HSS 404: Globalization and Medicine
Research Outline

Central Question: Barriers of blockchain based health records for a globalized world
Points to cover:

- Need for cross-border health record sharing
- Blockchain as solution
- Solutions
- Challenges in standardized records across globe
- Challenges in patient adoption of blockchain technology

Introduction

- Brief overview of existing systems in place for managing patient health records
  - Fragmented systems across countries and institutions
  - Privacy and Security concerns when sharing across systems
    - Examples of existing systems?
    - "Various forms of data, like Personal Health Records (PHR), enable individuals to take charge of their health information despite facing security concerns during data transfer. Electronic Medical Records (EMR) concentrate on medical histories within a specific practice, encountering challenges in interoperability." [7]
    - "Today, global healthcare spending could exceed $10 trillion", "industry spending increased by 4.1% per year globally between 2017 and 2021" [4]
- Importance of accessing heath records across the globs
  - Increased international mobility and medical tourism.
  - "Telemedicine usage is expected to remain at a high-level post-pandemic, with over 20% of patient appointments being handled through telemedicine" [7]
- Introduce all points paper aims to cover

Intro draft

Section One: Need for cross-border health record sharing

I. Current challenges that exist on a global context
   A. Language barriers
   B. Emergency care complications
   C. Duplicate testing
   D. Incomplete medical records
      1. "Common issues encompass difficulties in data exchange, security vulnerabilities, and the potential for Unauthorized access" [7]

II. How are the parties involved affected
   A. Patients
      1. "if a patient has insight into his health records, he can minimize the repetition of documents and medically unnecessary testing" [7]
   B. Healthcare providers
      1. "improve interoperability between different healthcare systems" [4]

Section Two: Technical overview of blockchain technology

I. How does blockchain work
   A. Basic principles
      1. "A blockchain can be seen as a chain of blocks that are time-stamped and linked using cryptographic hashes. These blocks are sealed in a secure and immutable manner" [1]
   B. Types of blockchain systems

1. "public permissionless, consortium (public permissioned), private" [1]

C. Privacy and Security advantages
    1. "(1) Decentralization, (2) Immutability, (3) Transparency, (4) Security, (5) Anonymity, (6) Cost effectiveness" [4]

Section Three: Potential solutions

I. Blockchain for handling solely EHR's with patient control in mind
    A. "Blockchain can significantly affect health service effectiveness and prices by giving patients full ownership over their prior health files" [7]

II. Combining IoT devices with Blockchain for data monitoring and sharing
    A. "IoT technology has greatly impacted the healthcare sector...integrating IoT into various applications such as EMR management, disease prediction, remote patient monitoring, and drug traceability" [4]
    B. "IoT devices frequently have limited resources, such as limited computational power, storage, battery life, and network connectivity" [4]

III. Uses of technology like digital identity to supplement blockchain EHRs
    A. "IoTBDId analysis report says about strong consent management that guarantees that patients have authority over their digital identities" [2]

IV. Existing solutions
    A. Medrac
    B. SimplyVital Health
    C. Novo Nordisk

Section Four: Challenges for implementation

I. Scalability
    A. "Scalability is a complex issue encompassing various factors, such as max delivery ratio, delay, start-up time, and cost per verified transaction" [4]

II. System interoperability
    A. "The lack of standardization among IoT devices can make implementing successful IoT systems in healthcare challenging" [7]

III. Data migration

IV. Trust in technology

V. Digital literacy

VI. Data protection laws
    A. "Because the healthcare industry requires a high level of privacy, using public Blockchains to store and distribute sensitive data is inappropriate" [4]

VII. Cross-border compliance
    A. "GDPR defined privacy policies across Europe to safeguard users' rights and secrecy over their health records" [4]

Annotations

[1] Annotation

1. Full citation

Hölbl, Marko, et al. “A Systematic Review of the Use of Blockchain in Healthcare.” Symmetry, vol. 10, no. 10, 2018, p. 470, https://doi.org/10.3390/sym10100470.

