RUTGERS
WINLAB | Wireless Information Network Laboratory

Quantum and Physics Inspired Computing for Large Scale Blind MIMO Systems

Intern: Amir Vincent Zaman
Advisors: Prof. Minsung Kim, Byongjun Kim

Project Wiki

MOTIVATION

Massive Multiple Input Multiple Output (MIMO) wireless technology is the backbone of modern wireless infrastructure. It enables many devices to communicate with one base station (BS) or access point (AP) simultaneously. Blind MIMO allows for the communication to exist without synchronization, scheduling, or coordination between the access point and the many distributed devices. The "blindness" comes with computational complexities that do not scale well using conventional methods. Simulating quantum mechanics offers a way to increase accuracy of the computations when at scale without sacrificing the speed necessary for real-time communications. n this work we use quantum inspired algorithms to use quantum inspired algorithms to increase the capacity of blind MIMO systems.

BACKGROUND

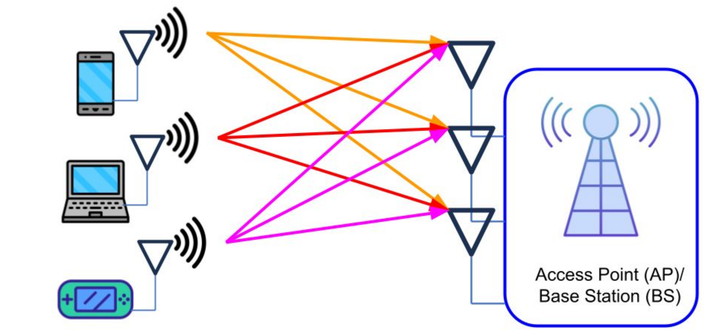

Fig 1. Cross interference in Uplink Multi-User MIMO where many user devices to transmit to one AP.

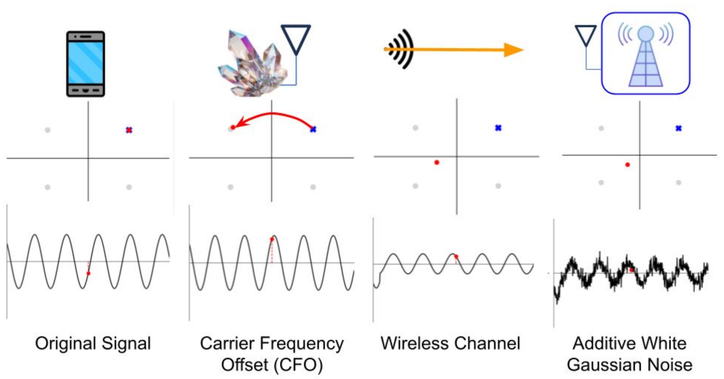

Fig 2. Sources of error in wireless signals. We can estimate the CFO and channel using matrix vector multiplication. AWGN limits naïve methods of estimation

Decoding is the process of taking the noisy signal and solving for the original intended signal, given we have an estimate for the channel and CFO.
Iris is a Blind MIMO solution that uses conventional methods to estimate channel and decode.
Paramax is a quantum inspired system that uses simulated quantum annealing and parallel tempering to decode MU-MIMO transmissions quickly and accurately.

SIMULATOR

I engineered a wireless simulator using the MATLAB programming language. The design was modular so that many types of solvers can be tested and components can be moved to a Software Defined Radio (SDR) pipeline in future work.

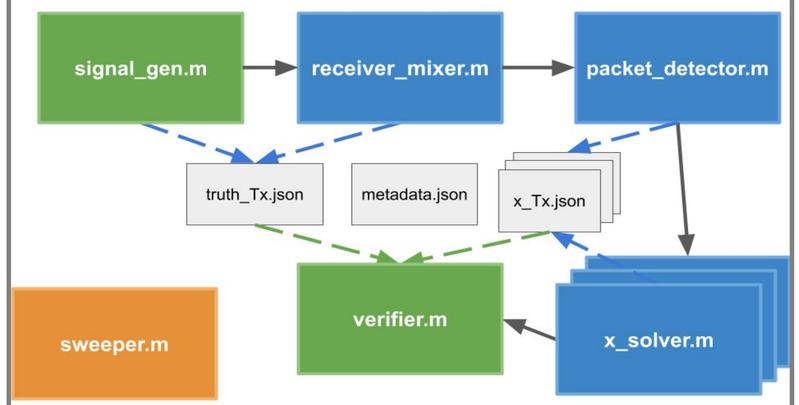

Fig 3. Blind MIMO simulator structure. Dashed lines show data ingress/egress. Green blocks are SDR ready

OPTIMIZER

$$\operatorname{argmin}_{\{\mathbf{x},\hat{\mathbf{H}},\hat{\mathbf{f}}\}} ||\mathbf{y} - \mathbf{Hfx} + \hat{\mathbf{H}}\hat{\mathbf{f}}\mathbf{p}||^2$$

Eq 1. Non-convex objective function of the Blind MIMO optimization problem.

