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Optimal pilot sequence design for machine learning based channel estimation in FDD massive MIMO systems

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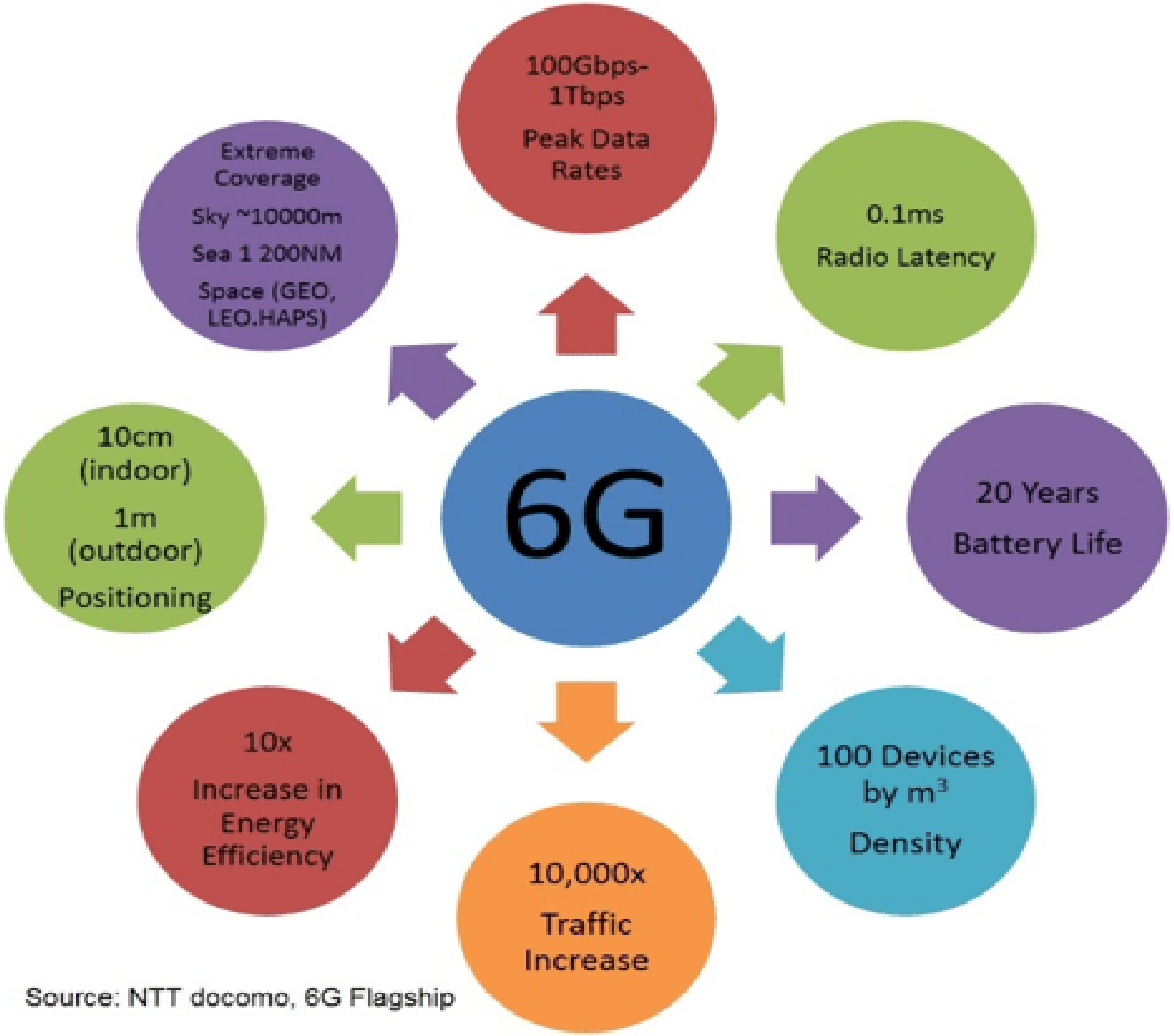
Session 1: **Enabling future wireless communication systems**

