# HapiFabric: A Teleconsultation Framework Based on Hyperledger Fabric

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**Abstract.** Due to longevity, the world population is getting older; this leads to an enormous number of patients with chronic diseases. Their vulnerability in facing viral and bacterial diseases, in particular in the case of the outbreak of the coronavirus, promotes teleconsultation since the latter reduces their physical interactions and consequently, their chance of contamination. Teleconsultation is considered more economical, comfortable, and practical compared to face-to-face consultations. Due to the criticality of the data and process in teleconsultation, there are numerous concerns, in particular in terms of reliability and security. Moreover, similar to all financial systems; the transparency concerns are also prominent in teleconsultation. To this end, we propose HapiFabric, a teleconsultation framework based on Hyperledger Fabric. Our proposed framework exploits this blockchain technology to improve security, reliability, and transparency of teleconsultation workflows. Without losing generality, we prioritize the elderly and patients with chronic diseases in HapiFabric becasue of their vulnerability. Our innovative teleconsultation workflows cooperate with a telemonitoring service to provide comprehensive medical care at the patients' homes. We exploited Hapicare, an existing healthcare monitoring system with self-adaptive coaching using probabilistic reasoning, as one of the main participants of HapiFabric which provides telemonitoring services. Moreover, HapiFabric has other participants, namely patients, doctors, insurance, and auditors. We have opted for off-chain data storage of medical data using the InterPlanetary File System (IPFS). We evaluate the HapiFabric framework using two scenarios.

**Keywords:** Teleconsultation · Blockchain · Medical workflow · BPMN · Hyperledger Fabric · IPFS

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## 1 Introduction

The emergence of technology has important impacts on several application domains, including ambient assisted living [13,15,18], rehabilitation [14], and healthcare [10,11,16,17]. In the healthcare domain, the necessity of a teleconsultation system is inevitable, especially with the outbreak of coronavirus (SARS-CoV-2) in 2020. As the governments implement lockdowns to stop the contamination cycles of this lethal virus, access to medical care become more difficult. The need is more critical for the elderly and people with chronic diseases prone to deaths because of coronaviruses [23]; they are also in need of regular visits to their doctors. In normal days, there is 0.6 consultation per year for each aged person [27]. However, the need for consultation arises during a health crisis. On the other hand, access to clinicians is not evenly distributed; people living in suburbs and small towns might require long trips to visit their doctors, which puts them at higher risk of contamination. Therefore, teleconsultation have recently achieved a huge amount of attention to deal with these challenges.

Besides the health benefits of teleconsultations during viral outbreaks, remote treatments tend to be economically and environmentally better solutions as they remove the need to travel for medical treatments.

Moreover, patients favor teleconsultation, given the aforementioned benefits and more comforts. A six-month pilot run of teleconsultation services[22] supports this claim, as it received full satisfaction from the patients. In this pilot run, more than one-third of patients opted for teleconsultation, who had averagely saved 66 min of travel in avoiding 49 km to the doctors' office. In [22], as well as the direct costs of a face-to-face consultation, the indirect ones are also discussed, particularly the costs related to the travel and absence from work of the accompanying persons. Although the teleconsultation system discussed in the aforementioned study focuses on specialist radiotherapy services, seemingly the results can be generalized for different types of teleconsultations. For example, TELEDIABE [5] is dedicated to patients who have diabetes; yet received similar positive feedbacks from its users. For each teleconsultation using TELEDIABE, the patients averagely saved 115 min and 80 euros.

Although teleconsultation has undeniable benefits over face-to-face consultations, there are various concerns that slow the deployment of such systems. These concerns can be generally categorized into two classes: (1) the security of medical information and (2) the financial aspects of such systems. One of the most tangible examples of the former class of concerns is the confidentiality of the data in transit required for teleconsultation; e.g., medical files, prescription, and video calls. Because of the criticality of medical information, they are used to be stored in an isolated network; however, for a teleconsultation, this practice is no longer applicable, which raises this concern of confidentiality. The latter class of concerns roughly exists in most online financial systems; however, teleconsultation is arguably more complicated. In common online systems only consists of providers and consumers; contrarily, in the teleconsultation, insurance acts as a third actor. Various approaches have been studied to address the aforementioned concerns; one of the recent technologies that can be applied for handling these concerns is blockchain technology. The latter is a chain of data blocks to form a decentralized data structure; the blocks in the blockchain are linked together using cryptographic algorithms. Blockchain is intrinsically considered secure, reliable, consistent, and transparent [9]. Hence, it is a perfect fit for the infrastructure of teleconsultation services.

