Healthcare Hyperchain: Digital Transformation in the Healthcare Value Chain

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Abstract

Healthcare organizations are currently in an era of significant digital transformation. Organizations are seeking to adapt within a globalized environment with ever-increasing complexity of care and regulatory requirements. To be successful in this new era, organizations must re-envision their value chain to improve patient outcomes, and be flexible and adaptable in their ability to respond to the competitive marketplace. The combination of traditional production and cyber-physical production will indicate the evolution from traditional business models to the emerging non-linear value chains. The aim of this paper is to review the healthcare value chain in the context of digitally-enabled technologies such as hyperledger and blockchain, which have the potential to extensively alter healthcare organizations. The research contributions include development of a reusable hyperchain artifact, construct development, and understanding the shift from the traditional healthcare value chain to the industry 4.0 digital healthcare value chain model instantiation of the hyperchain.

Keywords

Hyperchain, Hyperledger, Blockchain, Value Chain, Digital Transformation, Healthcare

Introduction and Importance

In healthcare, as digitally-enabled technologies become more pervasive, strategic opportunities to transform healthcare and improve patient outcomes are possible within the fourth industrial revolution. For example, mobile technology empowers patients with greater control and decision making over their health information and has the opportunity to improve patient education (Taylor, 2015; Woodside, 2016). According to Schwab (2016), the fourth industrial revolution is a blurring of physical, digital, and biological areas driven by the use of technologies such as mobile devices, artificial intelligence, Internet of Things (IoT), biotechnology, quantum computing, and robotics. As compared with the prior industrial revolutions, the fourth is moving at an exponential rate displacing and disrupting virtually every industry. While the fourth industrial revolution has the ability to improve the quality of life around the world, most of the value has been limited to those with access to or able to afford digital technologies. As a result, the revolution has the potential to create greater inequality, in particular as automation replaces labor. In addition to the societal issues and wealth gap, the pace of change is difficult to manage and anticipate from an executive management perspective. In response, executives are required to critically reexamine their business and adapt to the changing environment (Schwab, 2016).

Digital Ledger Literature Review

Blockchain is a shared digital ledger, which stores peer-to-peer transactions in blocks. In blockchain there is no centralized authority, instead all transactions are shared (Woodside, 2017). These transactions required verification before being added to the ledger and creating an immutable audit trail (White and Krawiec, 2017). While blockchain is best known for use within cryptocurrencies, blockchain can be utilized as a distributed database or ledger with metadata on each transaction. Blockchain enabled distributed ledgers support technologies such as smart properties and smart contracts, which are enabled through
In the healthcare industry, blockchain technologies have the ability to integrate processes to improve data flows, reduce costs, and improve patient outcomes and experience. The Hyperledger Healthcare Working Group was launched to identify additional opportunities for the healthcare industry. Hyperledger is an open source global consortium hosted by The Linux Foundation beginning in 2015, with the goal to advance block chain technologies across industries (Rosic, 2017). Hyperledger currently lists over 100 members, including healthcare companies such as Change Healthcare, Medicalchain, Hashed Health, and Kaiser Permanente, along with financial, consulting, and technology companies such as IBM, SAP, Intel and Samsung (Hyperledger, 2018). Current working group use cases include clinical trials, counterfeit drug prevention, electronic health records, provider credentialing, and insurance enrollment, claims, and regulatory reporting (Behlendorf, 2018). The healthcare industry has the potential to be the most important digital transformation area with the blockchain-distributed ledger, and can be used for storing, sharing exchanging, analyzing, recording, and validating healthcare information (Tsung-Ting et al., 2017). Pilot projects with blockchain technology have taken place for applications such as electronic health records through Beth Israel Deaconess Medical Center and population health management through the Centers for Disease Control (CDC). For example at the CDC, a ledger, which stores information on disease outbreaks, could be valuable to disaster relief and response. Currently, data often degrades over time, and a blockchain-based ledger could ensure data accuracy, transparency, and long-term storage for sharing (Shieber, 2017). Researchers have also developed a prototype of a blockchain based on Ethereum called MedRec, which allows the secure and interoperable exchange of complex health information (Orcutt, 2017).

