# Piecing Together the 5G Big Picture*

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5G

- It's touching every part of the communications networking industry and beyond, impacting investments, R&D, corporate cultures and long-term business strategies at companies with no obvious connection to radio heads, baseband capacity or antenna arrays.

- A successful 5G strategy will require network operators to address a very broad range of technologies and processes, all of which will play a critical role in enabling the full potential of 5G deployment.
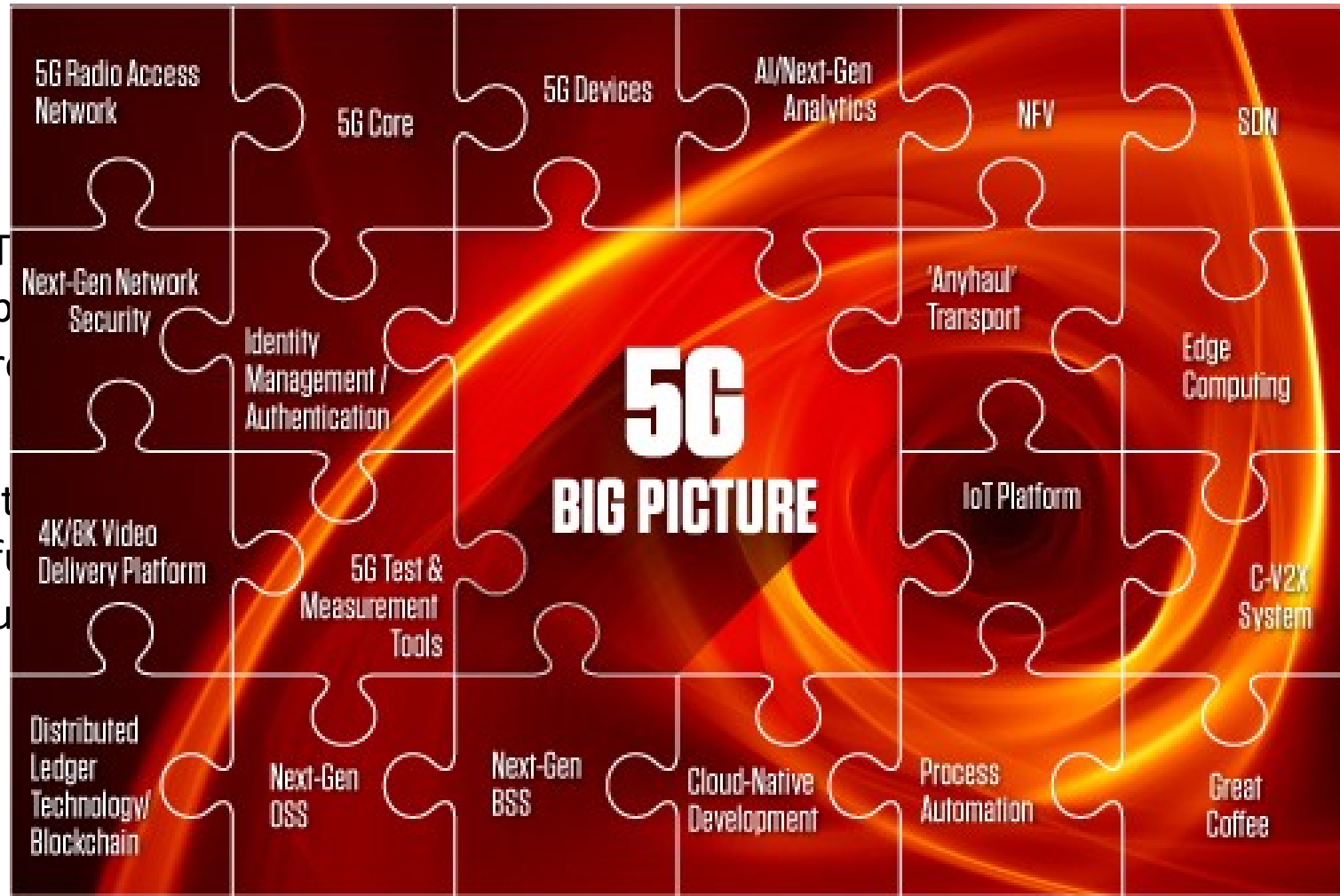
The Big Picture

- Who wants to build a 5G network if there are no 5G-compatible user devices (not to mention a lack of spectrum in certain countries)? And who wants to launch a smartphone if there are no networks that take advantage of its expensive 5G capability?

http://www.lightreading.com/author.asp?section_id=193&doc_id=746025&_ga=2.47737440.636819787.153689 4518-2086389426.1536894518

Is 5G Here?

