FARhang Wireless

Whitepaper – The MCMC Detector

Motivation

MIMO (multiple-input multiple-output antenna technology) can enable massive increases in range and data throughput of wireless devices, as seen since 2009 with the addition of MIMO to 802.11n and 802.11ac WiFi. Speeds have increased from a maximum of 54 Mbps before MIMO to 1900 Mbps in 802.11ac. Though MIMO has enabled massive speed improvements, size has stagnated at 3x3 since 2010. The primary reason for this halt in progress is the exponential increase in processing complexity when using larger number of antennas.

Figure 1: 802.11 WiFi router using 3-antenna MIMO.

At first implementation cost appears to increase linearly as it will be dominated by the linear addition of similar components, but starting at roughly 3x3 the cost increase shifts to exponential. This is because the math to do the 'detector' portion of the DSP in the receiver increases exponentially. After 3x3 this exponential increase in detector complexity begins dominating all other costs, requiring an exponentially larger and therefore more costly chip to perform the math. Likewise, power requirements initially appear to increase linearly until the exponential increase in math requires exponentially increasing power.

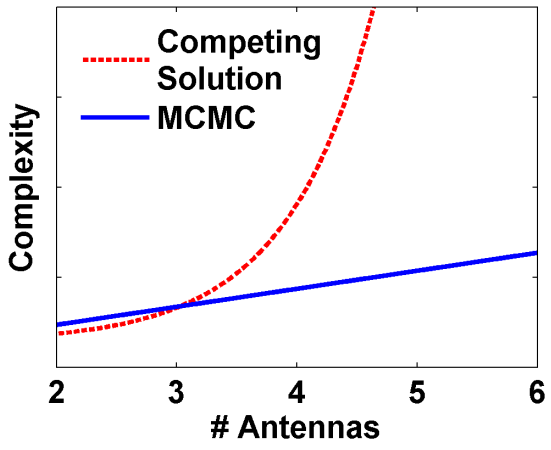

Figure 2: Comparison of relative complexity, which drives cost and power use, between MCMC and a typical competing detector solution.

Here is a quick example to demonstrate the dramatic cost increase possible because of exponential increase in detector complexity. If a 3x3 chip costs $10, then at 6x6 its cost exponentially increases to $100 or at 12x12 $10,000. These numbers are qualitative, but effectively communicate that this is a major problem in allowing continued performance increases through larger MIMO sizes. The WiFi standards have been ready for more antennas for 5 years with 802.11n allowing up to 4x4 and 802.11ac allowing 8x8, but chipset manufacturers have yet to deliver.

Detectors – What is MCMC?

To understand how our technology fits into the complex signal processing performed in modern communications equipment, think of it in the form of a flow chart. The data flows through sequentially with a specific part of the processing being done in each block. Each block has a specific "core" set of "intellectual property (IP)" determining its functionality and performance. For that reason these units are commonly called "IP cores" and it is common to sell them as enabling blocks to companies.

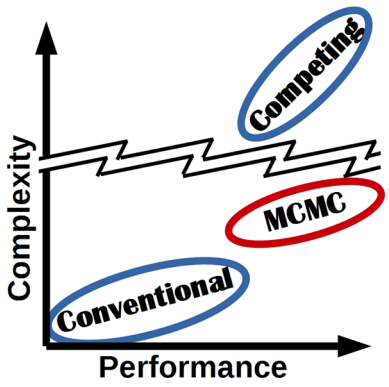

Figure 3: Detector comparison.

FARhang Wireless' IP cores target the **MIMO detector** block that translates the received signal into the individual binary 1&0's of the data. This math intensive operation can be done in different ways depending on the desired balance of performance and low complexity. Note that higher performance can provide a blend of longer range and higher data-rate. Low complexity requires less silicon in the chip, creating lower cost and power draw.

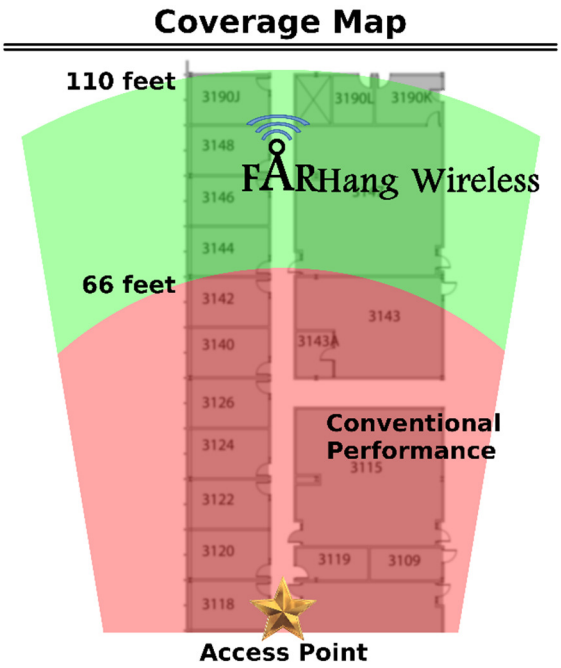

Figure 4: Real-world results showing performance in an office environment.

For simplicity let's consider three general classes of detectors. There are older **conventional** methods using **MMSE** (minimum-mean-square-error) which have lower performance and relatively simple math. The newer **competing** methods based on **ML** (maximum-likelihood) approximations improve performance but have the drawback of exponentially increasing complexity. **FARhang Wireless'** technology based on **MCMC** (Markov-Chain-Monte-Carlo) has similar high performance to the competing ML methods while keeping a low, linearly increasing complexity. See Figure 3 for a qualitative visual example of the differences between these three classes of detectors.

The conventional and MCMC detectors have been implemented and tested in a real office environment; see Figure 4. These 2.4GHz results show a consistent 2 to 3 dB performance improvement which can translate to a 67% increase in range compared to the conventional MMSE detector.

By upgrading existing chipsets with MCMC detector IP cores, FARhang Wireless enables existing manufacturers to produce competitive solutions of size 4x4 and greater.