iBF BeamformingTechnology

MediaTek's proprietary beamforming (iBF) technology is designed to improve data rate and communication range of any wireless system. An expansion of traditional implicit beamforming, MediaTek's solution addresses environments in which one of the devices does not support beamforming technology.

MediaTek White Paper

August 2015

The Problem of Fading WiFi Signals

Wireless systems frequently encounter fading as radio signals travel over multiple paths and interfere with each other when arriving at the receiver. Due to antenna characteristics and natural wave transmission loss, the wireless LAN communication throughput performance decreases as the distance between the Axis Point (AP) station and the client device increases. Indeed in the normal home environment the WIFI communication quality may vary from location to location.

Preprocessing the wireless signal at the transmitter using a technique known as beamforming can overcome multipath effects to improve link throughput and robustness. IEEE 802.11n and the latest 11ac standards specify a number of MIMO (Multi-Input Multi-Output) techniques that use multiple antennas to improve performance in a multipath environment. Beamforming (BF), or spatial filtering, is one of these techniques. BF is an optional feature in IEEE 802.11n, but is required in 11ac wave2. Beamforming has proved itself to provide significant improvement in wireless coverage and thus there is growing industry demand for this feature in various wireless applications.

Explicit beamformer and beanformee algorithms improve different data rates from three to eight dB respectively. In other words, with the same throughput performance, this technology will help increase coverage twice the distance. Unfortunately this improvement is only available when *both* the Axis Point station and the client side support the explicit beamforming feature. Legacy devices, such as older mobile phones and notebooks, were not designed to accommodate this advanced feature. Users complain when their old iPad, for example, has poor WiFi reception, not realizing that an improved router can solve their reception problems.

MediaTek is introducing the implicit TX beamforming (iBF) technology to overcome this usage limitation. With this feature, any Axis Point can support not only the explicit beamforming stations but also legacy stations, achieving 100% comparable performance even in complex multipath interference environments.

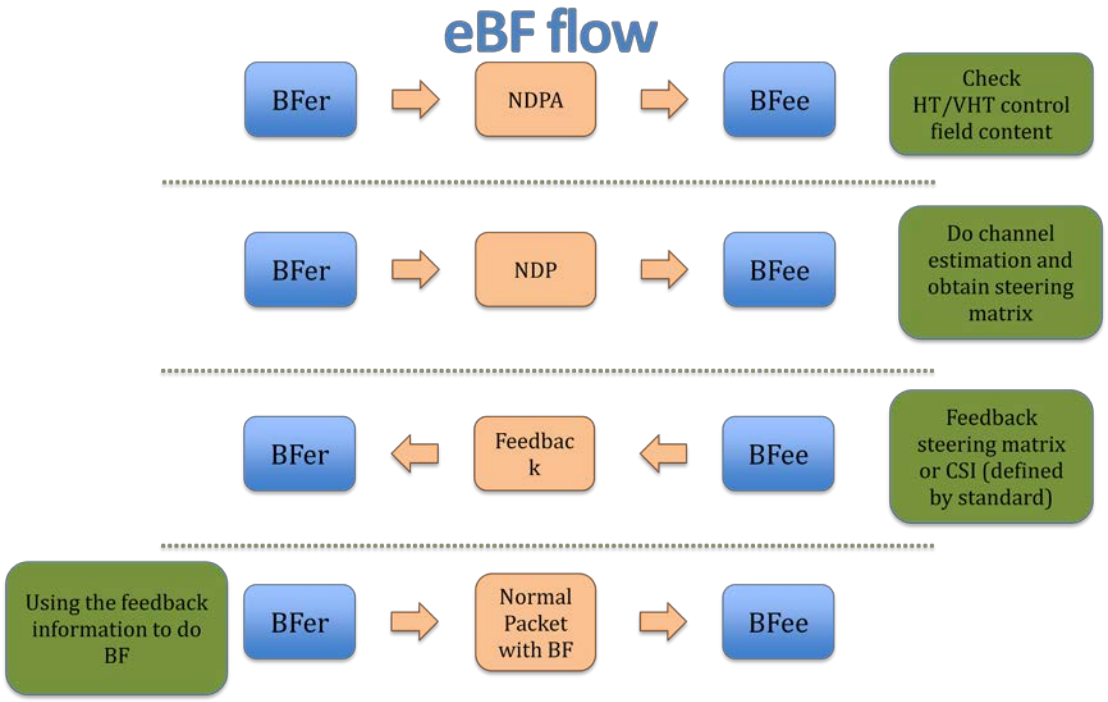
MediaTek, a pioneer in beamforming, shipped the industry's first beamforming implementation with 3x3 11n WiFi. This implicit beamforming (iBF) has shown great market success as it also supports beamforming with legacy 11a/n/g devices. Both standards-based beamforming and iBF have demonstrated their capability in increasing range, link robustness and throughput. MediaTek believes that it's important to enhance WiFi performance for not only the latest 11ac clients, but also the hundreds of millions of devices that don't support the latest 11ac spec. Therefore this white paper will focus on the discussion of iBF, provides some background on the beamforming technology, and presents measured performance data.

