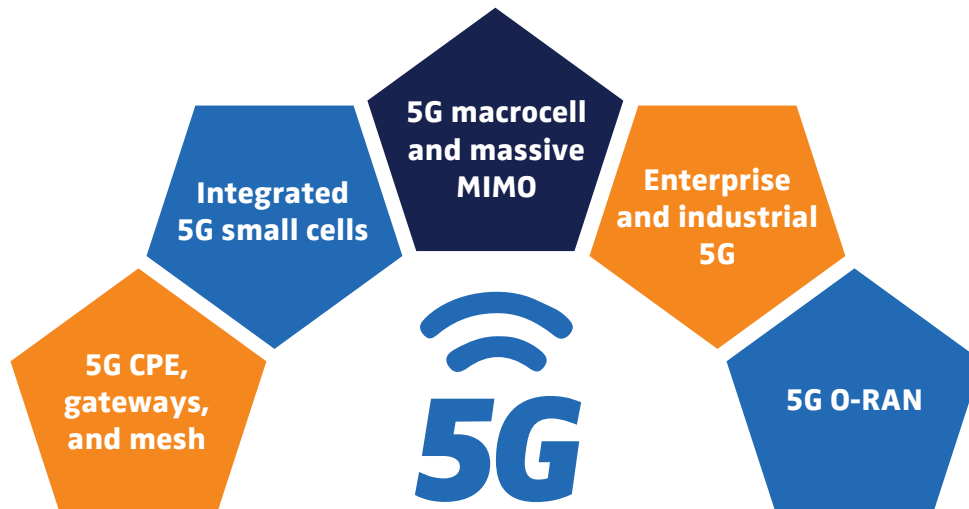# CommAgility

5G

5G New Radio Solutions

5G is the fifth generation of broadband mobile networks, bringing higher data rates, improved efficiency and lower latency. 5G New Radio (NR) is the Radio Access Technology (RAT) used by 5G, and is defined in a specification from industry body 3GPP.

5G NR introduces key improvements on LTE, including more efficient modulation, waveform optimization, and scalable numerology – thus offering advantages such as low latency, faster speeds, and high reliability. This means there is a wider range of end use cases for which 5G will be attractive.

CommAgility has over 15 years' experience implementing and verifying technology that adheres to 3GPP specifications. Because 5G builds on the earlier LTE releases, it can leverage this deep experience to deliver robust, flexible products from individual software blocks, as well as a full, production-ready, 5G gNodeB reference design. CommAgility is the go-to partner for customization and modification at all levels of a 5G private network to address specific customer needs, and to adapt to requirements outside the 3GPP specifications.

CommAgility is developing 3GPP standards-compliant 5G NR software, including UE and gNodeB PHY and Protocol Stack, as well as a 5G Core (5GC) for 5G small cells and private networks. In addition to a complete Rel. 15/16 small cell software solution, as a member of the O-RAN Alliance, CommAgility can support development of O-RAN compliant products.

As well as the main 5G NR software IP blocks, CommAgility provides production-ready reference solutions with integrated and validated 5G software. CommAgility's integrated 5G NR gNodeB is based on NXP SoC devices – NXP Layerscape® for the Protocol Stack and NXP Layerscape Access for the PHY – to achieve optimum performance and cost. Alongside RAN software development, CommAgility is developing a complementary range of hardware solution platforms, from board level to a complete, production-ready gNodeB.

5G base stations and small cells

The basic building block of a wireless network is the base station. For 5G, higher frequencies can be used, which means that transmission distances are lower than 3G or LTE, so more base stations are required to ensure coverage. These may be described as micro, pico or femto cells – or by the generic term small cells.

The diagram below shows the basic functional components required to build a 5G base station (gNodeB). The upper layers, Layers 2 and Layers 3 of the OSI model, are responsible for the packet processing elements of the stack and have less strict timing requirements than the Layer 1 PHY. These can run on general-purpose processors (GPPs), usually comprising multiple Arm or Intel® cores – the number of cores scaling with the cell throughput required. Packet accelerators for connectivity and security on the backhaul help processor offload to reduce power and improve throughput.