2. Where did/does the author work, what else has s/he written about, and what are her/his credentials? (What is their source of credibility, or limits of credibility such as conflicts of interest)

The article was published by *Symmetry*, an international peer-reviewed research journal.

Dr. Marko Höbil is currently a faculty of electrical engineering and computer science at the university of Maribor in Slovenia. He has written various papers under the topic of cryptography and privacy in computer systems.

3. What are the topics of the text?

The text covers the basis of blockchain technology and how it can fit into healthcare.

4. What is the main argument of the text?

The potential of blockchain technology in healthcare is significant, particularly for improving patient-centric approaches, connecting disparate systems, and enhancing the accuracy of electronic healthcare records (EHRs).

5. Describe at least three ways that the argument is supported.

- The article elaborates upon three types of blockchains, public permissionless, consortium and private. The private blockchain can allow for a more patient centric way of handling records as one needs permissions to perform transactions and view blocks. This would allow for data privacy
- Using a decision model proposed by Würst and Gervais, Marko explains how blockchain technology allows for secure and auditable data, multiple write access to single records, and an alternative to a trusted third party with the decentralized nature of the technology
- The use of smart contracts will allow for more automation and dynamic behavior within medical blockchains, allowing for easier accessibility of data

6. What three quotes capture the message of the text?

- “A chain of blocks that are time-stamped and linked using cryptographic hashes. These blocks are sealed in a secure and immutable manner” (3)
- “For personal medical data, the most adequate type of blockchain would be a private blockchain” (6)
- “a further use of smart contracts and the introduction of less constraining consensus algorithms would be, in our opinion, the primary area for further research and better integration of blockchain technology into healthcare” (16)

7. Additional notes

The work provides basic ideas on how blockchain technology can be applied in healthcare by giving an overview on how blockchain works along with different ways to implement it. Majority of the article is focused on how blockchain works rather than how it can be applied. Another chunk of the article goes over the methodology used in the research.

[2] Annotation

1. Full citation

Sanjay Kumar Jena, Ram Chandra Barik, Rojalina Priyadarshini, A systematic state-of-art review on digital identity challenges with solutions using conjugation of IOT and blockchain in healthcare,
Internet of Things, Volume 25, 2024, 101111, ISSN 2542-6605, https://doi.org/10.1016/j.iot.2024.101111.

2. Where did/does the author work, what else has s/he written about, and what are her/his credentials? (What is their source of credibility, or limits of credibility such as conflicts of interest)

The article was published in *Internet of Things; Engineering Cyber Physical Human Systems*, a peer-review journal with works from various reputable institutions like the NIST.

The author Sanjay Kumar Jena along with their co-authors Ram Chandra Barjk and Rojalina Priyadarshini are affiliated with the department of computer science at C.V. Raman Global University, a private institution in India. The work references various other credible sources.

3. What are the topics of the text?

The article covers technologies such as IoT, blockchain and digital identity. The article goes on to combine the technologies into IoTBDId (Internet of Things Blockchain and Digital Identity) and shows it applications in healthcare

4. What is the main argument of the text?

The main argument of the text is that the Digital Identity is a technology that will maintain privacy and security for a more advanced healthcare system allowing for better healthcare.

5. Describe at least three ways that the argument is supported.

- The article elaborates upon the technology of digital identity and describes it as a unique identifier in digital space. Currently, primitive versions of digital identity exist that encompass ip address, known internet accounts, behavior on the internet and others, but for a more complete digital identity and management system needs to be implemented.
- To ensure that a digital identity management system can be implemented, blockchain can allow for encrypted identities to be stored and used for unique verification.

- Another key technology is that of IoT but specifically IoMT (Internet of Medical Things). This consists of devices with sensors that allow for recording medical data such as heart rate, insulin, and other metrics of health.
- By using a combination of these IoMT devices, blockchain and digital identity, the authors propose a system where medical data can be monitored in real-time by designated physicians by using DId to sign data to a patient, blockchain for ownership of data by patient and to securely share the data with all necessary parties and IoMT devices to record the data that will be saved and shared via the blockchain.
- Such a system will allow for physicians to monitor patients from afar, keeping hospitals less crowded and potentially reducing costs for healthcare. It would also keep power in the hands of the patients by allowing them to keep control of their data.