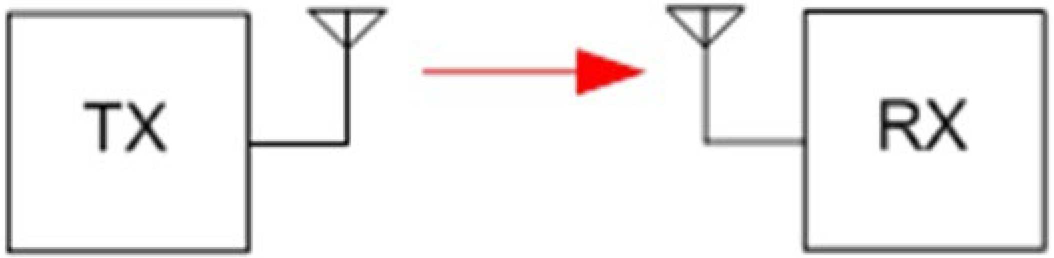
Paper S1.4: Optimal pilot sequence design for machine learning based channel estimation in FDD massive MIMO systems

Overview

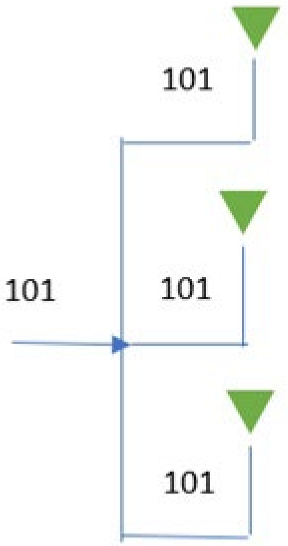


Source: NTT docomo, 6G Flagship

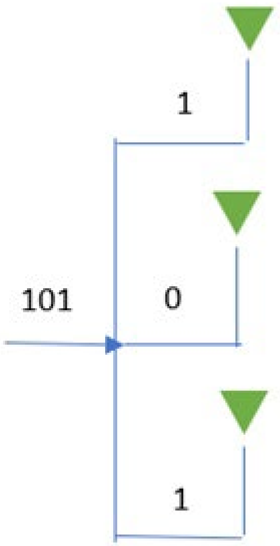
What is MIMO?



What is MIMO?