To the best of our knowledge, only a few studies had used blockchain technology for teleconsultation; the closest existing approach is DermoNet [12], which is telemedicine specific for dermatology. However, given the importance of security of medical data, many studies have been carried out to secure Electrical Health Records (EHRs) [24,25,28]. In [25], encrypting the records over the network while preserving a balance between the patients' privacy and data confidentiality. Similarly, FHIRChain is proposed in [28] which integrates blockchain technology in HL7-FHIR. The latter stands for Health Level 7-Fast Healthcare Interoperability Resources, is a standard for exchanging EHRs created by HL7 [8]. FHIRChain has improved HL7-FHIR in terms of modularity, integrity, access control, and trust; these improvements are because of intrinsic features of blockchain. Another approach of using blockchain is proposed in [24], which applies blockchain technology for aggreation of EHRs coming from different sources and implementing a content-based access control for patients. The benefits of these approaches in securing EHRs are indisputable; in particular they can be used even for telemedicine as well as other medical services. However, they fail to get the most of blockchain technology; in particular the transparency and modularity of medical workflow which are vital for addressing the concerns on financial aspects as well as the security concerns of teleconsultations. In DermoNet [12], blockchain technology is applied to avail the management of patients' data as well as vast access to specialists to the patients. Although DermoNet is a promising tool for its purpose, i.e., telemedicine for dermatology, it lacks the requirements for integrating with other health services, such as monitoring.

In this paper, we propose *HapiFabric*, a teleconsultation framework based on Hyperledger Fabric[1]; this framework couples with our previous work *Hapicare* [11] to provide holistic medical care for patients, in particular, the elderlies and the patients with chronic diseases. Hapicare is a healthcare monitoring system with self-adaptive coaching using probabilistic reasoning. Since the elderly and patients with chronic diseases were the target population of Hapicare, and they are vulnerable in face-to-face medical visits, we continue to prioritize them in HapiFabric. The proposed framework can be also useful for the general use and the benefits of the general public. Hapicare provides medical telemonitoring services for the patients when they are at their homes; in the case of a need for the intervention of a doctor, HapiFabric provides the infrastructure of a teleconsultation. Moreover, if doctors decide that their patients require continuous monitoring during a teleconsultation on HapiFabric, they can prescribe Hapicare. Hence, HapiFabric is coupled with Hapicare by design. Consequently, Hapicare is an additional actor in the HapiFabric framework for data collection required remote examination. HapiFabric and Hapicare are complementary to each other

[1] https://www.hyperledger.org/use/fabric.

and coupled together to improve the health of patients at their homes; Fig. 1 illustrates the interactions between these two frameworks.

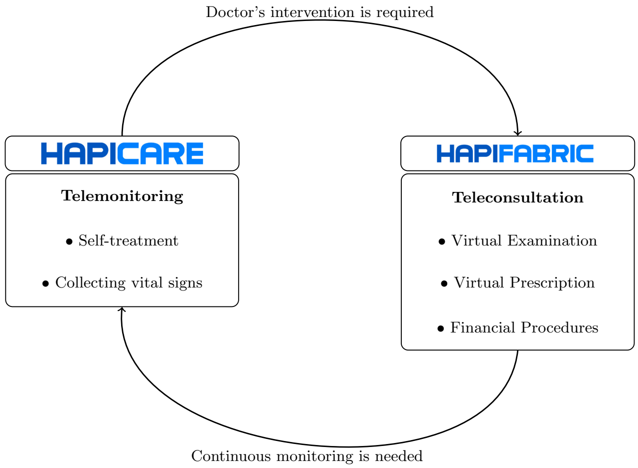


**Fig. 1.** The interaction between Hapicare and HapiFabric

The main contributions of *HapiFabric* are as follows:

- A framework for teleconsultation with modularity, security, reliability, and transparency using blockchain technology
- Use of Hyperledger Fabric as a private blockchain
- An innovative teleconsultation coupled with telemonitoring: in HapiFabric, we introduce teleconsultation services to add doctors' supervision to complete the telemonitoring in Hapicare.