The baseband PHY (Layer 1) requires a more time-deterministic architecture, and the multiple signal processing blocks are better suited to dedicated digital signal processor (DSP) units, which also improves efficiency. Again, throughput, bandwidth, carrier count and number of antennas determine the number of DSP units required.

At the Digital Front End (DFE), more DSP resource is required for digital filtering, up/down conversion and RF transmit power improvement techniques such as crest factor reduction (CFR) and digital pre-distortion (DPD). Tight integration with the digital transceivers (ADCs and DACs) is required, which can be on-chip or connected externally over an interface such as JESD. The RF analog front end comprises an RF transceiver to convert the analog baseband signal to the required over-the-air band, a power amplifier (PA) to provide the required gain, a low noise amplifier to recover the mobile signal, and associated filtering.
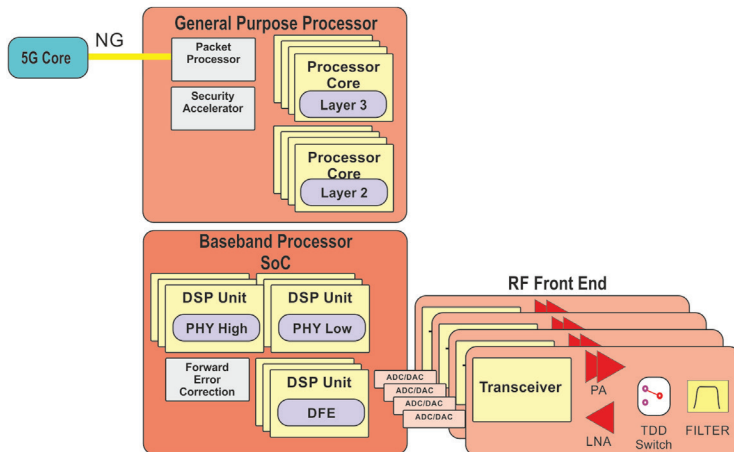
An integrated gNodeB includes a 5G Core, PHY, DFE and RF front end, as well as Layer 2 and 3 packet processing

OSI Layer		3GPP	CommAgility Product
3	Network	RRC	SmallCellSTACK-5G
2	Data Link	PDCP RLC MAC	
1	Physical	PHY	SmallCellPHY-5G

Compared to LTE, the processing and RF demands of 5G result in a need for higher performing, more flexible 5G NR hardware. The frequencies and spectrum supported now include a sub-6GHz range (FR1) with bandwidths up to 100MHz as well as a mmWave band (FR2) with bandwidths up to 400MHz.

Conversely, hardware must be physically compact for small cell and private networks where space and weight are tight – and, similarly, power consumption must be minimized to avoid excessive heat dissipation. At the same time, cost is an increasingly tight constraint.

To meet these demands, CommAgility's latest 5G systems are based on NXP's Layerscape processors, such as the LX2160A, which includes sixteen Arm® Cortex®-A72 cores optimized for L2/L3 packet processing. The LX2160A also provides 8MB L2 cache, and high-performance data path accelerators and peripheral bus interfaces including PCIe Gen3 and Ethernet up to 100Gbps. CommAgility's 5G development platform also includes an NXP LA1200 Layerscape Access baseband processor, which provides high performance from its vector signal processing architecture (VSPA) Vector Engines, delivering more than 1 TFLOP. The LA1200 is specifically optimized for 5G NR, providing the DSP and hardware acceleration needed for compact, power-efficient designs.

Private networks

While LTE has become the standard of choice for a wide range of specialized networks that were previously built on proprietary technology, there is now an opportunity to migrate to 5G. Deployment of 5G-based systems in specialized applications can create private networks that are secure, fast, and reliable. Private networks and specialized applications are predicted by many to potentially overtake operator networks in the market – for example, analyst ABI Research has suggested the private wireless networking market could reach US$16.3 billion by 2025.

