MoVR

The use of millimeter-wave (mmWave) spectrum has emerged in the 5G era as a key next generation wireless network technology to fulfill users' demands for low latency and high spectral efficiency for the wireless networks. In particular, it provides a possibility of untethering the high-quality VR systems, which previously required a wire connection for streaming the data. However, mmWave technology faces a big challenge due to its weak ability to diffract around obstacles with a size significantly larger than the wavelength. Since mmWave has an extremely short wavelength and a narrow beam, it experiences huge losses when a human body like player's hand blocks a line-of-sight (LoS) path between the transmitter and receiver, resulting in a significant SNR drop of 20dB. Moreover, because mmWave radios use highly directional antenna, transmitting beam and receiving beam must be aligned all the time. Yet, even a small movement of the VR headset will hamper the alignment. Hence, dealing with mobility is another challenge for using mmWave for VR/AR. To address the following challenges, the authors introduces MoVR, a self-reconfigurable mmWave mirror that detects the incoming signal and reconfigures itself to reflect it towards the receiver on the headset. When the signal to the headset is blocked, the MoVR provides an alternative non-blocked path. MoVR also ensures the link connectivity in the presence of mobility by leveraging the 3D location information from the headset to quickly localize the headset and correspondingly move the transmitter antenna's beam.

Regarding MoVR, we have initiated the discussion by asking the following question: instead of installing a single reflective node, what about putting perfectly reflective material on the entire wall? Although this approach may provide more options for alternative paths, it has a disadvantage of the nodes inside the room being unable to communicate with the nodes outside the room even if they are using lower frequency. Also, this approach was tried in a different context in datacenters with mirrors on the ceilings, but it is questionable whether this approach will work better than MOVR in the context of the VR systems.

MoVR leverages an adaptive amplifier gain adjustment method to compensate the signal leakage from the transmit antennas to the receive antennas. Regarding this approach, we questioned whether this is a correct way to depict saturation because high current can be the diagnosis to many scenarios, and not short-listed to saturation. A better estimate to saturation would be to sense the non-linearity of the gain transfer function.

We pointed out that the way the MoVR uses the out-of-band channels (i.e. Bluetooth) for coordination is a widely-used design pattern in many related papers like LAIA and RFocus. Then we concluded that although different smart surface mechanisms have been proposed, the overall architecture itself haven't been developed.

Lastly, for evaluation, we have agreed that more detailed analysis on the MoVR's mirror performance was needed. For example, the power limit for AP's output might be different from the power limit for the mirror's reflected signal. Yet, the authors did not explicitly mention the mirror's output power level. Since mirror amplification is not well evaluated, the readers cannot differentiate whether the SNR gain is from avoiding the blockage or purely due to the power amplification at the mirror side. Although analysis of SNR gain is not specified, MoVR still provides an SNR of 24 dB or more for all locations in the room and all orientation of the headset, even in the presence of blockage and player mobility, and thus provides its feasibility for VR applications.