The remainder of this paper is structured as follows: in Sect. 2, the principles of the blockchain are described. The details of the HapiFabric framework, is explained in Sect. 3. Two scenarios are provided and discussed in Sect. 4 to evaluate the HapiFabric framework. Lastly, conclusion and future works are presented in Sect. 5.

## 2 From BitCoin to Hyperledger Fabric

Blockchain belongs to Decentralized Ledger Technology (DLT) [20], which is a consensus of replication, share, and synchronization of data. The distribution can be completely decentralized without central data storage. Fundamentally, blockchain is a data structure formed by linked lists of blocks, chains of blocks. Each block stores a replication of data, as they all are distributed and shared across a peer-to-peer network. The connection between the blocks is via hash values and digital signature, which are one-way cryptographic functions; hence,

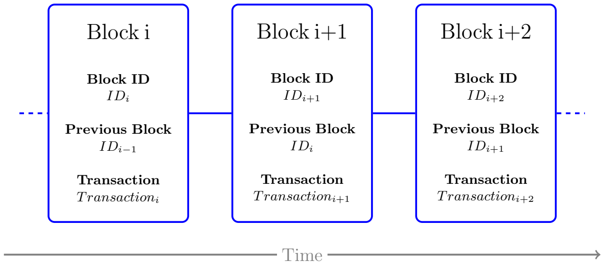


**Fig. 2.** A schema of blockchain network

modification of a block is only possible if all the blocks after that are modified [21]. Figure 2 depicts a schema of blockchain, in which the $ID_i$ is a cryptographic signature based on the contents of $i$th block; i.e., any change in the contents of this block would invalidate that signature. The most popular application of blockchain is a peer-to-peer anonymous cash system, named BitCoin [19].

Although blockchain was around for some years, with BitCoin's success, the background technology has also gained more attention; in other words, researchers try to apply blockchain in various domains. However, in BitCoin, the transactions are simple cryptocurrency transfer. To use blockchain for more complex transactions in other domains, structured scripting for application development in blockchain is needed, which promotes the second generation of blockchain. In which, *Smart contracts* have been introduced to enable using blockchain for workflows. Smart contracts can be defined as a program in which its execution is triggered once a transaction occurrs. This feature is useful for enforcing required actions upon different transactions, e.g., enforcing tax-payment upon the purchase of a product or service. Ethereum [6] is second-generation blockchain platform; which features smart contracts. In Ethereum, a modified version of the blockchain is used, i.e., it consists of state machines. Each transaction causes a change in the state. In other words, the next state depends on the data of the current state and the current transaction. For instance, in a finance system, the states are balance sheets of members of that system, and transactions are any activities that affect the states of the system. E.g., "Alice has 2 euros, and Bob has 5 euros" is a state, while "Bob transfers 1 euro to Alice" is a transaction which will change the state to the new state of "Alice has 3 euros, and Bob has 4 euros." In Ethereum, each script's execution would cost a fee depending on the complexity of the script referred to *gas*. Although Ethereum improves the blockchain platform to use more complex transactions, however, in Ethereum, similar to blockchain, all the nodes have a copy of the entire states; they are designed to be public; although they can be set up in a private network, any members of that network have access to node contents. They provide anonymity and transparency to the fullest, but the tradeoff is privacy and scalability; which makes them unsuitable for the application that a controlled transparency is required. Although this limitation can be mitigated

