PyQy - A protocol to enable open, trustworthy physician quality reporting and payments using the blockchain technology

Chintan Patel PhD, Sharib Khan MD, MA, MPH, Nadeem Nazeer, MS
Applied Informatics Inc, New York, NY, 10016

Introduction

The blockchain technology is currently revolutionizing the finance industry.[1] Some have equated the disruptive potential of the blockchain technology to that of the Internet.[2] The underlying notions of de-centralization, digital information, verifiable trust and openness are at the heart of this technology. One of the key properties of the blockchain is that it eliminates “middlemen”, thereby empowering every participant (“node”) to perform and verify a transaction.

In the healthcare ecosystem, there are several different players interacting with one another including the patient, provider, payer, healthcare organizations, software vendors and regulatory agencies. The blockchain technology with its aforementioned properties provides a promising approach to eliminate middlemen and establish trust, digital efficiency and cut down costs in the healthcare sector.

In this white paper, we propose the application of blockchain technology and smart contracts to the process of physician quality reporting and payments that are cornerstones of quality driven healthcare and pay for performance approach to health care.

Background

What is a Blockchain?

A blockchain is essentially a digital public ledger. The ledger maintains a list of transactions that cannot be tampered with once verified and added to the chain. This distributed ledger technology can be applied to a variety of purposes other than the transfer of digitally stored value. The same principles that allow the Blockchain to be a functional means of creating, verifying and transferring value can be applied to information or even to exercisable rights.

[1] http://knowledge.wharton.upenn.edu/article/blockchain-technology-will-disrupt-financial-services-firms/
[2] http://www.mckinsey.com/industries/high-tech/our-insights/how-blockchains-could-change-the-world

What are Smart Contracts?

Smart contracts are computer programs that can automatically execute the terms of a contract. The smart contracts ensure that when a pre-configured condition is met among the participating entities involved in a contractual agreement can be automatically made payments as per the contract in a transparent manner. The smart contracts when added to blockchain become immutable and open thereby incorporating trust among the interacting parties.

Quality Reporting and Merit based Payments

The Physician Quality Reporting system (PQRS)[3] was introduced in 2006 as an incentive-based payment model for providers to report quality data to the Center for Medicare Services (CMS). The quality is quantified based on standardized clinical quality measures (CQM) that measure health care processes, observations, treatments and outcomes. These measures are created and periodically updated based on evidence based medicine and clinical best practices.

The Meaningful Use program (as part of the HITECH Act in 2009) required certified Electronic Health Record (EHR) vendors to provide capabilities to generate CQM data in a standardized electronic format. The standard to represent the quality data is outlined as part of the QRDA Category I and III specifications.[4] This enables electronic exchange of quality data across systems. The EHRs are tested by Accredited Testing Laboratory (ATL) and certified by an ONC-Authorized Certification Body (ONC-ACB) to meet criteria adopted by the Secretary of the Department of Health and Human Services (HHS). The certified EHRs are listed on the Certified Health IT Product List (CHPL) (https://chpl.healthit.gov), which is a comprehensive and authoritative listing of all certified Health Information Technology.

The data collected from the PQRS also powers the Physician Compare website (https://www.medicare.gov/physiciancompare) that allows consumers to compare physicians and practicies based on the quality of care provided.

The focus on improving the quality of care has increased with the proliferation of new models of care delivery such as Accountable Care Organizations (ACOs) and Patient centered Medical Homes. In 2015, under the MACRA Quality Payment Program, the Department of Health and Human Services has set a goal of tying 50% of medicare related payments to quality and value based care by 2018.[5] The goal is to

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[3] https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/PQRS/index.html?redirect=/pqri/

[4] https://ecqi.healthit.gov/qrda

[5] http://www.hhs.gov/about/news/2015/01/26/better-smarter-healthier-in-historic-announcement-hhs-sets-clear-goals-and-timeline-for-shifting-medicare-reimbursements-from-volume-to-value.html

extend this model beyond medicare to private payers. The MACRA combines the PQRS and other related efforts into one umbrella to measure a provider based on quality, resource use, clinical quality improvement and meaningful use of EHRs.