Blockchain is still in the early stages and faces a number of obstacles, for example in order to fully realize the potential of blockchain, government backing is a foundational component (White and Krawiec, 2017). Key areas for managing blockchain technology and obstacles for a successful implementation include Political, Economic, Social, and Technical (PEST) components (Woodside, 2017). As on example, the transformative capabilities of blockchain may be applied to new models of health information exchange (HIE) improving efficiencies and health outcomes. The Office of the National Coordinator for Health Information Technology has called for interoperability within the U.S. allowing secure access, verifiable access, and authorized access (White and Krawiec, 2017). In Europe, the General Data Protection Regulation is one cause for the transformation to the ledger, as regulations that require patients to have greater control over their information. For example, storing genetic data, personal health records, electronic health records, and enabling access to the information for personalized and improved healthcare (Shieber, 2017).

**Healthcare Value Chain Literature Review**

In healthcare, value is often an ill-defined term, and may refer to the delivery, quality, availability, or cost of care (Okoye, 2015). Given the continued rising costs, countries around the world are seeking to redefine value in healthcare with economic and patient considerations. Despite significant technological changes over the last several decades, the business model and value proposition of healthcare has remained similar. Porter defines the value chain as a set of inputs, outputs, and processes that occur to produce a service. The value chain may show the greatest value points, highest costs, or waste (Okoye, 2015). Within healthcare, regulations have been created in an attempt to limit costs on support activities, for example, the 80/20 rule for insurance companies specifies that 80% of premiums must go to direct healthcare costs and quality, while no more than 20% may be used on supportive administrative activities (Healthcare.gov, 2018). Figure 1 displays a traditional healthcare value chain with primary and support activities following the 80/20 rule.

A value chain is a set of activities that generate value within a resource, product or service. A traditional value chain consists of primary activities, which contribute directly to the product or service such as manufacturing and operations, and support activities which contribute indirectly such as human resources.
The value chain includes interactions amongst the activities known as linkages (Kroenke and Boyle, 2017). The healthcare value chain consists of payers, fiscal intermediaries, providers, purchasers, and producers. The 1990s saw investments into the healthcare value chain as a result of vertical and horizontal integrations, changes in federal healthcare laws, reimbursement pressures, and the rise of the Internet. Many initial efforts were unsuccessful and instead led to consolidation among major members in the value chains and there was an open question whether this contraction resulted in improved or lessened levels of competitiveness (Burns et al., 2002). With the traditional value chain model, many value chain components were tightly coupled, and was more efficient and effective to own many parts of the value chain or consolidate vertically. This was due in part to the high costs of communication, information, and coordination. With the current digital transformation, these business models no longer hold due to the availability of information at low costs leading to a loosely coupled service based approach (Frank, 2013).

![Figure 1: Healthcare Value Chain](image)

**Hyperchain Artifact Development and Research Design Methodology**

This research methodology follows a design science approach with the steps of problem introduction and importance, artifact development and design, and evaluation with a contributory communication and conclusion section. Design science research utilizes a build-and-evaluate process approach with an output of an artifact. In this research, the objective is to define and develop an artifact that allows application of hyperledger to the healthcare value chain. Design science is a problem-solving approach and seeks to create innovations that define ideas that can be efficiently and effectively accomplished through information systems. A problem more generally is the gap between a target state and the current state, whereas problem solving reduces or eliminates this gap. Design science research can further innovation through stimulation of critical thinking among users, and can be applied to new areas thought to be out of touch (Hevner, et al. 2004; Peffers et al. 2007).

