# Interference Mitigating in Wireless Networks Using Prior Knowledge

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(EE 555)

# Multihop Wireless Networks

- Multihop Wireless Network (MWN):
  - A wireless network adopting multihop wireless technology without deployment of wired backhaul links
- Similar to Mobile Ad hoc Networks (MANET), but
  - Nodes in MWN is relative 'fixed'
  - MWN may introduce 'hierarchy' network architecture

# Multihop Wireless Networks

- Two categories:
  - Relay:
    - Tree based topology, one end of the path is the base station
    - Dedicated carrier owned infrastructure
  - Mesh:
    - Mesh topology, multiple connections among users
    - Routing by carrier owned infrastructure or subscriber equipment

# Multihop Wireless Networks

- Benefit of multi-hop technology
  - Rapid deployment with lower-cost backhaul
  - Easy to provide coverage in hard-to-wire areas
  - Under the right circumstances, it may
    - Extend coverage due to multi-hop forwarding
    - Enhance throughput due to shorter hops
    - Extend battery life due to lower power transmission
- Price paid
  - Routing complexity
  - Path management
  - Extra delay due to multihop relaying

# Objective

- Framework to mitigate interference in high data rate mobile wirelesss networking.
- Multihop wireless networking.
- Correlation with previous available data in the decoding process.
- Problem is interpreted as one of the transmission over multiple access channel with prior information.

# Introduction

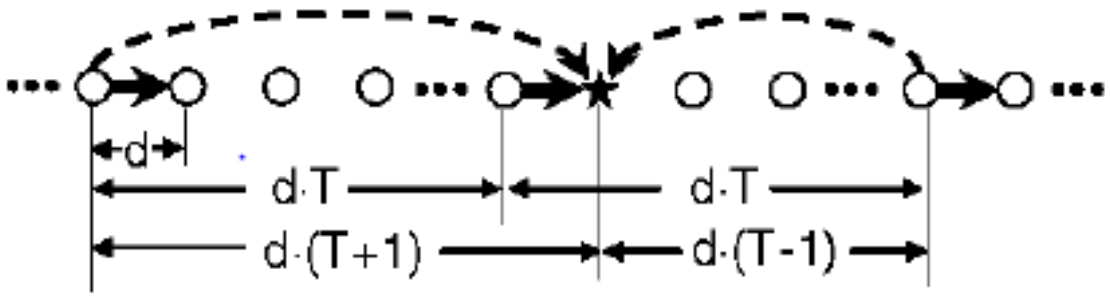


Fig. 1. The string topology. Each node transmits once every T time-slots. Nodes are uniformly spaced d meters apart. The direct transmission is shown with a solid line and interference is shown with a dashed line.

# Introduction (Contd.)

$$BR = BW \log_2(1 + SNIR)$$

$$BR(T) = \frac{BW}{T} log_2(1+ \frac{KP_T/d^{\alpha}}{N + \sum_{j=1}^{\infty} KP_T/(d(jT-1)^{\alpha}) + \sum_{j=1}^{\infty} KP_T/(d(jT+1)^{\alpha})})$$

$$BR(T) \leq \frac{BW}{T} \log_2 \left(1 + \frac{KP_T/d^{\alpha}}{KP_T/(d(T-1))^{\alpha}}\right)$$

$$= \frac{BW}{T} \log_2 \left(1 + (T-1)^{\alpha}\right).$$

# Introduction (Contd)

- Two decoding schemes to improve performance
  - Interference aware decoding
    - Statistics of interference are different from noise.
  - Interference mitigating decoding
    - Correlation existing between interference and previously available data to achieve improved performance.