Challenges and Issues with Current Approach to Quality Reporting

Although the current approaches to measuring and reporting quality provide a big step forward in improving care, there are several issues to consider as outlined below:

1. **Burden and Cost**: There is a significant increase in burden on the providers, healthcare organizations and software vendors to generate reports, submitting them to state and federal agencies and keeping the reports updated as per the new eCQM specifications each year. On the other hand, the local and federal government agencies also need to develop and maintain large scale systems and infrastructure to collect measures, report, calculate and distribute merit based payments.
2. **CMS Specific**: A large part of processes and software infrastructure for collecting quality data and generating payments is developed as part of CMS. If other payers/insurance companies were to adopt quality based payments, it would require them to develop similar infrastructure and processes that may or may not be open.
3. **Consumer Trust:** Quality data being fed to consumer websites such as the Physician Compare site, requires that consumers and providers trust a ".gov" website which implies that data has not been erroneously reported, misrepresented, redacted or modified inflight. In Figure 1, we depict how the performance data for football player is publicly available on multiple websites that is sliced and diced in different ways.
4. **Transparency in Payments**: Similarly the payments that are generated as part of the quality also are calculated as part of the "black-box" algorithm that is controlled by the CMS (or by the private payers) - the providers have no insight into how exactly the merit based payments are being calculated.

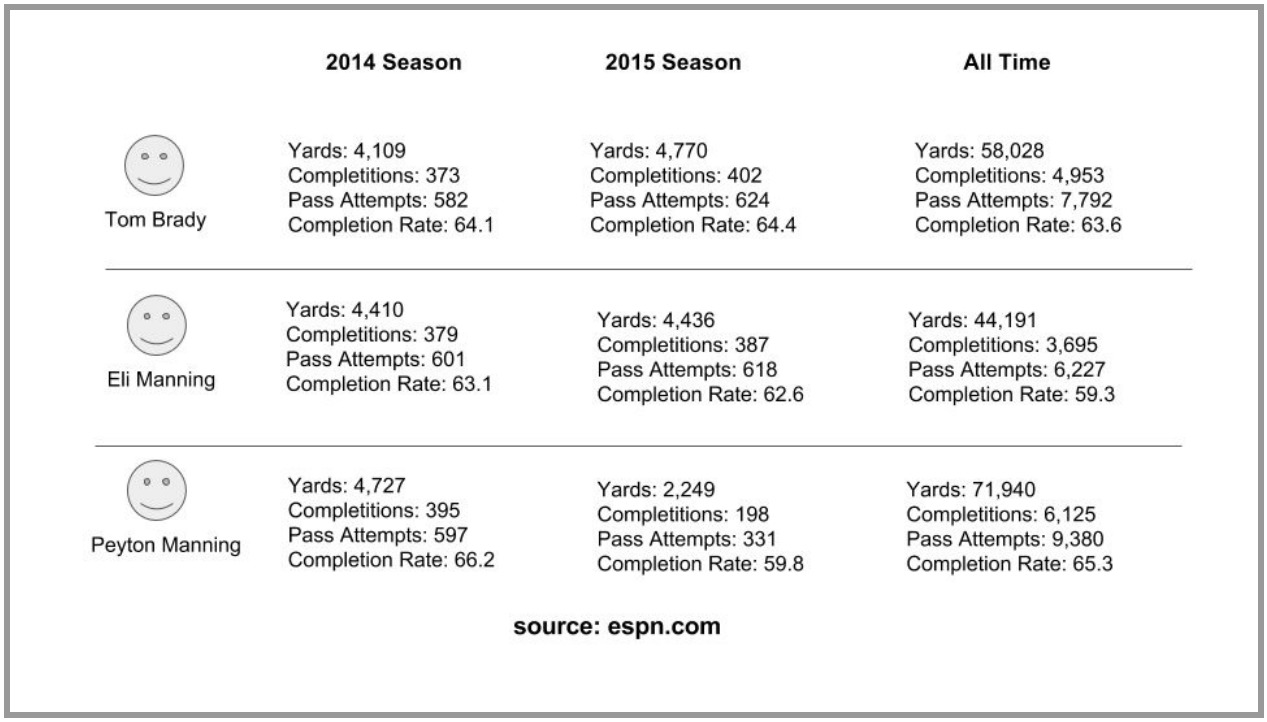

Figure 1. NFL football quarterback stats for 3 players for 2014, 2015 and all time. The data for every football quarterback is recorded by different agencies such as the ESPN and put on hundreds of websites where people can view them and rank players based on their past and current performance. In health care, we currently do not have an *open system* for recording and viewing performance data of providers. Our proposal is to create an open, secure, verifiable blockchain to record similar performance metrics for providers and healthcare organizations

