



# 5G and IoT Device Integration



# OBJECTIVES

- How 5G Enhances IoT Device Capabilities
- Case Studies on 5G and IoT Device Integration
- Group Activity on 5G-IoT Scenarios
- Homework Assignment



Recommended Book

[https://www.amazon.in/Internet-Things-Surya-Durbha/dp/0190121092/ref=cm\\_cr\\_arp\\_d\\_bdcrb\\_top?ie=UTF8](https://www.amazon.in/Internet-Things-Surya-Durbha/dp/0190121092/ref=cm_cr_arp_d_bdcrb_top?ie=UTF8)

# 5G Enhances IoT Device Capabilities



**10 x capacity**  
up to 1 mil  
devices per m<sup>2</sup>

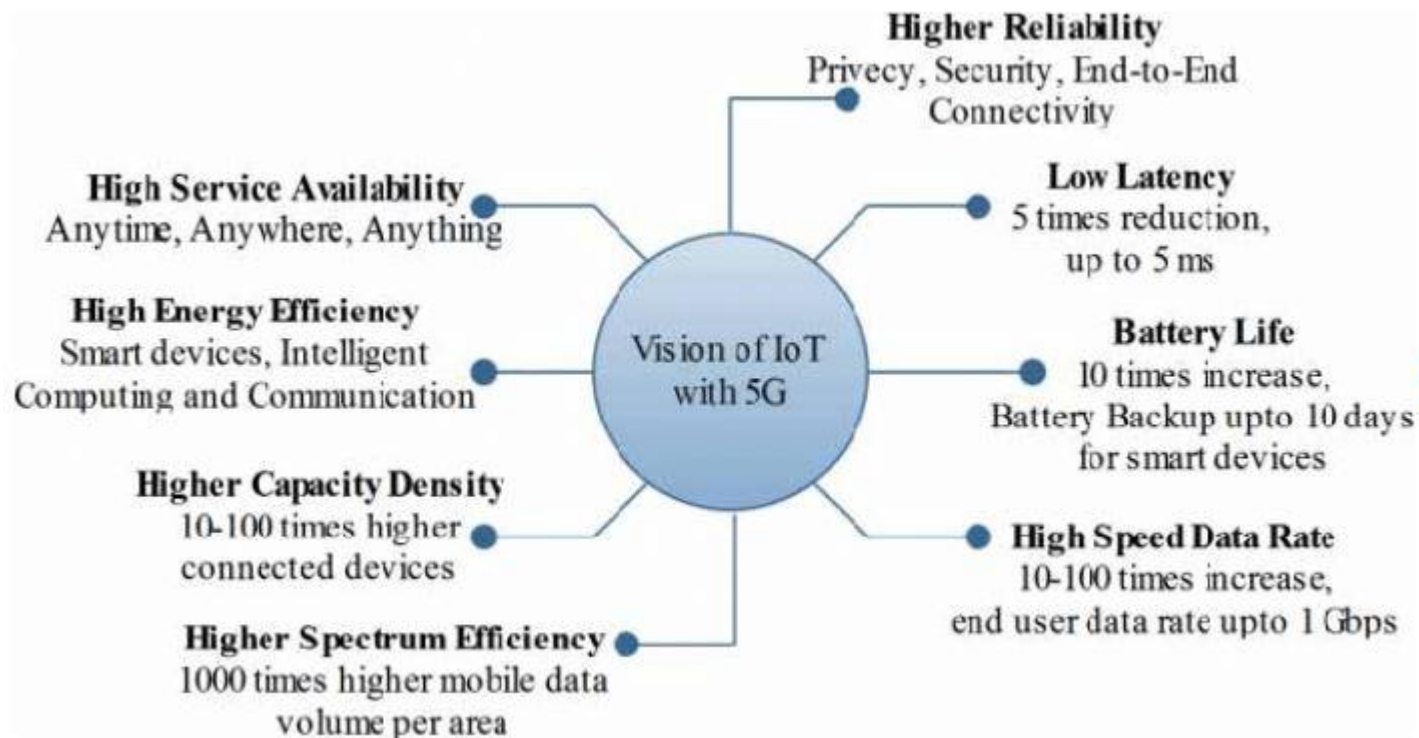


**10 x less latency**  
response in as  
little as 1 ms



**20 x speed**  
peak data rate  
at 20 Gbps

# Vision of IoT -5G

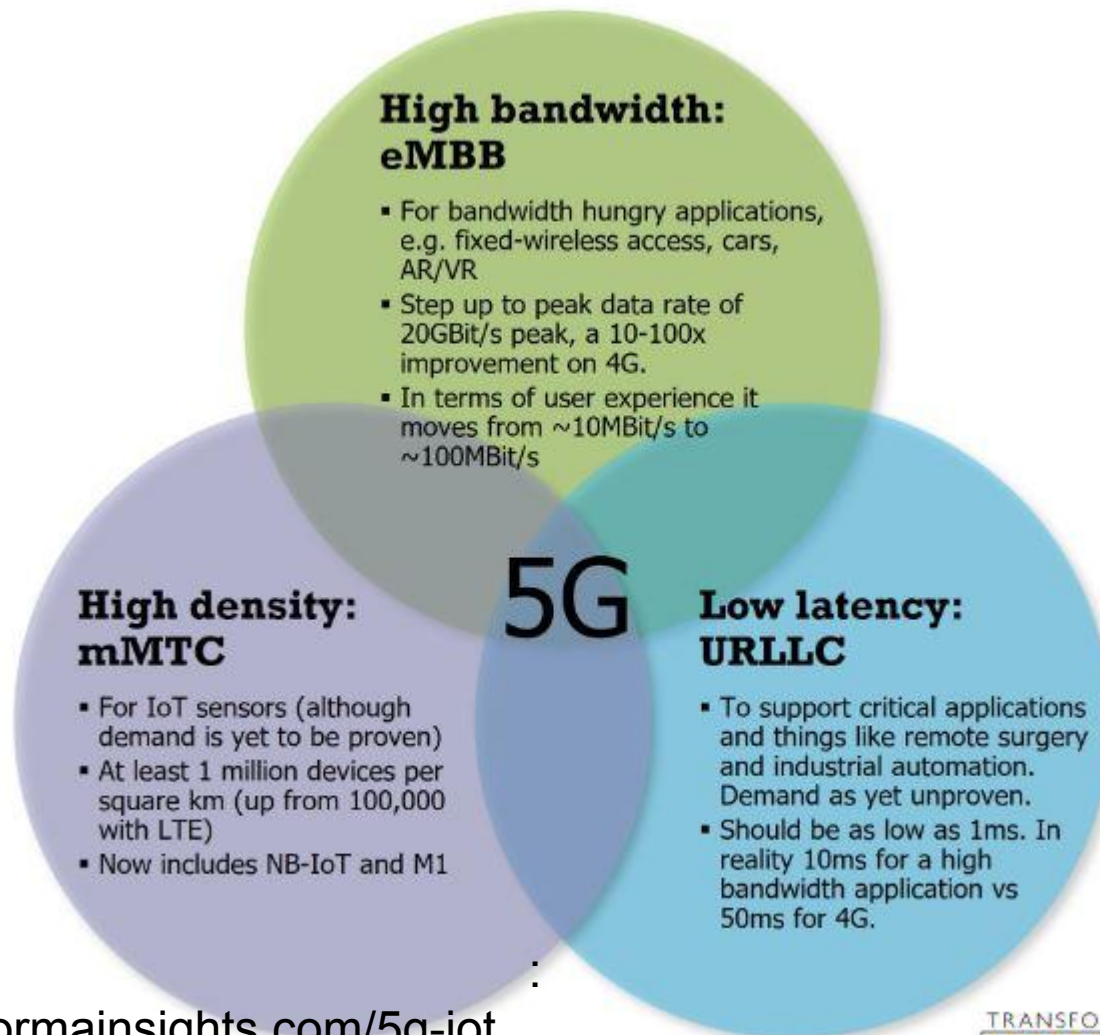




## How 5G Enhances IoT Device Capabilities

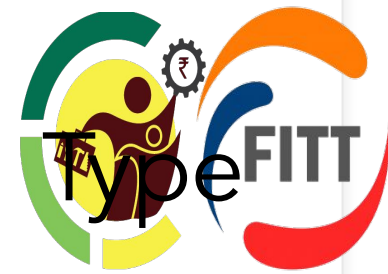
- Massive Machine-Type Communications
- Ultra-reliable low latency communications (URLLC)
- Enhanced Mobile Broadband
- Real-time data processing at the edge
- Enhanced security
- More energy-efficient network