Explicit Beamforming

Explicit Beamforming (EBF), defined in 11n/11ac spec, is a novel technology which can improve the receiver sensitivity (RxSEN) with a specific protocol. Using the protocol, the beamformee client makes channel estimation from the training symbols sent by beamformer, and sends the steering matrix back to beamformer. This EBF technology uses channel information to achieve beamforming gain, but needs some negotiating between the AP and the client to perform training and feedback.

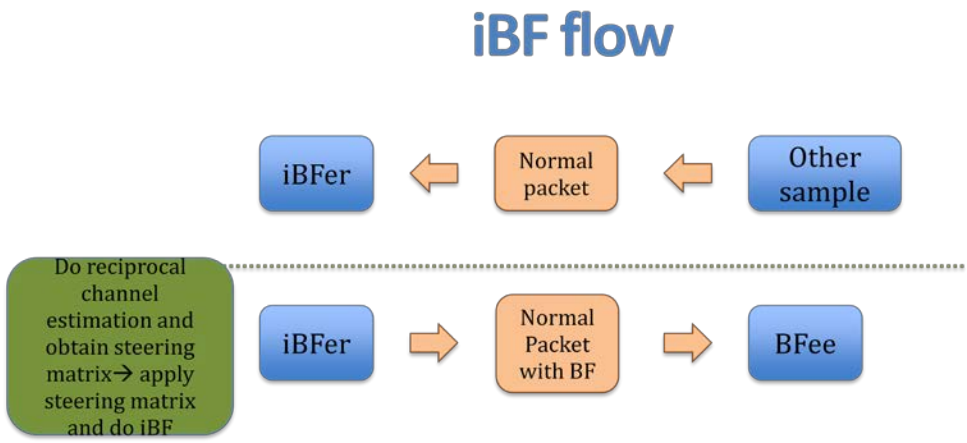
The image below, using 11ac as an example, shows EBF flow. The constraints of EBF technology are noted here:

- Needs more negotiations
- BFee needs to support BFee function



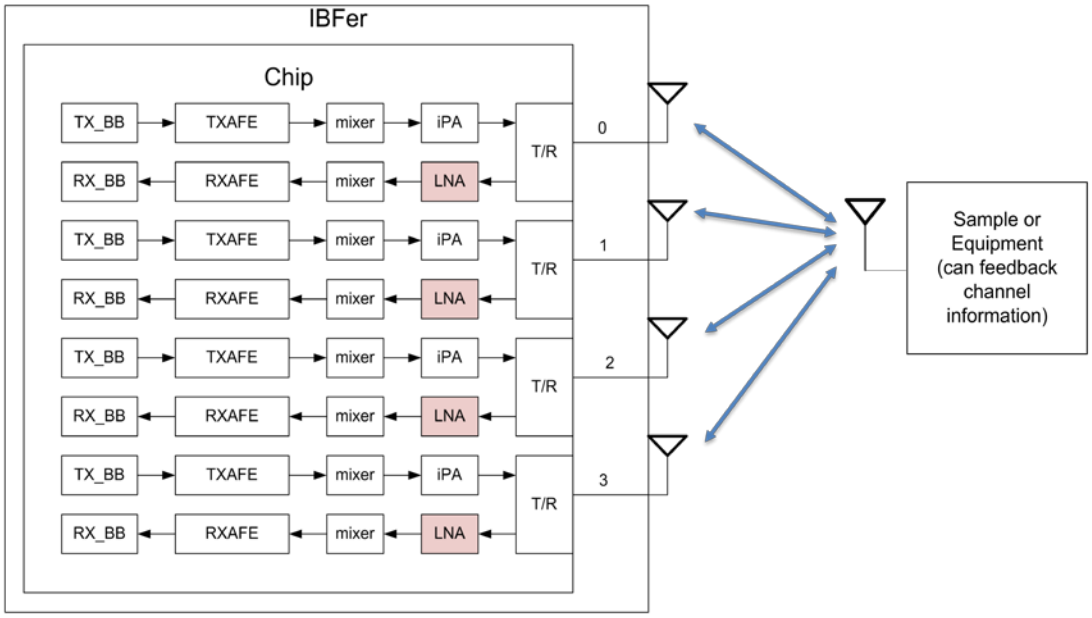
Implicit TX Beamforming

Implicit TX Beamforming (iBF), MediaTek's proprietary technology, does not require the protocol support to obtain the BF gain. For ITxBF to function correctly the RX path seen by the BFer must be the reciprocal of the TX path, a process handled by the iBF Calibration algorithm. The IBF process is completed within normal traffic. The MediaTek Implicit BFer (IBFer) handles all processes that BFee must handle in the EBF flow. It means that IBF can either save the overhead or get BF gain. The only cost is iBF Calibration to make channels reciprocal.

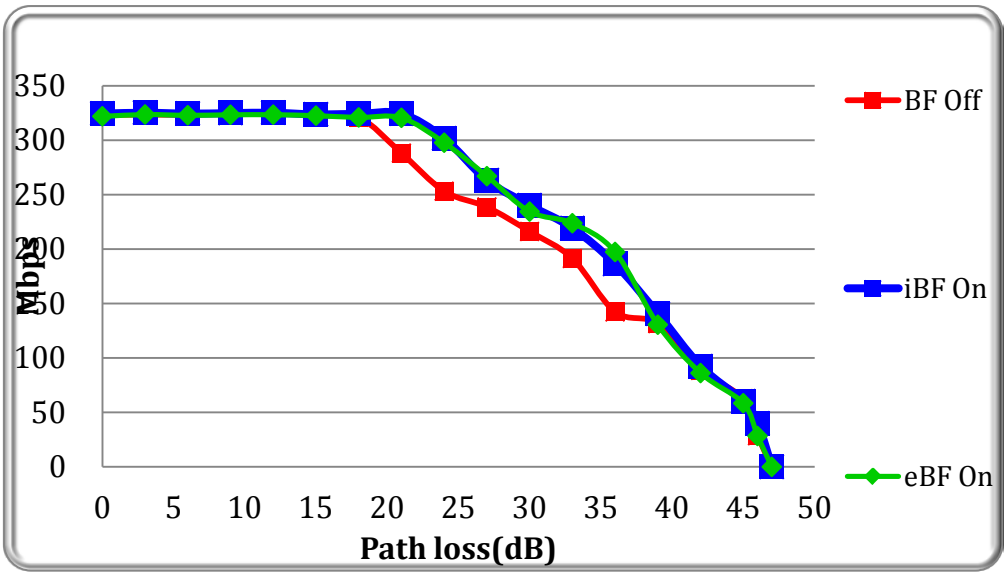


Each device needs to perform iBF Calibration only once in the factory, thereby enabling the BF gain even for the 11a (Legacy) device.

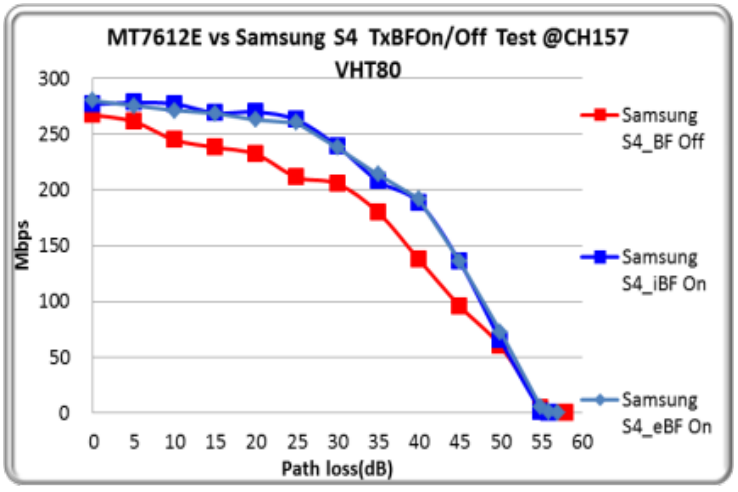
Assume a sample with *N* RF chains labeled ANT_N. Below is a block diagram of 4-RF chain showing the elements that are relevant to ITxBF Calibration.