- Ericsson lands $3.5B 5G deal with T-mobile weeks after Nokia did same.
- AT&T and Verizon are now both saying that the earliest commercial mobile 5G devices will arrive "late in 2018."
  - Verizon Communications will have 5G CPE from Samsung in 2H18 for residential broadband, and AT&T will have its mobile "puck" in late 2018.
  - Full-blown mobile 5G smartphones are expected to be launched in 1H19. Models from Huawei and Samsung are expected to be among the first. Verizon has announced that its first (3GPP) standards-based mobile offering is a Motorola Mod 5G radio module.
  - Sprint is promising "always-connected" 5G PCs on its network for mid-year 2019.

https://www.lightreading.com/mobile/5g/ericsson-lands-$35b-5g-deal-with-t-mobile-weeks-after-nokia-did-same/d/d-id/745992
https://www.lightreading.com/mobile/5g/verizon-to-launch-fixed-5g-service-on-oct-1/d/d-id/746018
http://www.lightreading.com/mobile/5g/a-5g-device-timeline-for-2018-and-beyond/d/d-id/745191

- Verizon says it will launch its initial fixed broadband 5G service in parts of Houston, Indianapolis, Los Angeles, and Sacramento on October 1.

- "5G Home" is a service that offers downloads of around 300 Mbit/s with "peak speeds" of nearly a gigabit, Verizon says. The company will use a fixed wireless connection to the home via 28GHz millimeter wave (mmWave) spectrum to achieve these speeds. Much like FiOS, Verizon envisages this being used to support broadband, video streaming and multiple device connections in the home.

- Verizon uses a window or roof-mounted 28GHz antenna to grab the 5G signal, which is distributed via WiFi from a home router indoors.
  - It is suitable for dense urban environments because of the signal propagation capabilities of millimeter wave spectrum.
  - https://www.lightreading.com/mobile/5g/verizons-fixed-5g-a-cable-alternative-is-coming!/d/d-id/743405

- Millimeter wave spectrum is the band of spectrum between 30 GHz and 300 GHz. Wedged between microwave and infrared waves, this spectrum can be used for high-speed wireless communications - way to bring "5G" into the future by allocating more bandwidth to deliver faster, higher-quality video, and multimedia content and services.

- High frequency means narrow wavelengths, and for mm waves that sits in the range of 1 millimeter to 10 millimeters. It's strength can be reduced due to vulnerabilities against gases, rain and humidity absorption. And to make matters even less appealing, due to those factors millimeter wavelengths only reach out to a few kilometers.