# Capabilities of 5G-IoT

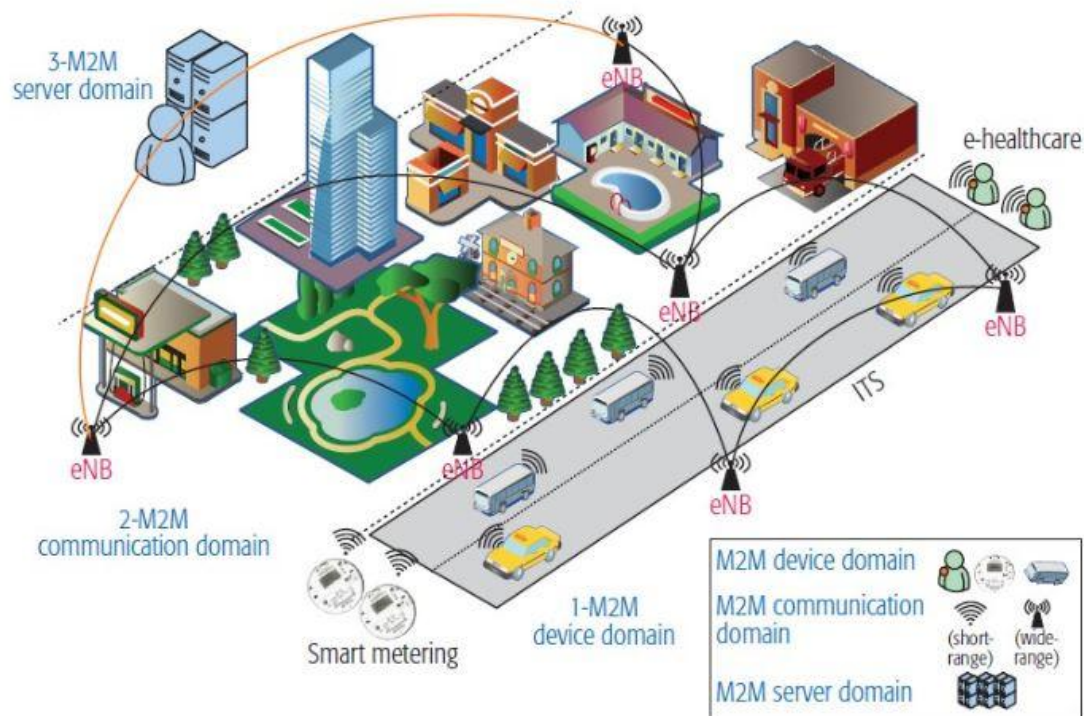


Source :  
<https://transformainsights.com/5g-iot>

# mMTC (Massive Machine Type Communications)



- mMTC is developed by 3GPP (3rd Generation Partnership Project), the organization responsible for standardizing 5G networks and providing new 5G services for the telecommunications industry.
- Massive Machine Type Communications (mMTC) refers to a collection of 5G technologies that are tailored to support the Internet of Things (IoT) through enhanced mobile broadband (eMBB), ultra reliable low latency communication (uRLLC) and massive Internet of Things (mIoT)



Source:  
<https://itnspotlight.com/massive-machine-type-communication-in-5g-and-beyond-network/>





# Benefits of mMTC

- Increased Network Performance
- Reduced Latency
- Lower Energy Usage

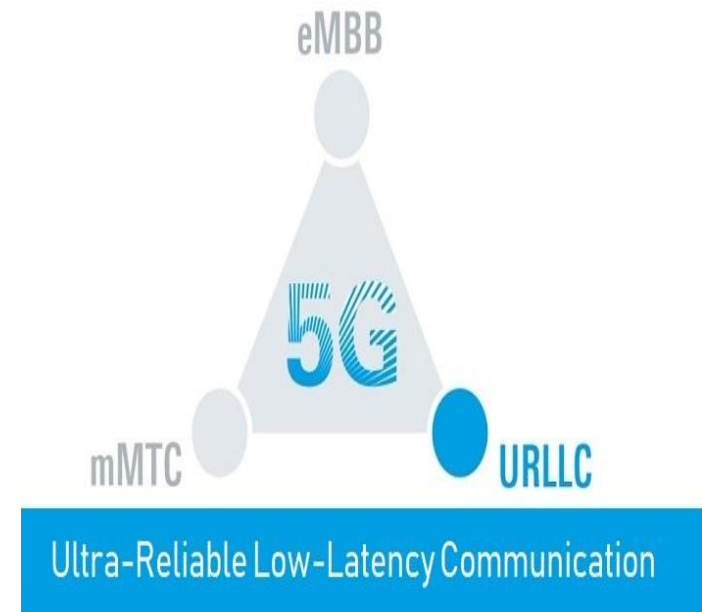


# How mMTC Works

- Network Topology
- Message Structure
- Network Protocols
- Security

# Ultra-reliable low latency communications

- Reliability
- Latency
- Difference between the Reliability and latency



Source :

<https://www.everythingrf.com/community/what-is-urllc>

# 5G URLLC



- URLLC plays a crucial role in 5G networks
- fast data transfer and minimal delay, enabling seamless communication between users and devices.
- URLLC technology enables **multiplexing**, which allows multiple users to share resources and enhances network efficiency.

