The Path to 5G for Health Care

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Abstract

The healthcare vertical globally is all set for a paradigm change with an increasing adoption of devices with sensing equipment, technology and telemedicine evolution. In this paper, we examine the various ecosystem needs, evolving technology and adoption of some of the initial use cases leading towards 5G. We will also address some of the key motivation factors such as bandwidth, real-time response, critical services and wearables that will influence the technology evolution. [2]

Keywords: *cMTC (critical Machine Type Communication), mMTC (massive Machine Type Communication), URLLC (Ultra Reliable and Low Latency Communication), IoT (Internet of Things), IoMT (Internet of Medical Things)*

Introduction:

The healthcare segment is a fast expanding market with an increase in the number of applications that will use the network – distinct types of data in varying size and formats which in turn will place complex demands on the network in terms of bandwidth, data rate and latency among other factors. This will begin with sensor devices in health care centers running on existing technologies such as Wi-Fi, Bluetooth and low power related technologies. As this market matures, the connectivity needs for the explosive growth of devices and machines with sensor based applications in larger hospitals will fuel the growth of Massive-Machine Type Communication (mMTC). Further use cases such as Tactile Internet and robotic remote surgeries will spur the need for Critical Machine Type Communication (cMTC) or Ultra Reliability and Low Latency Communications (URLLC)

Technical challenges and the path to 5G

Today the healthcare ecosystem is faced with numerous challenges ranging from infrastructure, connectivity, optimal resource, need for experts, precision, data management and real-time monitoring. A close examination of the worldwide statistics with available data for 2005–2015 also indicate that around 40% of countries have less than one physician per 1000 population and less than 18 hospital beds per 10,000 population. [3] This clearly sets the stage for various technology models in health care to meet this huge gap and requirement. We propose to take a multi-layered approach in examining each of these areas:

- **Connectivity:** Depending on application needs, basic connectivity can be handled by Wi-Fi/related technology: for sensor applications, LTE: 100 Mbps kind of applications, LTE-A: 1 Gbps data rates, LTE-A Pro: 3 Gbps data rates and finally leading into 5G: 10 Gbps and beyond. Applications and criticality of the use case is crucial to decide the connectivity bearer.
- **Bandwidth:** Depending on the usage, bandwidth requirement can vary from a few Mbps to the order of Gbps. These could very well be served by Wi-Fi, LoRa, Bluetooth, LTE and ultimately 5G. This is again dependent on the ecosystem, application and the use case ranging from a primary health care center, a connected hospital, a network of connected hospitals, external to hospital connectivity, and telemedicine.

- **Latency:** Devices used could have a response time of few seconds to few milliseconds. The key would be to identify those aspects with acceptable levels of latency. For example, advanced robotics could need URLLC while wearables meant for monitoring could do with order of seconds for reporting to a central cloud system.
- **Spectrum:** Short range communication needs will play a center stage for intra-hospital type communication and hence higher frequency bands could be used; whereas remote healthcare could very well use the lower bands in sub 6 GHz range to accommodate coverage needs.
- **Network slicing:** Medical care could be a separate vertical that occupies a network slice. As per ABI research, network slicing will act as an enabler for high-tech healthcare by managing vital statistics from millions of connected devices, providing privacy and security to medical and patient data. Slicing could also provide e2e support for conducting specific tasks such as active monitoring, condition analysis, and vital data transmission. [2]

Key technology drivers in health care

- **IoMT devices:** Management of massive amount of data created by IoMT devices (wearables, implantable medical devices, and smart sensing remote/inhouse monitoring devices)
- **Smart wearables:** health parameters like heart rate, basic blood pressure, breathing rate can be monitored.
- **Tactile Internet:** remote healthcare involving 2-way interaction and robotics places a special premium on millisecond level latency and immediate response times.
- **Critical communications:** remote health monitoring of blood sugar, ECG, temperature interworking with QoS mechanisms to reserve capacity for critical communication.
- **Emergency medical services:** ambulance services communicating back to nodal hospital with relevant patient information like high resolution images/videos in timely manner.
- **Privacy and Security:** Privacy and data integrity of patient data is of paramount importance and necessitates special mechanisms to be adopted. Data handling will be expected to ensure required levels of privacy, preferential network resource handling and guaranteed Quality of Service (QoS).
- **Analytics:** With the spurt of UEs and ubiquitous wireless connections in health care, the amount of data processing that must be accomplished exponentially increases. Various parameters such as user location, services used, signalling information, and applications in use form a composite big data set which needs to be processed and handled. This gives rise to new models and use cases that range from data extraction, data formatting, storage and presentation.

A summary of various scenarios for health care is indicated in the table below.

Scenario	Driver	Technology	Latency	Data Rate
Wearables M2M in a primary care setup	Connectivity for data collection	NB-IoT (interconnected devices) LoRa (sensor applications) Zigbee (data collection) Bluetooth (D2D sensors)	10 to 700 milli second range	Few Kbps to Mbps

Digital Hospital	Inter campus communication	Wi-Fi	Non-guaranteed 10s to 100s milli seconds	Order of few Mbps
Emergency Medical Services	Emergency communication and speedy response	LTE LTE-A LTE-A Pro	100 to 20 milli seconds	Up to 100 Mbps Upto 1 Gbps Upto 3 Gbps
Remote surgery	URLLC between various locations	5G	20-30 ms with guaranteed QoS	Order of few Gbps
Haptic feedback - Tactile communication	URLLC, eMBB	5G	< 5 ms with guaranteed QoS	Order of few Gbps
A combination of above scenarios	Communication, latency, bandwidth, applications	Seamless co-existence of 5G, 4G, Wi-Fi, Bluetooth	ms level latency with guaranteed QoS	From few Mbps to order of Gbps

Figure 1 Technology drivers and path to 5G

Conclusion

There is not a single technology or solution that will be utilized completely by the health care segment. This will be a methodical, stepwise and need based evolution from existing technologies to the future. Healthcare models are rapidly changing due to demographic and socio-economic changes from a hospital based, specialist focused approach to a distributed patient centric care model. [5]

References

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