**Improving Latency**

Currently latency (delay) for 4G networks is about 50 msec and for 5G and WiFi 10 msec.

Data rate is not the whole story. Latency of 10 msec or better open the door to a range of applications that high bandwidth alone can’t. These include virtual reality, multiplayer games, autonomous vehicles and factory robots.

Research is underway on pushing latency down to 1 millisecond. Every part of the communications process needs to be re-engineered. This includes encoding, transmitting and routing data to shave off even the smallest sources of delay.

Latencies below 1 millisecond open up applications such as:

* Haptic communications (sense of touch). Balancing a pencil on your finger tip requires a reaction time in milliseconds and would be necessary for a human-controlled tele-operated robot.
* Robots that are not human controlled benefit from 1 msec latencies in not falling over or dropping something. Brains of the robot could be in a data center. Robots would then be lighter and need less energy. However because of the speed of light in a fiber (200 km/ms) the brains of such a robot in a data center needs to be within 100km, not counting other sources of delay.
* A solution to this problem is edge computing where the data center is close to (not to far from) the robot. This push for sub-millisecond latency is a motivation for edge computing.
* Factory robots.
* Remote surgery.
* Multi-player gaming.

**Some required latencies**:

150 msec VoIP, Video Chat

30 msec Multiplayer Gaming

10 msec Virtual Reality

2.5 msec Augmented Reality

2.5 msec Haptics (sense of touch)

2 msec Autonomous Vehicles

1 msec 6G Networks

**Contributions to Delay**

* Frame duration.
* Random access (as in WiFi-latest versions of WiFI use scheduled transmission – WiFi Certified 6 based on IEEE P802.11ax).
* Congestion delays (effective transmission rate varies with time, unpredictable).
* Queueing delays (related to congestion delays).
* Hampered by connection handoffs (obstacles blocking beam can result in frequent connection interruptions).
* Speed of light

From S. Panwar, “Breaking the Millisecond Barrier”, *IEEE Spectrum,* Nov. 2020, pp. 44-49.