6. What three quotes capture the message of the text?

- “A genuinely effective identity access management system should streamline and make it easier for Information Technology (IT) personnel to manage the entity, devices, and applications in their healthcare delivery companies while also enhancing security and compliance without creating time-consuming inefficiencies” (1)
- “The IoT and digital identity play a crucial role in the healthcare sector, enabling improved patient care, efficient operations, and secure access to medical information” (15)
- “IoTBDId analysis report says about strong consent management that guarantees that patients have authority over their digital identities” (17)

7. Additional notes

The proposed use of IoTBDId has potential to revolutionize the way healthcare is administered. It also had the potential to medicalize different aspects of life with the use of different devices to monitor behaviors and bodily metrics. For example, the article proposes the use of IoT devices such as smart fridges to track eating habits, smart couches to track sitting habits, and various other smart devices to track the way an individual lives to help physicians understand what’s wrong with patients. This could lead to physicians having authority on aspects of life that once were not under medical jurisdiction.

[3] Annotation

1. Full citation

Kasyapa, Meenavolu S. B., and C. Vanmathi. "Blockchain Integration in Healthcare: A Comprehensive Investigation of Use Cases, Performance Issues, and Mitigation Strategies." Frontiers in Digital Health, vol. 6, 2024, doi:10.3389/fdgth.2024.1359858.

2. Where did/does the author work, what else has s/he written about, and what are her/his credentials? (What is their source of credibility, or limits of credibility such as conflicts of interest)

3. What are the topics of the text?

Covers blockchain with regard to EHR management, supply chain, clinical trials, and insurance claims. Covers technical challenges and potential solutions for implementation of BT

4. What is the main argument of the text?

The main argument is how significant blockchain technology is in transforming healthcare through secure data sharing and management.

5. Describe at least three ways that the argument is supported.

- Tackles multiple ways to go about improving healthcare using blockchain. One idea proposed was the use of BT in tacking pharmaceutical drugs from productions to distribution (7).
- Highlight technical challenges presented with implementing this technology, and provide solution frameworks for them, using both on and off chain solutions.
- Not only within the supply chain or EHRs, but BT can help in things like Clinical trials. Clinical trials are difficult to keep track of and manager on an international scale. BT would make this easier as all trials would be on the chain, easily viewable and accessible to all (9).

6. What three quotes capture the message of the text?

- "Stakeholders can assure the authenticity and traceability of pharmaceuticals, medical devices, and other healthcare products. This would lower the prevalence of counterfeit items in the healthcare industry, which endangers patient safety [...] BT-enabled supply chain management will record every detail of products at every stage, such as origin, manufacturing processes, quality control checks, transportation information, and more" (Kasyapa and Vanmathi 7).
- "BT enables researchers to assure data accuracy, eliminate fraud, and streamline trial processes. Furthermore, blockchain can make clinical trials more affordable for patients while improving overall traceability and transparency by saving time and effort" (Kasyapa and Vanmathi 9).
- "Since BT is implemented with an eye on genuine progress in the healthcare sector that may be challenged by adaptation. There could be a need for verified as well as strict international standards. The already defined standards may be helpful to compute the dimension and set up the data interchanged in blockchain services" (Kasyapa and Vanmathi 13).

7. Additional notes
The work provides a view on how blockchain fits into healthcare while acknowledging the difficulties in getting it implemented. The authors emphasize the need for stakeholder collaboration to fully implement this technology and also the technical solutions needed. This paper is a good resource to refer to when looking at technical difficulties in integration of the technology.

