Intel Atom® C3000-Series Processor Family 5G Base Station

White Paper

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Revision History

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574135	1.0	Initial Release	August 2017

1   Introduction to 5G Requirements

Over the last few decades, mobile communications have significantly contributed to the economic and social progress of both developed and developing countries. Today, mobile communications form an indispensable part of the daily lives of billions of people in the world, and are expected to continue to become even more widespread in the future.

In that future, however, it is foreseen that the growing demand for higher volumes of traffic, more connected devices with diverse service requirements, and better and uniform quality of user experience will bring a need for evolved systems with extended capabilities.

ITU-R Study Group 5 Working Party 5D (WP5D) issued a new recommendation, "IMT Vision – Framework and overall objectives of the future development of IMT for 2020 *and beyond*"; it lists the following usage scenarios:

- Enhanced Mobile Broadband
- Ultra-reliable low-latency communications
- Massive machine-type communications

Figure 1 Usage scenarios of IMT for 2020 and beyond
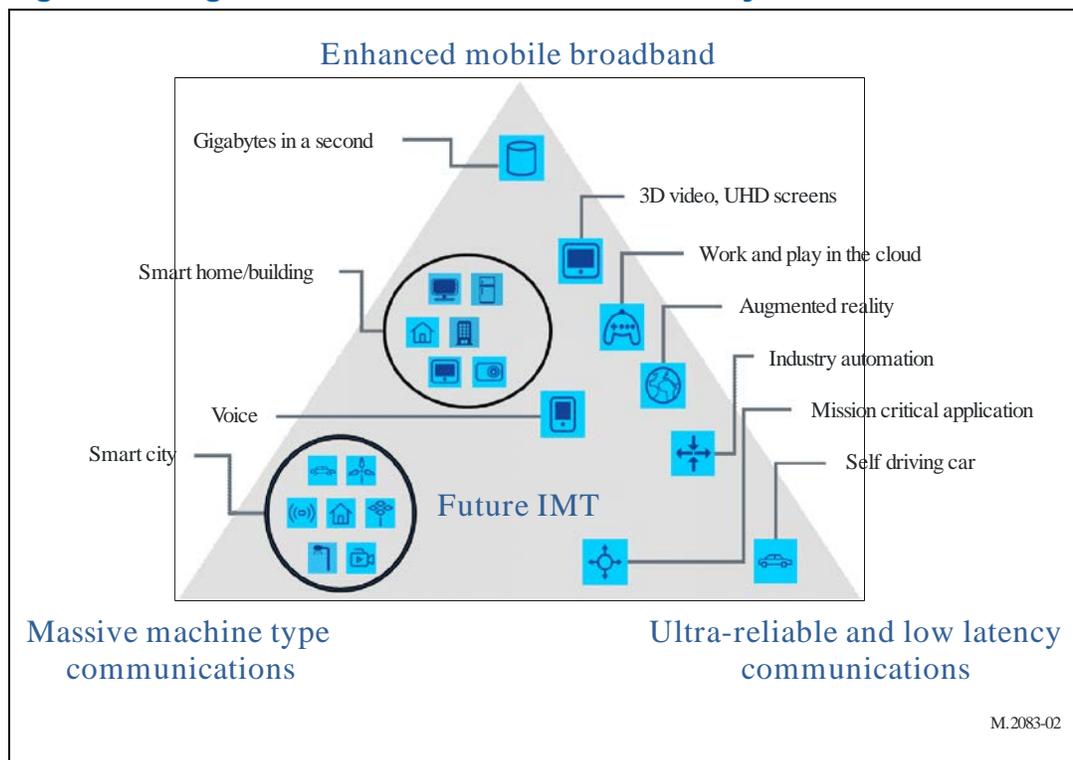
These usage scenario trends can be categorized and summarized as follows:

- Everything will be connected wirelessly to enable monitoring, collection of information, and control of devices. Technologies based around remote monitoring and real-time control of a wide variety of devices will support machine-to-machine (M2M) communication and the Internet of Things (IoT), enabling services such as connected cars, connected homes, moving robots, and sensors.

- Wireless services will become more extensive and enriched through content being delivered in real-time, with safety and lifeline communications being ensured. Examples of such emerging services, which may use new types of mobile connectivity, include:
  — High-resolution video streaming
  — Tactile Internet
  — Media-rich social network services
  — Augmented reality
  — Road safety

1.1 5G General Requirements

The trends in mobile applications and services are expected to impose new requirements on service levels. Table 1 shows the 5G wireless communication system requirements.