To eMBB and beyond!
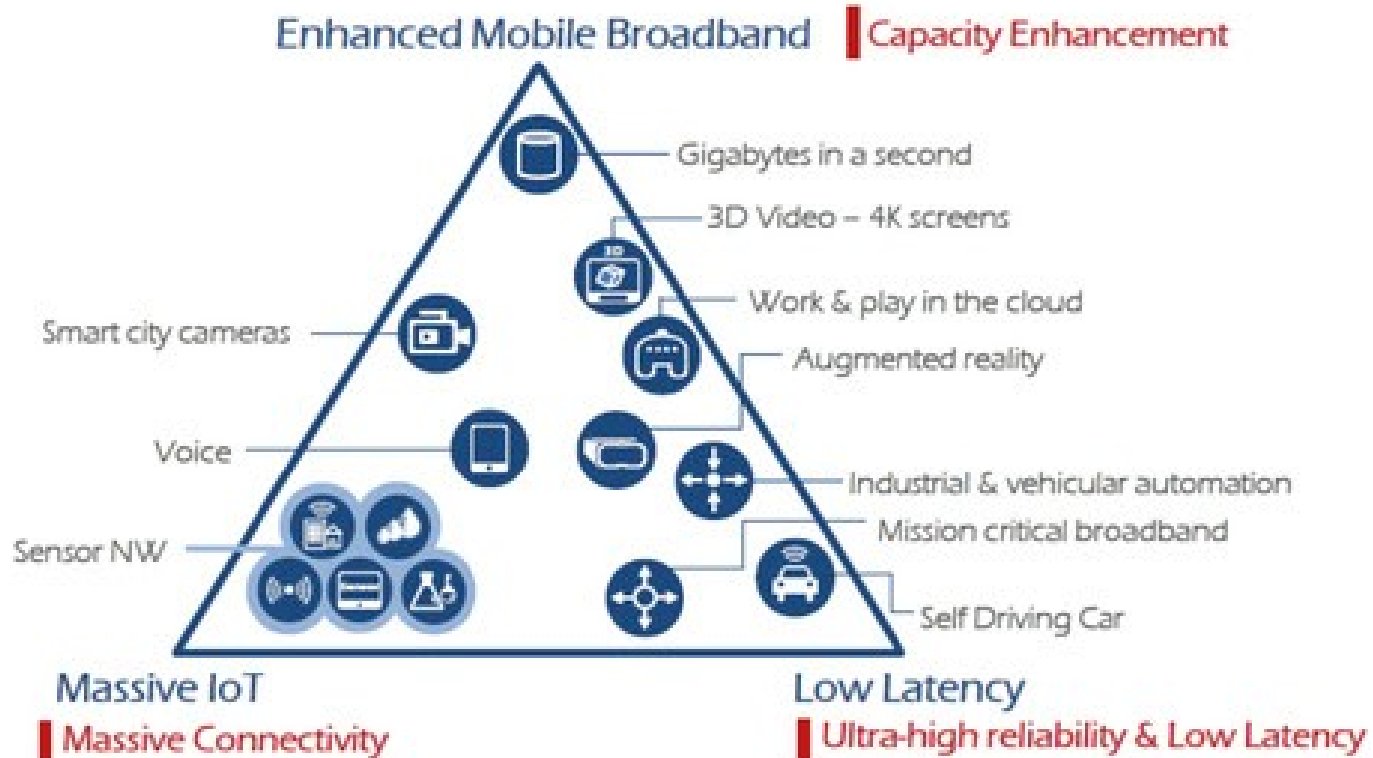
(Source: ETRI graphic, from ITU-R IMT 2020 requirements)

To eMBB and beyond!

- **enhanced Mobile Broadband (eMBB)** - will enable emerging services such as AR/VR and 8K video to mobile devices.

- Such services require, at the very minimum, network upgrades in the radio access network (RAN) and supporting "anyhaul" (fronthaul and backhaul) packet and optical transport networks that carry video and data traffic to and from end-user devices.

- These launches do not require a full 5G Big Picture deployment.

- **massive Machine Type Communications (mMTC)** - enabled by an extensive Internet of Things (IoT).

- All those billions of devices - 20 billion by 2023 (according to Ericsson forecast) - will need to be managed and while some of them will require very little in the way of data traffic flows, either to or from, some will put strain on networks, especially once high-resolution streaming video surveillance cameras become the norm in smart cities.

- These mMTC applications will require a significant number, but not the full suite, of elements.

- The major challenges come down the line when autonomous vehicles are let loose on the roads, and **Ultra Reliable Low Latency Communications (URLLC)** services - aka "Critical Communications" including industrial robot automation and remote surgery are launched.
  - The target latency for 5G is 1 millisecond

- That's when all the puzzle pieces need to be in place.

What are these 20 elements?

- **5G Radio Access Network:** There isn't going to be much happening in the 5G world without next-generation radio access network deployments and the early 3GPP specs are out - this is the element that defines most references to 5G and will continue to do so.

- **5G core:** The intelligent heart of the 5G network that will allow capabilities such as network slicing.

- **5G devices:** Coming soon! And more than just smartphones of course - end-user devices could be just about anything you can fit a 5G chip into.

- The initial "non-standalone" implementations of 5G will, after all, use a 4G core and the radio access network of 5G will blend the New Radio air-interface with legacy cellular technologies as well as other wireless standards such as WiFi.

- For telecom operators embarking on 5G one of the first steps they should consider is densifying the network. This involves the addition of small cells and the extension of fiber closer to more cell sites (fronthaul).

- In areas of high demand, operators will need dense networks comprised of macro and small cells transmitting in multiple frequency bands. The need to coordinate radios to minimize interference is driving the development of new Centralized RAN (C-RAN) architectures - vRAN, Elastic RAN, and Cloud RAN. Part of the baseband processing is in the edge cloud, making possible fast capacity upgrades.

https://www.lightreading.com/mobile/5g/5g---gee-whiz-or-g-force/a/d-id/745863

- The first version of 5G specifications was completed in 3GPP Release 15 in December 2017, enabling full blown commercial networks by 2019. 5G is deployed initially alongside LTE. The specifications for standalone 5G networks will be completed in June 2018.