For these private networks, designers must address technical challenges that often extend beyond those of the 3GPP 5G NR standard. Specialized private networks often require different performance and capabilities in areas such as coverage, power, propagation delay, and Doppler shift. These issues must be carefully managed for applications such as high-altitude platforms (HAPS), air-to-ground (A2G), and satellite communications for which the 5G standards and protocols were not intended.

Similar to LTE, deploying a specialized or private network with 5G requires a RAN, which connects base stations (often called small cells, access points or gNodeB) and a mobile device (UE) with 5G core software, providing a link to a core/backhaul network. The software to manage the network includes a PHY as well as a protocol stack.
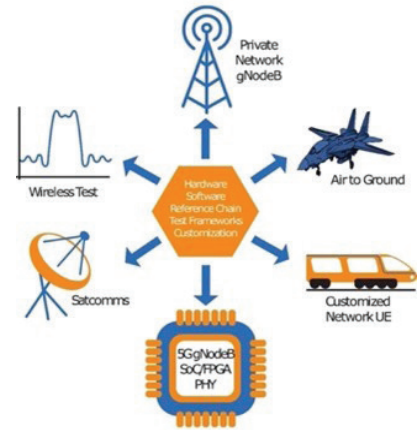
For many applications, there will be a need to migrate products from LTE to 5G, and then to customize them beyond the 3GPP 5G specification to meet particular demands. Systems must facilitate the migration to 5G, and should be sufficiently flexible and scalable to enable vertical markets to cherry-pick appropriate specification features.

This requires in-depth knowledge of 5G NR, and specialized expertise on extending the system beyond the 3GPP specification. Working with its customers, CommAgility can deliver the adaptations and modifications needed for a broad range of private network designs and deployments through a robust and customizable range of hardware, software, and reference design solutions.

Air-to-ground

Driven by increasing passenger demand for in-flight Wi-Fi and aircraft monitoring, airlines are looking to add A2G communication solutions to replace today's expensive satellite connectivity. Connecting from an aircraft traveling at typical cruising speeds of over 900 km/h and altitudes above 10,000 meters creates a specific set of technical challenges. In particular, the network must be able to support high speeds and large cell sizes as well as flight certification for airborne equipment.

Tactical

Tactical systems and related research projects have a range of specialized requirements, often involving adaptations to mitigate or avoid other signals in the RF domain. The CommAgility SC-RF2-5G platform is flexible and high performance, ideal for research and development as well as deployment in networks customized for tactical applications. CommAgility also has experience in ruggedizing hardware to meet standards such as MIL-E-540 and MIL-STD-461B.

Satcom

Satellites and other high-altitude platforms offer the potential of increased broadband coverage to remote communities and emergency communications capabilities. For proper deployment in a satcom system, the 5G network requires algorithmic and protocol adaptations to deal with problems such as higher latency, specific interference, or multiple parallel channels. For example, ground stations supporting low-earth-orbit (LEO) satellites experience an increase in Doppler shift due to their fast relative motion, while geosynchronous equatorial (GEO) satellites operate at much higher orbits, resulting in an increased signal delay, which must be allowed for.

Research projects

Research participation is at the heart of CommAgility's innovation strategy. Its modular hardware solutions, 5G PHY and protocol stack software, and test vectors and configurations enable it to modify any aspect of a wireless solution. This has allowed CommAgility to be at the forefront of driving both LTE and 5G into new markets such as ground-to-air and satellite communications.

CommAgility's software is being used in a variety of 5G technology development and research projects, including programs that involve 5G mmWave repeaters, 5G base stations and small cells, and private network deployment. In each case CommAgility customizes the software to the specific requirements of its clients' projects, simplifying the development process, cutting time to market and reducing risk.

For example, CommAgility participated in COHERENT, a Horizon 2020 5G-PPP project funded by the European Commission, to help research and develop 5G radio access networks. It is also taking part in 5G-CARMEN, a project to drive the research, implementation, and demonstration of 5G solutions for connected and automated mobility. This included extensive trials across the road from Bologna to Munich, spanning 600 km and connecting three countries.