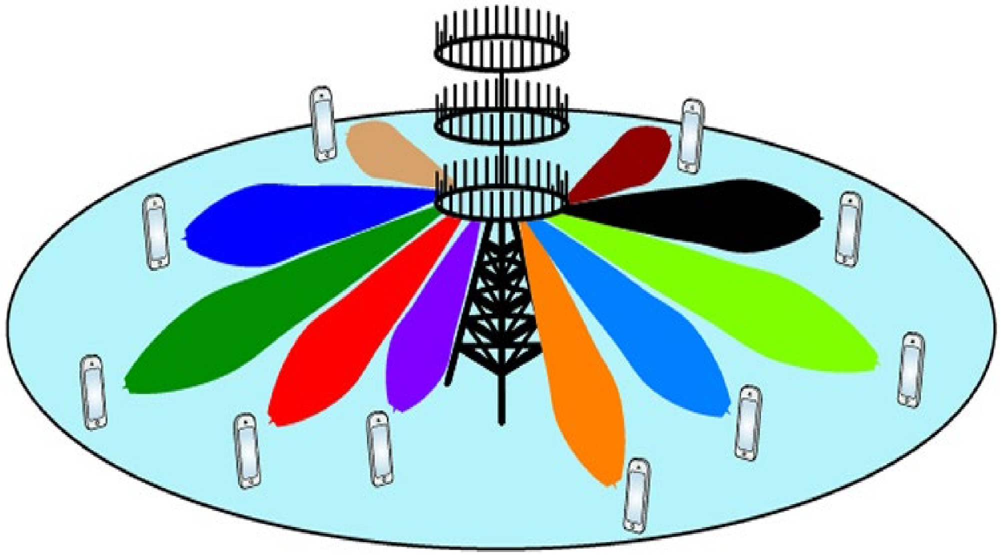
MIMO with Diversity



MIMO with Multiplexing

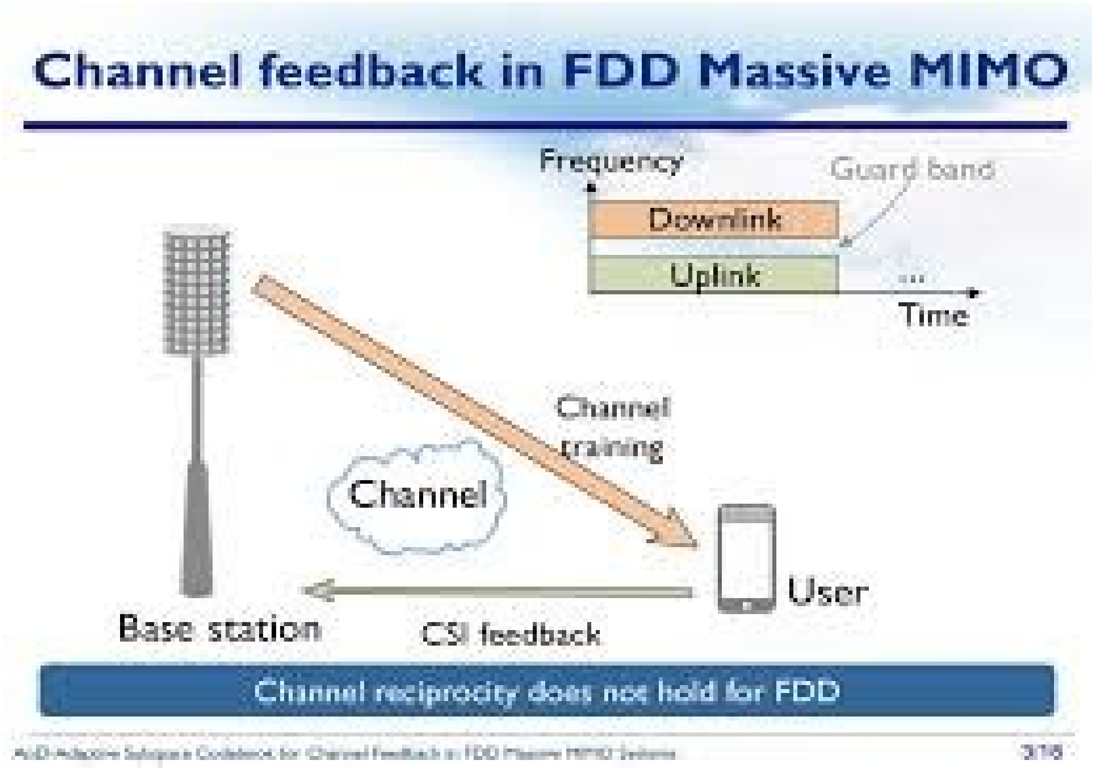
Massive MIMO

- System using a large number of antennas at the BS;
- accordingly, a signicant beamforming can be achieved;
- and the system capacity can serve a large number of users.



Massive MIMO Main Challenge

- The antennas at the base station send orthogonal pilots to the mobile stations and the channel will be estimated by the mobile station.
- The estimated channel will be then fedback to the base station. Hence, the number of orthogonal pilots is proportional to the number of antennas.
- That makes FDD impractical when employing a very large number of antenna arrays at the base station.



Aims & Objectives

Motivated by massive MIMO outstanding performance

And Considering Pilot Overhead Problem

We need to develop new techniques and approaches to construct a channel estimation scheme with a limited number of pilots to address the pilot overhead problem.