# String Topology

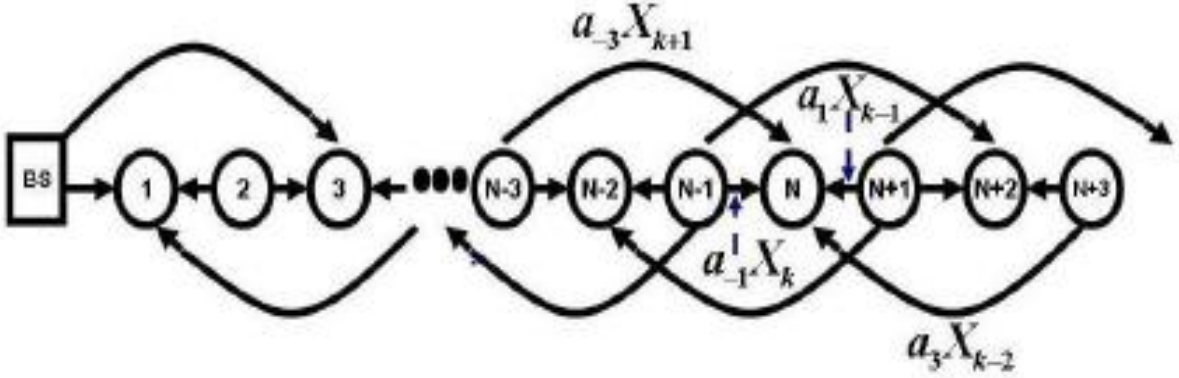


Fig. 2. An even time-slot is shown where all odds numbered nodes transmit and even numbered nodes receive the sum of all transmissions.

# String Topology (Contd)

- Signal received by node N
  - $Y = a_{-3}X_{k+1} + X_k + a_1X_{k-1} + Z.$
- Behavior of node 3
  - time-slot 1: $Y_1 = a_{-3}X_1 + Z_1$
  - time-slot 3: $Y_3 = a_{-3}X_2 + X_1 + Z_3$
  - time-slot 5: $Y_5 = a_{-3}X_3 + X_2 + a_1X_1 + Z_5$
  - time-slot 7: $Y_7 = a_{-3}X_4 + X_3 + a_1X_2 + Z_7.$

# String Topology (Contd)

- Interference aware decoding
  - During time slot 3, interference $a_{-3}X_2$ is not noise but data transmission.
  - Multiple access decoding with two users allows $U_1$ to be decoded in the presence of $a_{-3}x_2$.

# String Topology (Contd)

- Interference mitigating decoding
  - 2 steps are taken
    - First, during time-slot 1, node 3's estimate of $U_1$ is denoted $U_1$. This estimate is based on the perhaps weak signal $a_{-3}X_1$.
    - Next, during time-slot 3, node 3 makes a second estimate of $U_1$, we denote this estimate as $U_1$.

# String Topology (Contd)

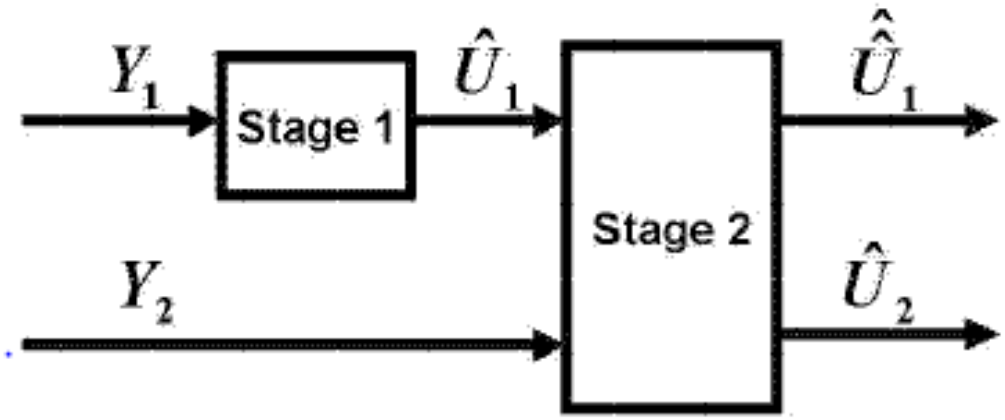


Fig. 3. Interference mitigating decoding in string topology decodes packet in two stages.

