

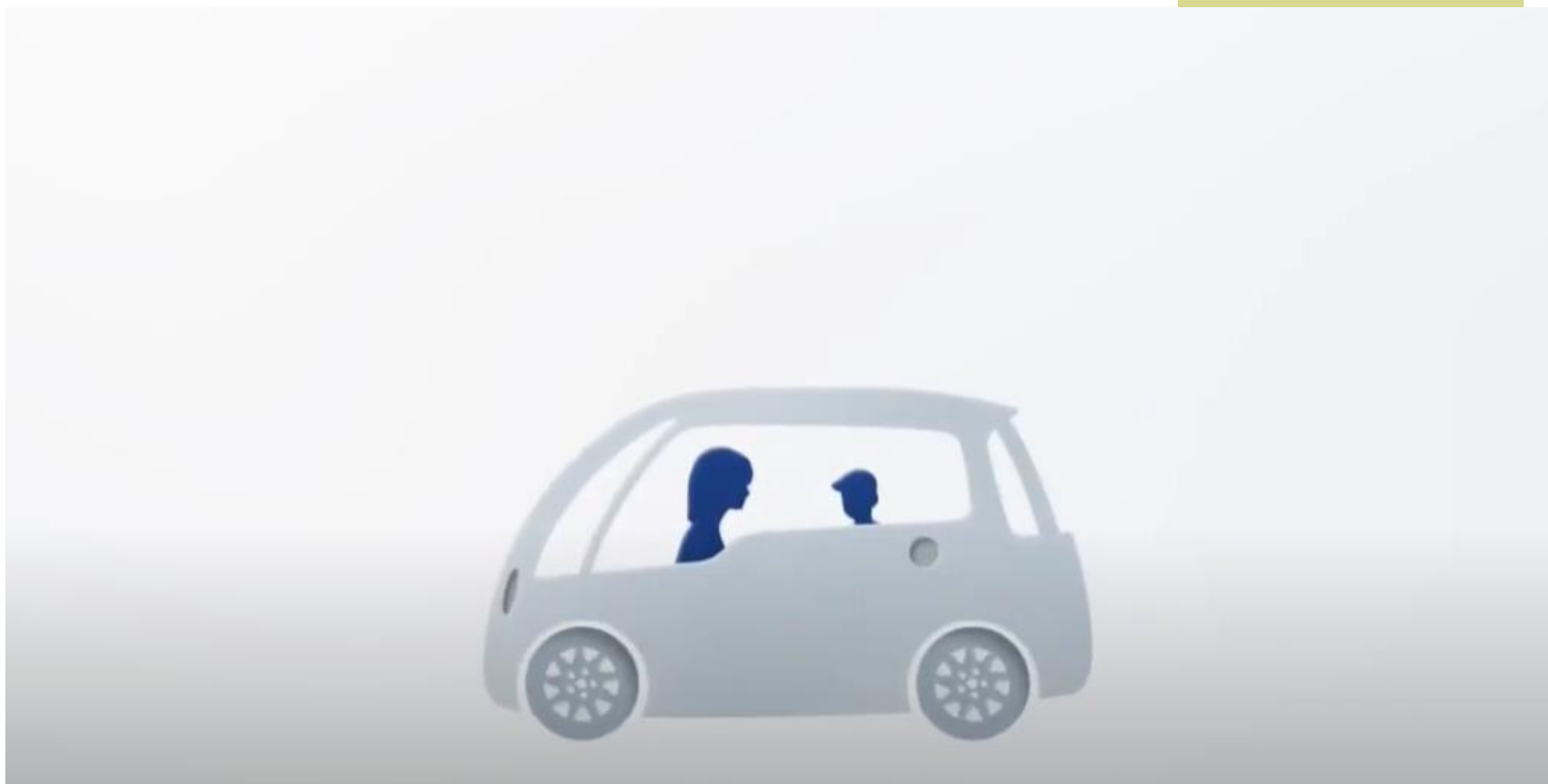
Chapter 7

5G

5G

- The 5th-generation of telecom networks
- 5G is expected to unleash a massive IoT (Internet of Things) ecosystem
- 5G networks can serve communication needs for billions of connected devices, with the right trade-offs between speed, latency, and cost.