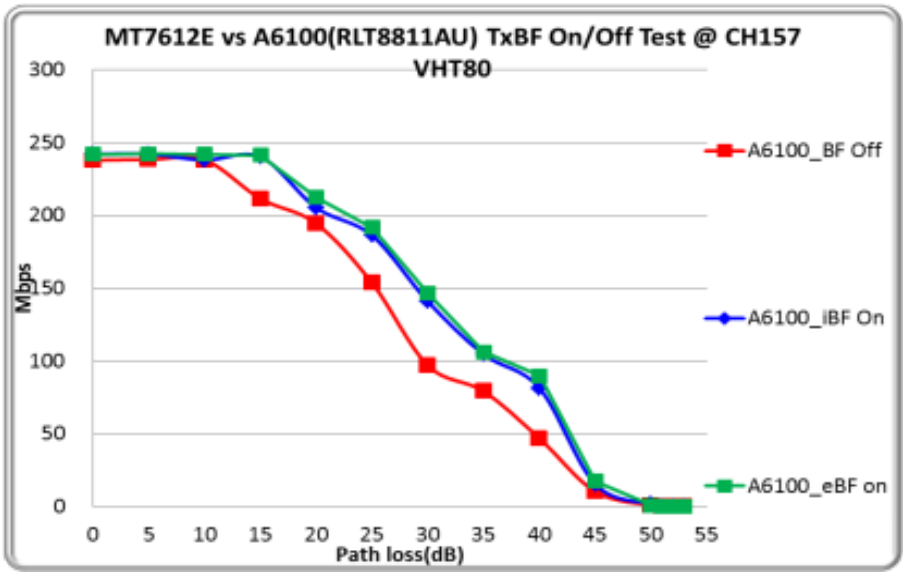


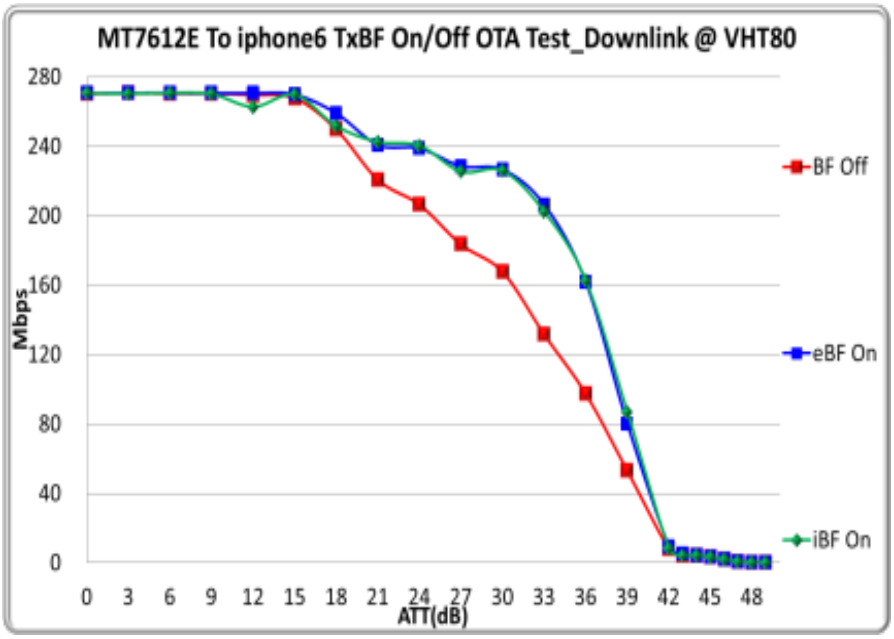
If the iBF Calibration is perfect, the TX and RX paths are reciprocal, and IBF can achieve similar performance as with EBF. Here, we use a VHT80 throughput as an example. However, the perfect IBF calibration needs more factory calibration time. MediaTek can provide the trade-off solution between IBF calibration time and the acceptable IBF gain.