# Star Topology

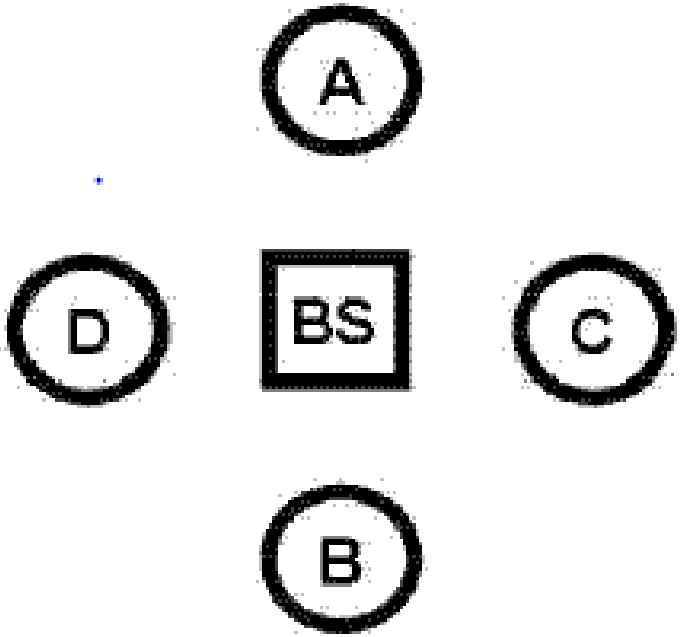


Fig. 4. Star topology with 4 nodes around base station.

# Star topology (Contd)

- 1st time slot
  - $Y_1^A = X_1 + Z_1^A$
  - $Y_1^B = X_1 + Z_1^B$
  - $Y_1^C = X_1 + Z_1^C$
  - $Y_1^D = X_1 + Z_1^D$
- 2nd time slot
  - $Y_2^B = X_2 + aX_1 + Z_2^B$
  - $Y_2^C = X_2 + bX_1 + Z_2^C$
  - $Y_2^D = X_2 + bX_1 + Z_2^D$

# Star Topology (Contd)

- Interference aware decoding
  - Interference during time slot 5 is not noise but data transmission.
  - Mulitple access decoding allows $U_5$ to be decoded in the presence of $bX_4$.

# Star Topology (Contd)

- Interference mitigating decoding
  - 3 steps are taken
    - During timeslot 3, node A's estimate of $U_3$ is denoted $U_3$'.
    - Next, during time-slot 4, node A uses $U_3$' as a prior information to obtain an estimate of $U_4$, denoted as $U_4$'.
    - Again, during time-slot 5, node A makes use of $U_4$' to obtain the estimate of $U_5$.