[4] Annotation
1. Full citation
Allam, A.H., Gomaa, I., Zayed, H.H. et al. IoT-based eHealth using blockchain technology: a survey. Cluster Comput 27, 7083–7110 (2024). https://doi.org/10.1007/s10586-024-04357-y
2. Where did/does the author work, what else has s/he written about, and what are her/his credentials? (What is their source of credibility, or limits of credibility such as conflicts of interest)

3. What are the topics of the text?
IoT and blockchain integration within healthcare systems. Security and privacy challenge in eHealth systems.
4. What is the main argument of the text?
Existing IoT solutions greatly enhance healthcare delivery with remote monitoring and data collection. IoT devices are not capable of robust security protocols and therefore face security and privacy concerns. Blockchain technology would allow IoT devices to safely and securely transmit data.
5. Describe at least three ways that the argument is supported.
- The paper cover various existing IoT applications, such as remote patients monitoring, disease prediction, patient tracking, showing the adoption of IoT devices in healthcare
- By explaining features of blockchain such as decentralization, immutability, transparency, security, anonymity and cost-effectiveness, the paper explains how its integration can help supplement IoT devices.
- Using 110 other papers, the authors provide empirical data to help support integration of blockchain with IoT devices to improve healthcare systems.

6. What three quotes capture the message of the text?
- "The eHealth sector has witnessed significant growth due to technological advancements, facilitating care delivery in patients' homes and moving away from traditional hospital settings" (7083).
- "Blockchain technology is being explored as a potential solution for addressing security challenges. This has led to increased interest in using blockchain to safeguard sensitive data" (7084).
- "The IoT system is made up of billions of diverse IoT devices that are often manufactured with minimal focus on security measures. IoT devices with weak security measures are vulnerable to various security risks" (7102).

7. Additional notes
The paper provides a detailed analysis of consensus algorithms that are more suitable for healthcare applications, specifically Proof of Elapsed Time and Stellar Consensus Protocol, as both are well suited for IoT devices. The paper does highlight a call to action, stating that practical implementations are needed to evolve these frameworks.

[5] Annotation
1. Full citation
Khan F. Emerging Trends and Challenges of IoT in Smart Healthcare Systems, Smart Cities and Education. Sensors. 2024; 24(17):5735. https://doi.org/10.3390/s24175735
2. Where did/does the author work, what else has s/he written about, and what are her/his credentials? (What is their source of credibility, or limits of credibility such as conflicts of interest)

3. What are the topics of the text?
Covers topics such as IoT applications in healthcare systems, smart cities and education systems. Also brings up Cybersecurity challenges and solutions.
4. What is the main argument of the text?
The main argument of the text is that IoT devices need to be integrated with other modern technologies like blockchain. These integrations can greatly increase security, efficiency and service delivery. Not only blockchain but also the integration of AI can greatly improve the usability of these IoT devices. IoT devices are increasingly becoming more prevalent in every field, it is important to supplement them with other technologies to increase their performance and reliability.
5. Describe at least three ways that the argument is supported.
- The scale of the challenges that currently exist was highlighted by using Covi-19 data, where over 700 million people were infected and over 7 million died (1). IoT solutions can greatly help with monitoring and using technologies such as AI, preventive steps can be taken through predictions.
- Paper also highlights existing cybersecurity threats, that almost half of the working class faced cybersecurity threats In the form of phishing attacks (2).
- Presents 13 papers that showcase studies of IoT applications in various fields

6. What three quotes capture the message of the text?

- "IoT in healthcare, along with blockchain, is the most important and has many advantages, including improved security, decentralization and privacy" (1).
- "After COVID-19, IoT is considered a backbone for the healthcare system as well as for other institutions like the education system" (1).
- "Many fields related to COVID-19 data analysis, like AI along with IoT, blockchain, machine learning and deep learning, collectively combatted COVID-19" (1).

7. Additional notes

This paper is a quick overview of current challenges with IoT implementation and how they are already implemented. It primarily focuses of how Covid-19 was a catalyst for mass adoption of IoT devices in various fields. The paper does not go much in depth but rather summarizes the work of others.

[6] Annotation

1. Full citation

Almalki, J. State-of-the-Art Research in Blockchain of Things for HealthCare. Arab J Sci Eng 49, 3163–3191 (2024). https://doi.org/10.1007/s13369-023-07896-5

2. Where did/does the author work, what else has s/he written about, and what are her/his credentials? (What is their source of credibility, or limits of credibility such as conflicts of interest)

3. What are the topics of the text?

IoT and blockchain integration in healthcare with technical architectures and implementations.