An artifact is considered the item utilized to solve identified problems and may range from structured software to unstructured language descriptions. Novelty of the artifact is important in that it solves a problem for a specific domain in a more efficient and effective way through an innovative approach (Hevner et al., 2004). As this application of re-envisioning the healthcare value chain within industry 4.0 is a novel and innovative approach, an iterative evaluation of artifacts through design science is fitting. Given industry 4.0 digital transformation, a redesign of the traditional healthcare value chain is required. Constructs are the language, vocabulary or symbols by which the artifacts are defined and communicated. The initial artifact can be seen as largely an experiment dependent on trial and error to find an optimal working system. Following construct or practices identification, a model or artifact is generated to create a general framework for application to a variety of contexts (Hevner et al., 2004). The construct comparison results between the traditional healthcare value chain and the healthcare hyperchain are shown in Table 1.

<table>
<thead>
<tr>
<th>Component</th>
<th>Value Chain</th>
<th>Hyper Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component Integration</td>
<td>Tightly Coupled</td>
<td>Loosely Coupled</td>
</tr>
<tr>
<td>Component Cost</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Activities</td>
<td>Primary and Support</td>
<td>Consumer and Producer</td>
</tr>
<tr>
<td>Focus</td>
<td>Product-Centric</td>
<td>Patient-Centric</td>
</tr>
<tr>
<td>Storage</td>
<td>Centralized</td>
<td>Decentralized</td>
</tr>
<tr>
<td>Environment</td>
<td>Local and Slow-Changing</td>
<td>Global and Fast-Changing</td>
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**Table 1. Healthcare Value Chain and Hyperchain Component Constructs**
The hyperchain activities may be brokered by a distributed service, with each version listening for data requests. The data requests are cryptographically signed by the requester such as a patient, in order to authenticate the requester and validate the authorization for data. Once approved, the data is sent to the requester. For new records, these are posted to the blockchain after the patient authorization occurs. Ownership of data is often complex question, with compounding issues including control, privacy, bureaucracy, cost, and value. Ownership may be a simple assignment, such as ownership belong to the record creator, though the degree of ownership often does not equate with the degree of responsibility. Instead, the degree of ownership can be driven by the value that each actor or participant generates from the information. This has the ultimate goal of global data sharing to increase knowledge and improve healthcare (Loshin, 2001). While privacy is an ongoing concern, conditions may be developed that would allow adequate sharing of information, including public sharing of information (Loshin, 2001).

This hyperchain artifact includes a set of activities and actors, which are categorized, by data producers and data consumers. Data producers often do not recognize the impact on data consumers and vice versa. To be successful both data producers and consumers must work together. For example even within a standard healthcare claims process, several players are involved including health plans, patients, providers, claims administrators, clinical services, analytics and technical services, and network managers (Soares, 2012). The primary data produced by the patients and providers are consumed or mined by the data consumers such as payers, researchers, employers, governments, and manufacturers. The activities, which bridge the data producers and data consumers within the hyperchain, include patient consent records, electronic health records, health information exchange, insurance processing, contract management, eligibility, clinical research, and pharmaceutical. The actors include patients, providers, payers, medical researchers, employers, governments, and manufacturers.

**Figure 2: Healthcare Hyperchain**

### Conclusion and Future Directions

Global complexity challenges and digital transformation are prompting the re-envisioning of the healthcare value chain into the healthcare hyperchain. This emerging research contribution includes the development of a hyperchain artifact. Hyperchain constructs are identified to provide a clearer framework for innovation and creative practices, which can be applied to a set of organizations and situations. In design science the artifacts, constructs, and methods must be able to be implemented in a business and technical environment and allow communication to both business and technical audiences (Hevner et al, 2004). Future directions include the demonstration and evaluation of the artifact following well-selected experimental evaluations for usability, including development of situational use cases and summary of evolutionary adoption levels for healthcare value chain participants within the developed hyperchain artifacts following a design science approach (Hevner et al., 2004, Pefferz et al., 2006). Similar to the 1990’s, 2018 is anticipated to be the beginning of another era of integration and significant change because of digital transformation in Healthcare (Swartz, 2018).
REFERENCES