# Multiplexing techniques in 5G



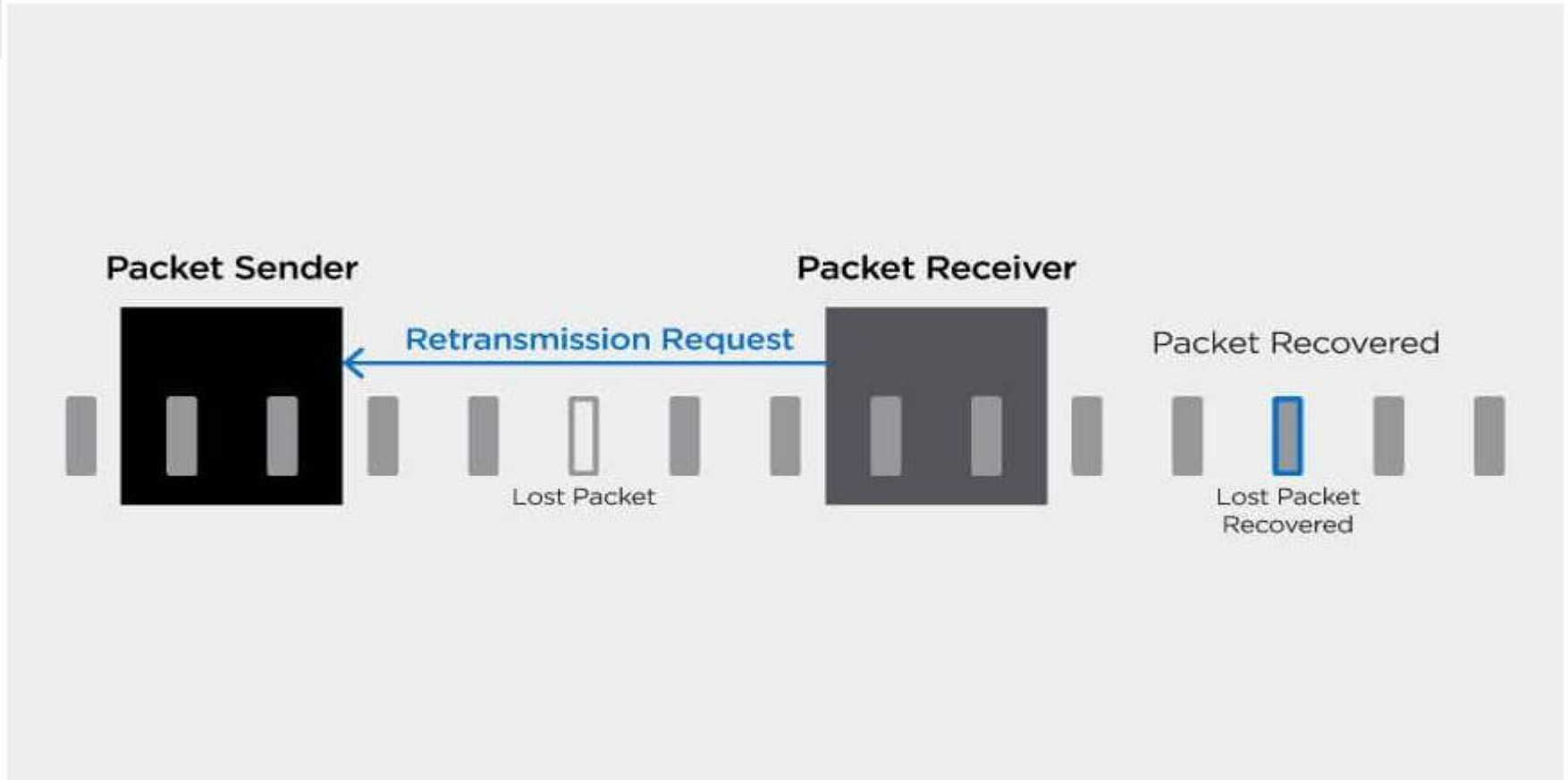
- multiplexing refers to the sharing of a system resource (SR) to a set of users
- difference between multiplexing and multiple access
- With multiplexing, multiple channels or users can all share the same SR.
- Multiplexing is a great way to boost the efficiency of utilizing the SR and the transmission capacity of the system.