The current solver uses the same approach as Iris for CFO estimation, the Nelder Mead algorithm. Decoding and channel estimation is done iteratively; the ongoing transmissions are decoded using Paramax, that solution allows us to isolate the channel variable and solve for it using ZF. This is a feedback loop converging until the residual error defined in the objective function is minimized.

RESULTS

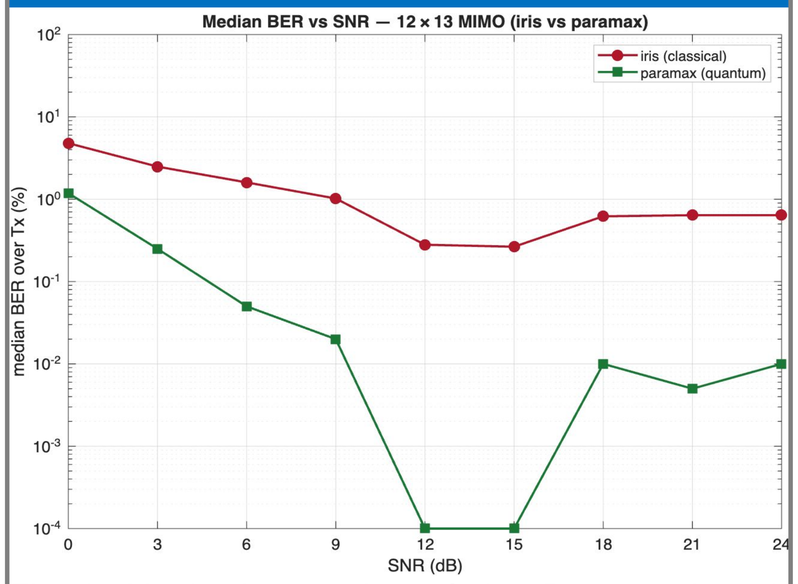

Fig 4. My implementation of the Paramax based quantum inspired solver shows a 95% improvement of BER at 12x13 MIMO size.

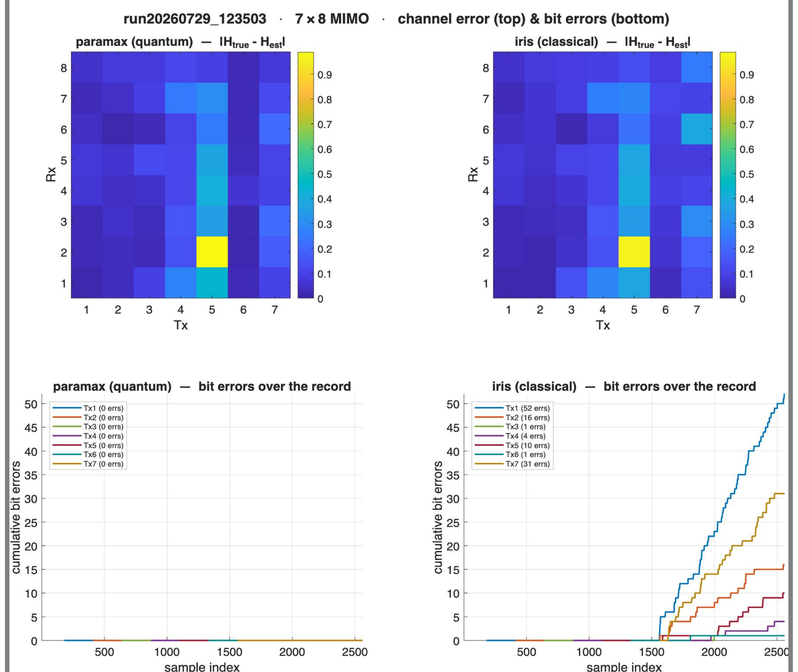

Fig 5. The Iris and quantum inspired solver get similar channel estimates. Robust Paramax decoding reduces the BER of all transmissions to zero.

REFERENCES

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