**Table 1.** A simplified overview of comparison between Hyperledger Fabric versus Ethereum [26]

| Criterion | Ethereum | Hyperledger fabric |
|---|---|---|
| Type of membership | Permissionless and Permissioned | Only Permissioned |
| User Identifications | Decentralized Anonymous Users | Centralized, the nodes are known |
| Sybil attack protection | Using huge power required for computing proof-of-work | Using identity management |
| Latency | Poor-up to 1 h | Depends of implementation-matter of milliseconds |
| Throughput | 15 transactions per second | More than 10,000 with the existing implementations |
| Temporary forks | Possible (might lead to double-spending attacks) | Not pssible |
| Consensus finality | No | Yes |
| Consensus Protocol | Proof-of-Work [6] | Practical Byzantine Fault Tolerance [26] |
| Smart Contract Language | Solidity [6] | Go and Java [26] |
| Scalability [7] | Less scalable | More scalable |

with the installation of Ethereum in a private manner; it rests another limitation in its throughput, as it is limited to only 7 to 15 transactions per second [2]. To this end, another approach is private blockchain networks, commonly known as permissioned blockchain. The latter features protocols for authentication, authorization, and permission of actions. They often have central identity management and hence are not ideal for a very large number of nodes. However, their throughput can be more than 10,000 transactions per second [26], which is incomparable with the throughput of BitCoin and Ethereum. *Hyperledger Fabric* is an implementation of permissioned blockchain for running smart contracts, using familiar technologies [3]. For instance, the smart contracts in Hyperledger Fabric are called *Chaincode*, and they can be written in Go[2] or Java languages[3]. Hyperledger Fabric is built on a modular architecture and allows scalable consensus mechanism which enhance the global scalibilty of the application use case. Table 1 presents an overview of differences between the Ethereum and Hyperledger Fabric. In which, *Sybil attack* is an attack wherein the attacker creates

[2] https://golang.org/.
[3] https://www.java.com/.

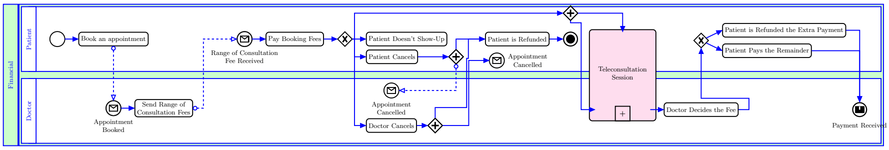


**Fig. 3.** The simplified process model of a financial aspects of a teleconsultation session

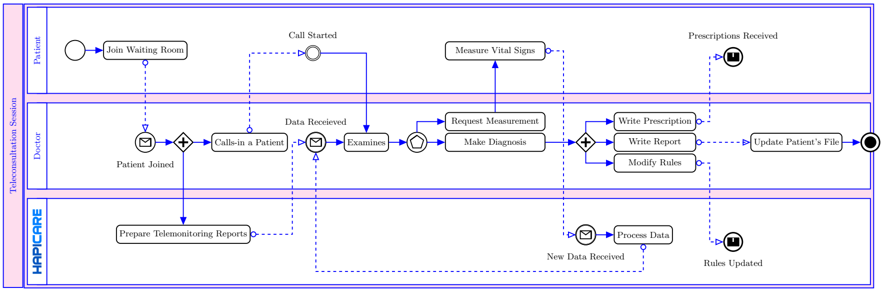


**Fig. 4.** The simplified process model of a teleconsultation session

numerous fake identities to affect the system. Moreover, *consensus finality* is the affirmation that blocks in the blockchain are final and will not be revoked.

The Hyperledge Fabric is a permissioned network, the nodes are all identified and can have three roles, namely *Clients*, *Peers*, and *Ordering Service Nodes*, defined as follows [3]:

- *Clients* submit the proposal of transactions.
- *Peers* execute the proposals of transactions, and validate them. Peers keep blockchain ledgers. The latter contains the immutable records of transactions. Only a subset of peers, namely the endorsing peers (also known as endorsers) can execute the proposals. The committing peers (also known as committers) validate the transactions.
- *Ordering Service Nodes* (also known as orderers) collects the transactions that are approved by endorser and distribute them between the committers.

## 3 HapiFabric

Given the aforementioned challenges in the workflow, namely the security and modularity concerns, and the properties of Hyperledger Fabric, we introduce HapiFabric, a teleconsultation framework coupled with telemonitoring exploiting Hyperledger Fabric. We have opted for this blockchain technology. It provides more flexibility and throughput, which are vital for our application.