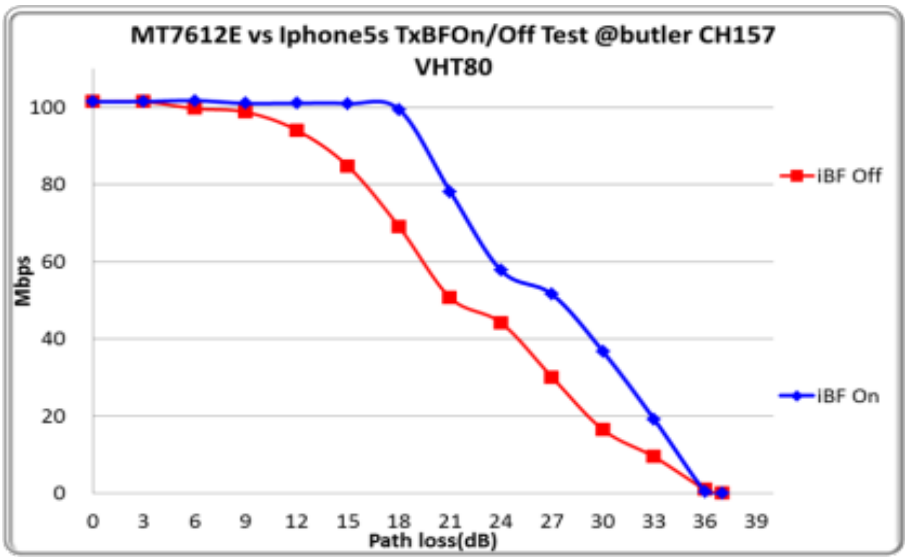
MediaTek i-BF

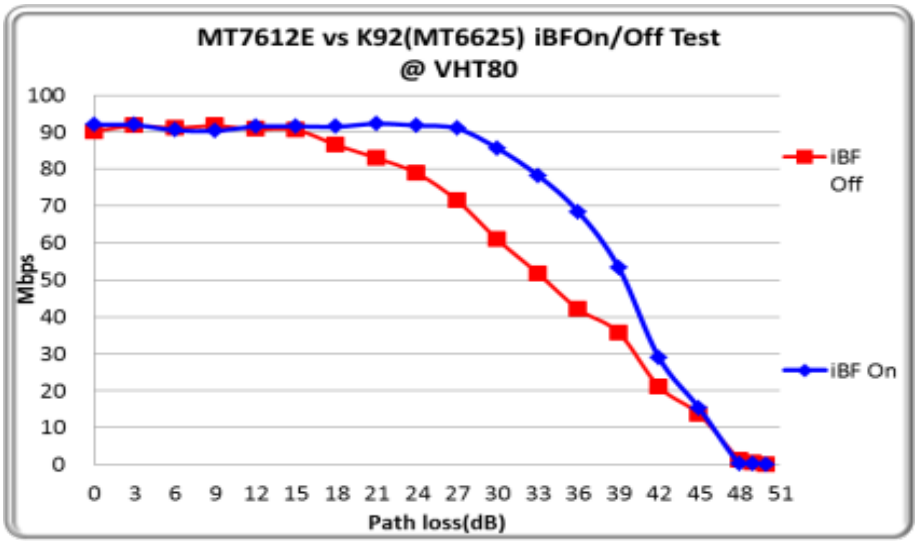




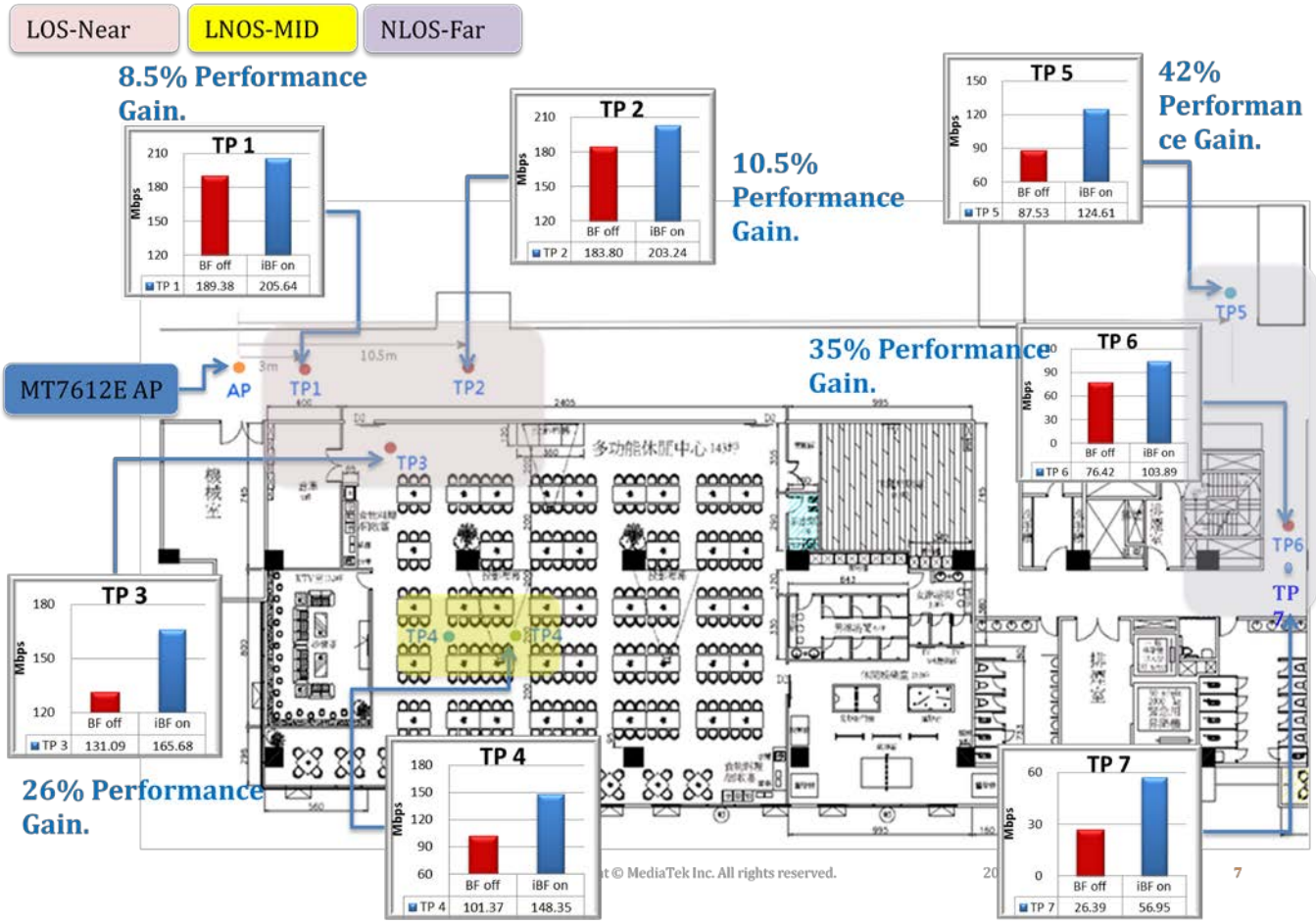


Legacy Phone No eBfee Support





Below is an illustration of the performance in an office setting. The blue indicates the improvement provided by MediaTek's solution.



Conclusion

Beamforming can be used to overcome the effect of multipath fading to effectively improve data rate and communication range of any wireless system. In particular, it significantly increases the robustness of a single spatial stream wireless link. The feature allows single spatial stream devices to experience the diverse benefits of multiple antennas at the Axis Point. This will drive significantly higher throughputs, lower power consumption, improved coverage range and increased network capacity. MediaTek's 11ac product family—MT7612 (2x2 11ac) and MT7615 (3x3/4x4ac)—support both standard-based beamforming and iBF in different configurations. In particular, beamforming at the transmitter (AP) using multiple transmitters can achieve diversity improvement equivalent to using the same number receive chains in the client device. This an appealing advantage for many mobile and consumer devices, such as smartphones, tablets and TVs. These devices often have only one or two radio chains and antennas due to their form factor, power and cost constraints. And many of them still

do not support 11ac standard beamforming. Finally, beamforming has been shown to enable the demanding application of wireless high definition audio and video streaming. By extending range and throughput, beamforming can allow a single set-top box and gateway equipped with MediaTek WiFi chipsets to distribute multiple video sources to several locations throughout the entire home.