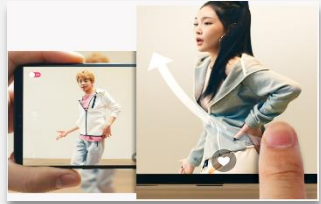


# Scenario 1: Enhanced Mobile Broadband (eMBB)



AR

60Mbps



VR

30Mbps



Cloud Gaming

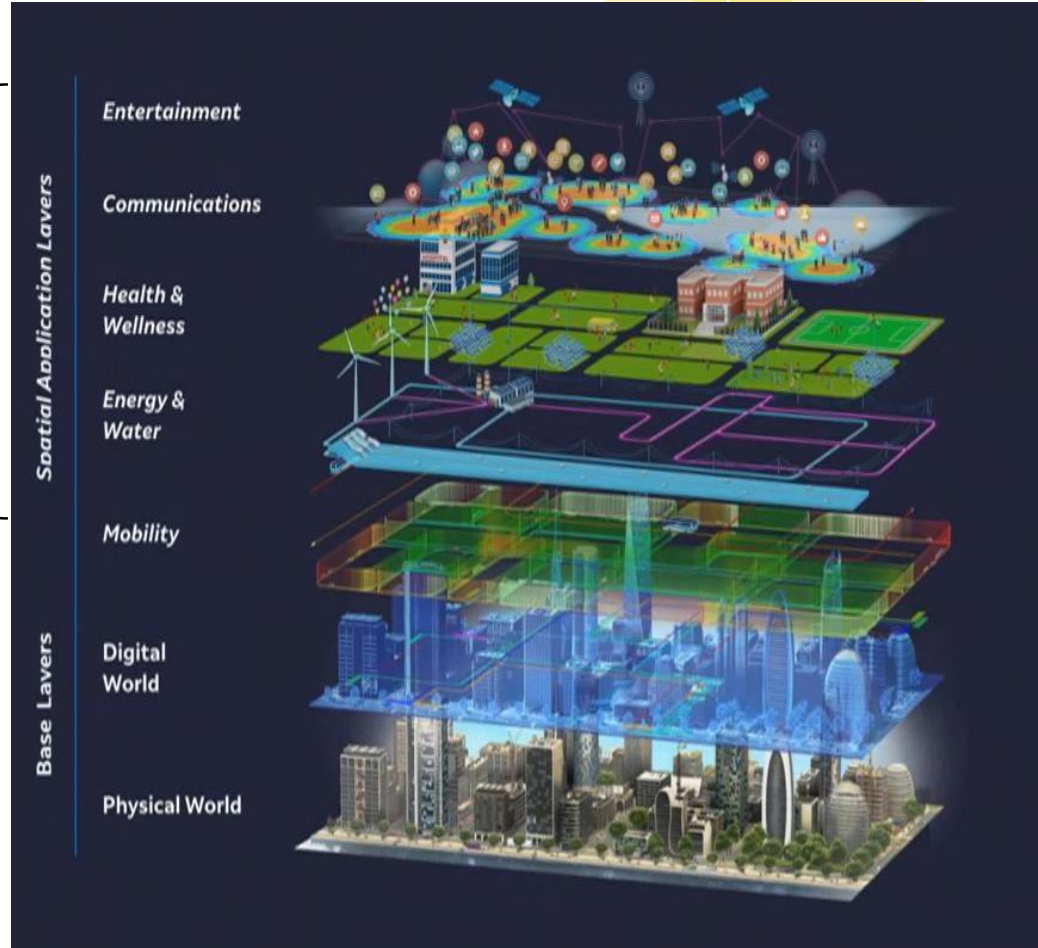
50Mbps

AR application

AR&VR and cloud gaming services in the first phase have been put into commercial use. Future XR services require higher rates.



AR cloud: physical world + digital content overlay, some applications requiring a rate of over 100 Mbit/s



AR cloud

The real world

AR cloud will be the entrance to the virtual and physical world, creating a new business ecosystem in the future.