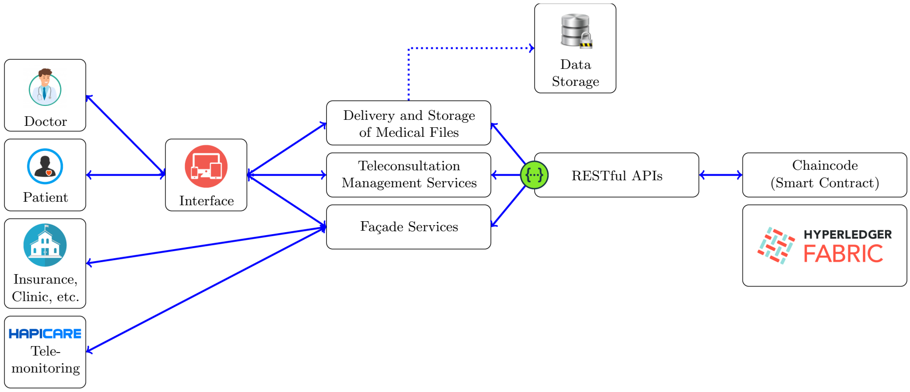


**Fig. 5.** Architecture of HapiFabric Framework

### 3.1 Architecture

The general architecture of HapiFabric is depicted in Fig. 5. The chaincodes are the core of blockchain applications built on Hyperledger Fabric; we use the Representational state transfer (REST) interface for accessing these codes. There are generally three types of REST application programming interfaces (APIs): (1) APIs used for the management of medical files; e.g., delivery and storing of them; (2) APIs used for teleconsultation management; e.g., appointment management, scheduling, document sharing, and video conferencing; and (3) Façade APIs used for organizational access; e.g., telemonitoring and insurance. Doctors and patients can use the APIs through the web interface.

### 3.2 Participants and Assets

A typical teleconsultation service consists of a doctor who gives out the consultation and a patient who receives that. Mapping a typical teleconsultation into Business Process Model and Notation (BPMN) consists of two actors, and the shared resources can be agendas, waiting room, video call channel, prescription, and report. In HapiFabric, as we couple teleconsultation with telemonitoring, we have an additional actor, which brings additional shared resources.

The main members of the BPMN of HapiFabric, commonly known as participants, are listed as follows:

- *Doctors* provide teleconsultation. Doctors hold the video conference sessions, author prescriptions reports, and compose medical rules.
- *Patients* use HapiFabric to receive teleconsultation.
- *Hapicare* [11] provides telemonitoring services to the patients. This participant consumes collected data from the patient and the medical rules from the doctor and provides analyzed data to the doctor and some coaching to the patient.

– *Insurance companies* interact with doctors for reimbursements. This member share financial assets with doctors and patients.
– *Auditors* examine the transactions, e.g., fiscal auditors.
– *Clinics* act as the intermediate between doctors and patients.

The main resources used in the BPMN of HapiFabric, usually known as assets, are the followings:

– *Agenda* is the group of assets related to doctors' available time-slots and the booked ones by the patients.
– *Video channel* is used as a medium of teleconsultation. This asset is shared between the doctor and the patient of a teleconsultation session.
– *Virtual waiting room* is a place resembling doctors' waiting room; that holds the patients who are online and waiting to be called in.
– *Prescription* is one of the primary outcomes of teleconsultation sessions. This asset could contain some drug names, their dosages, and their use guidelines. Presciptions could also include some additional diagnostic steps, such as blood exams.
– *Payment* is the group of assets related to the financial transaction, including payment card details, prepayment amounts, and fees.
– *EHRs* are the medical files of patients, which include all the visit reports.
– *Monitoring reports* are the products of *Hapicare* telemonitoring services. This asset contains vital signs, symptoms, and other information about the patients during their stays at home.
– *Monitoring rules* are based on the expert knowledge used in *Hapicare*. The rules are used to analyze captured data and provide suitable coaching based on the medical conditions.