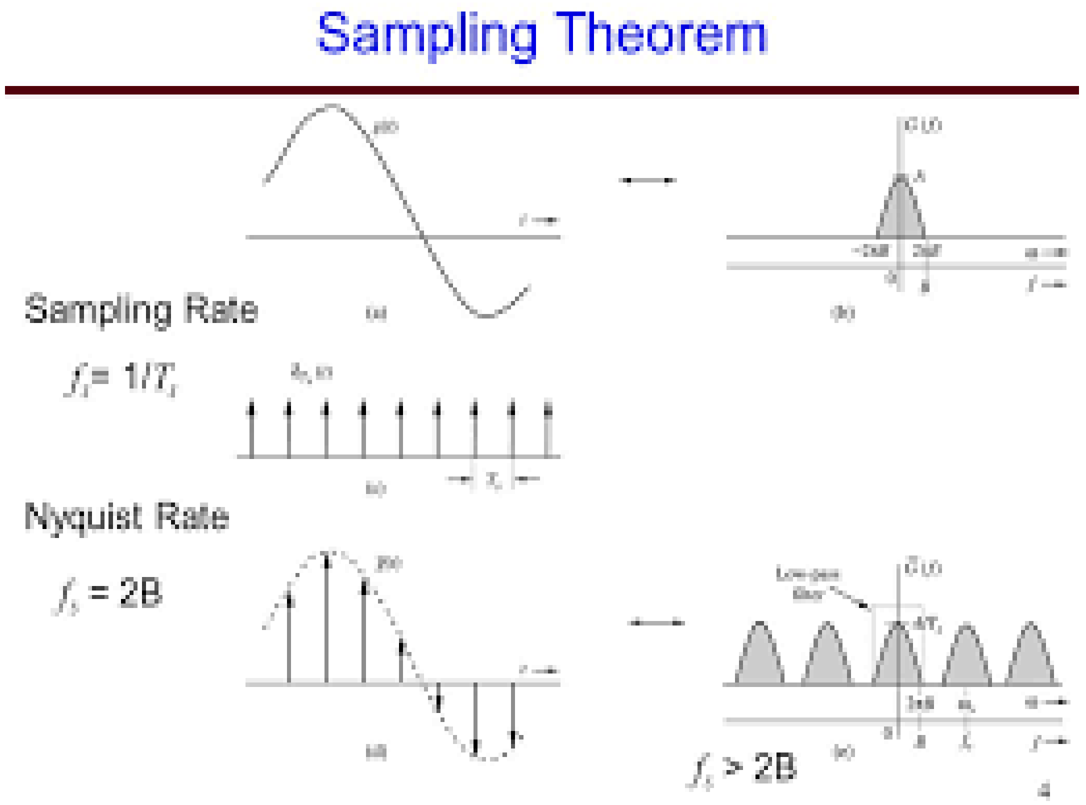
Contributions

Compressed Sensing	Exploit the sparse nature of the Channel to reduce the required number of antenna to address the pilot overhead problem of FDD Massive MIMO.
Bayesian Estimation	Exploit the statistical knowledge regarding the channel scarcity to improve the estimation accuracy.
Optimal Pilot Design	The Optimal pilots are designed to minimize the MSE under the total transmit power constraints based on optimization problem formulation.

Compressed Sensing (CS)

- Compressed sensing (CS) techniques can recover the unknown signals from only a small number of measurements,

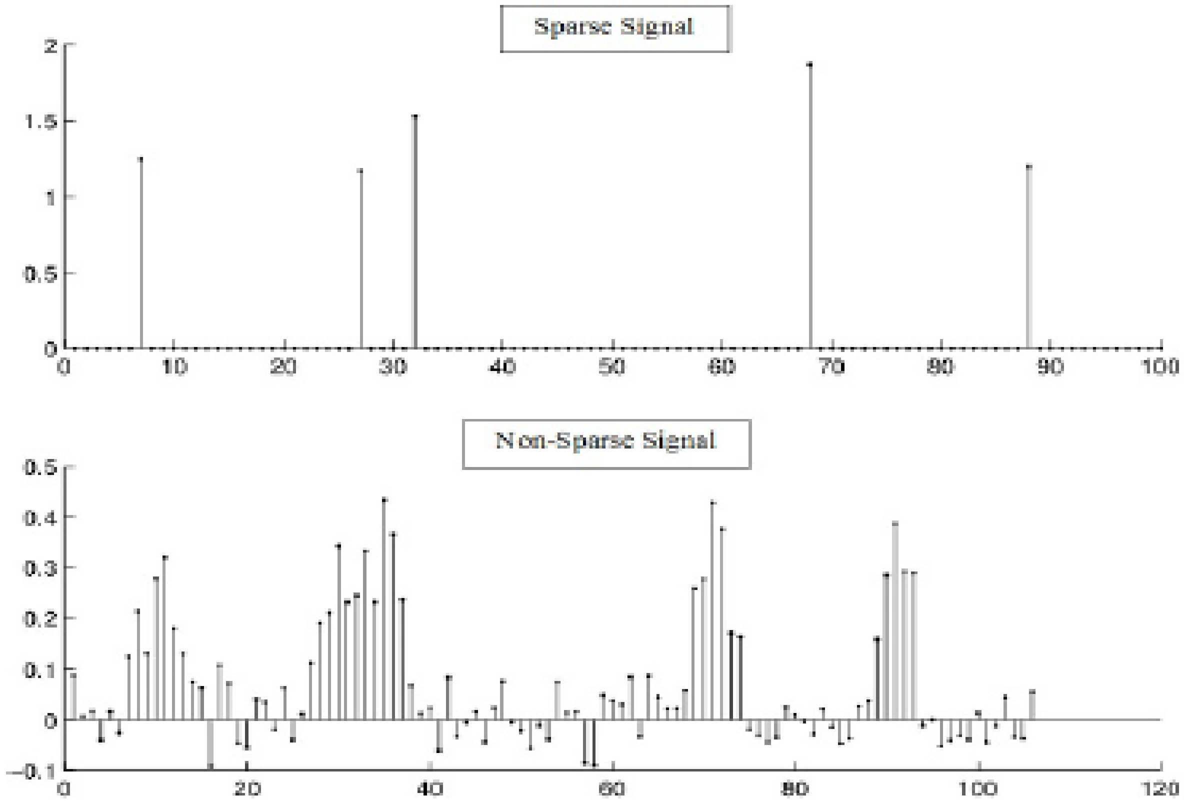
- Significantly far fewer samples than via the conventional Nyquist.



