MIMO Enabled Efficient Mapping of Data in WiMAX Networks

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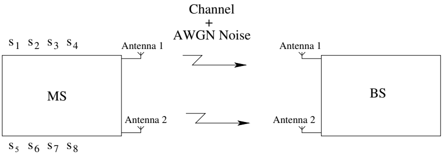
Introduction to WiMAX Networks

- Uses Orthogonal Frequency Division Multiple Access (OFDMA) scalable from 1.25MHz to 20MHz
- Supports multiple antennas at both Base Station and Mobile Station
- Supports advanced antenna techniques such as spatial diversity, spatial multiplexing, beam forming, and collaborative spatial multiplexing
- Supports adaptive modulation and coding techniques
- Supports multiple QoS classes
- Popular wireless broadband solution

Multiple Input Multiple Output (MIMO) Techniques

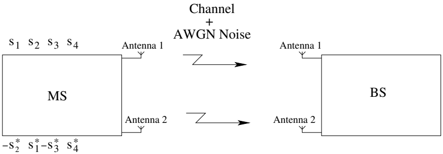
- Spatial Multiplexing
- Spatial Diversity
- Hybrid techniques

Spatial Multiplexing



- Different symbols (data) are transmitted across different antennas in the same slot
- BS also utilizes multiple antennas to receive the transmitted symbols
- Improves the throughput of the network

Spatial Diversity



- Variant of the data transmitted at one antenna is transmitted at another antenna
- Increase in diversity order improves the reliability of transmitted data

Hybrid Techniques

- Combination of diversity and multiplexing techniques can be used
- Trade-off between throughput and reliability is a well studied topic

Problem Statement

Propose a MIMO technique that provides reliability same as Diversity techniques, and throughput comparable to Multiplexing techniques, for uplink transmissions

Probable Applications

In high mobility conditions,

- Channel quality can not be determined perfectly all the time
- Currently, MIMO techniques are switched adaptively to maximize performance
- With the proposed solution, adaptive MIMO switching is not required

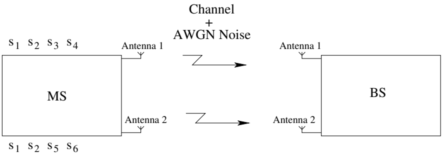
Solution Overview

- Transmit redundant data across different antenna only for first 2 slots
- Works only when data from one antenna is received with error, and the other stream is received without error
- Determine and Eliminate the error in the erroneous stream

Result

- Higher throughput is achieved
- Proved that reliability of transmitted data is same as that of Diversity techniques

Proposed Technique



- Only the first two slots across both the antennas contain the same data
- Remaining slots at both the antenna will contain different data
- Both antenna transmit same data across all slots in Diversity techniques
- Both antenna transmit same data across few (2) slots in proposed technique
- Throughput is improved comparatively

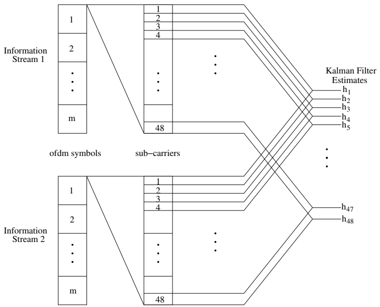
Challenges

- Improving reliability of the transmitted data across all slots

Solution

- Works when one of the streams is erroneous and the other is received non-erroneous
- Determines the error in the erroneous stream by comparing with the correctly received stream, as same data is transmitted in first 2 slots of both streams
- Uses Kalman Filter at sub-carrier level to determine the error in erroneous stream
- The error determined remains constant for further slots, and data from the erroneous stream is recovered by removing the error

Error Determination

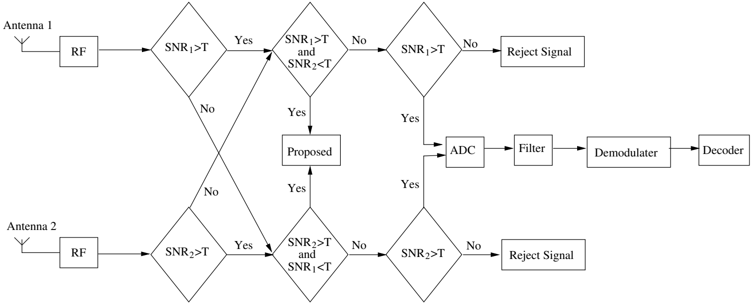


- Estimate 'h_1' for sub-carrier 1
- Update the estimate repeatedly for all the sub-carriers in one OFDM slot, for each sub-carrier separately
- The estimated error is constant for the given two streams, and Kalman filter updates converge to a value after an average of 40 estimations

Assumptions

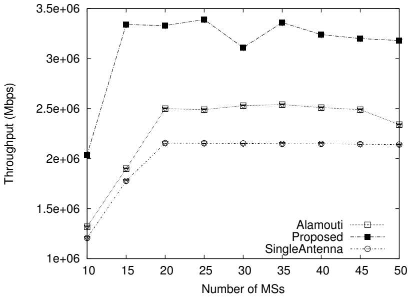
- Channel quality remains constant for each MS in a 5 *ms* frame
- Noise value remains in a Galois Field when a signal is processed

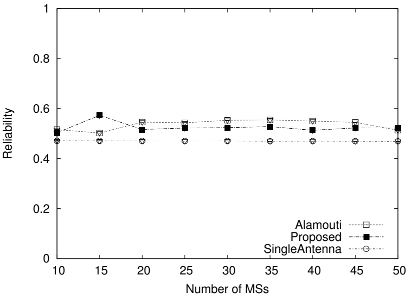
Signal Level Block Diagram



- Erroneous stream is convolved with inverse of the determined error signal, and the error is eliminated
- Traditional decoding techniques are used to retrieve data

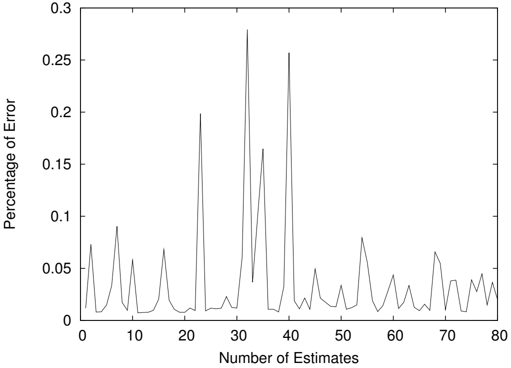
Network Performance Results





- Higher throughput is achieved
- Reliability equivalent to that of Diversity technique is achieved

Kalman Filter Convergence



- The estimated error remains $< 5\%$ after 40 iterations
- Proved that Kalman filter is applicable

Conclusion

- Throughput is maximized with highest possible reliability
- Works under the assumptions
  - Channel quality remains constant in one OFDMA frame of 5 *ms*
  - Data transmitted from only one antenna is received with out errors

Future Work

- Relaxing the above assumptions to provide a solution
- Studying the characteristics of a mobile in high mobility situations

Thank you !