### 3.3 Teleconsultation Workflow

Teleconsultation is defined as medical consultation services provided at distance. Multiple workflows form a teleconsultation service. The followings are the main workflows in teleconsultation:

1. Agenda management: The doctor provides a list of his/her available times, and the patient selects and books one of them.
2. Virtual examination and prescription: The doctor asks the patient for symptoms and exam results for his/her diagnosis and consequently providing a prescription.
3. Finance management: The doctor bills the patient based on the type of consultation, based on the insurance plan of the patient, the sum will be paid to the doctor via the patient and the insurance company.
4. Income share: The amount might be received by a clinic, which would share the amount with the doctor and the infrastructure provider.

An overview of third workflow is shown in Fig. 3; in which the second workflow is depicted as a box. Before the teleconsultation session starts, a few prerequisite steps happen: a doctor previously has provided some time-slot for the times at which he/she is available for teleconsultation sessions; then a patient upon his/her will or based on the suggestion of Hapicare books one of them. It is common in medical consultation that the exact fee is not decided until the end of the session, as different types of consultations cost differently. At the time of booking the appointment, the patient would select a reason for consultation; on that basis, a range of consultation fees are provided. One of the doctors' concerns is false bookings; i.e., since the procedure of booking is very simple, malicious users book the time-slots of a doctor without the intention of using them; it blocks real patients from accessing the doctors. To this end, one common practice is prior payment; since the exact consultation fee is not decided in the booking time, the patient would pay a defined fee enough to discourage false booking. Either party can cancel the appointment, resulting in the refunding the prepayment. Upon concluding the teleconsultation session, the doctor decided a consultation fee; if this fee is lower than the prepayment, the extra amount is returned to the patient; otherwise, the patient pays the difference. Once the doctor has received the payment, it will be stored in his/her logbook for future reference for insurance reimbursements and fiscal aspects.

The core of teleconsultation is the *virtual examination and prescription* workflow; the simplified process model of this core workflow is shown in Fig. 4. The core workflow, depicted as a box in Fig. 3 and detailed in 4, starts on the time of appointment. The patient logs-in the system to join the virtual waiting room. Similar to physical consultation, a waiting room is vital to provide flexibility for doctors to spend enough time with each patient. Upon joining each patient, the doctor is notified, and the waiting room is updated. The doctor (or his/her secretary) can always check who is in the waiting room, consultation reasons and scheduled appointments, and how long patients are online in the waiting room. This information allows the doctor to manage better his/her time to visit all the patients in a timely manner.

Moreover, Hapicare starts preparing all the data about the patient who has joined the waiting room. Once the doctor selects a patient to start the video call, this data is transferred to the doctor to help him to have holistic information about the patient. The doctor examines the Hapicare file and asks some questions; he/she might ask for additional measurements. The patient can provide them using his/her connected sensors. After measuring the vital signs, Hapicare will collect the information and transfer them to the doctor. Once the doctor has enough information about the patient to make a diagnosis; he/she would typically write a prescription for the patient; the prescription might include additional diagnosis steps, such as blood exams or referral letters for a specialist. The doctor would also write some reports in the medical file of the patient. If necessary, he/she might also update some of the telemonitoring rules in Hapicare, based on his/her diagnosis; with the conclusion of the teleconsultation session, the rest general workflow (see Fig. 3) continues with *the doctor deciding a consultation fee.*

The workflow is dynamic and might differ based on the needs. For example, a doctor can impose some regulations to charge last-minute cancellations. Moreover, given the pace of advancement in technology and consequently, the change of procedures, it is inevitable to have changes in the workflows of teleconsultation. For example, in the near future, with the necessary infrastructure, the prescription might be sent directly to an online pharmacy. The patient receives his medications at his home. The dynamicity of teleconsultation workflows calls for an adaptable system to consider such charastric.

On the other hand, there are various security concerns to be considered regarding teleconsultation. The most critical concern is the confidentiality of data; because the teleconsultation inevitably involves some confidential information, such as medical files of patients. Other security concerns include the availability of teleconsultation services, the integrity of prescription and reports, the integrity of payment logbook, and transparency of prescription history. To this end, we use blockchain technology to address the challenges mentioned above in teleconsultation. Given the comparison discussed in Table 1, Hyperledger Fabric better suits the requirements of teleconsultation, as it provides access control and a higher level of performance.