Table 1 Requirements for 5G wireless communication systems[4]

Figure of merit	5G requirement
Peak data rate	10 Gb/s
Guaranteed data rate	50 Mb/s
Mobile data volume	10 Tb/s/km2
End-to-end latency	Less than 1 ms
Number of devices	1 M/km2
Total number of human-oriented terminals	≥ 20 billion
Total number of IoT terminals	≥ 1 trillion
Reliability	100.00%
Energy consumption	–
Peak mobility support	≥ 500 km/h
Outdoor terminal location accuracy	≤ 1 m

1.2   SDN/NFV benefits on the path to 5G

In 5G networks, Network Function Virtualization (NFV) and Software-Defined Networking (SDN) concepts will serve as key enablers to provide the needed flexibility, scalability, and service-oriented management.

Today's networks cannot be provisioned for every scenario of low, medium and high traffic requirements. Flexibility allows for tailored functionalities to be made available on-demand. This flexibility must be enabled in order to fulfill the requirements of contradicting services, such as massive Machine-Type Communication (mMTC), ultra MTC (uMTC), and extreme Mobile BroadBand (xMBB) (for example, by inclusion of adequate access procedures and transmission schemes). Service-oriented management will also be realized by flow-oriented control and user planes enabled by joint NFV and SDN frameworks.

As next generation radio access has to fulfill a broad range of requirements, the design of future network architectures will be driven by demand for flexibility, scalability and service-oriented management. Even though not directly associated with 5G, NFV and SDN will complement each other and enable the implementation of these fundamental requirements that will provide an easier path to 5G and its associated services.

5G networks that respond to changing market conditions will be much faster compared to legacy networks (3G or 4G). The path to implementation can begin today via co-deployments of 5G ready components with LTE evolution. By provisioning multi-Radio Access Technologies (multi-RAT) and introducing new RAN technologies, greater efficiencies can be realized without a severe economic impact. Additionally, the flexible placement of network functions will pave the way for better matching of functional splits in service requirements, user density, and propagation conditions, as well as mobility and traffic profiles.

To enable all these benefits, it is essential to provide both the necessary flexibility of communications among the arranged network functions along with the standardized interfaces that allow for interworking of multivendor equipment.

2 Intel Atom® C3000 Series Platform

2.1 Intel Atom® C3000-Series Processor

Intel Atom® C3000-series processor is the 3rd generation Intel Atom System-on-a-Chip (SoC) targeting solutions that require very low power, high density, and high I/O integration in network, storage, and server applications.

Its key features are:

- Intel® VT-x and VT-d for best virtualization performance
- Integrated Intel® QuickAssist Technology (Crypto and Compression accelerator)
- Up to 4x 10 GbE Ethernet
- Up to 20 flexible HSIO lanes
    — Up to 16 SATA 3
    — Up to 16 PCIe* 3.0
    — Up to 4 USB 3
- x86 software compatibility enables seamless reuse of standard software environments
- Wide range of SKUs (2-16 Core) enables scaling one design across multiple target use cases
- Address extreme low power requirements (less than 10W TDP) and high-density form factors
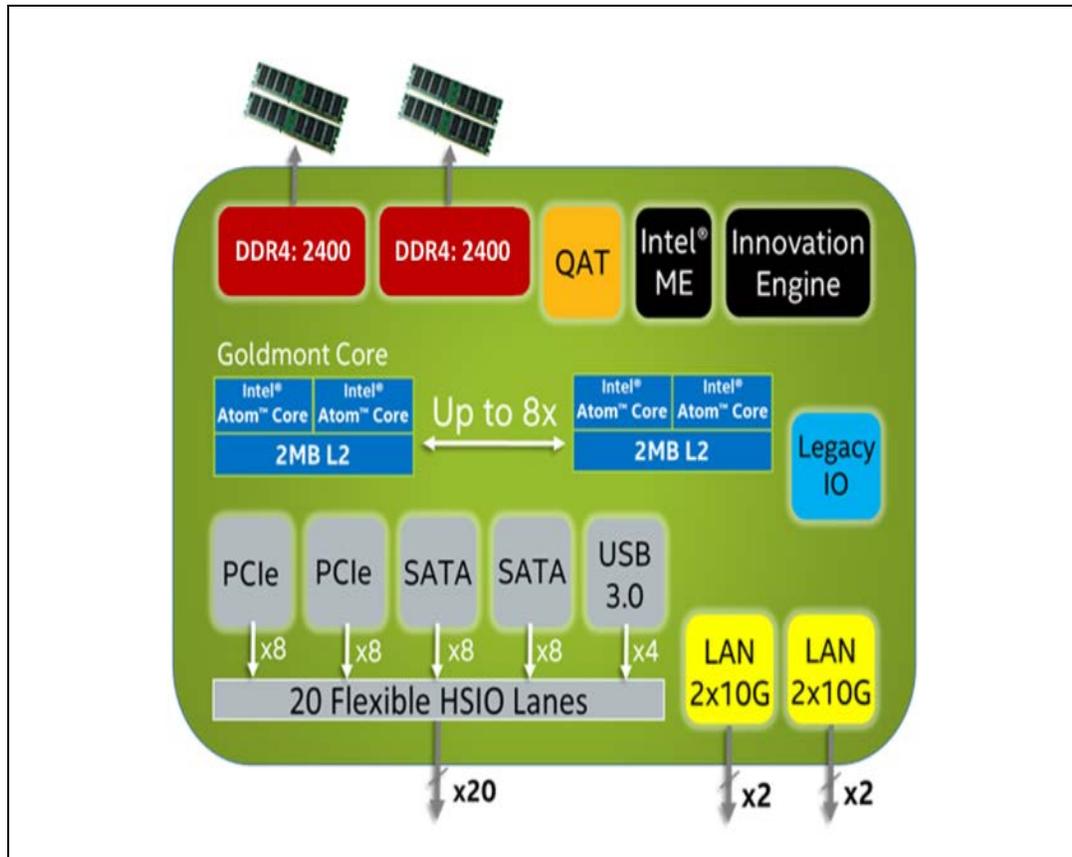
2.2 Integrated 10G Interface

