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A Survey on Blockchain Application for Healthcare Informatics Beyond 5G

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ABSTRACT

The 5^(th) generation (5G) is a wireless network which is on the way to be deployed all over the world. It is the fifth generation technology standard for broadband cellular networks, which cellular mobile companies began deploying worldwide in 2019, and is the planned successor to the 4g networks, which that provide connectivity to most current mobile phones. South Korea, china and United States are the countries that lead the world in building are deploying 5G technology. Block chain brings the ability to manage WAN data through its secure distributed tags and immutability, decentralization and transparency, which are expected to track the security issues of current 5G networks. The recent advances in the applications of block chain in 5G IoT are also surveyed in a wide range of popular use-case domains such as smart city, healthcare, smart automation and smart grids. The main findings derived from the comprehensive survey.

Keywords

5G networks, block chain, 5G services, Machine Learning, Security and privacy.

Introduction

5G networks have the potential to change and enhance all essential elements of healthcare, a topic that is particularly relevant today given the proliferation of the coronavirus, which has put immense strain on healthcare systems around the world. 5G aims to deliver critical levels of access to allow a modern health network capable of meeting the needs of patients and providers accurately, reliably, and conveniently, cost-effectively and on a large scale However, in order to fully understand the promise of 5G networks in healthcare environments, network reliability and data protection must be prioritized.

A new health ecosystem

If the use of 5G in healthcare grows, and its implementations are aided by advancements in robotics, IoT, and AI, a new integrated healthcare environment will emerge. This ecosystem, in our opinion, will resonate with a relatively new concept known as 4P medicine, that is, it will be predictive, preventative, customised, and participatory. In this report, we outline ten 5G healthcare usage cases that, as healthcare providers look to the future of their digital initiatives, will help the industry's long-term transition and shift to digital health. While some of these usage cases can be delivered without 5G, once 5G requirements are established and coverage is extensive enough, 5G can serve as a driver for widespread implementation by enhancing end user experience and lowering potential barriers for current networking solutions. In our latest report about how COVID-19 is transforming digital health, we discussed the surge in telehealth use cases as healthcare providers, insurers, and policymakers scramble to satisfy unprecedented demand and pressure on medical services. Healthcare services have changed almost instantly

had to transform in order to manage both the urgent needs of COVID-19 patients and the ongoing needs of former patients. In the aftermath of the pandemic, healthcare professionals must decide which aspects of their accelerated digital transition to create and scale, as the emphasis moves from acute care to chronic condition management, and there is a shortage of patients who have not received the necessary therapies How 5G's technologies will affect healthcare

10 5G healthcare application scenarios

Remote healthcare is now possible thanks to 5G.

Patient care through the internet

Ambulance linked

Digital appointments in high definition

Prescription control via video

Usage cases for augmented reality/virtual reality in healthcare

Blind people may benefit from augmented reality and virtual reality.

Distraction and physical therapy

Collaboration of surgery with a remote specialist

AR/VR curriculum and preparation

Case studies of 5G-enabled on-site applications

High-throughput, real-time statistical analysis

Behavioral recognition using video analytics

Remote healthcare allowed by 5G

1. Connected ambulance

Some believe that “connected ambulances” could help emergency departments achieve more strict goals while still improving patient outcomes. When the patient is being transferred, a linked ambulance and its crew gather and pass information on the patient, either by wearables, monitors, or broadcasting of HD video/body cameras, back to hospital A&E units. This way hospital staff have a better understanding of a patient before they arrive. In some situations, specialists can be engaged to help guide paramedics through certain procedures or diagnostic assessments without the need to travel to the hospital, creating efficiencies across the emergency services. Unlike other use cases, connected ambulances cannot be implemented without 5G’s capabilities. This is attributable to the:00 y 5G will carry – data and video must be submitted in real-time to hospitals/clinicians as split second decisions can have tremendous

effect in emergency scenarios. High bandwidth of 5G will enables video to be streamed live from emergency respondent body cams in the field without loss of quality or buffering

Increased reliability and security of 5G

Emergency services could also have their own private “slice” of the network due to 5G’s network slicing

2. High definition (HD) virtual consultations

To perform initial screening tests and routine check-ups, two-way HD video is used between the patient and a primary/secondary care provider. (which do not require physical procedures), therapy/rehabilitation sessions, and increasingly visual diagnoses (e.g. identifying dermatological conditions and symptoms). By conducting these appointments over the air, patients do not need to travel to see healthcare professionals and vice versa, reducing the burden on the patient and decreasing the cost of each appointment. 5G will enable two way HD virtual consultations to happen at scale when compared to other connectivity solutions through the promise of:

Mobility versus in-home connectivity solutions such as Wi-Fi.