4. What is the main argument of the text?

The main argument of the text is that even though IoT devices have been integrated ,and that blockchain integration will allow for various new opportunities for healthcare application, there are several challenges that remain. Until a full “Blockchain of Things” is realized, critical challenges need to be addressed (3181) .

5. Describe at least three ways that the argument is supported.

- The paper highlights technical challenges such as resource constraints of IoT, scalability issues, security vulnerabilities and Data management complexities.
- To demonstrate the capabilities of “Blockchain of Things”, the article dives into existing implementations in healthcare. “Hospital and medicine management”, “mHealth blockchain” and “data storage” are some examples provided in the text. The text then goes onto explain existing limitations with these implementations.
- One of the critical challenges that needs to be addressed is privacy vs transparency. Many industries require transparency in their operations to improve trust, and blockchain is suitable for this. When it comes to fetching data in IoT platforms like eHealth, transparency is also important, but with the transparency customer privacy is compromised (3184).
- Another critical difficulty presented here is that of scalability. Blockchain transactions can be timely, and this transaction per second measurement is a useful one when measure scalability. For reference, the article brings up Bitcoin and how it has about 7 transactions per second while VISA can handle 2000+. When sharing data using multiple IoT devices, this limitation can add up and slow down the entire system.

6. What three quotes capture the message of the text?

- "Blockchain can significantly affect health service effectiveness and prices by giving patients full ownership over their prior health files, comprising records, financial information, lab results, x-rays and sign checks" (3169)
- "Due to recent technological advancements in IoT, the connectivity has allowed the access of patient information, safe medication monitoring, hospital resources, and intelligent devices which have promoted with blockchain-driven healthcare" (3169)
- "Critical industries like banking requires the transaction openness. Blockchain is a suitable solution to achieve this. However, while fetching data from the IoT platforms, like eHealth that are enabled with blockchain, there are chances for the customer privacy compromise" (p.3184).

7. Additional notes

Unlike other papers, this paper mostly focuses on the limitations of existing technologies we have. Some other papers like [2] propose solutions that can address these issues, such as the one of transparency vs privacy with the use of Digital Identity. The paper highlights the importance of a lightweight solution due to the limitations of IoT and Blockchain.

Work Cited:

[1] Hölbl, Marko, et al. “A Systematic Review of the Use of Blockchain in Healthcare.” Symmetry, vol. 10, no. 10, 2018, p. 470, https://doi.org/10.3390/sym10100470.

[2] Sanjay Kumar Jena, Ram Chandra Barik, Rojalina Priyadarshini, A systematic state-of-art review on digital identity challenges with solutions using conjugation of IOT and blockchain in healthcare, Internet of Things, Volume 25, 2024, 101111, ISSN 2542-6605, https://doi.org/10.1016/j.iot.2024.101111.

[3] Kasyapa, Meenavolu S. B., and C. Vanmathi. "Blockchain Integration in Healthcare: A Comprehensive Investigation of Use Cases, Performance Issues, and Mitigation Strategies." Frontiers in Digital Health, vol. 6, 2024, doi:10.3389/fdgth.2024.1359858.

[4] Allam, A.H., Gomaa, I., Zayed, H.H. et al. IoT-based eHealth using blockchain technology: a survey. Cluster Comput 27, 7083–7110 (2024). https://doi.org/10.1007/s10586-024-04357-y

[5] Khan F. Emerging Trends and Challenges of IoT in Smart Healthcare Systems, Smart Cities and Education. Sensors. 2024; 24(17):5735. https://doi.org/10.3390/s24175735

[6] Almalki, J. State-of-the-Art Research in Blockchain of Things for HealthCare. Arab J Sci Eng 49, 3163–3191 (2024). https://doi.org/10.1007/s13369-023-07896-5

[7] Mutambik, I., et al. "Identifying the Barriers to Acceptance of Blockchain-Based Patient-Centric Data Management Systems in Healthcare." Healthcare, vol. 12, no. 3, 2024, p. 345. doi:10.3390/healthcare12030345.