PyQy Blockchain Protocol for Quality Reporting and Payments

Proposed Approach

We propose PyQy (pronounced as “Pwai Qwai”) protocol, an innovative open and trustworthy solution using blockchain for quality reporting and smart contracts for payments that alleviates the challenges and issues outlined above. The key idea is to de-centralize the quality reporting using blockchain and leveraging existing standards such as the QRDA III to encode the performance metrics. The overall architecture of the approach is shown in Figure 2

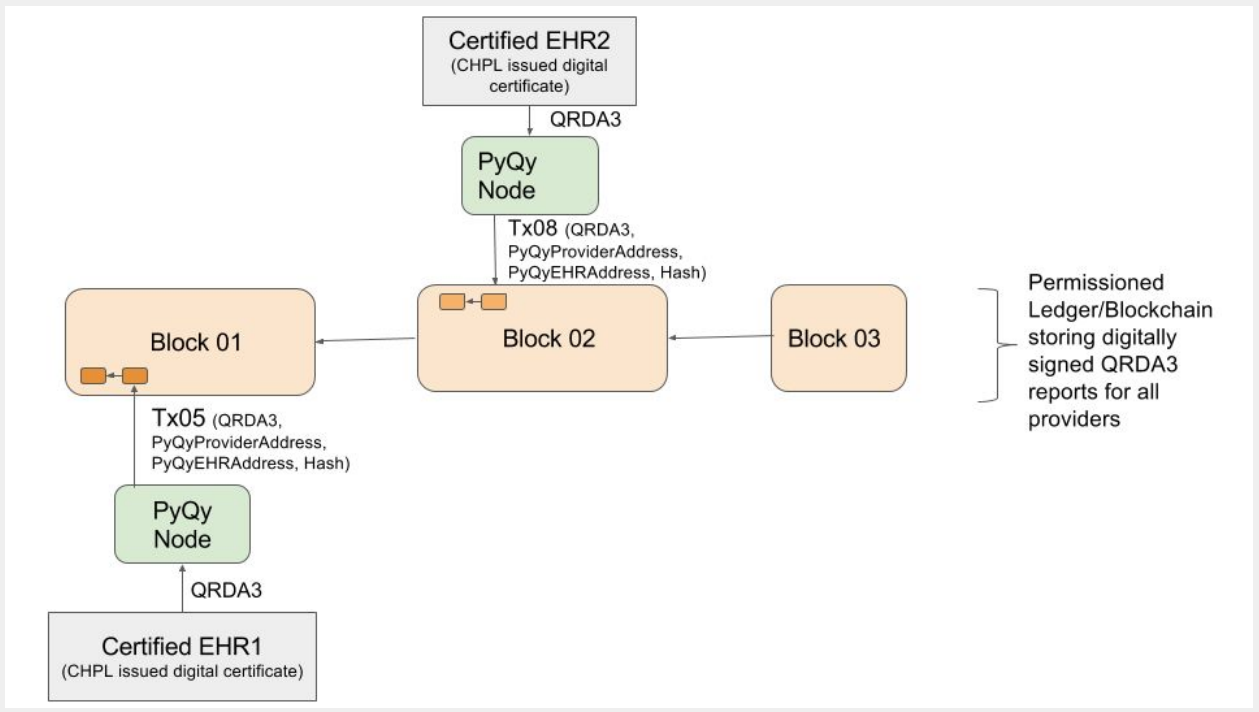

Figure 2: The implementation of blockchain to store physician quality data. A certified EHR (with a digital certificate issued by CHPL) will use a the open source PyQy node software to write the quality report to the blockchain.