Compressed Sensing (CS)

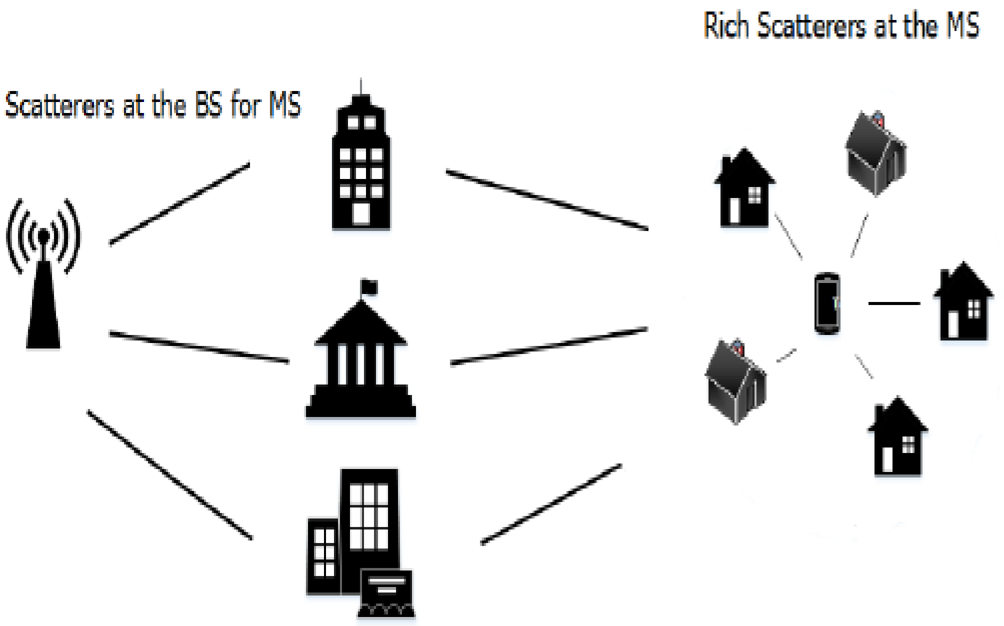
- CS to exploit the sparse nature of signals (that is, only a small number of components in a signal vector are non-zero).

- CS allows for accurate system parameter estimation with less training, thereby addressing the pilot contamination problem and improving the bandwidth efficiency.



Compressed Sensing (CS)