Nokia 5G for Connected Vehicles



Nokia

Ericsson 5G IN USA



Ericsson

QUALCOMM 5G: Future of 5G

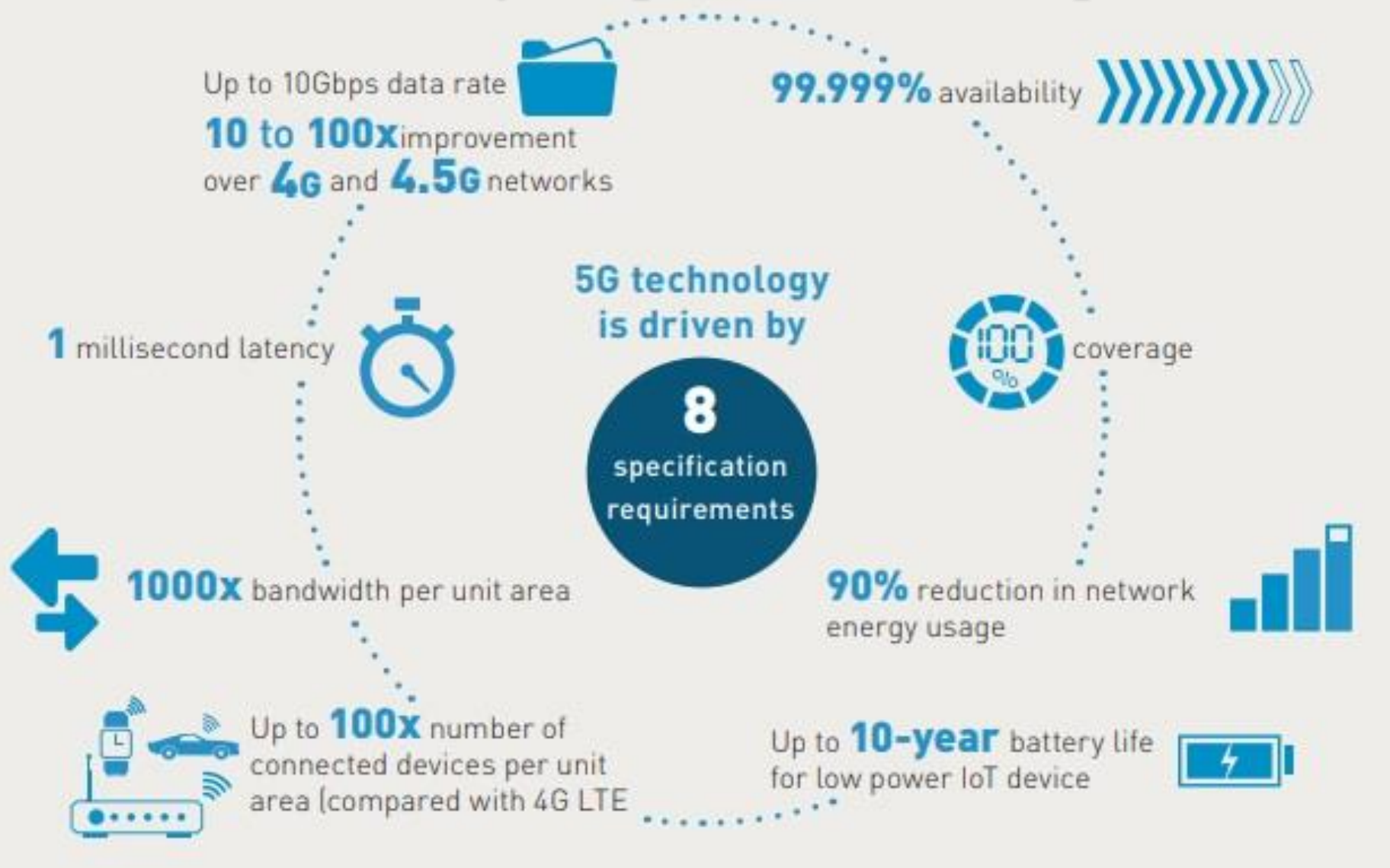


Qualcomm

Driven by 8 specification requirements

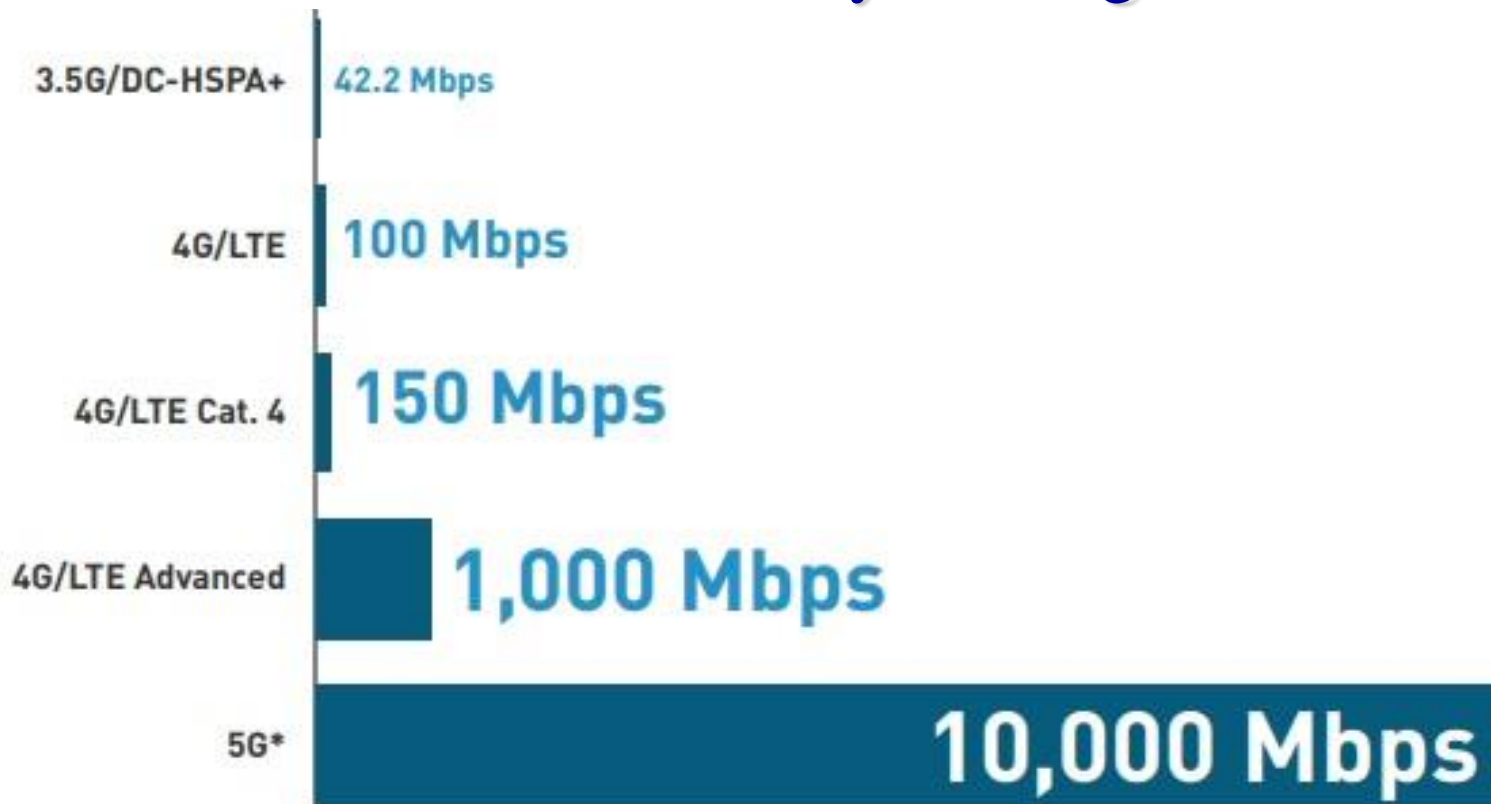
- Up to **10G**bps data rate - > 10 to 100x speed improvement over 4G and 4.5G networks
- **1-millisecond** latency
- **1000x** bandwidth per unit area
- Up to 100x number of connected devices per unit area (vs 4G)
- 99.999% availability
- 100% coverage
- 90% reduction in network energy usage
- Up to 10-year battery life for low power IoT device

5G is driven by 8 specification requirements



How fast is 5G?

5G tops out at 10 gigabits per second (Gbps). 5G is 10 to x100 faster than what you can get with 4G.