# Scenario 2: mMTC—Internet of Everything

## Smart Home



## Smart City



**Both URLLC and mMTC are IoT-oriented application requirements.**

- mMTC is designed for massive scenarios with low power consumption, low bandwidth, low cost.
- URLLC is oriented to high reliability and low latency scenarios.





# Scenario 3: Ultra-Reliable Low-Latency Communication (URLLC)

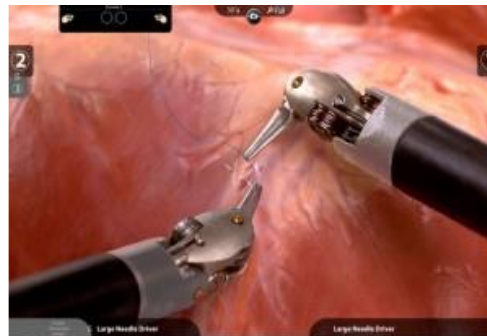
## Automated Traffic Control and Autonomous Driving



C-V2X

## Industrial Internet

Remote control






Remote surgery



UAV: unmanned aerial vehicle





# The Internet of Things

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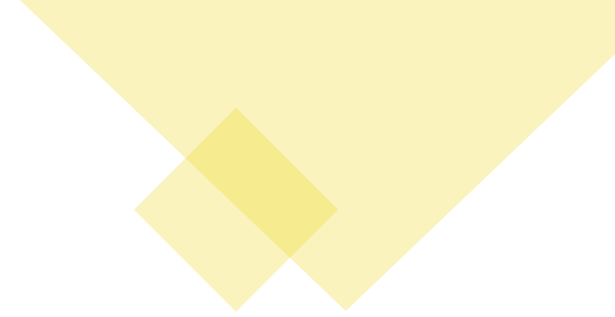
**Deloitte., 2021**



## **Internet Of Things**

The Internet of Things (IoT) **connects the digital and physical worlds by collecting, measuring, and analysing data to predict and automate business processes.**

As sensor prices continue to drop, we are on the cusp of an era where everything can be connected – people, businesses, devices, and processes – to each other. The melding of the physical and digital world brings every asset into a digital domain where software dominates.





# 31 billion

By the end of 2021, a total of 31 new billion IoT devices would have been installed around the world.



# 100 billion

estimated number of active IoT devices in 2025

# 152,200

IoT devices will be connecting to the internet per minute by 2025,

# \$4-11 trillion

Will be the potential generated in economic value by 2025



# \$742 billion

Is the estimated value in 2020 for Global IoT market was impacted by the COVID-19 pandemic. (IDC)



# 3.5 billion

Is the number of cellular IoT expected connections in 2023. (Forbes)

1. 83% of organizations have improved their efficiency by introducing IoT technology.
2. The consumer IoT market is estimated to reach \$142 billion by 2026 at a CAGR of 17%.
3. 94% of retailers agree that the benefits of implementing IoT outweigh the risk.
4. The amount of data generated by IoT devices is expected to reach 73.1 ZB (zettabytes)