5G networks will provide a much faster connection for consumers versus 4G with standards requiring 10 Gbps high-speed connections. The Intel Atom® C3000-series processors are designed to meet such requirements with four integrated 10Gb network ports providing high-speed connections to the core network while integrated networking helps contribute to the small form-factor design of the base station.

2.3 Integrated Intel® QuickAssist Technology

In the 5G network, security is an indispensable requirement. The base station must use air interface security to connect to the user equipment (UE), and an IPsec connection to connect to the core network. The base station must support high-performance crypto algorithms like AES at the IP level and ZUC/Kasumi/Snow3G at the PDCP level.

To support these requirements the Intel Atom® C3000 processor series integrates Intel® QuickAssist Technology providing up to 20 Gbps of crypto performance.

Table 2 Intel Atom® C3000 QuickAssist Technology performance

Performance	Single Intel Atom® C3000-NS Solution
SSL	20 Gbps
Bulk Crypto + Authentication	20 Gbps
RSA Decrypt 1024	92K Ops/sec
RSA Decrypt 2048	20K Ops/sec
ZUC/Snow3G/Kasumi F82	12Gbps

NOTES:
1. The packet size is 1 kB, using AES-CBC-HMAC SHA1 at 320 B packets.
2. Results have been estimated based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance.
3. Estimates are subject to change.

2.4 Intel® Virtualization Technology

Virtualization is generally viewed as a software technology; Intel has added hardware features to multiple platform components in order to improve the performance and security of virtualization. Developers can augment software-based virtualization technologies with a complementary hardware-assist technology called Intel® Virtualization Technology (Intel® VT).

- Performs various virtualization tasks in hardware (for example, memory address translation, which reduces the overhead and footprint of virtualization software and improves its performance).

- VM to VM switching time is significantly faster when memory address translation is performed in hardware instead of by software.

- Intel® VT increases the robustness of virtualized environments by using hardware to protect the software running in one VM from interfering with the software running in another VM

The Intel Atom® C3000-series processor supports Intel® Virtualization Technology, including VT-x, VT-d, and VT-c. With the Intel® VT technology, 5G system designers can easily implement flexible and high-performance SDN/NFV platforms with Virtual Machines and Containers.

3 ZTE* 5G base station solution

ZTE* Corporation (0763.HK / 000063.SZ), a major international provider of telecommunications, enterprise, and consumer technology solutions for the mobile internet, has launched a next generation 5G IT baseband unit (BBU) with the Intel Atom® C3000-series processor. The IT BBU is the world's first software-defined networking/network function virtualization (SDN/NFV) technology-based 5G RAN solution[5] (shown in Figure 3)