O-RAN

Beyond the integrated small cell, a disaggregation model such as O-RAN provides a standardized way for 5G network equipment to be physically located in more appropriate environments. CommAgility is a member of the O-RAN Alliance, and has the capability to support O-RAN with its 5G software.
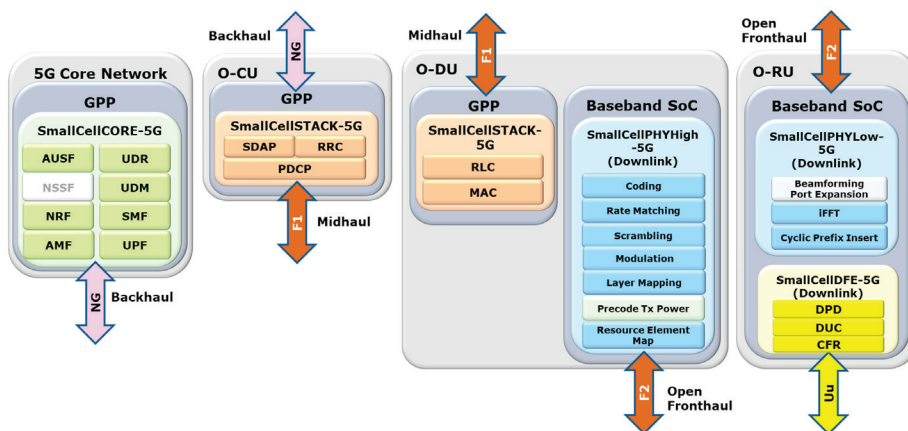
Disaggregation of the gNodeB with an O-RAN architecture

For example, Layer 3 processing which is performed by a general-purpose Intel or Arm-based processor (GPP) can be handled in a central unit (O-CU) closer to the core network and deployed in server type equipment. The O-CU can support multiple distributed units (O-DUs) that run Layer 2 on a GPP and high-PHY on a dedicated baseband SoC with FEC accelerators. These units can be deployed either centrally or close to the radio sites, which in turn determines whether the equipment is based on plug-in cards to server equipment or in a custom outdoor cabinet unit.

In turn the O-DU can support multiple radio units (O-RUs), which can be reduced to only the RF and low-PHY elements which run on baseband SoCs or FPGAs. O-RUs are dedicated equipment that minimize size and power to allow installation at sites with limited access or to reduce cell site rental costs. This allows more units to be deployed for densification, at reduced cost, while also supporting a mix of operating bands and throughput at different sites.

Hardware

As well as the main 5G NR software IP blocks, CommAgility provides production-ready reference solutions with integrated and validated 5G software. CommAgility's integrated 5G NR gNodeB is based on NXP SoC devices – Layerscape for the Protocol Stack, and Layerscape Access for the PHY – to achieve optimum performance and cost.

CommAgility products support 5G StandAlone (SA), as well as 5G Sub-6GHz Non-StandAlone (NSA) when paired with CommAgility's CA-K2L-RF2 eNodeB, an integrated and cost-effective 4G product for the anchor channel.

In addition to delivering 3GPP standards-compliant products, CommAgility's team of highly experienced engineers are available to customize the company's products to meet special requirements. Although 5G standards will ultimately expand to cover some of today's 4G customized solutions, only companies with deep wireless knowledge and capabilities can actually support customers to successful product deployment for niche applications

Software

CommAgility is developing 3GPP standards-compliant 5G NR software, which is scalable to use lower cost and power silicon devices where desired. The software includes:

- UE and gNodeB PHY available as reference chains, providing ultimate flexibility to improve portability and scalability
- Pre-ported and validated PHY and Stack, delivering an IP hardware and software block for integration into a silicon design
- Pre-integrated PHY and Stack on silicon devices, for immediate use in a wireless product development
- Full source code availability and design services for tailored applications
- 5G Core (5GC) for 5G small cells and private networks
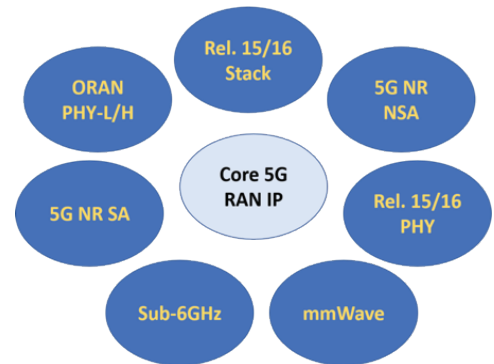
Software Platforms

Platform	Description
SmallCellPHY-5G	5G small cell base station (gNodeB) implementation of PHY layer
SmallCellSTACK-5G	Complete 5G protocol stack
SmallCellCORE-5G	5GC for R&D
PHYRefChain-5G	5G gNodeB, UE PHY reference chains

Technology foundation for multiple RAN scenarios

The foundation of CommAgility's 5G portfolio is the 3GPP Rel-15/16 RefChain: a complete and bit-accurate non-real time PHY, including the algorithm development and validation associated with the 3GPP specifications. The RefChain is the foundation of a real-time physical layer for baseband SoCs.

In creating the RefChain, CommAgility is developing hundreds of test vectors for physical layer and radio validation that can be applied to standard and customized gNodeB and UE test frameworks. From this foundation, a real-time 3GPP Rel-15/16 Physical Layer has been developed for NXP's Layerscape Access architecture. The modular architecture for CommAgility's 5G PHY gives product developers flexibility for supporting any O-RAN PHY-L/H section 7.x splits. Alternatively, combining the PHY with CommAgility's 5G NR Protocol Stack or a third-party stack supports creation of O-RAN products on customer or CommAgility hardware. CommAgility has also developed a 5G Core (5GC) for private networks and demonstration purposes.

Reference Designs and Systems

CommAgility offers two reference platforms for 5G development, based on the NXP Layerscape Access 5G integrated SoC chipset. These are pre-integrated and tested systems, including both hardware and software, saving time and reducing risk.

The platforms will be useful to UE and gNodeB product developers, 5G researchers and 5G network engineers. For specialized applications, CommAgility can also provide customization services, source code and test vectors/test cases, as well as integrated applications. Initial support is included in the purchase price.

As well as these platforms for gNodeB development, CommAgility can also provide UE capabilities such as timing extraction and signal analysis. A full UE reference platform is planned.

SC-RF2-5Gn78 indoor 5G small cell standalone gNodeB reference platform

The SC-RF2-5Gn78 combines CommAgility's industry-leading SmallCellPHY-5G and SmallCellSTACK-5G software, with its baseband and RF hardware based on NXP's Layerscape and Layerscape Access SoCs, all pre-integrated and tested to reduce risk and effort.

The platform provides a 5G gNodeB base station, which can be used as a complete small cell solution. It supports wireless baseband processing and a 2x2 MIMO air interface in radio test systems and gNodeBs.

The main processor is the LX2160A, the highest performance member of the Layerscape multicore communications processor family. It provides 5G Layer 2-3 processing with Ethernet connectivity to the core network, including security acceleration.
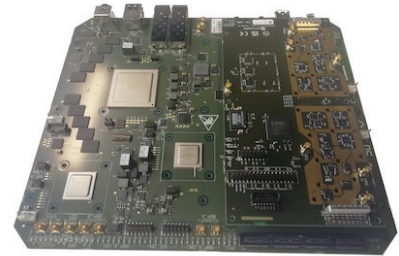
An NXP Layerscape Access wireless SoC provides the L1 PHY processing, combining VSPA DSP cores with wireless accelerators and RF transceivers. RF output power up to +14dBm average is supported and bandwidths up to 40MHz on each of two RF channels.

5G reference gNodeB NXP development platform

The platform is based on the LA1224-RDB, which is an NXP development platform featuring an LA1224 Layerscape Access baseband SoC. It is coupled with an NXP LX2160A.