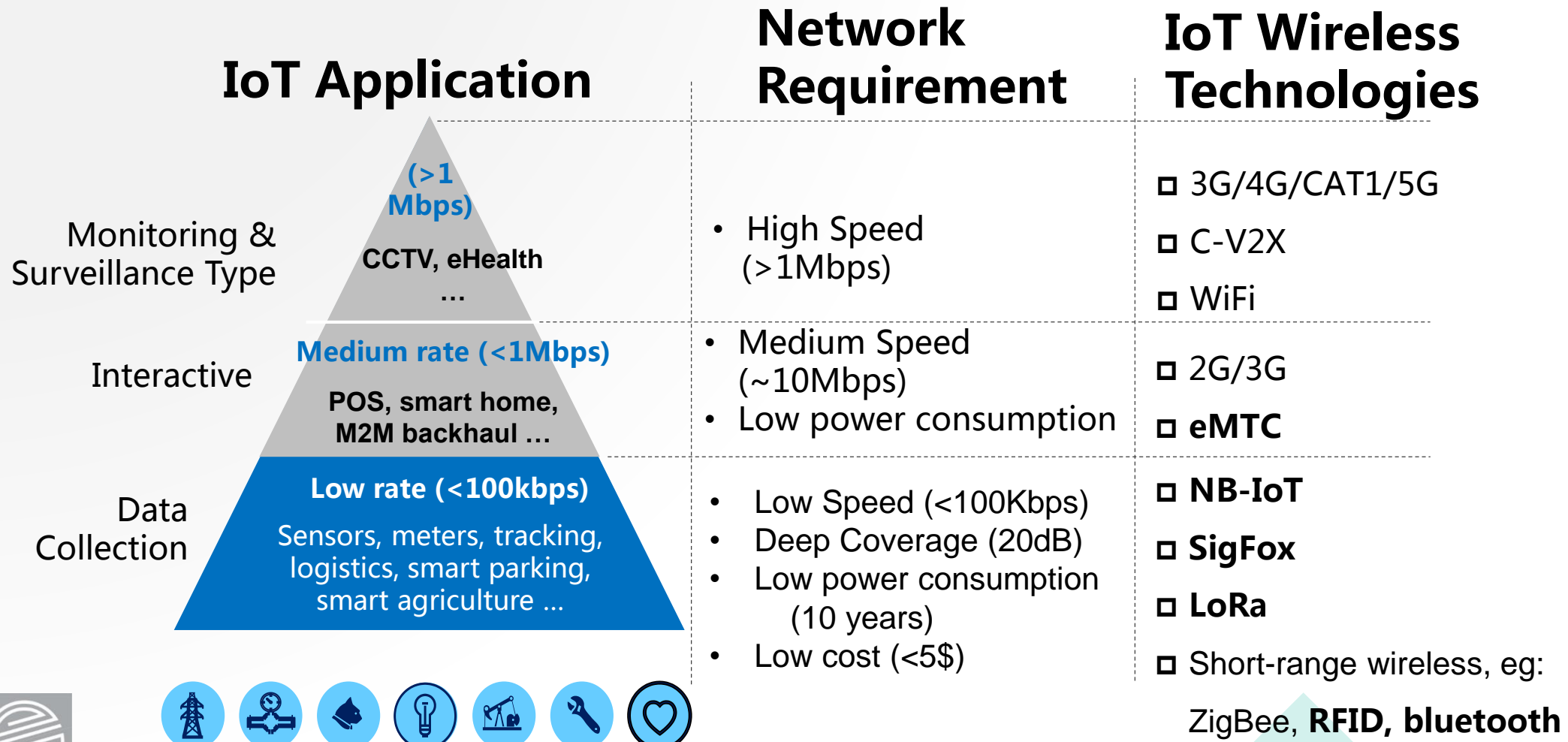


by 2025.





# Application Scenarios of each IoT Wireless Technology





# IoT diversity drives rich wireless

IoT category key requirements	Market share	Typical IoT applications	Wireless connectivity technologies and evolution		
			Past	2016-2018	Future
<b>High-end IoT</b> > 10–100 Mbps, module < \$15-30 Mobile, HD voice & video support	10%	<ul style="list-style-type: none"> <li>• Vehicle infotainment</li> <li>• Video surveillance</li> <li>• M2M gateway/IoT aggregator</li> </ul>	4G LTE Cat-3/4/6 and beyond		
			3G HSPA+		5G eMBB/uMTC
<b>Mid-end IoT</b> 100 kbps – 10 Mbps, module < \$5-15 Mobile, basic voice & video support	20%	<ul style="list-style-type: none"> <li>• Vehicle telematics, eCall etc.</li> <li>• Cloud-connected elevators</li> <li>• Fleet/vehicle dispatch mgmt.</li> <li>• Smart grid mgmt.</li> <li>• Smart locator and phone for junior, senior and VIP</li> <li>• Smart watches/wearables</li> <li>• ...</li> </ul>	4G LTE Cat-1		eMTC evolution
			3G UMTS/HSPA	eMTC	
			2G GSM/EGPRS		5G mMTC
<b>Low-end IoT (LPWA)</b> 100 bps – 100 kbps, module < \$3-5 Static/semi-static, data-only <ul style="list-style-type: none"> <li>• Low Speed (&lt;100Kbps)</li> <li>• Deep Coverage (20dB)</li> <li>• Low power consumption (10 years)</li> <li>• Low cost (&lt;5\$)</li> </ul>	70%	<ul style="list-style-type: none"> <li>• Smart utility metering</li> <li>• Smart city parking/lighting</li> <li>• Building/home automation</li> <li>• Environmental monitoring</li> <li>• Retail POS terminals</li> <li>• Asset trackers for pets, bikes, scooters, containers, etc.</li> <li>• Healthcare monitors</li> <li>• ...</li> </ul>	Non-3GPP LPWAN: Sigfox, LoRA, ZigBee...		NB-IoT evolution
			2G GSM/EGPRS	NB-IoT	
				EC-GSM	5G mMTC
			Non-3GPP Short-Range Wireless: ZigBee, Bluetooth, WiFi, RFID		