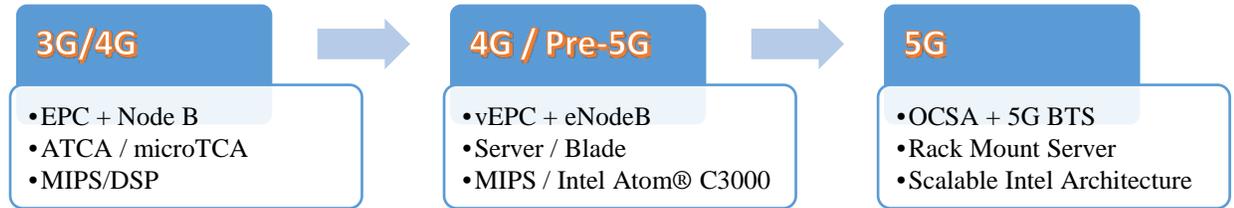**Figure 3 ZTE* IT BBU for 5G Basestation solutions**
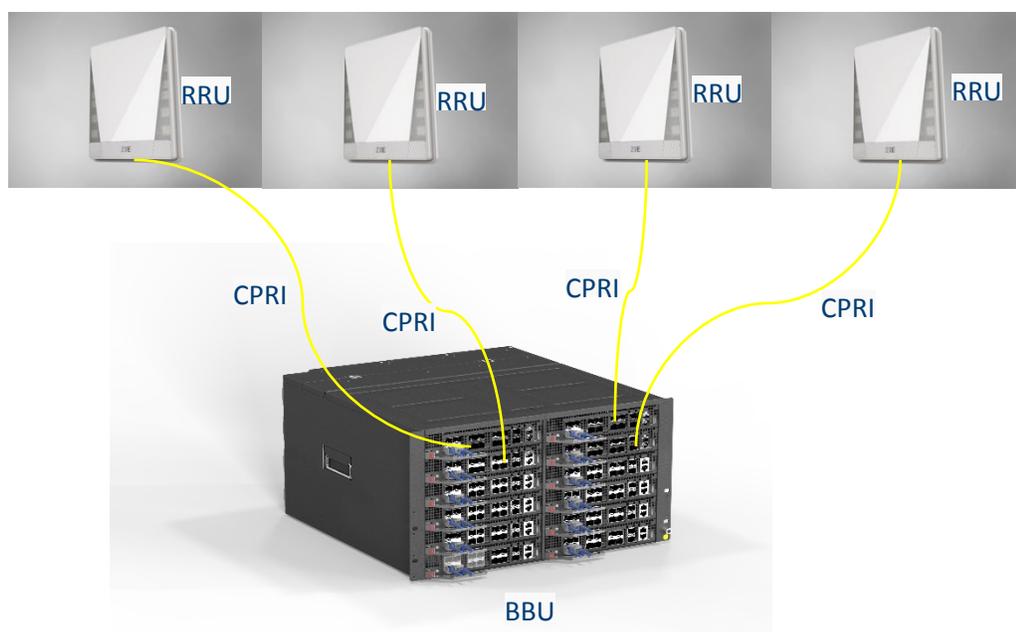
By utilizing advanced SDN/NFV virtualization technology, the modular IT BBU is compatible with 2G/3G/4G/Pre5G, and supports cloud-radio access networks (C-RAN), distributed-RAN (D-RAN), and both 5G central and distributed units (CU/DU), which equips it with a robust ability for future development. This new generation of modular baseband processing platforms, based on Intel® architecture has increased capacity, high level integration, and multi-mode flexible networking features. Some of its key features include:

- Significantly reduced energy consumption with sophisticated algorithms and mechanisms.

- Support for various vertical markets with flexible deployment.

- Support for 4G and 5G hybrid networks simultaneously to effectively protect the operator's investment.

Traditionally, mobile networks expand scale and functions by increasing hardware, but this method increases energy consumption, as well as operation and maintenance complexity. The result is an increase in total cost of ownership (TCO), which is harmful to a network's long-term development and evolution. Figure 4 shows the progression of ZTE's approach to the 5G architecture across the wireless generations (3G, 4G, 5G) with a notable increase in virtualization, software defined networking and commercial off the shelf form factors to provide an agile infrastructure that allows for maximum flexibility.

Figure 4 Progression of ZTE Wireless Architectures

3G/4G
- EPC + Node B
- ATCA / microTCA
- MIPS/DSP

4G / Pre-5G
- vEPC + eNodeB
- Server / Blade
- MIPS / Intel Atom® C3000

5G
- OCSA + 5G BTS
- Rack Mount Server
- Scalable Intel Architecture

The IT BBU, ZTE's new generation network platform, utilizing SDN/NFV technologies, can help address these challenges. By virtualizing functions such as the evolved packed core (vEPC) and introducing the Open Network Foundation Certified SDN Associate (OCSA) (see Figure 4 above), the baseband processing platform can carry diversified network functions more flexibly, significantly accelerating network deployment and optimization, in addition to reducing the overall investment cost.

4   References

#	Title	Link
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