



Multipath Content Delivery Framework for Legacy WiFi and WiGig Networks

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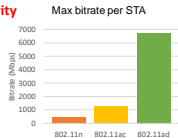
1. 60 GHz Next-generation Wireless Networks

60 GHz radios provide link-level multi-Gbps connectivity

- Recent standards for 60 GHz networks: 802.11ad, 802.11ay, WirelessHD
- 802.11ad: span 14 GHz spectrum, up to 7 Gbps bitrate

Enabling many demanding applications

- Wireless Backhaul
- Mobile-to-screen Video Cast
- Untethered Virtual Reality



3. Multi-link Transmission Framework

Virtualize WiFi and WiGig interfaces into one

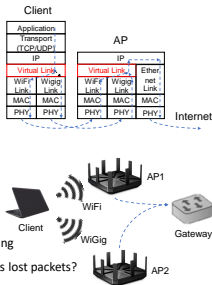
- Key Idea:** design a middlebox between the IP layer and WiFi/WiGig link layers, which automatically splits packets among multiple wireless interfaces at the client side and reassemble them at the AP side.

Benefits

- Achieve higher bitrate by aggregating multiple bands
- Achieve better link connectivity/stability by seamlessly switching among interfaces
- Transparent to the network and upper application layers

Technical challenges

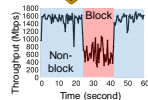
- Up to 20x rate difference: need to handle packet reordering
- Distinct reliability: should WiFi retransmit parts of WiGig's lost packets?
- Different coverage: need to aggregate links with separated APs



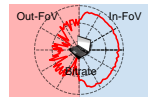
2. Directional Link and Vulnerable to Blockage

Adopt many-element phased array antenna

- Form a highly directional beam towards the receiver
- Vulnerable to human blockage and device orientation**
- Harmful for time-sensitive applications, e.g., wireless VR
- Feasible solution: falling back to sub-6 GHz band**



- Fast Session Transfer (FST)
 - Migrate traffic to WiFi after 60GHz link breaks
 - Reactive and may cause the link temporarily "blackout"
- Multipath TCP
 - Require server-side support and modification
 - Work for the TCP, but many streaming applications use UDP



4. Research Problems

Traffic Scheduler

- Real-time content delivery
 - Scalable video coding: a low-quality base frame and multiple detail frames
 - WiFi reliably delivers high priority content --- base frame, and 60GHz delivers high quality details
 - The user could see the base frame whenever the 60GHz link breaks, suitable for applications, such as wireless VR.
- Energy efficient networking
 - Applications with light data traffic, e.g., web-browsing, is sent over WiFi
 - Heavy data traffic, e.g., video streaming, is sent over WiGig



Cross-interface optimization

- Physical-layer information assisted traffic scheduling adaptation
- Predict 60 GHz link quality through the WiFi channel information: mobility and range prediction
- Decouple control plane and data plane: WiFi for control signaling and WiGig for data backend