# Star Topology (Contd)

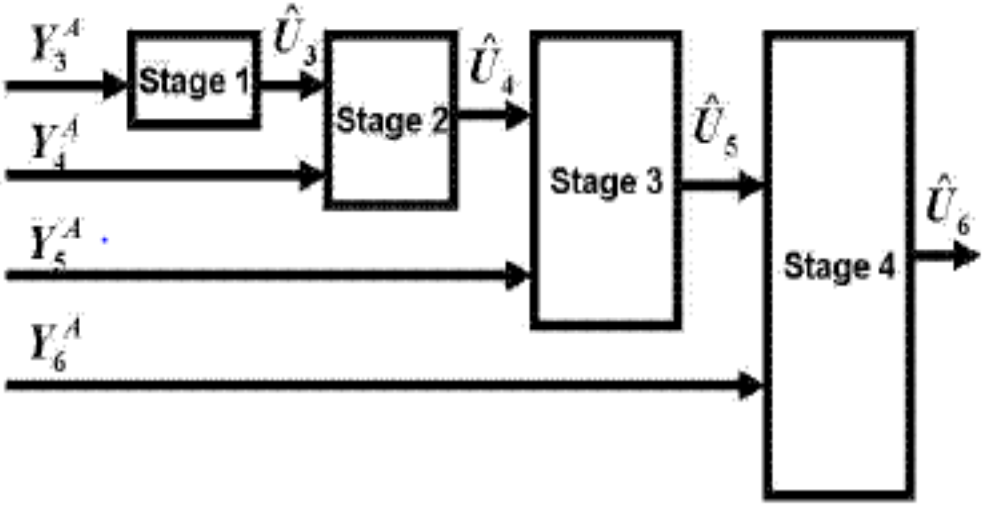


Fig. 6. Interference mitigating decoding for a star topology with 5 nodes decodes packet in four stages.

# Simulation Results (String)

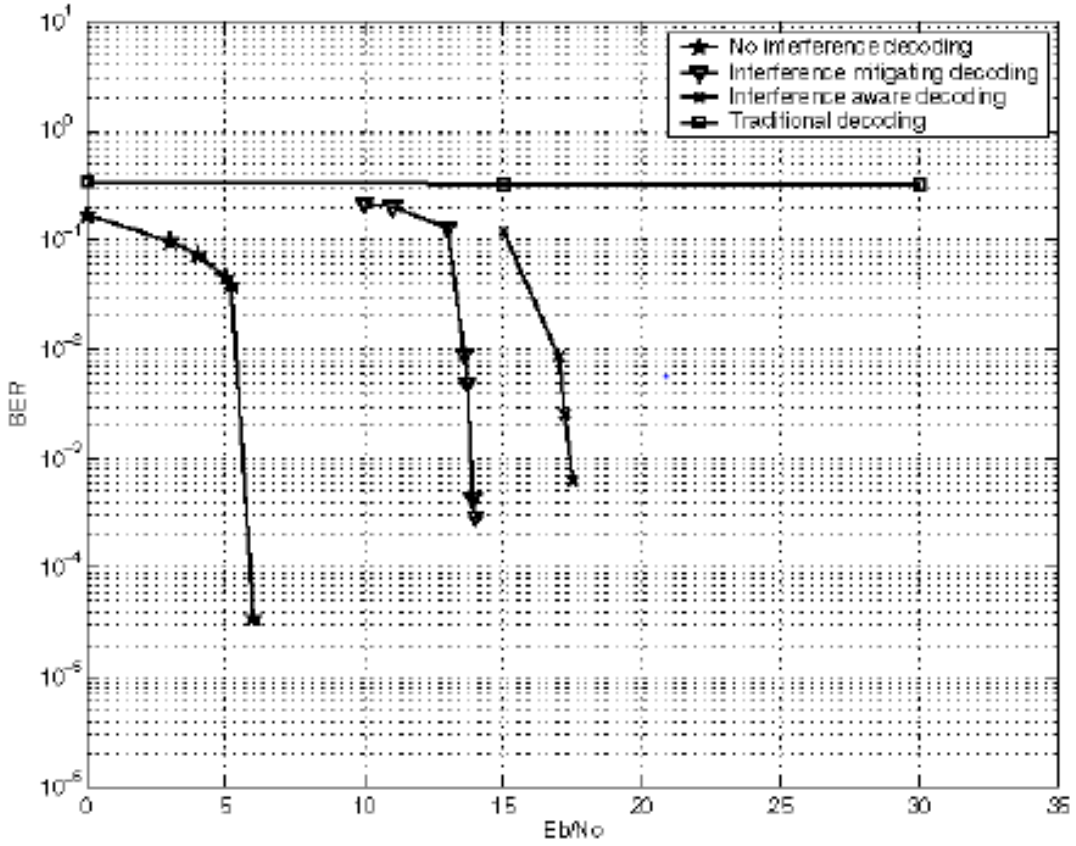


Fig. 7. For the string topology, performance of interference mitigating and interference aware decoding methods. In these plots it is assumed that the amplitude of the interfering signal is one third of the amplitude of the primary signal.