The proposed PyQy physician quality report blockchain has 2 key actors:

1. **Certified EHR**: Only the Certified EHRs can write to the blockchain. The identity of the EHR is verified based on the digital certificate issued by the CHPL after certification. The ledger is a permissioned ledger as only the nodes that have this certificates are allowed to write to the PyQy chain. The Certified EHR performs following tasks:
    a. Generate a valid QRDA3 (tested against Cypress during the certification) from patient record
    b. Send the QRDA3 to local PyQy node with relevant keys
2. **PyQy Node Software**: An Open Source PyQy node plugin that will have implementations written in all major languages and it will integrate locally with EHRs. The PyQy node performs following operations:
    a. Takes as input the QRDA3 generated by the EHR
    b. Adds a digital signature using with provider's private key and EHR's private key.
    c. Uses a hashing algorithm that uses the provider's NPI or organizations TIN (Tax Identification Number) in the QRDA3 to create a PyQyProviderAddress (a unique address for the provider on the chain, similar to the Bitcoin Address but linked to the real identity)

d. Uses a hashing algorithm that takes in the EHR certification ID to generate a PyQyEHRAddress
e. Traverses the ledger to find the last known block (previous report submission done by the provider) for the given PyQyProviderAddress
f. Generates a unique hash based on the QRDA3, the digital signature, PyQyProviderAddress and PyQyEHRAddress and the last known address.
g. Adds a block to the chain with the unique Hash, the QRDA3 report, PyQyProviderAddress and PyQyEHRAddress
h. Verifies the non-verified blocks in the ledger in terms of all data added by other nodes in terms of hash generated. Once a transaction block is verified, a PyQy can add a “proof of work” hash that contains the digital signature of the EHR node that performed the verification (note other nodes can still go ahead and re-verify the ledger periodically)
i. Ensures that only digitally certified products are adding to the chain, if the ledger contains transaction blocks that do not contain a valid signature are removed from the ledger and all following nodes are recalculated.

The process of generating the digital keys and certificates is shown in Figure 3A. The key idea is that chpl.healthit.gov acts as the trusted “bundle” store with all public keys of the Certified EHRs. These keys can be used any PyQy node to verify the digital signature on the blocks. Similarly the public keys of the provider can also be pushed to CHPL or some other central sources (or even shared by every PyQy node) to digitally sign the report (Figure 3B).

