)
a)


Bit Error Rate
Frequency(KHz)
b)

Method

- Long guard intervals degrade the efficiency of OFDM
  - Detect the subcarriers with large delay spread(close to cutoffs)
  - Abandon those subcarriers and reallocate bits and power to other available bands.
- Subcarrier delay spread estimation
  - Variance based method
  - Coherence bandwith based method

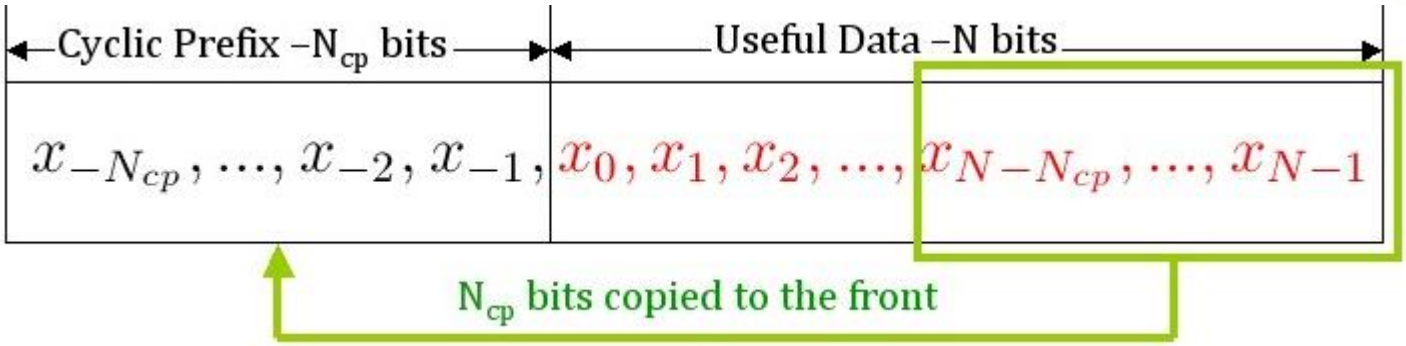
Method

- Variance based method
  - Sending multiples training symbols to estimate channel response
  - Variance of samples indicates the amount of interference
- Coherence bandwidth based method
  - Coherence bandwidth is the reciprocal to delay spread
  - Frequency Correlation function:

$$C(\delta f) = \frac{\sum_{-L/2}^{L/2} H(f)H^*(f+\delta f)}{\sum_{-L/2}^{L/2} |H(f)|^2} \qquad C(\delta f = B_{sub}) > 0.5, B_C > B_{sub}$$

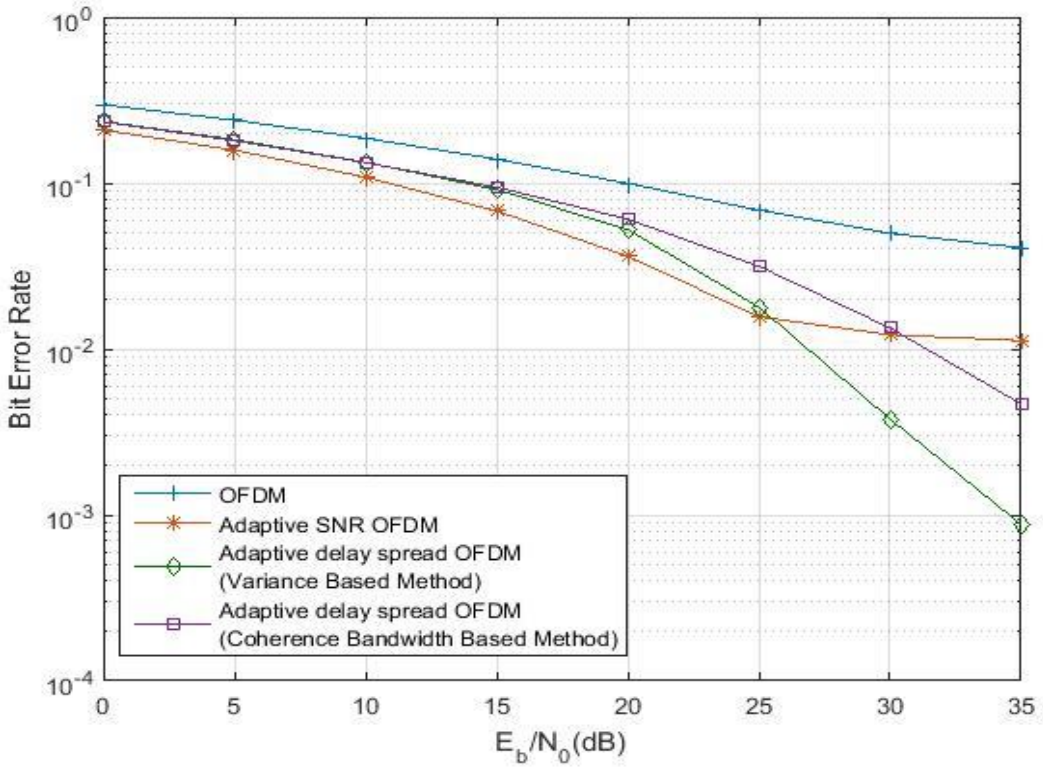
Simulation results

- Parameters
  - Total Bandwidth: $B = 40\ \text{kHz}\ (10\ \text{kHz}\sim 50\ \text{kHz})$
  - Number of total subcarriers: $N = 512 = 2^9$
  - Carrier spacing: $B_{sub} = \frac{B}{N} = 78\ \text{Hz}$
  - Number of cyclic prefix: $N_{cp} = \frac{N}{8} = 64$
    - Cyclic prefix refers to the prefixing of a symbol with a repetition



Experimental results

- Results



Conclusion and Future Plans

- Identify special features of Mobile wideband waveguide channel
- Exhibits non USWSS properties
- Use adaptive delay spread OFDM
- Demonstrated to perform well
- Future plans
  - Use FYP to prototype system
  - Extend to channels with fast fading