# 5G URLLC



- How does it work?
- Network slicing (Discussed in the previous session)
- Beam forming
- packet retransmission protocols

# Packet retransmission protocols





## 5G URLLC Contd.

- With grant-free uplink access, 5G technology can achieve super low-latency transmissions.
- Handshake for data exchange





# Applications of URLLC

- Autonomous Vehicles
- Industrial Automation
- Healthcare
- Augmented/Virtual Reality
- Smart Grids
-



# Enhanced Mobile Broadband

- EMBB is designed to provide higher data rates, better bandwidth, higher throughput, increased reliability and lower latency as well as improved multimedia functionality for the end user.

## **Benefits of eMBB**

- Faster data transfer rates
- Strong indoor connectivity
- Higher capacity networks
- Reliable IoT connections
- Immersive VR experiences
- “Hot spot” situations



# Enhanced Mobile Broadband Use Cases

- Video Streaming
- Internet of Things (IoT)
- Virtual Reality (VR)
- Mobile Gaming
- Telemedicine



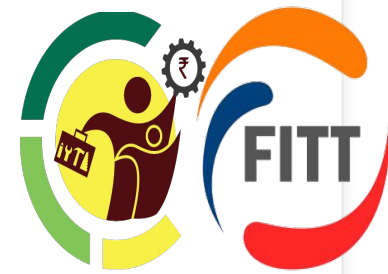
# Real-time data processing at the edge

- Processing data in real-time at the edge is a computing technology that allows organizations to locally process and filter data, even without an internet connection.
- By implementing this solution, organizations can quickly respond, streamline operations, and enhance overall efficiency.



# Enhanced security

- 5G security focuses on safeguarding the 5G infrastructure and devices from potential threats such as data loss, cyber attacks, and malware.
- **security improvements in 5G**
    - Encryption
    - Authentication
    - Enhanced Subscriber Identity Protection
    - Network interconnect security



# Energy-efficient network

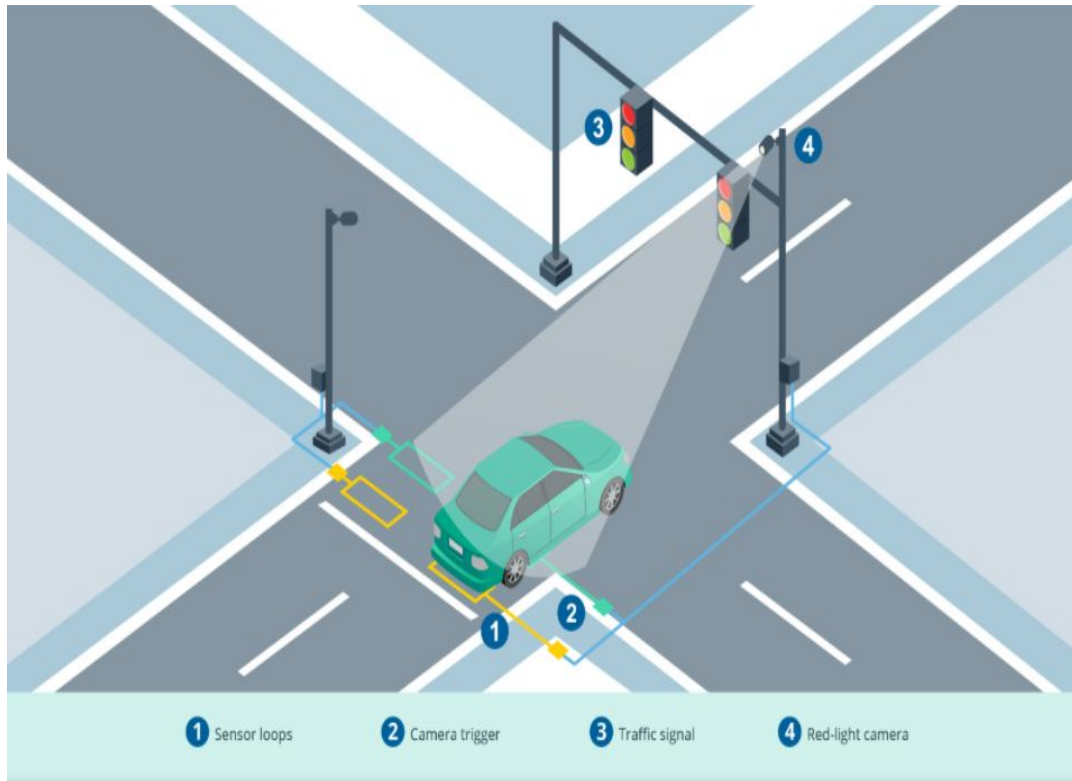
- 5G networks exhibit superior energy efficiency compared to preceding cellular technologies.
- VIAVI Solutions Inc. states that 5G networks are 90% more efficient than 4G networks in terms of data bits per kilowatt.
- 5G networks use modern technologies such as Massive MIMO and network slicing, which enhance energy efficiency.
- 5G facilitates the implementation of environmentally friendly solutions such as intelligent power grids, advanced urban infrastructure, and precise farming techniques.