Higher bandwidth versus existing cellular connectivity bringing the necessary consistent quality of service in the field.

Increased reliability and security of 5G.

3. Remote patient monitoring

Remote patient monitoring is seen as a key driver for more efficient and proactive delivery of healthcare services and chronic disease management. By using sensors, wearables and e-health devices, patient attributes can be collected and analysed without the need for patients to travel to primary care facilities and have a face to face appointment with a medical professional.

5G will enable remote patient monitoring to happen at scale when compared to other connectivity solutions through the promise of:

Greater reliability and security of the service

Increased capacity for number of connected devices per square kilometer

Mobility versus in-home connectivity solutions such as Wi-Fi

4. Video-enabled medication adherence

Adherence to prescription regimes is a key challenge in the healthcare industry, especially with some elderly or mentally ill patients forgetting if and when they have taken their prescription

medication. 5G can help tackle this problem through the use of video-enabled medication adherence, connecting qualified pharmacists and carers directly to the patient via video to ensure the correct precipitation and dosage is taken at the right time. An example of this use case in PAMAN, a video-enabled “Medihub” currently in engaged in a proof of concept in a UK 5G testbed. 5G will enable video-enabled medication adherence at scale through:

Increased bandwidth enabling video to be streamed at high quality in real time

Ease of installation of SIM based technology versus other solutions (e.g. Bluetooth/Wi-Fi).

Increased reliability and security of 5G versus 4G

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Augmented reality & virtual reality use cases in healthcare

5. Augmented reality and virtual reality assistance for the blind

Those with low, impaired, or even no vision can often be hindered in doing tasks that able-bodied individuals may take for granted, such as crossing the road, reading a website, entering a building etc. Using a 5G-enabled AR/VR headset or set of video streaming glasses, visually impaired individuals can be connected in real time to a live advisor who can guide the patient through certain activities in their daily life. Aira is a company looking to deliver such a service to its customer base.

5G will enable AR/VR assistance for the blind to occur at scale through:

Higher bandwidth enabling higher quality video to be streamed to the guide.

Low latency means the video can be streamed in real time to the guide which, in situations like crossing the road, would be significant. Furthermore, lag and jitter while using AR/VR headsets can cause the user to feel sea sick, and so low latency is essential for user experience.

5G’s mobility though Wi-Fi meets the performance requirements, many of the activities for AR/VR assistance will happen on the move.

6. Distraction and rehabilitative therapy

Augmented reality and virtual reality can be used within a hospital or clinical setting to improve the experience of patients. An example of this is using AR/VR for distraction and rehabilitative therapy. In the case of distraction therapy, a child that is about the receive an injection can wear the headset (which through 5G could stream cloud based videos/applications of the child’s choosing in real time) to be transported to a new environment and distracted from the potential fear of receiving the jab. In the case of rehabilitative therapy, the headset could be used, for example, on an amputee to virtually overlay relaxation of the lost limb in order to relieve phantom limb pain.

This use case will require 5G's capabilities because:

Low latency and high bandwidth enable cloud-based streaming of applications and videos – this means information does not need to be downloaded and held on the device (reducing cost and bulkiness of the headset). It also provides the user with increased choice of application. Low latency also improves user experience by reducing lag and jitter, which can make patients feel nauseated (latency should be below ~20ms to reduce sea sickness for VR applications).

7. Remote expert for collaboration in surgery

In the context of 5G, a use case that is often mentioned for healthcare is "telesurgery", where a specialist can perform an operation from a remote location. Though this use case would clearly require 5G's capabilities, we believe it is over hyped and, at least for the foreseeable future, unrealistic for mainstream use (few doctors would be willing to perform surgery on someone using a remote controlled robotic device that they had not set up and checked in person). A more realistic short-term opportunity is using a 5G-enabled AR/VR headset to allow a specialist to watch in on a surgery taking place in real time, guiding the in-person surgeon and commenting on what they see based on their own experience. This could also be extended to include haptics such that for example the in-person surgeon could receive vibratory cues for where and when to move from the remote guide, or the guide receives haptic information on the texture patients body in order to better assess the situation.