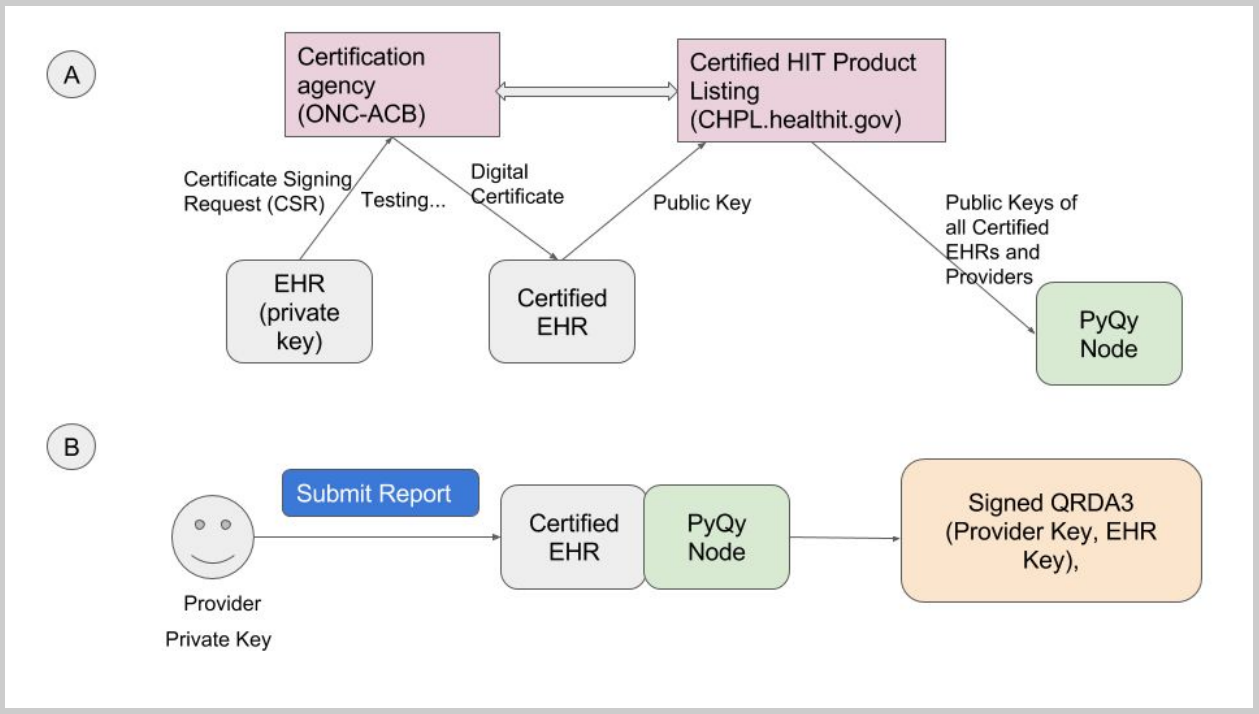

Figure 3 A). Every EHR that goes through certification receives a digital certificate and corresponding public key is stored by CHPL. The PyQy Node software fetches all public keys from CHPL. B). The process of Provider submitting report through EHR and generating a QRDA3 report digitally signed by private keys of both the provider and the Certified EHR.

PyQyQuery: Retrieving the Quality Reports

To query the blockchain in order to get the QRDA3 reports for a given provider or organization, we propose a tree parser implementation. This will take as input NPI on a TIN and traverse the entire blockchain to get the nodes that contain corresponding PyQyProviderAddress. Since we also store a parent pointer in the blocks, once we find one node the traversal of nodes only need to following the pointers backwards in the chain. We can use existing tools such as the blockparser[6] or bitiodine[7] to analyze the chain and query the reports.

PyPay: Making Payments

The final piece of the puzzle is to device a mechanism to perform payments based on the quality and other business rules specified openly in a smart contract. We propose an add-on protocol/approach, PyPay to perform payments using the blockchain technology. Figure 4 shows a possible architecture to perform the payments using a blockchain and smart contract infrastructure.

[6] https://github.com/znort987/blockparser
[7] https://github.com/mikispag/bitiodine