- The drivers for a wide range of wireless IoT options are **modem cost, battery life, coverage** and **voice (&video) support**.
- The mobile industry is relying on the **cellular LPWAN** technologies (standardized in 3GPP Rel-13) to grab the ever-growing IoT market.





# **Other Emerging Technologies**

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# Cloud Computing





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## Cloud Computing

Cloud computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence over the Internet (“the cloud”) to **offer faster innovation, flexible resources, and economies of scale.** You typically pay only for cloud services you use, helping you lower your operating costs, run your infrastructure more efficiently, and scale as your business needs change





- 1. Public cloud:** Public clouds are owned and operated by a third-party cloud service providers, which deliver their computing resources, like servers and storage, over the Internet. Microsoft Azure is an example of a public cloud. With a public cloud, all hardware, software, and other supporting infrastructure is owned and managed by the cloud provider. You access these services and manage your account using a web browser.
- 2. Private cloud:** A private cloud refers to cloud computing resources used exclusively by a single business or organization. A private cloud can be physically located on the company's on-site datacenter. Some companies also pay third-party service providers to host their private cloud. A private cloud is one in which the services and infrastructure are maintained on a private network.
- 3. Hybrid cloud:** Hybrid clouds combine public and private clouds, bound together by technology that allows data and applications to be shared between them. By allowing data and applications to move between private and public clouds, a hybrid cloud gives your business greater flexibility, more deployment options, and helps optimize your existing infrastructure, security, and compliance.





The diagram features a central blue cloud icon labeled "Cloud Services". Three dashed lines extend from the cloud to three columns. Each column contains a blue rounded rectangle with a service type, a text description, and a dark blue rounded rectangle with an action verb. The columns are: 1. SaaS (Software as a Service) with the verb "Use"; 2. PaaS (Platform as a Service) with the verb "Build"; 3. IaaS (Infrastructure as a Service) with the verb "Move".

## Cloud Services

SaaS

Software  
as a Service

Use

PaaS

Platform  
as a Service

Build

IaaS

Infrastructure  
as a Service

Move

05

## Types of cloud services

Types of cloud services:

1. IaaS,
2. PaaS,
3. serverless, and
4. SaaS

Most cloud computing services fall into four broad categories: infrastructure as a service (IaaS), platform as a service (PaaS), serverless, and software as a service (SaaS). These are sometimes called the cloud computing "stack" because they build on top of one another.

# Blockchain



Blockchain is a term widely used to represent an entire new suite of technologies. There is substantial confusion around its definition because the technology is early-stage, and can be implemented in many ways depending on the objective. “At a high level, **blockchain technology allows a network of computers to agree at regular intervals on the true state of a distributed ledger,**” **Which industries could blockchain disrupt? “All of them,** “The technology is what economists call a general purpose technology, and we will see many applications across different verticals.



Christian Catalini

Assistant Professor @ MIT Sloan  
*an expert in blockchain technologies and  
cryptocurrency*