This use case will require 5G's capabilities to be delivered:

Low latency across a wide area – to enable real time communications and video streaming between the surgeons

Reduce jitter to reduce nausea as well as for consistent haptic response

High bandwidth to send extremely high definition video as would be required for remote surgery

Reliability and security drop in QoS could lead to loss of life

8. Augmented reality & virtual reality for training and education

Especially now in the wake of COVID-19, organizations across all verticals (including healthcare), are searching for new virtual ways to train and educate new staff and students. Using an AR/VR headset, either in the hospital, classroom, or even at home, could enable medical students and trainee specialists to perform practice procedures in a virtual environment (on virtual/non-real patients) and even collaborate on these virtual procedures in real time. This use case will require 5G's capabilities for:

Low latency –to enable real time communications and video streaming between participants in the class Reduce jitter to reduce nausea of users

High bandwidth to send extremely high definition video as would be required for the level of detail in a surgical process Reliability to provide a consistent quality of service, otherwise adoption for the use case would be prohibitively low.

5G-enabled on-site use cases

9. Real time high-throughput computational processing

In healthcare, there are many high-resolution images and files which may require high-throughput computational processing for diagnostics and design. With 5G, for example, after receiving an MRI or CT-scan, images can be sent in real time to where they need to be analysed to provide a diagnosis. Furthermore, there is an increasing use of insilico high-throughput screening for more effective drug design in the pharmaceuticals industry. 5G can enable sending and analysis of molecular models and structures to the cloud to leverage the higher compute/graphic processing power and cheaper resource compared to a local high-end desktop. Workspot, Netgain, and Fordway are organizations leveraging Virtual Desktop Infrastructure to enable low latency, cloud-based computation in healthcare and life science. High bandwidth to send high resolution files in real time without buffering/delay

Mobility versus fixed connectivity means machinery and equipment does not need to be tethered to a specific location

Low latency for using cloud based processing means images/models can be rendered and iterated in real time

10. Video analytics for behavioral recognition

In hospitals, care homes, psychiatric centres etc. video analytics can be used in the hallways to identify patients who are behaving out of the ordinary, have had an incident such as falling, or are becoming a danger to themselves or others. Hosting the analytics on device using smart cameras can lead to prohibitively expensive hardware and so the analytics should happen in the cloud (or more likely using an edge compute to maintain data localization and security).

5G can be used to enable this use case owing to:

Increase in bandwidth allowing high definition video to be sent for processing and analytics

Low latency enabling analytics to occur in real time and improving patient outcomes

Security and reliability protecting patient data (e.g. through 5G slicing)

Increased flexibility of the solution vs fixed connectivity – easier to add/remove cameras as SIM based-solution

This is the second installment in a series looking at healthcare use cases for emerging technology. We have previously looked at edge computing healthcare use cases and will be exploring IoT1, AI, and blockchain healthcare use cases in our upcoming articles. For more information on the

impact of 5G on the healthcare industry, read our report quantifying the benefit of 5G use cases for free. If you're working within the healthcare sector and you would like to understand if/how you might benefit from our insight, please do not hesitate to get in touch. Digital health is a key practice area for us and we would be keen to work with those exploring and pursuing the opportunities within the sector.