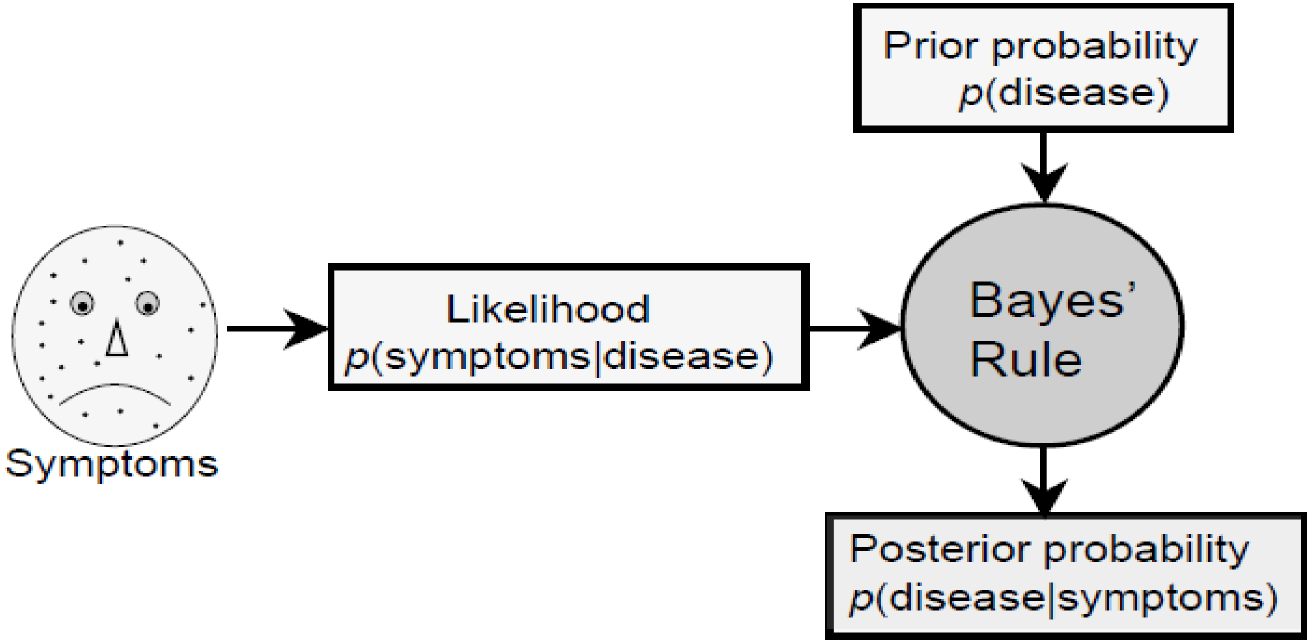
- Based on the physical properties of outdoor electromagnetic propagation, the channel impulse response (CIR) in wireless communications usually possesses several significant channel taps, i.e. the CIR are sparse.
- So, the number of non-zero channel taps is much smaller than the channel length, hence CS techniques can be applied for sparse channel estimation.
- This sparsity feature can be exploited to reduce the necessary channel parameters needing to be estimated.
- In this case, we can address the pilot overhead problem by using fewer pilots than the unknown channel coefficients.



Bayesian Estimation

- In common literature, channel estimation methods are classified into:
  - Parametric approach.
  - Bayesian approach.
- A standard parametric approach is the best linear unbiased estimator, which is often referred to as least squares channel estimation.
- In contrast to parametric methods, the Bayesian approach treats the desired parameters as random variable with a-priori known statistics.
- Clearly, the a-priori probability density function (PDF) of the channel is assumed to be perfectly known at the receiver.
- Based on the Bayesian channel estimation philosophy, the estimation of unknown parameters is the expectation of the posterior probabilistic distribution.

Bayesian Estimation



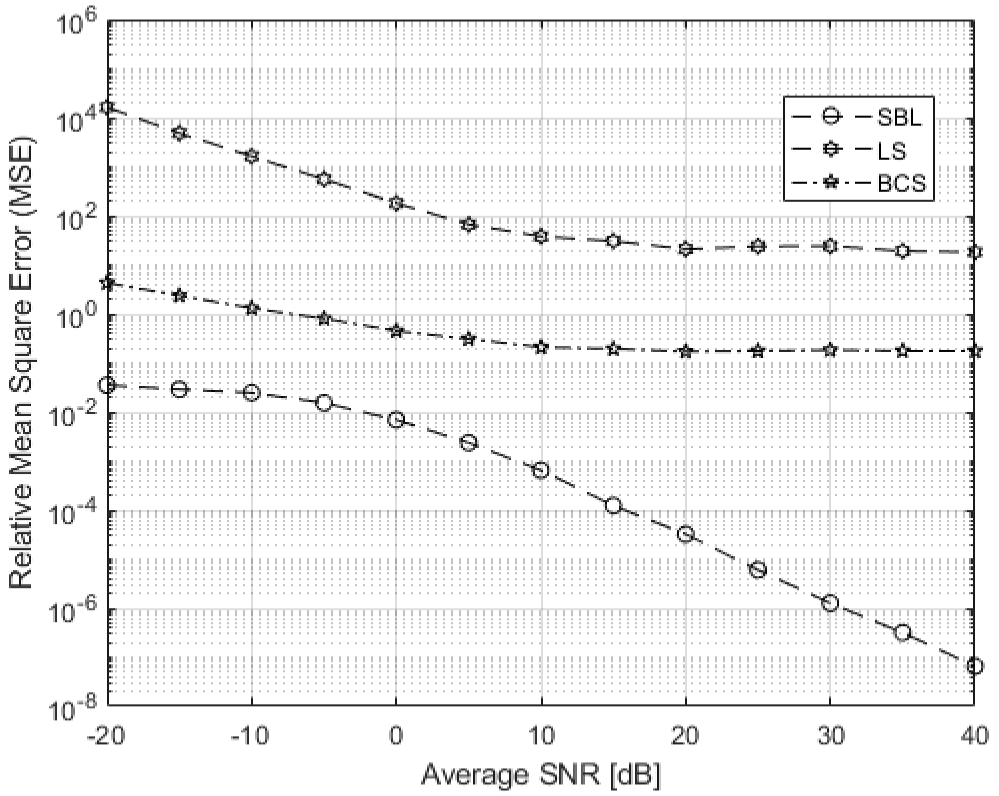
- The posterior probabilistic distribution is proportional to the prior probability and the likelihood of the unknown parameters.