Supplied with CommAgility's SmallCellPHY-5G software, the LA1224 provides the 5G L1 PHY processing. CommAgility's 5G Stack provides 5G Layer 2-3 processing with Ethernet connectivity to the core network, including security acceleration, running on the LX2160A.

RF capabilities are provided by the CA-RF2-5Gn78, an RF front end module developed by CommAgility. It has two integrated RF transceiver channels, and provides a complete baseband and RF small cell solution with a 2x2 MIMO air interface (for lab-based use only).

Easy configurability

CommAgility's engineers, based on years of product and project experience, have developed a 5G Management Tool for use with CommAgility's Protocol Stack or Reference gNodeB products, that demonstrably saves effort, time and cost.

The Management Tool provides an easy-to-use interface for managing and manipulating the hundreds of configuration parameters that are loaded by the Protocol Stack on start-up. It also monitors multiple parameters during operation of the gNodeB. Key Performance Indicators (KPIs) give a view into the network for the engineer and give information that includes throughput, data usage and channel quality. These parameters can be used to optimize the network or aid in deployment.

CommAgility

CommAgility is a developer of embedded signal processing and RF modules, and PHY/stack software, for 4G and 5G mobile network and related applications. Combining the latest DSP, FPGA and RF technologies with advanced, industry-leading software, CommAgility provides compact, powerful, and reliable products for integration into high performance test equipment, specialized radio and intelligence systems, and R&D demonstrators. CommAgility engineers work closely with customers to provide hardware and software solutions for the most demanding real-time signal processing, test and control challenges in wireless baseband, semiconductor processing, medical imaging, radar and sonar applications.

Wireless Telecom Group, Inc., comprised of Boonton, CommAgility, Holzworth, and Noisecom, is a global designer and manufacturer of advanced RF and microwave components, modules, systems, and instruments. Serving the wireless, telecommunication, satellite, military, aerospace, and semiconductor industries, Wireless Telecom Group products enable innovation across existing and emerging wireless technologies. With a product portfolio including peak power meters, signal generators, phase noise analyzers, signal processing modules, 5G and LTE PHY/stack software, noise sources, and programmable noise generators, Wireless Telecom Group supports the development, testing, and deployment of wireless technologies around the globe.

Boonton

Boonton Electronics is a leader in high performance RF and microwave test equipment for radar, avionics, electronic warfare, satellite and wireless communications, and EMI/EMC applications. Used across the semiconductor, military, aerospace, medical and communications industries for more than 70 years, Boonton products enable a wide range of RF power measurements and signal analysis for RF product design, production, maintenance and system integration. The Boonton product portfolio is designed and manufactured in the USA and includes peak and average RF power meters, Real-Time USB Power sensors, RF voltmeters, modulation analyzers, and audio analyzers.

Holzworth

Holzworth Instrumentation is a leader in high-performance phase noise analyzers and signal generators for test and measurement solutions in government, commercial, and academic environments. Optimized for ultra-low phase noise performance, Holzworth products offer fast switching speeds, spectral purity, accuracy, and high reliability while meeting stringent performance specifications in a unique form factor. The Holzworth product portfolio includes real-time phase noise analyzers, broadband RF and microwave synthesizers, frequency dividers, amplifiers, downconverters, phase detectors, and phase shifters.

Noisecom

Noisecom is a leader of RF and microwave noise sources for signal jamming and impairment, reference level comparison and calibration,receiver robustness testing, and jitter injection. Electronic noise generation devices from Noisecom come in a variety of product types including, noise diodes, built-in-test modules (BITE), calibrated noise sources, jitter sources, cryogenic noise standards and programmable instruments. Calibrated noise sources are available from audio to millimeter wavelengths in coaxial or waveguide modules. Programmable instruments are highly configurable and able to generate precise Carrier-to-Noise, Signal-to-Noise and broad band white noise. Noisecom products arecustomizable to meet the unique needs of challenging applications and can be designed for high power, high crest factor, specific filter responses with a wide selection of input and output options.