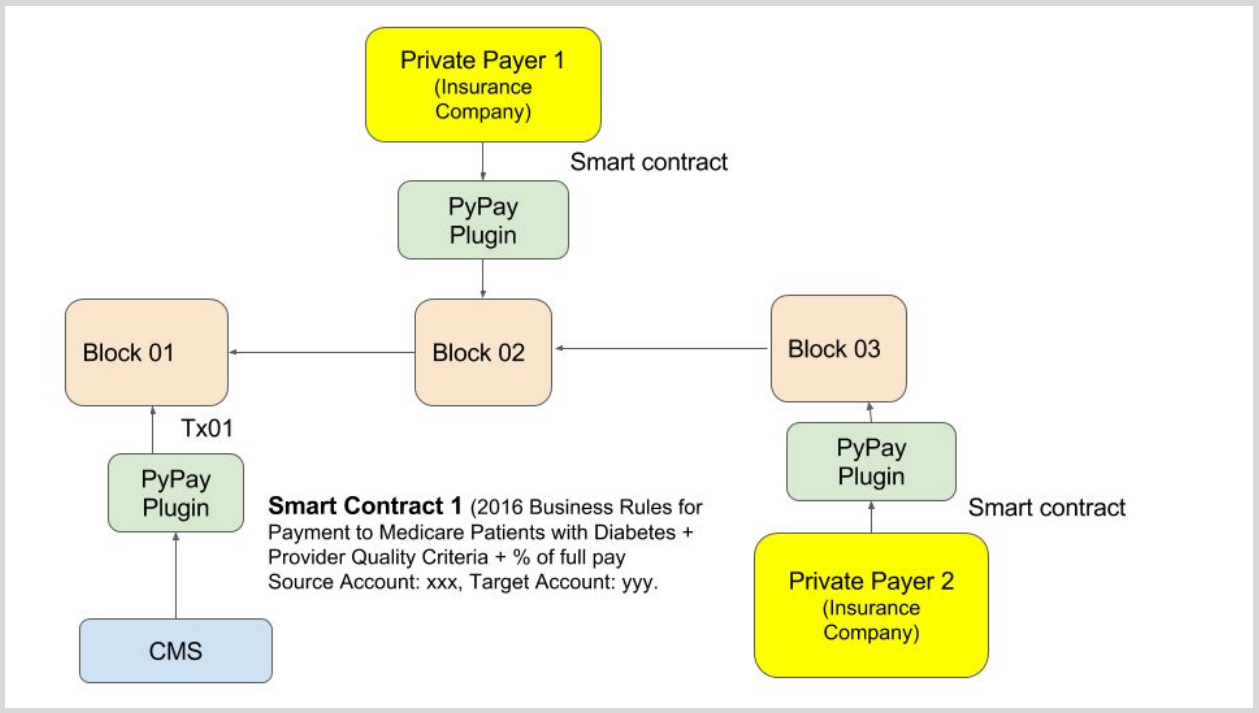

Figure 4. Using smart contracts to automate payment to providers based on quality. Smart contracts contain verifiable code that performs payment transaction from payer (government or private payer) to the provider based on explicit rules specified in the contract.

The key idea is that smart contracts are specified by any public or private payer and stored on the blockchain. So as provider meets the requirements in terms of quality (and volume) of care performed he can be payed in a smart and transparent way. Note the payments can also be performed via traditional route, where the smart contract invokes some local module that triggers a mailing of physical cheque or bank money transfer and for the brave souls sending money via bitcoins (BTC).

Discussion

Report submissions are currently exclusively tied to agencies and programs such as the ONC, PQRS and CMS, serving as the trusted third party who process, verify reports and then mediate payments. The role of these trusted third party systems is to validate, safeguard and preserve transactions of these payments. But along with these type of systems there arises different types of bottlenecks and issues caused due to being manual communication-bound, non-distributable, non-transparent. These types of issues become unavoidable in transactions that needs mediation by these centralized yet closed systems.

The proposed PyQy and PyPay approach intends to use cryptographic proof as used by Bitcoin instead of the trust in the third parties and then doing smart payments employing “Smart Contract”, all happening on the blockchain.
A verifying node(miner) needs to ensure two things before recording any submission:

1. Provider owns the report
2. Report is valid.

First issue can be is protected through the use of a digital signature. Each report submission is sent to the “public key” of the receiver digitally signed using the “private key” of the provider. In order to submit report, owner of the report needs to prove the ownership of the “private key”. The entity receiving the report verifies the digital signature –thus ownership of corresponding “private key”--on the report using the “public key” of the provider. Each submission is broadcast to every node in the PyQy network and is then recorded in a public ledger after verification. Every single submission needs to be verified for validity before it is recorded in the public ledger.

PyQy will store the actual report and the cryptographic digest of the report, linked to the time in which provider submitted the report. In this way, it can be later certified that the data existed at that time. This service will allow one to publicly prove that provider had certain information without revealing the data or him, with a decentralized certification based on the bitcoin network.

Permissioned Ledgers also called private blockchains, allow for distributed identical copies of a ledger, but only to a limited amount of trusted participants only. When a new record is added, the ledger’s integrity is checked by a limited consensus process. This is carried out by trusted actors, the digitally certified EHRs . A permissioned ledger is usually faster than an unpermissioned ledger because there are limited verifiers(miners). As EHR’s are digitally certified it implies they produce valid reports, current re-validating by PQRS can be bypassed and relying on EHR(verifier nodes) for marking block as valid should serve the purpose. EHR(nodes) in addition to submitting reports of their providers and then may additionally on blockchain can take up the orphan reports(transactions) and validate them and charging bitcoins from providers

Conclusion

The proposed PyQy protocol proposes to create an open infrastructure to store physician quality reports using the blockchain technology thereby enabling transparency, innovation, better consumer tools and moving towards pay for performance.