Enabling High-Quality Untethered Virtual Reality

NSDI 2017
Headset’s cable not only limits player’s mobility but also creates a tripping hazard.
Go Wireless

- **Wifi**
  - Cannot support required data rates
  - Zotac has gone as far as stuffing full PC in player’s backpack

- **mmWave**
  - High frequency RF signals in range of 24 GHz and higher
  - 802.11ad operates in mmWave and can transmit over 2GHz bandwidth and deliver up to 6.8Gbps
mmWave - Fundamental Challenges

● Blockage
  ○ mmWave links require line of sight between transmitter and receiver
  ○ A small obstacle like player’s hand can block the signal

● Mobility
  ○ mmWave radios use highly directional antennas
  ○ Transmitter’s beam needs to be aligned with receiver’s beam
How to maintain LOS at all times?
Programmable mmWave Mirrors

- mmWave mirror works by capturing RF signal on receive antenna, amplifying it and ‘reflecting’ using transmit antenna
- Control
  - Angle of incidence
  - Angle of reflection
- Can be steered electronically in a few $\mu$s
- AP transmits VR content
- AP transmits control information to mirror over Bluetooth

SNR is good!
Beam Alignment and Tracking (I)

1. Beam alignment between **AP** and **mirror**
   - Set mirror’s transmit and receive beams in same direction, $\alpha$
   - Set **AP**’s transmit and receive beams in same direction, $\beta$
   - Try all combinations of $\alpha$ and $\beta$, pick the one that maximizes SNR

2. Beam alignment and tracking between **AP** and **headset**
   - VR systems already track location and orientation of headset using laser trackers and IMU
   - Co-locate AP with one of VR laser trackers and exploit VR tracking system
3. Beam alignment and tracking between mirror and headset
   ○ We can get angle between AP and mirror as explained earlier
   ○ To estimate angle between mirror and headset
     ■ AP transmits to mirror
     ■ Mirror tries every beam angle to find the angle that gives highest SNR at headset