# Simulation Results (String)

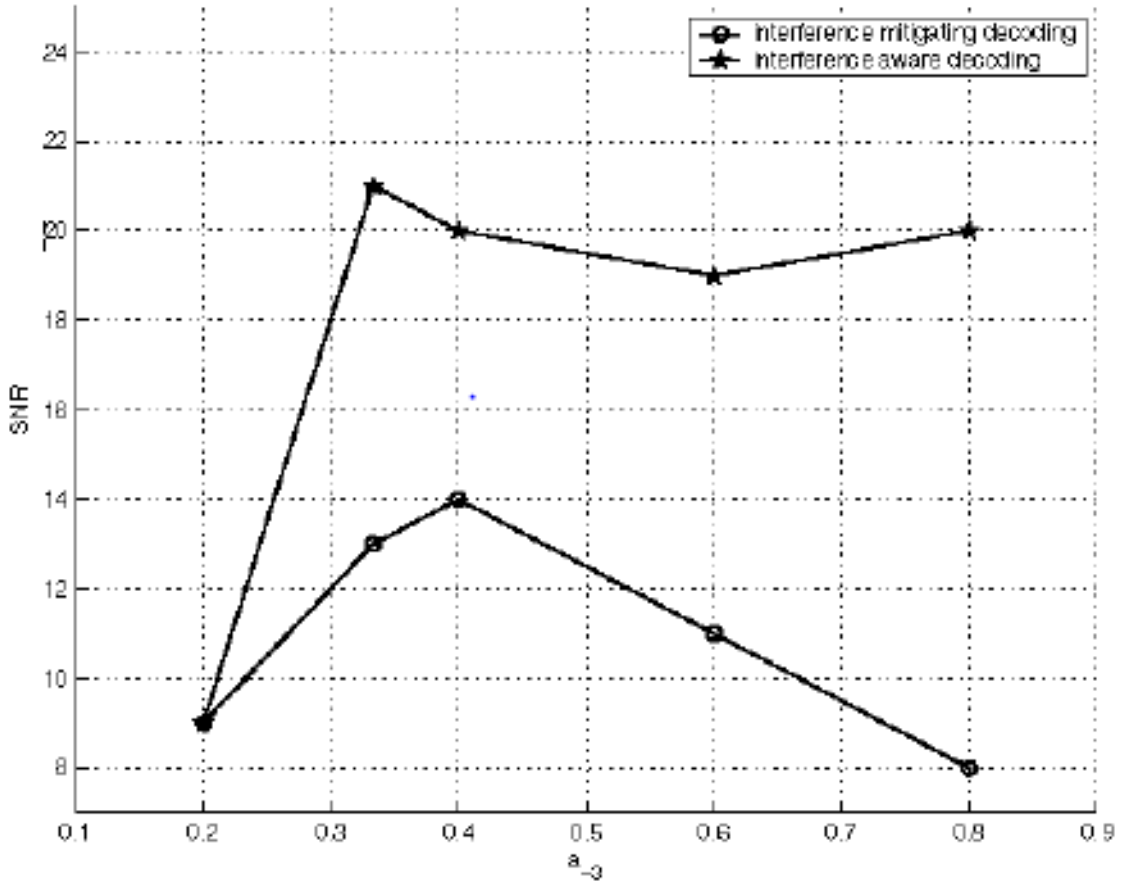


Fig. 8. For the string topology, required SNR for reliable information transmission ($BER < 10^{-5}$) as a function of the interference power.