# Case Studies on 5G and IoT Device Integration

- Smart traffic mobility
- Smart grid automation
- Video surveillance
- Smart city
- robots
- Automated guided vehicles (AGVs)
- connected drones and
- public safety applications.

# Smart traffic mobility



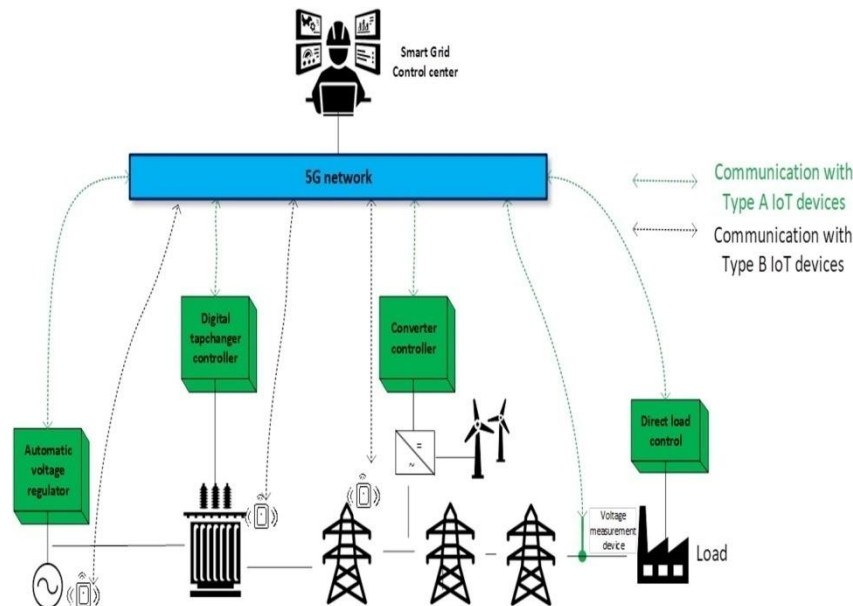
collecting and analysing real-time traffic data from the roadside infrastructure and the vehicles on the road, such Intelligent Transportation Systems would be able to timely warn drivers about hazardous road conditions, traffic blocks and safety compromising situations.

Source :

<https://www.telematicswire.net/smart-and-shared-mobility-the-overviewdefinition-and->



# Smart grid automation



With the integration of IoT enabled sensors and measuring instruments with the aforementioned components, and with the deployment of the 5G communication system