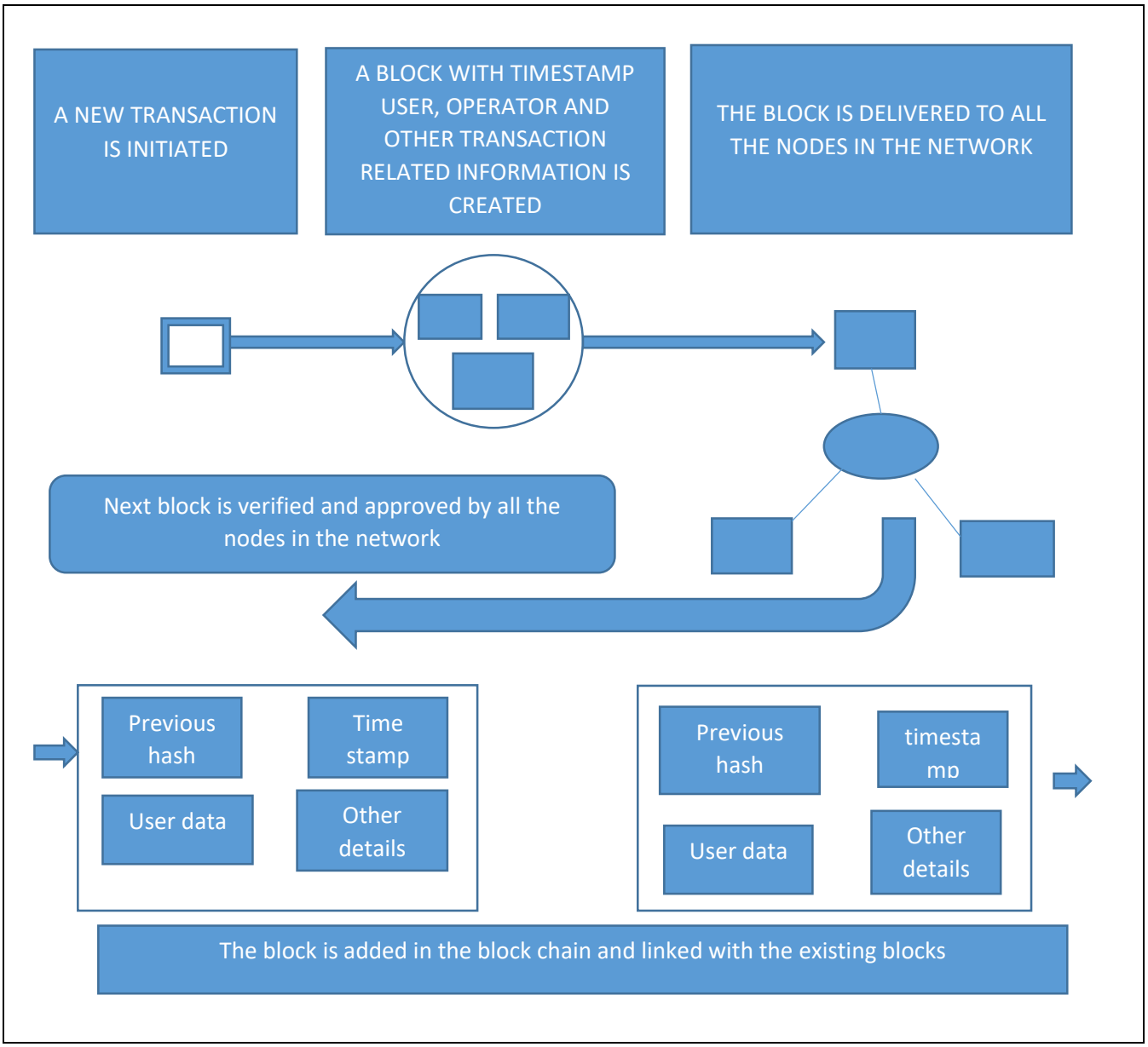

Figure 1. Basic workflow of blockchain

Literature survey

Author	year	description	Merits	demerits
Dorii et.al[1]	2016	Proposed a lightweight architecture for IoT based on blockchain.	Use of overlay networks to reduce the computation time for blocks.	Security against certain vulnerabilities, such DoS Attacks, not clarified.
Christidis et.al[2]	2016	Examined the potential of blockchain in IoT sector.	Exhaustive discussion on the role of blockchain and smart contracts for IoT.	Challenges related to the Implementation not explored.
Khan et al.[3]	2018	Focused on the security requirements of IoT using blockchain.	Discussion of state of the art IoT security issues and solutions.	Detailed discussion of implementing blockchain together with IoT not included.
Floera et al.	2018	Described the use of blockchain technology as a data provider in IoT applications	Discussed IOTA network, which is labeled as the 'backbone of IoT'.	Field devices are currently not configured to do PoW.

Miraz et al.	2018	Assessed the implementation of blockchain for IoT security.	Detailed research to ascertain the applicability of blockchain for augmented IoT security.	Blockchain usage in Industrial automation was not explored.
bbrAtlam et al.[4]	2018	Provided an overview of the integration of IoT and blockchain, while highlighting its benefits and challenges.	Detailed comparison of current and blockchain-based IoT systems.	Device-to-device communication not considered

Conclusions.

When end users get to experience 5G networks, the combination of blockchain with IoT devices would be a game changer. We provide readers with information about the commercial implementations of blockchain in 5G-enabled IoT devices in this article. The debate is divided into three sections. First, the history of blockchain, IoT, and 5G is briefly explored, followed by respective industrial application. The use of the technology discussed in this work on a shared device is still a long way off due to the high-end hardware specifications and lack of flexibility with high network access. The majority of industrial applications have been covered in this work, where blockchain can be used to preserve encryption while allowing for smoother data flow. However, beyond the small-scale production and rollout of particular applications, a significant amount of technical research is required to meet the unique demands associated with the collaboration of these technologies. Finally, a comparative study of emerging blockchain-based industrial implementations is conducted using precise criteria. In future, we would minimize our discussion on healthcare only and plan to propose a blockchain based secured healthcare system.

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