# Simulation Results (Star)

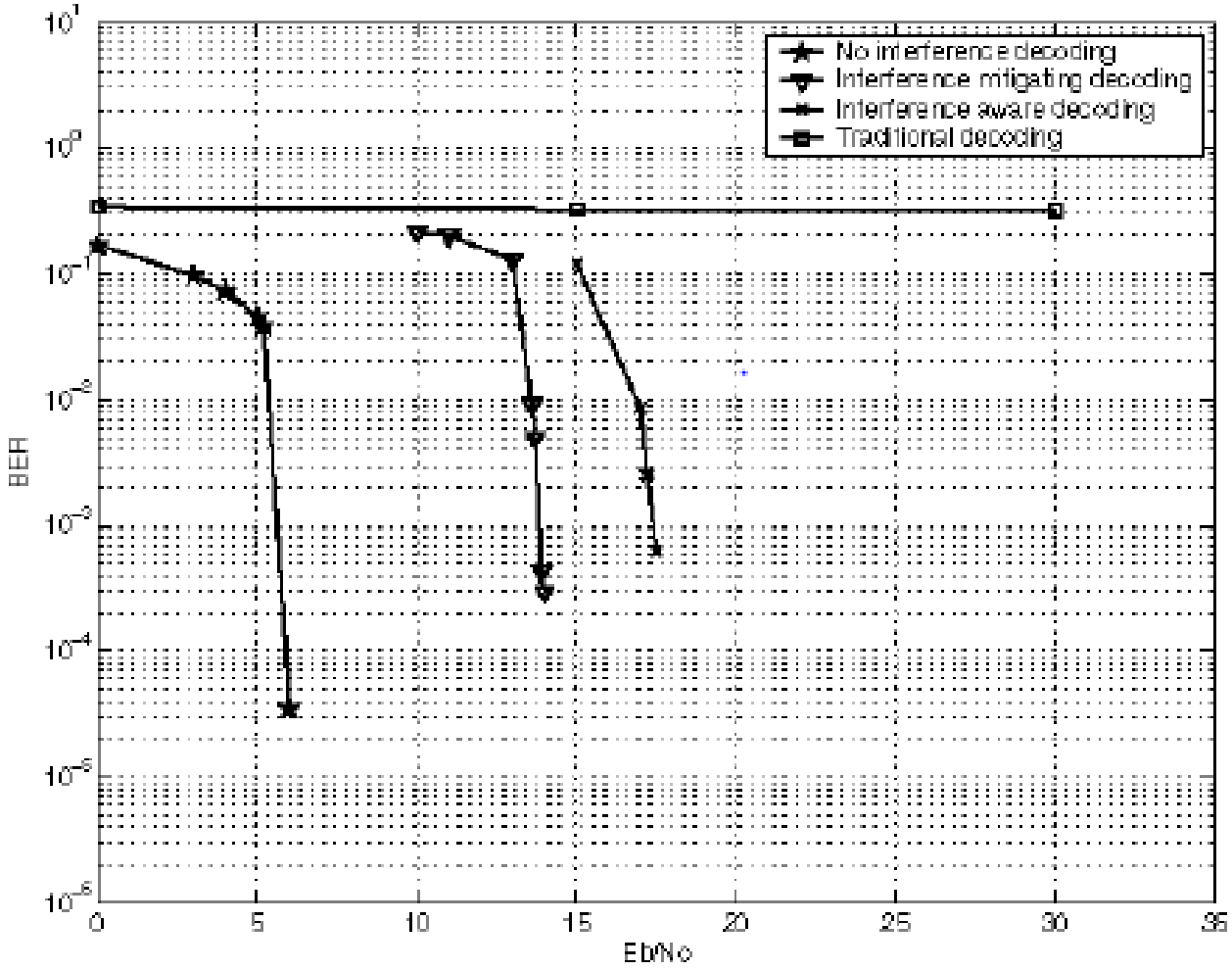


Fig. 9. Performance of interference mitigating and interference aware decoding methods for a star topology with 4 nodes.

# Conclusion and Future Work

- Both interference aware decoding and interference mitigating decoding perform better than traditional decoding schemes.
- Model can be extended to complicated environment with multiple neighboring nodes with prior information.