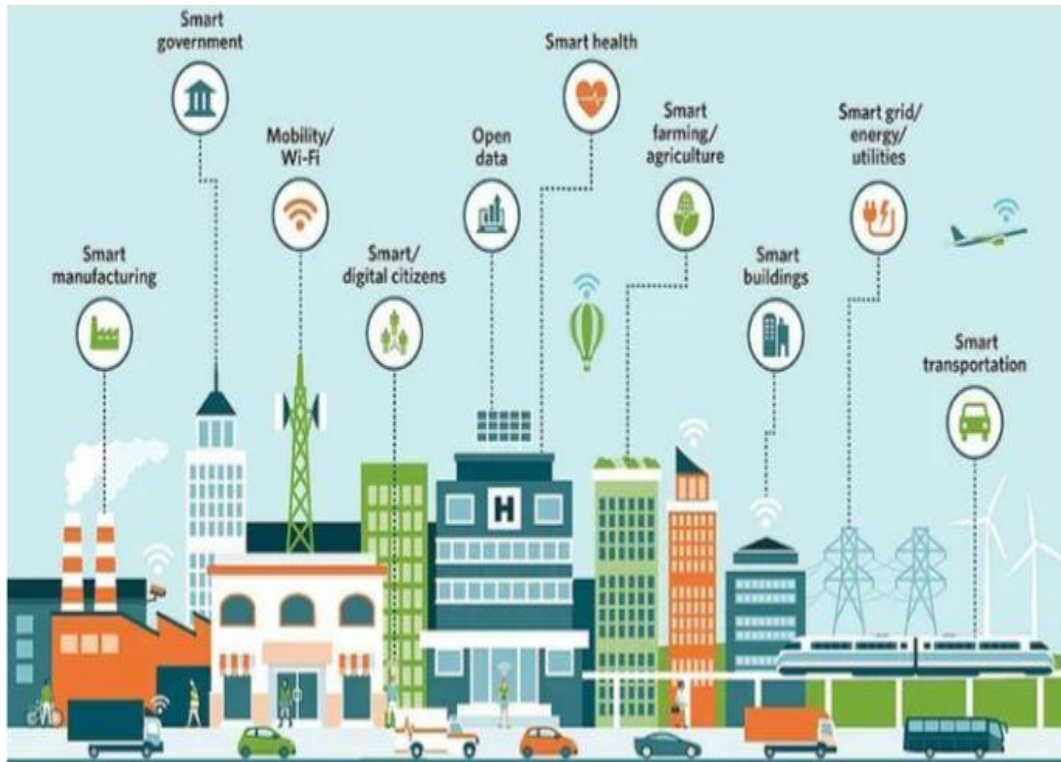
# Video surveillance

- video surveillance systems rely on wired connectivity, but the adoption of wireless networks can result in fast set-ups and lower costs, boosting connectivity and performance as compared to the wired ones.



Source : <https://www.vmukti.com/5g-cctv-camera>

# Smart city



- With integrating the technology in various functions, Smart cities can deliver the goals of innovation, sustainability, economic progress and city engagement and can improve the quality of life for residents, visitors and businesses as well.

Source :

<https://wh516x.medium.com/smart-cities-development-with-5g-iot-and-cloud-computing-51010dd02a82>

# Robots in 5G

- Robotic assisted surgery
- Robots for manufacturing
- Delivery robots



Source 1 : <https://www.u-blox.com/en/autonomous-mobile-robots>

Source 2 : <https://www.pickit3d.com/en/media-hub/5g-and-automation>



# Automated guided vehicles



- Industrial AGV  
Networking Enhanced  
Solution Enables  
Real-Time Control and  
Optimization in Factory  
Automation

<https://www.robustel.com/industrial-automation/industrial-agv-networking-enhanced-solution/>

# Connected drones

- How 5G will help drone operations?
- Essential Supplies



Source : <https://www.einfochips.com/blog/5g-drones-eye-in-the-sky-helping-to-fight-against-covid-19/>

Source

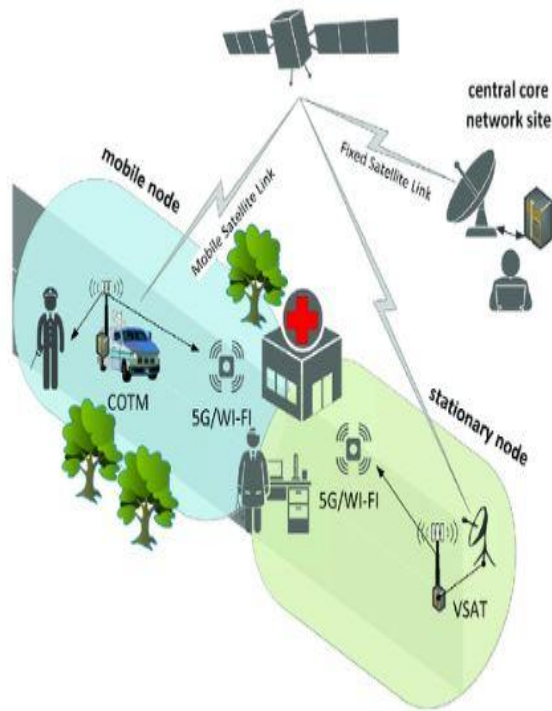
<https://www.telefonica.com/en/communication-room/press-room/telefonica-makes-5g-communication-be>

# Smart Agriculture



Source :1  
<https://etinsights.et-edge.com/ai-is-transforming-agriculture-in-india-by-providing-cutting-edge-solutions-for-farmers/>  
<https://m2msystems.medium.com/from-traditional-to-agriculture-5-0-2ed49a69928>