5G offers extremely low latency

- The delay between the sending and receiving of information. From 200 milliseconds for 4G, we go down to 1 millisecond(1ms) with 5G.
- A millisecond is 1/1000 of a second.
- The average reaction time for humans to a visual stimulus is 250 ms (1/4 second), i.e., your car could react 250 times faster than you.
- Use cases:
 - V2X (Vehicle-to-Everything) communication: V2V: (Vehicle-to-Vehicle), V2I (Vehicle-to-Infrastructure), autonomous, connected cars
 - Immersive Virtual Reality Gaming
 - Remote surgical operations
 - Simultaneous translating.

5G Standard Essential Patents

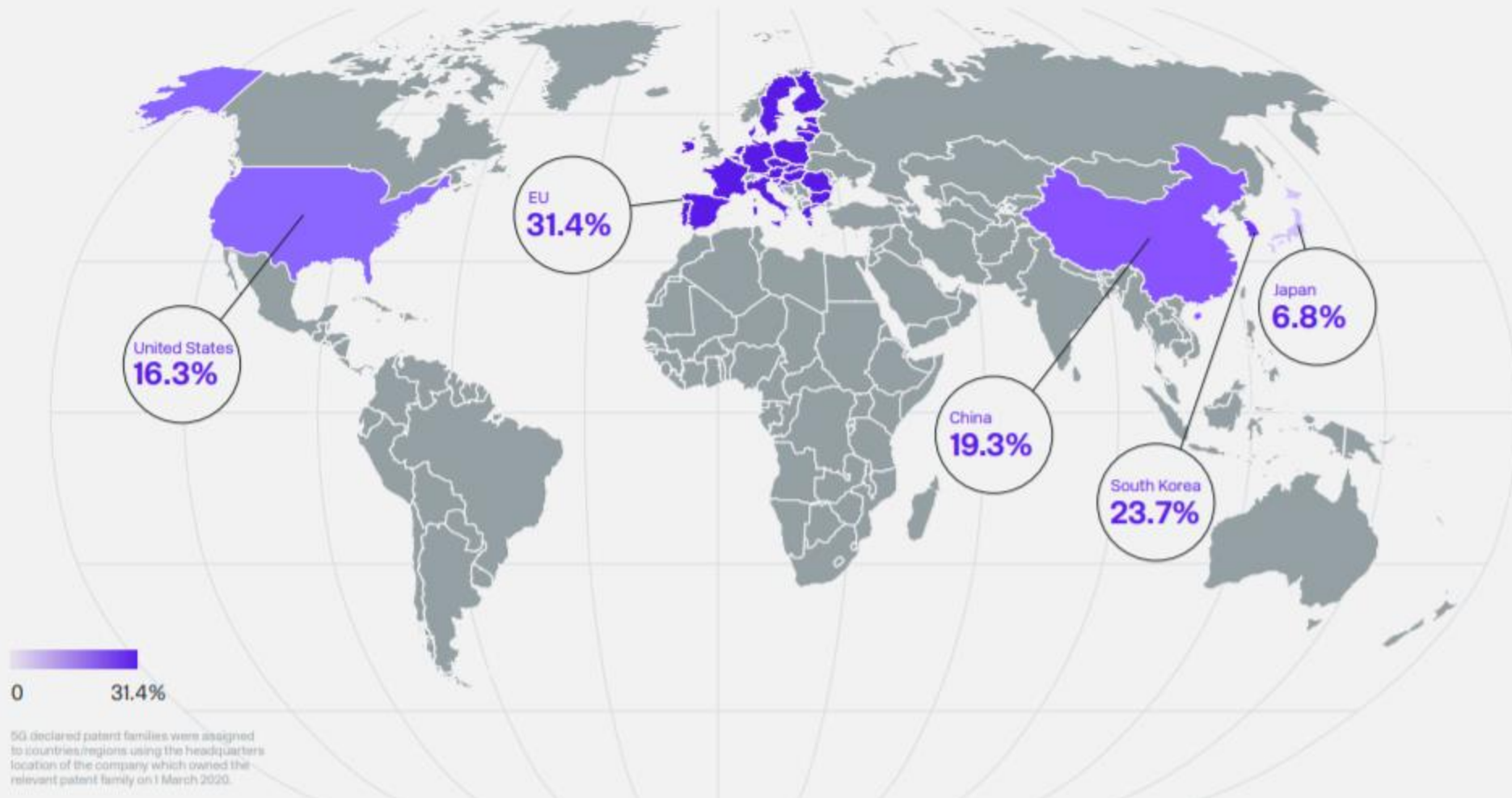
5G Standard Essential Patents Over Time



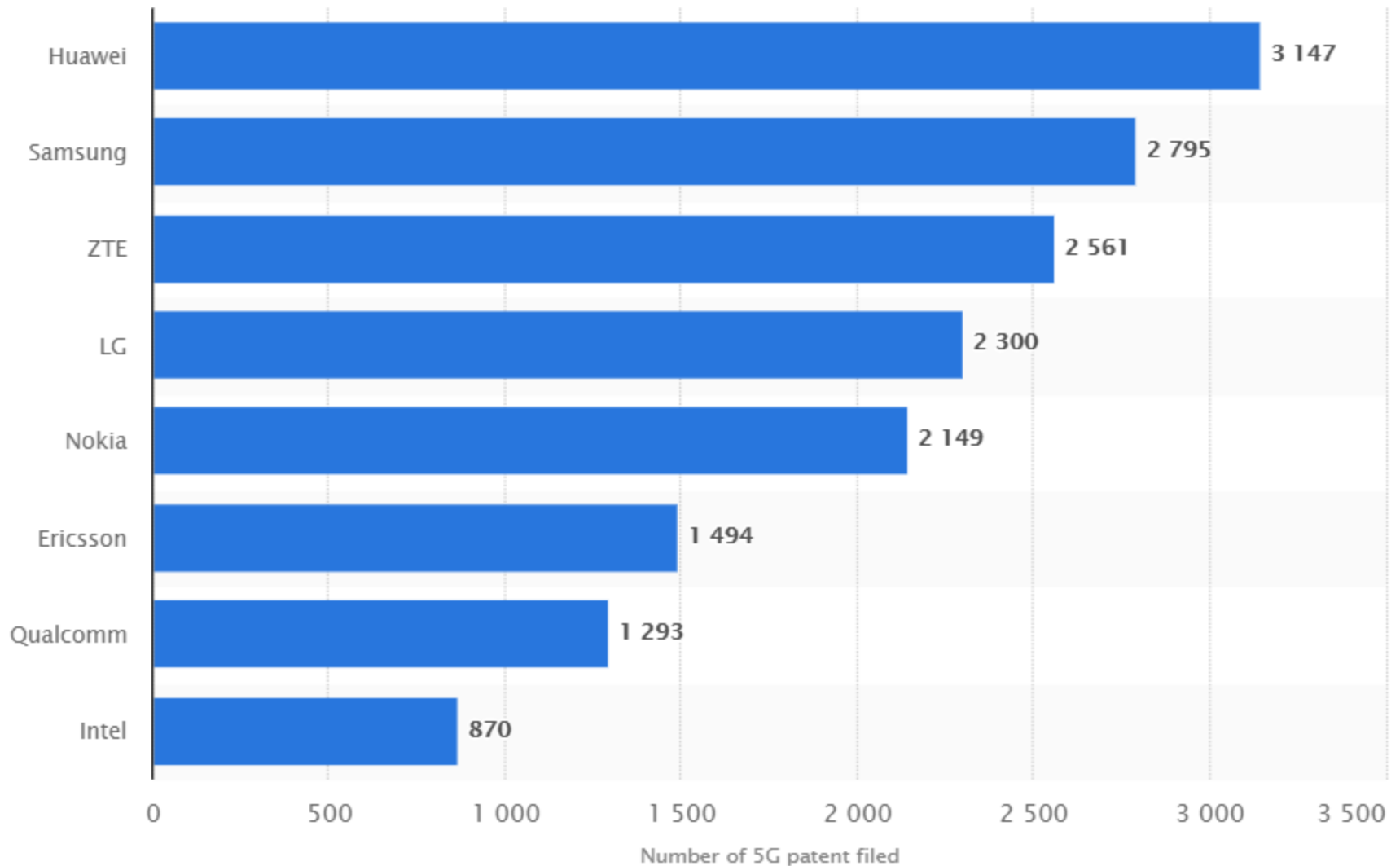
*As to April 2019

5G patents by countries/regions

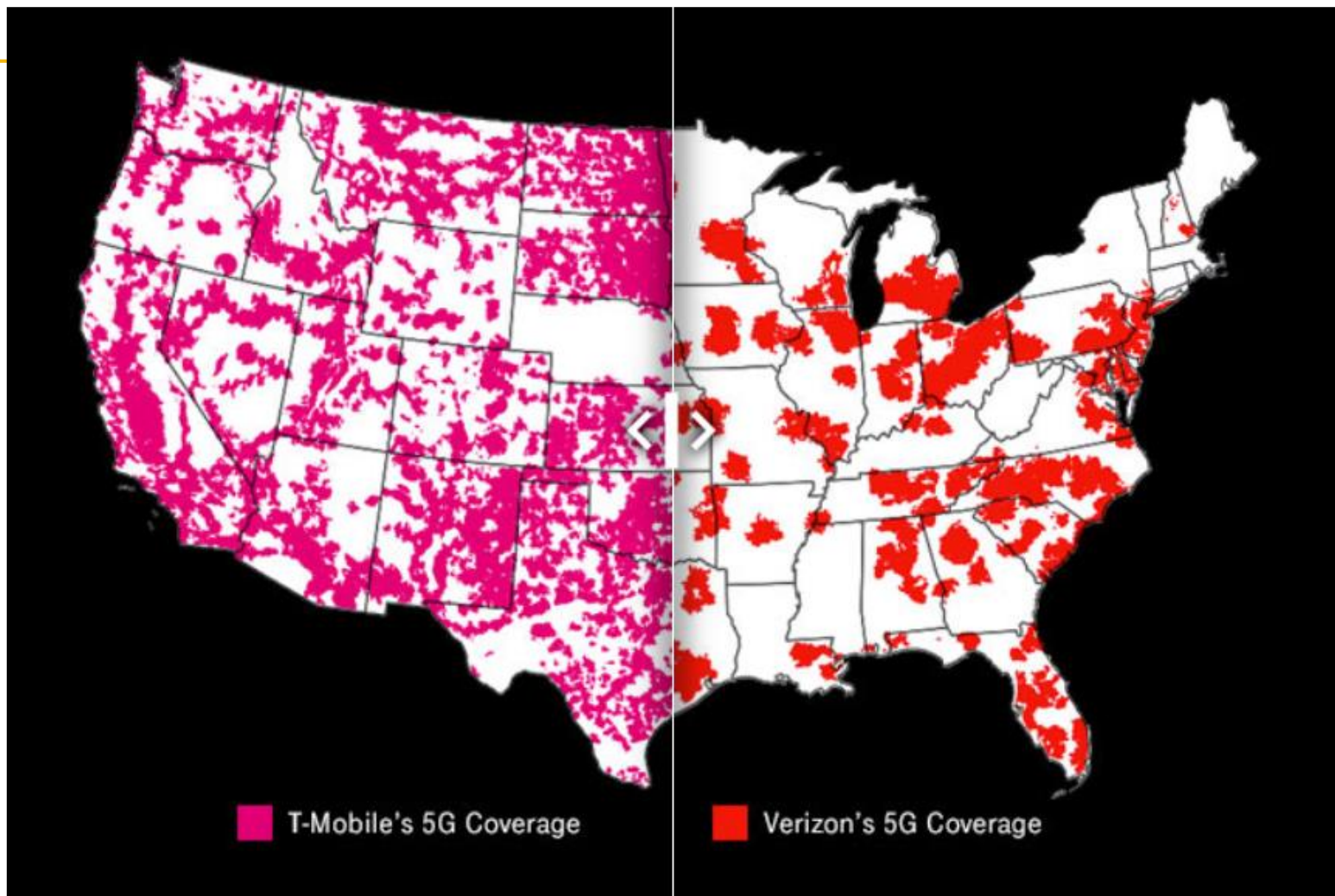
Assigning 5G declared patent families to countries/regions puts the European Union in the lead when essentiality and jurisdiction quality filters are applied



Number of 5G patents as of Feb. 2020 by large company



5G Networks in USA



5G Stations

- Nokia has won a 5G network deal from Taiwan Star Telecom (台灣之星)



5G Stations

- China has over 600,000 5G base stations installed in 2020.