### 3.4 Storage

In HapiFabric, there are two groups of data; the transactional data, which are arguably equivalent to logs in traditional systems, and the functional data which include medical files, profiles, appointment data. The blockchain data structure is optimized for the validation of transactions; it is not best suited for storing a large amount of data [1]. Hence, we opted for off-chain data storage for the functional data. IPFS [4] stands for InterPlanetary File System, a decentralized file system that allows access, storage, and security of files on a distributed network. Given its characteristics, IPFS is a common practice for off-chain data storage. Hence, in HapiFabric, we use IPFS for storing the functional data; and use chaincodes for the access control.

### 3.5 Chaincode

Chaincodes are the core of the HapiFabric; we use Go for developing the chaincodes. The main chaincodes related to the functionalities of HapiFabric are as follows:

- *Agenda Management* are the transactions related to doctors' availability and their booking by the patients. Both parties can update the appointment assets and submit them to the system.
- *Payment Management* is a group of transactions that are related to payments. That includes the prepayment by the patient, the decision of fee by the doctor, and paying the outstanding amount by the patient. Hence, both parties can write in this transaction to submit to the system.

– *Treatment* is the transaction that includes the treatment plan of the doctor; in other words, it is a combination of Hapicare rules, prescriptions, and consultation reports. Doctors write this transaction.
– *Telemonitoring* is the transaction that records the reports of patients during their stay at home. Hapicare writes this transaction.

Blockchains, including Hyperledger Fabric, operate on the principle of assets, participants, and transactions. Hence, upon creating, updating, or deleting any of the assets, participants, and transactions, Hyperledger Fabric records this event and appends it to the immutable logbook on the distributed ledger. The trails provide transparent details of operations in the network, which are useful for the auditors.

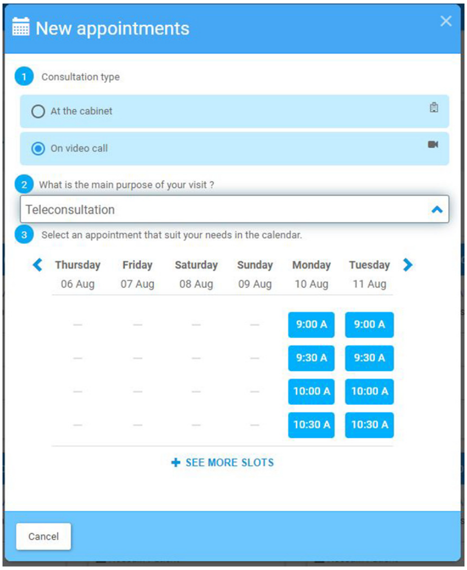


**Fig. 6.** Patient's view of the appointment selection

## 4 Use Case

HapiFabric is in the continuation of Hapicare; they are complementary to each other (see Fig. 1). The proposed framework is evaluated using two different scenarios. The screenshots of the

### 4.1 Scenario - 1

In this scenario, we follow the use-case discussed in [11]. The doctor and the patient use Hapicare as a telemonitoring system and HapiFabric as a teleconsultation system. Jack is a patient of Dr. Smith; he had been diagnosed with diabetes about two years ago. Recently, Dr. Smith has prescribed him to switch to insulin. Hapicare monitors Jack's vital signs and symptoms to make sure his blood sugar stays normal. Hapicare records multiple hyperglycemia; it then suggests Jack to take an appointment using HapiFabric based on the analysis of the measurements. Dr. Smith has provided time-slots for teleconsultation, and Jack selects one of them for booking (see Fig. 6). Dr. Smith requests a prepayment of 5 euros to discourage false bookings. Once Jack selects a time-slot and pays the prepayment amount, the appointment transaction and payment transactions are executed and committed in Hyperledger Fabric.