# 5G Remote deployment



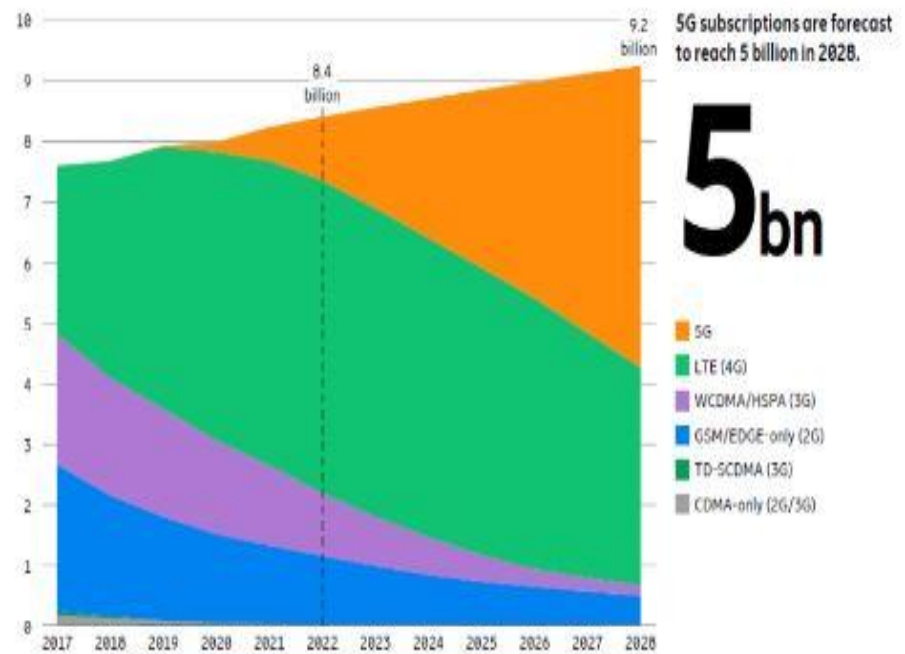
The 5G Low-bands Sub-1 GHz Spectrum has been important to Cellular Communication. Sub-1 GHz spectrum bands are very important for expanding 5G coverage to rural areas and providing 5G cellular service across different geographies and terrains. The way 5G spectrum allocation works is by auctions of sub-1 GHz spectrum in the United States to Cellular Carriers using already assigned spectrum licenses.

[https://www.researchgate.net/figure/Remote-hospital-deployment\\_fig1\\_352508454](https://www.researchgate.net/figure/Remote-hospital-deployment_fig1_352508454)



# Cellular IoT in the 5G era

- Global cellular networks based on 3GPP technology are enabling seamless connectivity between devices and individuals worldwide.
- Consumer electronics, automotive, railway, mining, utilities, healthcare, agriculture, manufacturing and transportation sectors



Source

<https://www.fonearena.com/blog/379755/5g-50-percent-mobile-subscribers-india-2028-ericsson-mobility.html>



# Cellular IoT in the 5G era

- There are four distinct sets of requirements for wireless connectivity across various industries.
- Massive IoT
- Broadband IoT
- Critical IoT and
- Industrial Automation IoT

# 5G Needs Smart Antennas



- MEC is not enough to ensure optimization as 5G systems
- Smart Antennas are utilized to enhance coverage and mobility while reducing the necessity for hand-over between 5G and 4G RAN.
- Smart Antennas are essential for optimizing LTE, but they are essential for enabling mobility support for several advanced 5G applications and services, including virtual reality, autonomous vehicles, linked vehicles, and Voice over 5G.

# 5G Needs Smart Antennas



- 5G NR, in particular, requires Smart Antennas since it uses millimeter wave RF transmission.
- 5G NR uses a substantially shorter wavelength and hence a higher frequency.
- higher frequencies require more power and/or coverage since an RF signal fades faster than a lower frequency signal. So an order of magnitude more antennae than are necessary for LTE.
- The United States will go from around 30,000 antennas to 300,000 or more nationwide.



# Narrowband IoT in 5G networks

- This standard aims to facilitate the connection and transmission of small data amounts in a batch transmission scenario for low-cost, battery-operated IoT devices.
- Some battery-operated IoT devices aim to have a maintenance-free lifespan of up to 10 years. (absolute energy efficiency)



# Role of Narrowband IoT in 5G networks

- IoT Connectivity
- Spectrum Efficiency
- Low Power Consumption
- Coverage and Penetration
- Enhancement to 5G Ecosystem
- Standardization and Evolution

Source :

<https://www.telecomtrainer.com/explain-the-role-of-narrowband-iot-nb-iot-in-5g/>



# Group Activity on 5G-IoT Scenarios

- Healthcare.
- Education.
- Entertainment.
- Industrial Internet of Things (IoT)
- Autonomous Vehicles.
- Smart Cities.
- Agriculture



# Group Activity on 5G-IoT Scenarios

- Identification of Sensors
- Identification of Microcontroller Boards
- Software tools
- Data Analytics and Visualization
- Predictive analysis
- Cloud based Tools
- End user Application





# Colab Link

<https://colab.research.google.com/drive/1kRT4zIqITYU0vq0CI53txj3egNTiN6Fs>



# Homework Assignment

Identify the 5G IoT Use Cases for Business

What are the challenges of 5G in IoT?

Design a IoT based smart healthcare system

What is an example of a narrowband IoT?

How a 5G antenna is made?

Why does 5G need more antennas?