- The industry is currently conducting 5G trial and development phases and rapidly progressing towards commercial deployments.

- The main spectrum for 5G deployment globally is between 3.3 – 4.9 GHz, which could become the most widely licensed spectrum ever for mobile communication. Low bands below 1 GHz are used to provide coverage and outdoor-to-indoor penetration. Millimeter waves at various frequencies (24-28 GHz and 39 GHz) are used for local hot spot capacity for both outdoor and indoor deployments.

- 5G radio is designed to be flexible, allowing all different spectrum options to be used together. Massive MIMO beamforming with active antenna arrays will be commonly used for 5G base station at mid bands. Beamforming is initially needed mainly for coverage, to match the cell range of LTE at 1.8 GHz band. 5G at 3.5 GHz will be deployed on existing base station sites to bring a major capacity boost on top of LTE networks, while providing approximately the same coverage.

What are these 20 elements?

- **AI/next-gen analytics:** Vast volumes of data will need to be sorted and analyzed, at the edge of the network as well as in central repositories, for advanced business and consumer services - particularly the URLLC services.
  - Machine-learning tools will underpin automated network management and operational processes: Manual processes will not be able to keep pace with requirements.

- **NFV:** To enable to rapid implementation/instantiation of services, 5G networks will be cloud-native NFV infrastructure (NFVi) architectures hosting VNFs.

- **SDN:** It will be required to efficiently and effectively control the network and service delivery platform resources used to deliver services over the telco cloud and provide customers with control of the services they use.

What are these 20 elements?

- **Next-gen network security:** Manual network security processes will be pointless in a full 5G deployment - machine learning-enabled security systems will pre-empt to mitigate security threats across the distributed 5G network landscape.

- **Identity management/authentication:** A scalable approach will be needed to support services across billions of devices and multiple network slices without overloading the signaling infrastructure.

- **'Anyhaul' transport:** The data traffic volumes and disaggregated nature of 5G radio access networks will require high-capacity, low-latency fronthaul (links from remote radios to baseband processing pools) and backhaul connectivity (links from access aggregation points to the metro network).
  - Collectively, fronthaul and backhaul is referred to as "anyhaul."

What are these 20 elements?

- **Edge computing:** The latency requirements of many services running over 5G can only be met by the deployment of a distributed cloud architecture, including the deployment of compute and storage resources at the network edge - at cell tower and base station sites, in revamped central offices, and even in time at the "street furniture" level.
  - https://wia.org/wp-content/uploads/WIA_RoleOfStreetFurniture-final.pdf

- **4K/8K video delivery platform:** High-definition video will need to be delivered and managed as part of 5G service offerings, so the appropriate video infrastructure will be required.

- **5G test and measurement tools:** Neither the vendors nor operators will get too far without being able to test and verify their new 5G systems and services, making these tools essential.

What are these 20 elements?

- **Distributed ledger technology/blockchain:** Blockchain technology is looking increasingly likely to play a role, alongside and supporting traditional databases, in helping to manage and secure transactions and identities once 5G is fully deployed.

- **Next-gen BSS:** Cloud-native business support systems with APIs to network and service controllers will be required to "monetize" and provide customer experience management for the broad array of cloud-based 5G services.

- **Next-gen OSS:** Silos of legacy operations support systems are not going to cut it in a 5G world - like the BSS systems, cloud-based management tools will be required.

- **Cloud-native development:** There is a growing realization among network operators that DevOps processes, including Continuous Integration/Continuous Delivery (CI/CD), will need to be adopted to ensure service support and delivery once 5G telco cloud is deployed.

What are these 20 elements?

- **IoT platform:** Dedicated IoT platforms will be needed to manage and monitor the billions of devices that will be connected in a 5G world.

- **C-V2X system:** Cellular Vehicle-to-Everything is a dedicated cellular specification designed to connect vehicles to each other and anything else that's relevant - an essential component of advanced 5G service deployments.

- **Process automation:** Without automated processes, whether in the back office or at the front line, service providers will lack the speed and efficiency needed to survive in a 5G world.
  - The shift towards automation will be slow but continuous (identify and break down into pieces that can be replicated in code).