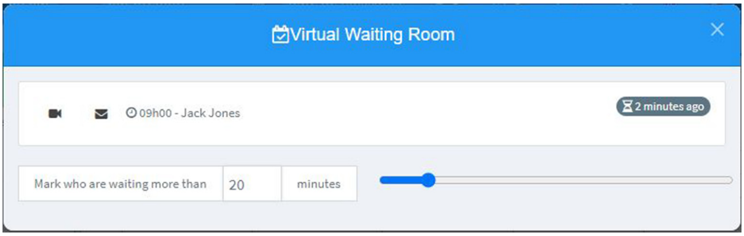


**Fig. 7.** Doctor's view of the virtual waiting room

At the time of appointment, Jack joins the waiting room; Dr. Smith will get notified of his presence, and he can call him in (see Fig. 7). Dr. Smith accesses the *telemonitoring* transactions that include the reports of Jack's frequent hyperglycemia. Moreover, he also accesses the *treatment* transactions to know his course of treatment. Dr. Smith concludes to prescribe Jack for an additional dosage of insulin. He also writes an additional rule for Hapicare to monitor him more closely for the coming days for symptoms of hypoglycemia. This new prescription and the new medical rule, are written into the treatment transactions and committed in Hyperledger Fabric. Dr. Smith decides the fee of consultation is 25 euros by writing into the payment transactions. Jack would pay the difference in the HapiFabric web interface.

### 4.2 Scenario - 2

Jill, 62 years old, had a mild heart attack recently. Her doctor, Dr. Brown, has recently been diagnosed with COVID-19. However, Dr. Brown's condition is not severe, but he opted for teleconsultation to avoid the risks of contamination. Dr. Brown asks Jill to take an appointment on HapiFabric to follow-up her treatment. During the teleconsultation, Dr. Brown understands that Jill's children have stopped visiting her because of the lockdown related to COVID-19; there is no person to take care of Jill's health situations. Hence, Dr. Brown prescribes Jill to use Hapicare to monitor her conditions continuously. In this case, Jill's treatment transaction has been updated and submitted to the Hyperledger Fabric. The appointment and financial processes are similar to the previous scenario.

### 4.3 Discussion

In the given scenarios, the cooperation between the two telemedicine solutions, namely HapiFabric and Hapicare [11], is shown. In the first one, Hapicare would redirect the patient to HapiFabric when a doctor's intervention was required; and in the second scenario, the doctor has prescribed Hapicare to monitor the patient at home using HapiFabric.

HapiFabric has two sources of added values: (1) telemedicine services and (2) Hyperledger Fabric. The scenarios show how telemedicine helps patients without any replacement at their maximum comfort. In particular, teleconsultation saves both parties' time and money, as they avoid the trips to the clinic or doctors' office. Another bold benefit of teleconsultation is during health crisis and viral outbreaks, as it promotes a healthier solution for medical consultation.

Hyperledger Fabric has easily configurable access control, which promotes the confidentiality and privacy of the medical data. The trails are tamper-proof; hence auditors can quickly look up the logbooks to see for the events in HapiFabric. Moreover, Hyperledger Fabric enables modularity; hence the dynamic changes in HapiFabric are straight-forward. Because of the architecture of Hyperledger Fabric which splits the execution of chaincodes (smart contracts), HapiFabric can also perform well in scale.

## 5 Conclusion

The population is growing old across the globe; almost all of the elderly suffer from chronic diseases. Managing them is necessary and costly; hence, it is vital to use technology to deal with this challenge. The outbreak of the coronavirus in 2020 has pointed the importance of remote medical care. Although telemonitoring is vital for managing patients at their homes, yet in many cases, it is not sufficient. In other words, telemonitoring brings e-nurses to the patients' homes; but sometimes it is important to bring doctors, too. Teleconsultation can be considered as an efficient approach for this matter. It has multiple advantages over traditional face-to-face consultations; including removing the time and costs of travel to the doctors' office and removing the physical contact, which increases the chance of contamination. In this paper we have proposed HapiFabric, a framework for a teleconsultation service coupled with telemonitoring service. HapiFabric is a BPM implementation of teleconsultation service over Hyperledger Fabric technology. The latter is a permissioned blockchain technology that provides access control in addition to transparency, and security to our framework. In this paper, we have discussed two scenarios to show how HapiFabric and Hapicare can cooperate, and how HapiFabric exploits blockchain technology to deliver teleconsultation service. In terms of research perspectives to this study, an interesting topic is to formally model the HapiFabric workflows and verify their strength against various attacks. Another interesting research direction to explore is to deploy HapiFabric for use in the real world to receive feedback from doctors and patients.

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