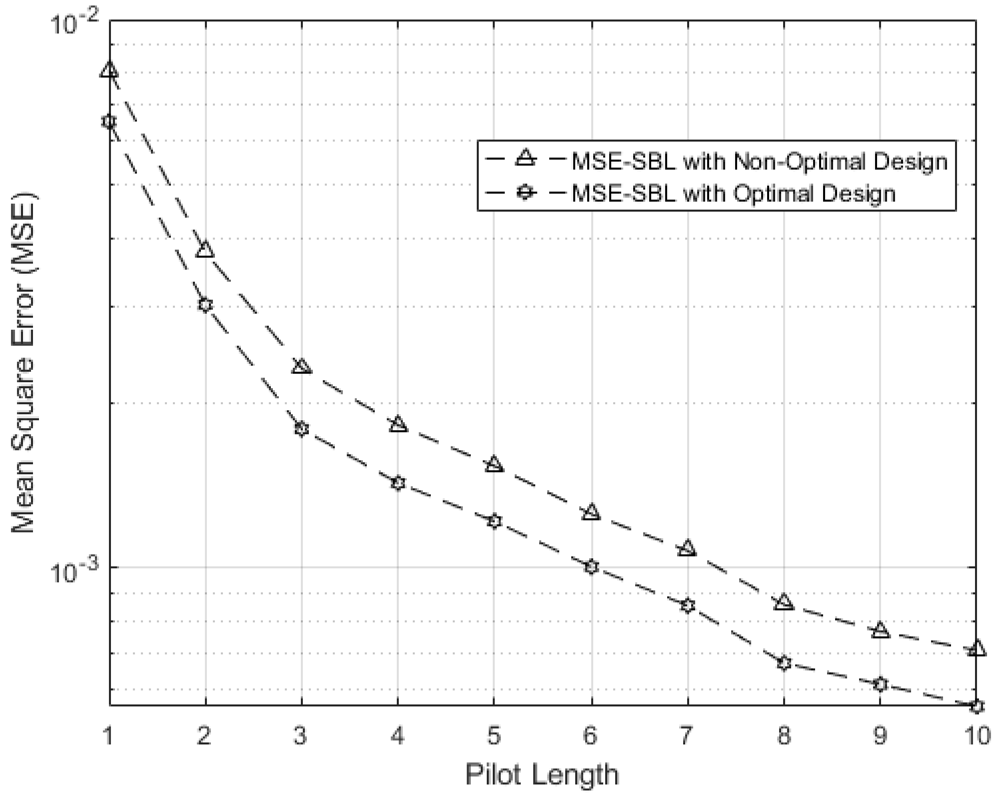
Posterior = Prior * Liklihood

Optimal Pilot Design

- In order to accurately estimate the CSI with the aid of the limited pilot resources,
- we operate the proposed channel estimation process using an optimally designed pilot set to improve the performance of the proposed technique.
- The optimal pilots are designed to minimize the mean square error (MSE) under the total transmit power constraint based on optimization problem formulation.

Results & Findings





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Thank you!